DANIEL KRAFT INTERVIEW PART ONE - INTRO

Hello Ars Technica listeners. This is the latest serialization of an episode of the After On podcast. We're splitting this one into two segments, starting today. And I'll be talking to medical futurist Daniel Kraft

Rob Reid: I don't know anyone with a broader purview on the crazy range of medical developments that are now vying to extend or radically improve our lives.

I've known Daniel socially and professionally for years. He founded and runs the exponential medicine Conference, which is one of the largest truly cross-disciplinary gatherings of life science researchers and innovators of the world, and he also founded and runs the medical faculty at Singularity University, a wonderfully unique academic institution that could only have arisen from the fertile soil of Silicon Valley. We actually conducted our interview at Singularity University and we'll be talking quite a bit about that institution during the interview.

When Daniel does a presentation, he's the opposite of that speaker we've all seen who has to do everything possible to pad their words and their slides to fill up their time slot. With Daniel, I always feel like there's an entire presentation lurking behind each and every slide that he puts up on the screen. He just has so much surface area because of those two very complimentary jobs of his, they put him in touch with hundreds of startups and researchers every year. Daniel is particularly deep in medical devices, ranging from consumer-grade gear to tools that only turn up in research hospitals. And as an oncologist, he's of course, deeply informed about cancer as well.

Just a couple more words of context before the interview starts: As you may know from previous episodes here on Ars, my podcast dives deep into complex issues in science, tech and society which are worth understanding a bit better. Each episode's built around an in-depth interview with a world-class expert in the relevant field**.** I do 20-30 hours of up-front research and preparation before sitting down with my guests. And I structure my interviews carefully, so that their information density hopefully feels a bit more like TED talk than a meandering long-form interview.

And with that, let's start my interview with Daniel Kraft.

TRANSITION MUSIC

Rob Reid: So Daniel, it's great to be here in Singularity University's headquarters in this gorgeous old building on this vast and historic stretch of land. Could you tell us the official name of this complex and a bit about its history?

Daniel Kraft: NASA Ames Research Park, we were originally a Naval base and if you look out the window here you see this huge Hanger One that was built in the early '30s to house airships the size of the Hindenburg and they'd float out of the ocean looking for German U-Boats. This was a very active base all the way through the '90s and this piece of land here is quite amazing 'cause we're like one exit from Google, we're like 15 minutes from Stanford, we're 40 or minutes or so from San Francisco, so it's this quick conversions point and now we're seeing everything from Singularity University to Google's building, C Mellon's here, the airstrip here, which NASA still uses, the actual NASA Research Center across the gate where they have wind tunnels, flight simulators-

Rob Reid: And I have to say Hangar One is simply massive. I remember when I was an undergrad you'd go way up on Skyline Boulevard, which is this fairly distant high ridge many miles away and you would look at the sweep of Mountain View and Palo Alto you just see this giant black building like Darth Vader's garage.

Daniel Kraft: Right, at its time it was like one of the largest rooms in the world. And actually, if you look next to the hangar today, there's a B-17 and a B-24 and a B-25 bomber from World War II vintage. And I love old aviation, I'm a pilot, I love war birds. I'm going to take you after our interview to go climb around some old-

Rob Reid: Yes.

Daniel Kraft: ... warplanes.

Rob Reid: We're going to make pilgrimage to these fighter planes, but first we're going to talk a bit about the future of medicine and let's ease into that by reviewing your own background. You're from the East coast, right?

Daniel Kraft: I grew up in the D.C. area, inside the beltway. I always liked and gravitated to science and biology a bit, but when I was in high school, I did a little internship at the NIH, the National Institute of Health-

Rob Reid: I didn't realize that.

Daniel Kraft: ... and that was 10th grade, and 11th grade, we had to do a science fair project and I'd worked in the lab helping make some of these early monoclonal antibodies to study immunology, the IGE receptor, which is responsible for releasing histamine when you have allergies. To make a super long story short, I came back to the lab with this idea that we could use some of those monoclonal antibodies that we were using to study these receptors to block them from IGE binding, which is what happens when you have a pollen allergy. Those little pollen proteins get in your bloodstream, they cross link this IGE and it triggers these cells to release histamine, which makes you sneeze and feel miserable. This whole approach ended up being a potential way to cure allergies.

We took it into rat models and showed we could cure them of their allergies and my thought was we should take this to humans. And the folk says oh great idea Daniel, but we can't humanize antibodies yet, this is in the mid to late 1980s, to date myself. Fast forward 10 years later, I'm a Stanford medical student, I get a call from Genentech. And they said, "Daniel, can we see the very early papers you did on this side trip project 'cause we're in a patent dispute with another biotech company for what is now a very popular drug called Xolair, which is doing exactly the same approach, blocking this IGE molecule through an injection of antibodies.

Rob Reid: So your high school paper was prior art in an actual significant intellectual property and potential lawsuit?

Daniel Kraft: As I understand it. And my joke was at Genentech, "I'm here for my royalty check." That's what kind of got me into Brown University, where I did a biochemistry undergrad.

Rob Reid: So of course you were premed, which is not unusual. A bit more unusual though, you were also really heavily into flight, which has remained an ongoing theme in your life and career.

Daniel Kraft: Yeah, I'm like the kid who never really grew up. I have a four year old who's really into dinosaurs. When I was a four year old, I was really into space and flying. Grew up in the D.C. area, we used to go to the Smithsonian all the time and my father was a journalist and another journalist friend, we went down and saw the very last Apollo mission. Apollo 17 launch to the moon so I was like four or five, I was at the last Apollo mission. It was a night launch. And the first geologist, the first scientist was on that mission, so I always had the space and flying bug, always wanted to be an astronaut and be a fighter pilot. I think I probably went to the Air and Space Museum hundreds of times.

Rob Reid: Oh man, I would have hated you at that age because I grew up in Connecticut, which was close enough to go to the Air and Space Museum once as a child, but not close enough to go hundreds of times.

Daniel Kraft: So I had this space and flight bug and at Brown University, it turns out they had a flying club and you could literally learn to fly in a 1970 Cessna 150 and so as a freshman, I said oh my gosh, I'm going to learn to fly. Got my pilot's license in a year, later was the president of the flying club. We'd do some fun crazy things like take the planes to Martha's Vineyard and do flower bombing competitions on these grass airstrips.

Rob Reid: So when you got to Stanford, you went through medical school. You also studied aero astro, correct?

Daniel Kraft: Yeah, one of the wonderful things about Stanford as a medical school, first of all, it was pass fail, which was helpful for the first couple of years. So I took a

class in aero astro engineering. I was the only non-engineer and I got to do all the life sciences planning for a mission to Mars.

Rob Reid: A mission that was deemed to be plausible at that time.

Daniel Kraft: It was a seriously developed plan, this was back in 1990, it was still with the Soviets so we even had a visiting set of Soviets.

Rob Reid: They were some of the last Soviets if it was 1990. You caught them in their last several moments as Soviets.

Daniel Kraft: Yeah and so we worked out all these elements from the physics to do we do microgravity, 'cause it's like six months to nine months or longer to get to Mars. What kind of crew do you put together, what kind of life support system. So I was kind of the input on that. I had some background 'cause when I was an undergraduate at Brown, I spent all summer at Kennedy Space Center diving into where biology and medicine meets space. Think about life support to countermeasures to diet, we were there in actual hangar where the Apollo missions rolled out of. We would go down that exact elevator that Armstrong and Buzz Aldrin and Collins went out, we'd ride it every day down to lunch.

Rob Reid: I would have been tempted to, when nobody was looking, carve the initials NA into the wall of the elevator, just knowing the generations of people thereafter would all whisper, "That was Neil Armstrong who carved that." How cool would that be?

Daniel Kraft: That would be a trip.

Rob Reid: You feel like giving a gift to all future passengers of that elevator. So then you got out of medical school in Stanford, you went to Harvard for your residency. Is that when you joined the International Guard? Was it when you were at your residency at Harvard?

Daniel Kraft: I was in life sciences group. We could hear a B-17 bomber fly by right there.

Rob Reid: I love that you can identify the plane by the sound.

Daniel Kraft: Actually, that might have been a P-51 Mustang.

Rob Reid: I was going to say, I was going to say.

Daniel Kraft: The sound of a Merlin engine. But circling back, five years later when I was a resident at Mass General, I did some research and found that there was a International Guard unit on Cape Cod which flew F-15s and I went out to visit and they said, "We'd love to have you" and so I raised my right hand and was signed in to the service of the United States government as a flight surgeon and the International Guard is a bit like the Air Force Reserves. I joined and I took my

vacation time and spent six weeks at Brooks Air Force Base in Texas and we had six weeks of training in aerospace medicine. As a flight surgeon, you're not operating in the sky, you're basically the team doctor for the pilots and there's some rules about keeping them healthy or of they have a certain issue, what you can fly and you can't fly. Part of your role was to fly with them, and so I got to go up and dog fight and do in-air refueling and a bunch of stuff that you're never otherwise get to do, particularly when we got to do missions.

For example, I went with my squadron to Saudi Arabia in 2000. We did the no-fly missions over Iraq at the time.

Rob Reid: Really?

Daniel Kraft: And I could say I've flown over Iraq in an AWACS jet.

Rob Reid: Now going to the academic side of your training during that. When you got to Harvard, you focused in a diversity of things. Pediatrics hematology and oncology, correct?

Daniel Kraft: I did a sort of combined program at Mass General Hospital and at Boston Children's Hospital. I had an intense but pretty amazing four years. It was a great four years.

Rob Reid: So I would imagine at that point, you would have presumed yourself to be on an academic course, maybe do some clinical work, but it sounds like you were on a trajectory to be in a medical research oriented setting, but a couple of things took you on this exotic path of being a health futurist and the TED Conference kind of changed your life, didn't it? You came to TED, what was it, in '06?

Daniel Kraft: Was it '06, 12 years ago and I was still a Hem/Onc and [Bomer 00:12:42] Transfer fellow-

Rob Reid: Hem/Onc meaning Hematology/Oncology.

Daniel Kraft: Hematology, and a friend of mine had gone to the TED Conference and said, "This is perfect for you." I'd seen the website, I was not too far away and I was lucky to apply and get a academic partial scholarship and went to my first TED. And that was life changing.

Rob Reid: In part because you crossed paths with Peter Diamandis, the founder of the X Prize who later called you when he started Singularity University. Was that shortly thereafter?

Daniel Kraft: So I reconnect with Peter, who I'd known since I was 22 years old. And then a couple of years later when Peter was putting together the initial planning for Singularity University, and the whole idea was Peter read the book The Singularity is Near by Ray Kurzweil, a famed inventor and futurist about the

rapid pace of Moore's Law and other technologies improving and accelerating to the point where your smartphone has more computing power than all the computers in the world. And that folks weren't necessarily in that exponential mindset and the future of solving big problems was to bring today's and future's leaders to understand these exponential technologies.

So the summer of 2009 we had our first SU, Singularity University GSP, Global Solutions Program and we had 40 amazing participants from all around the world who got full scholarships and came. It was supported by the Googles and the Autodesks and others in the Valley, and that was our first summer of now 10 years. The theme then was to have folks who came in with backgrounds in medicine, biotech, nanotech, 3D printing who had an entrepreneurial and a global mindset to not just solve a problem to make money, but to have a big impact on the world. A lot of new startups have come out of Singularity. A lot of new relationships and conversions have evolved-

Rob Reid: In the summer program, it's 10 weeks?

Daniel Kraft: 10 weeks living right here-

Rob Reid: Residential, everybody's on campus.

Daniel Kraft: Right. Full ride, now we're up to 90 participants, which is about all that can fit in the housing and our main classroom.

Rob Reid: Full ride, they're on full scholarships.

Daniel Kraft: Full scholarship, room and board. So it attracts a really interesting set of folks. The early 30's is probably the average age. It's not folks who are really in graduate school. Some are.

Rob Reid: So more practitioners than academics.

Daniel Kraft: Folks who have deep technical, business, entrepreneurial and global experience. I think we had like 26 countries represented last year.

Rob Reid: Yeah, I was going to ask you so about 50-50 international U.S.?

Daniel Kraft: Probably more 80% international actually.

Rob Reid: 80% international.

Daniel Kraft: And half women now.

Rob Reid: Wow, so that is a very intense experience, 10 weeks of that. And then describe a typical day in class.

Daniel Kraft: It's actually the first let's say third of the summer is getting people on the same page. Cross training and AI robotics, 3D printing, nanotech, block chain, whatever, getting folks to understand them. Being taught by everything from astronauts to Nobel Laureates to start up founders down the street-

Rob Reid: And these piles of people who come through for a lecture and then there's people like you who are basically running part of the faculty.

Daniel Kraft: Right, so I've been the Chair of the medicine side, so I put together 12 different lectures, plus workshops, we do site visits to Stanford, after the first third we do a deeper dive, where folks who want to maybe focus more on health or energy or environmental elements could do those deeper dives. And then roughly the second half of the summer, teams would form to create a new initiative and a geo, a new startup that would solve some challenge with exponential technology. So one of the examples of companies that have come out of here is Matternet, and our second summer 2010, they saw early drones, which at the time were still toys. So this is on an exponential trend, could you use drones to deliver things like medical packages and blood and vaccines to parts of the world after a flood or an emergency. Initially a crazy idea, drone can deliver anything? And that now has evolved Matternet and others using drones to deliver serious packages to the point where it's obvious that Amazon will do that soon.

I'm holding here in my hand a 3D printed ratchet from a company called Made In Space, from one of the early summers, they looked at the future of manufacturing. Hard to get supplies to space station, what if you could print one there. And they designed a 3D printer that could fly in space and operate in microgravity. I'm holding a ratchet here that actually was one of the first things they printed 'cause they lost this ratchet on the space station.

Rob Reid: Oh so they actually created a space friendly 3D printer, put it in the international space station so that things could appear up there when they were needed as opposed to being flown up.

Daniel Kraft: It's just like Star Trek, not the holodeck, but the-

Rob Reid: It's the transporter, the transporter beam.

Daniel Kraft: And they even last printed for the first medical device. An astronaut tweaked his finger, needed a little brace, they could scan his finger and print it. The whole idea of exponential thinking at Singularity University is to think about with a couple more clicks [inaudible 00:16:50] where will AI be? Where will digital manufacturing be? Where will low cost genomics be on that trajectory and how can you combine those to solve a problem that couldn't be solved in the normal way today.

Rob Reid: You were kind enough to let my wife and I crash for one day and that was actually an astonishing day. I was amazed at the quality of faculty that came through and all the different things they talked about.

Daniel Kraft: Yeah, the faculty and the people that show up in the room, from serious investors and folks who just exited companies to CIA agents to Governors and leaders from around the world. It's an amazing experience to go through and you can get tons of information at SU.org if you ever want to come.

Rob Reid: And then out of this erupted this conference that you now run called Exponential Medicine.

Daniel Kraft: We recognize everyone's interested in health and medicine, personally, their own health, a family member, in our society, and many folks had technologies and videos that could apply to medical issues, so there was no place to really see what's the cutting edge in the future of medicine. Most medical meetings and conferences are very siloed. I'll go to oncology conferences, cardiologist go to cardiology ones. Every 'ology has it's own siloed conference. It was very rare that you blend doctors, nurses, technologists, patients, investors together and let them see a whole spread of what's happening in wellness diagnostics, therapy. Everything from drones to chatbots, and see how that could shift healthcare.

And so I kind of experimented. We did this initial program and held it here at Singulairity University and it was quite magical and we now have this every November at the Hotel Del Coronado, this oldest resort on the West coast and we now bring 700 folks together. I think 38 countries-

Rob Reid: 700 attendees.

Daniel Kraft: 600 attendees, 80 faculty, 50 startups and we spend like the first half day is a bit of sort of Singularity 101, what's happening in AI, robotics, 3D printing, nanotech, block chain, et cetera.

Rob Reid: So lecture-based.

Daniel Kraft: A little bit lecture, kind of getting folks up to speed with what's happening. Getting people to understand the pace of exponentials. And then we'll dive into what's happening with digital health and connected devices and what's happening with OMIX from geno to microbiol to protium, how that's being impactful to understanding disease or therapy. What's happening with robotics? What's happening with global health, how do we democratize healthcare around the world and not just have an expensive stem cell therapy or gene therapy, but how can we use a simple smartphone and a simple wearable or a AI handheld ultrasound to enable a nurse in a rural village in Africa, how might I use virtual reality in medical training or chatbots for coaching.

We have an incredible array of folks who come and it's catalyzed a lot of new relationships, startups, funding, and I think it's quite unique to a quote unquote medical conference.

Rob Reid: And it's four days, is that right?

Daniel Kraft: Four days.

Rob Reid: It's four days. So the purview that you now have as a result of curating the several dozen people who come and speak every year at Exponential Medicine and also this constant refreshment of the faculty here at Singularity University, you have an extravagantly comprehensive overview of the innovation side of medicine, like what's happening both at a consumer level and on a deep medical basis. You often talk about the transition from sick care to true healthcare, with sick care basically we're doing today, being very reactive and only realizing something's wrong when it's so wrong that it's evident to the naked eye. Moving to what you call true healthcare, which you characterize as being continuous, proactive and participatory, when I hear that phrase and particularly the word continuous, I think of the explosion of data that's starting to radiate from our bodies as a result of recent and ongoing technological developments. This is a process that's only just beginning.

Daniel Kraft: Right. So with this convergence of low costs, computing and mobile and batteries, we now can fit into a little sensor on your wrist a whole set of technologies which would take the size of this room 30 years ago, 'cause that's the power of exponentials. And so today, what I'm wearing, I've got a Fitbit, maybe last year's version, but it still can now do continuous heart rate, which is pretty amazing. It can track basic steps, it can track pretty finite elements of my sleep, how much time in deep, light, REM, how much I'm awake. My Apple watch on my other wrist, it can also track my heart rate and sleep. It also has a little sensor on the wristband from a company called AliveCor where it can do a full on EKG from my watch. And apparently Apple has a bunch of other potential technologies already built into their watch and they haven't turned on because of the battery life issues.

Rob Reid: Really?

Daniel Kraft: We're entering this era now where you could pack so much technology into a Fitbit or an Apple watch or hundreds of other wearables that are similar. The challenge is creating a lot of digital exhaust. What do you do with that? What does it mean? We can now, with the accelerometer on your wrist, not just how many steps you're taking, but if your gait has changed. It may be able to predict whether you're about to have a fall or have seizure.

Rob Reid: Let's talk about gait. It would be gait that would tell you about a pending fall or a seizure?

Daniel Kraft: We might learn that there's a digital signature for folks who ... someone in their 80s or 90s might have a fall or break their hip. Is there something that changed in their gait a day or two before? Right now we're only in an early era where we're able to capture this digital exhaust. It usually lives on your smartphone, but we're starting to connect that to big databases and crowdsource that.

Rob Reid: Define digital exhaust.

Daniel Kraft: It means like the data about your steps or your sleep or your movement or your voice can be digital exhaust.

Rob Reid: Just all this stuff that's coming out of your body and is getting captured by one of these increasingly sophisticated devices.

Daniel Kraft: Right. It could be this digital BandAid that tracks heart rate, respiratory rate, movement, actual EKG, that's a lot of digital signatures. It could be the tonality of your voice. It could be the molecules in your breath, and a company out of Israel called UpRight can measure your posture in today's smartphone era, we have often smartphone neck. Our posture's not great. This is a little brilliant device, you put it in the back and just measures your posture and if you're hunched over for too long, it just gives you a gentle buzz. And that trains your physiology over about a week of using this, retrain your parasympathetic system, sit up straighter.

Rob Reid: So that becomes automatic, you don't have to wear it anymore?

Daniel Kraft: Exactly, and that apparently has some great outcomes for folks who already have lower back pain-

Rob Reid: It feels to me that when the data becomes continuous, it becomes an almost qualitatively different sort of input. Like an analogy might be somebody who is a really small investor, back in the '90s with a personal brokerage account who would look at yesterday's stock price in the newspaper and compare that data situation up to the millisecond real time feed with all kinds of exotic builtin analytics that a modern professional trader would have. Those two data situations are so different, they're almost unrelated as tools, it's al-

Rob Reid: They're almost unrelated as tools. It's almost as different as leeches versus penicillin. With medical data, we are going from this time where you would have these radically infrequent snapshots, like maybe my doctor would know my blood pressure every third year to constant, constant, constant checking of all this different data. The challenge with that to extend the trader analogy, is if you took that mid-90s small investor into a modern trading floor, they would have no idea what to do with the data. Similarly, you're implying by your discussion when you're talking about gait for instance, maybe someday we'll figure out by retroactively looking at this big wad of data that these are the

warning signs, but we sure don't know what they are now. We're going to have to spend a lot of time inhaling this stuff.

Daniel Kraft: Exactly. It's a bit of a so-what if you're just having piles of exponential amounts of data. You don't want data. You want actual information and knowledge that you can apply, use that in an integrated way to say, "Rob, your sleep is changing. Your resting heart rates gone from 55 on average to 63. Maybe something's going on with your cardiovascular system."

Rob Reid: We're in this awkward phase now where a bunch of us need to start exhaling this digital exhaust and capturing it so we can figure out what in the world it means. There are already some interesting signs. Tell us the story about the person whose life was saved by their Apple Watch.

Daniel Kraft: It was an individual who noticed that his Apple Watch showed him his heart rate was 180, when he's normally in the '60s.

Rob Reid: The watch nudged him, or he just happened to notice?

Daniel Kraft: I think he happened to notice it. He was like, "This doesn't seem right," and he took himself to the emergency room. It turns out he had a pulmonary embolism, a clot in his lungs which could have killed him. He normally wouldn't have felt that his heart rate was double its normal rate. I like to call that the early version of check engine light for the body.

Rob Reid: I love that analogy, which I've heard you use before. Today's 1.0 version of the check engine light makes this data available to an observant person, which is very simple but was enough to save this guy's life clearly. Version 2.0 would probably involve the watch nudging you when it realizes that your heart rate is spiked to 180 even though the GPS and the accelerometer on your phone say you're sitting still.

Daniel Kraft: 3.0 is when the Apple Watch calls you an Uber ambulance and takes you to the emergency room. And by the way, Uber and Lyft are getting into health care to help bring patients to clinics and hospitals. What's interesting is the Apples and the Samsung's and the Googles all getting into this to the point now where my iPhone can collect this data and connect it back to my medical records at Stanford. My doctor literally could log in and look at my weight from my scale, my blood pressure if I was using a connected blood pressure cuff, my sleep data.

Where this will hopefully go is if my doctor has 2000 patients, he might see five patients in the morning on this dashboard that are moving into yellow or red, that they have something going on, he might want to call them proactively.

Rob Reid: Some of that analysis would have to be done by the system, not by him because he can't crunch data on 2,000 patients. He wouldn't know what to look for. What you just pointed at I think is interesting and important; your doctor can

now see the data from your Apple Watch. That wasn't the case for anybody as recently as a year ago. This is the first baby step in that direction. What was it, 40 hospitals?

Daniel Kraft: Apple pioneered with one of the big electronic medical record systems, Epic, that they could connect the dots from your health kit app into your medical record at about 40 hospitals. As of two months, my medical record from Stanford I can see on my Apple phone.

Rob Reid: It goes both ways. You can see the data stored at Stanford on your phone, and Stanford can pick up the data that's radiating out of your watch.

Daniel Kraft: It's that combination. We talked about the fact that you usually get very intermittent data and occasional blood pressure, an occasional EKG, some snippet of information when you're in the clinic, which is hopefully .000001% of your life. Intermittent data means we're reactive; we'll wait for the heart attack, stroke cancer to come. We're at the beginning ages of connecting those dots going from quantified self where I just have this information from my Fitbit and my scale to quantified health where that data's going to flow to my health care system and be useful in tuning prevention and optimizing my health, picking up disease early. If I have a disease like high blood pressure or even a cancer or heart disease, it can help me manage the feedback looped system to optimize care.

Rob Reid: This deal with Apple and these 40 hospitals, and that is a sub-1% of the United States population, but there was a time when a tiny sliver of 1% of people had access to GPS because they had high-end cars that had it built in, which was the only way you could get it. This is big. It's happened at 40 influential hospitals, and it will, presumably, radiate far beyond that. The other thing is finding all the patterns in the data that nobody would recognize right now. We talked about gait. It may well be that weird patterns in the way that somebody walks is highly predictive that they're about to come down with Lou Gehrig's disease, which does impact somebody's gait. There is no way that you or I or the smartest doctor in the world could go through 15,000 person years of data coming off of these watches and come to that conclusion.

I've always worried when I thought of this thicket of data radiating from these watches and other devices how are we ever going to parse that. You told about this mind boggling work that was just done at Google with irises, which, again, like the Apple 40 hospital deal, is but the first and earliest sign of how something is going to get fixed.

Daniel Kraft: We're now in this early but so exciting convergence of artificial intelligence, big data, machine learning, being applied to now this explosion of health data from digital exhaust from our wearables to our genomics to our microbiome data to our connected homes to all these things. The trick now is what do you do with it? How do you analyze it?

Rob Reid: How do you get the correlations that have actionable information?

Daniel Kraft: For example, now with your smartphone and the camera and a simple attachment, you can take a picture of your retina, the back of your eyeball, the arteries and veins of your eye, which can indicate lots of issues. Now, Google and others have developed ways to take pictures of your retina and apply machine learning. They can tell if it's a boy or a girl just from looking at the retina, which no clinician can do. They've now been able to pick up, for folks who have diabetes who might have diabetic retinopathy, who's likely to progress from that, so they can predict projection of disease. What they published a couple of months ago, very powerful, just by looking at the retina and, again, analyzing the blood vessels and changes there and patterns, who's likely to get a heart attack or a stroke. You might get a little ping based on your retina scan that the next two weeks, you have high risk of having a heart attack or a stroke. Maybe you want to go see your cardiologist.

Rob Reid: This is coming up with insights that no doctor could ever possibly replicate. They can determine gender, as you said, they can approximate age, they can determine whether or not somebody smokes. No person could do that. They literally took in 300 thousand eye scans, they matched it to the known data on these people, do they smoke, how old are they and so forth, and they got to the point where they could take this massive data and make powerful predictions. To me, that points to how in the world are we going to interpret gait and whether gait is predictive of a stroke. This is precisely the template.

I don't think anybody outside of this research team could have possibly guessed a year ago that looking at a bunch of eye scans, we'd suddenly be able to tell gender, do they smoke, are they in danger of diabetic retinopathy and all these other predictive things pumping this gait information, this breath, the sweat information, which we'll talk about in a second, all these other things through a similar machine learning process will create totally unexpected, correlative reality and allow us to take these steps.

Daniel Kraft: It's moving really fast. Now there are already companies out with ways to basically already do a better job of radiologists, so looking at chest x-rays and CT scans. There's the dermatology side. There's all these things. I don't think we'll replace the radiologist, pathologist, dermatologist, but hopefully augment them.

Rob Reid: Some people think that the radiologists in particular are doomed.

Daniel Kraft: It's going to change their practice for sure, but right now, they might spend 80% of their time looking at normal chest x-rays. In many parts of the world, there are not enough radiologists or it takes too long to get the results back. It's going to be a bit of a blend. It's a huge sea change. The challenge is, no doctor even wants to look at some of that raw data from your Fitbit or get those check engine light signals because they don't want to be liable for it.

Rob Reid: Would the doctor even know what to do with continuous heart rate information really?

Daniel Kraft: One classic one, this AliveCor EKG thing, this company started doing over a million EKGs a month. It's a device you can buy on Amazon today.

Rob Reid: They're already doing a million EKSs per month, this little startup. That's probably more than anybody has ever done ever. They're probably getting data that has never been fathomed before.

Daniel Kraft: Absolutely. This is this big data era. You've heard of probably the Framingham trial. That was 80 years ago in Massachusetts, a pretty limited set of European derived folks. That is still driving a lot of what we do today based on that small subset of that population from 60 years ago.

Rob Reid: Now to be clear for those who don't know, the Framingham Study followed these people very rigorously over a period of decades and all their health outcomes and weighed them and checked their blood pressure on an annual basis, right?

Daniel Kraft: Exactly.

Rob Reid: Which is a speck of data compared to what we're talking about now. The significance of that, how many major health insights ended up radiating out of the Framingham Study?

Daniel Kraft: A lot of insights, a lot of standard operating procedures for when you might get screened, what kind of medications will work or won't work. Some of it's pretty flawed. It's still a pretty homogeneous type of population in Massachusetts.

Rob Reid: Nonetheless, it had a major shaping influence on health care in the 20th Century, this one study with this relative speck of data, right?

Daniel Kraft: Correct, but what's happening just this last month, just launched out of the NIH is this new platform called the All of Us Trial. They're going to take a million Americans and trying to get not just Caucasians but Asians and Hispanics and African Americans in different socioeconomic classes, but they'll volunteer their data including their wearable device data. Some are going to get full genomic and other scans from genome to microbiome, and we're going to be doing basically a Framingham Study on steroids in real time-

Rob Reid: With a million people of incredibly diverse backgrounds with radical amounts of data as opposed to the few things they could get on an annual doctor's visit.

Daniel Kraft: Absolutely. Hopefully, that will inform what to do with this digital exhaust, how to tell that your gait is changing or your tremor is picked up by your watch that might be early Parkinson's. When you pick up disease early at stage zero or

stage one, then you have a much better chance of treating it or curing it. We talked a little about crowdsourcing. We all can become data donors, but if we share some data, just like we share our data when we drive, very few people listening to this podcast drive anymore without Google Maps or Waze. We're sharing some pretty private data. In exchange, we get the map of the traffic and even can tell where the cops are hiding out. If we had that Google Map or Waze for health care where we're incentivized to share data still anonymously, we get our own health care map. When I'm trying to be on my health care journey for myself or my patients, I can guide them in a way that's real time informed and might mean that you need to take a different rout if you have a certain set of genes or conditions.

Rob Reid: The Waze analogy is actually a really, really good one because if we all just think about what it used to be like driving with a physical printed map, even a really good one like the Thomas Guide in Los Angeles. It was remarkably comprehensive. You couldn't get around without it, but comparing that to Waze, to this real time thing that's taking in data from millions of other drivers, crunching it and routing people, and that's the step up we're going to take.

To me, again, that eye scan study was so profound because it is the first indication that, yeah, we can take this morass of data, put it through very smart machine learning algorithms and start coming up with those predictive points much in the way that we're all very viscerally experiencing the fact that it's done with traffic data. With that context, I think it becomes really interesting to talk about the next things that are going to enter the check engine light equation, some of the things that we aren't quite monitoring yet but are probably on the menu in the coming five years.

END INTERVIEW ELEMENT OF PART ONE

Hello Ars Technica listeners. Sorry to end on a big of a cliff-hanger there, but our time is up for today. And btw I'll open tomorrow's installment by repeating those last several lines to re-set context. But if you can't wait to hear the rest of it – or, if you'd like to browse my other 30-ish episodes, you can just head on over to my site, at after-on.com. Or, type the words After On into your favorite podcast player. This interview originally ran on May 29th of last year. You'll also find lots of other stuff about life sciences - above all, genomics and synthetic biology. Conversations about robotics, privacy and government hacking, cryptocurrency, astrophysics, drones, and a whole lot more.

If you like what I do, I hope you'll consider subscribing to my podcast and listening to some of the episodes in archive - all of which were designed to have long shelf lives, and none of which have gone stale yet.

And of course you can join me here tomorrow on Ars, when we'll continue with Part Two of this interview.

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