Transcript Details

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The Future of Restoring Functionality in Stroke Survivors

Dr. Weisman:
Every 40 seconds, that's how often someone in the U.S. has a stroke and it's common for many of these patients to experience impaired functionality for the rest of their lives. But now, thanks to the latest research, something that seems straight out of a science fiction novel, brain/computer interfaces might be able to restore the functionality when combined with already-existing robotic braces for patients with stroke.

Welcome to *NeuroFrontiers* on ReachMD. I'm David Weisman and joining in me to discuss his research is Dr. Mijail Serruya. Dr. Serruya did is MD/PhD at Brown, he did a neurology residency at Penn, and he's now the cofounder of three companies touching on this area. Dr. Serruya, welcome to the program.

Dr. Serruya:
Thanks for having me, Dave.

Dr. Weisman:
So let's just dive right into your research, Dr. Serruya. Tell us about your recent research on long-term stroke care.

Dr. Serruya:
The study we just did, the main part of, the implantation phase we're calling the Cortimo Study, it was designed to address an unmet need of stroke care, like you mentioned, which is how do we improve that long-term disability that many people who have had a stroke have to endure for the rest of their lives. And the more specific question was, "Could we have a person who's had a stroke regain abilities using the brain implant paired to a robotic brace?" and we answered that question. The answer was "yes." We implanted electrodes about the size of an M&M into the brain with our neurosurgery colleagues, the wires extending out of the skull with a percutaneous connector. Then they're plugged in, literally, to a cable and amplifiers amplify those brain signals, convert them into electric control of a computer curser or the arm, the orthosis that the patient was using and basically, the system is listening to those brain signals on the other side of the stroke and decoding them in real-time and using that to open and close the hand.

Dr. Weisman:
To be able to interpret the nerve cells and code that into robotic movement, it just sounds like hurdle after hurdle. How did that happen?

Dr. Serruya:
The idea is that the brain represents all kinds of movements and we just have to find a way to make sense of that, and previous work that I had done in my doctoral work and then in the cyber-kinetics startup some 15+ years ago, we put these electrode arrays in the cortical surface of, first, nonhuman animals and then human patients who had quadriplegia due to spinal cord injury and tried to figure out what those cells were saying, and we using a bunch of machine learning algorithms, some of which were actually pretty straight-forward, what we call linear filter, which is a kind of Matrix analogy of the quasifield line, right? Y=mx+b, it's sort of like saying for every neuron that we can record on an electrode tip, how many discharges does it make per a number of amount of time, within certain number of milliseconds? You count that up, multiply it by a number, put it together, and then you make a prediction of where you think the hand is in space, or what you think the hand is trying to do, so open or close. So, we've been working on that for many years and there's a lot of different approaches. I think going towards the motor cortex or the cortex, itself, is important, meaning it is possible to use a substitute signal. One could imagine opening, closing a hand brace with your heart rate, it would just be extremely difficult because you would have to concentrate and if anything exciting happened, you'd lose control of your arm, so rather than trying to use a substitute signal that's very unnatural, we wanted to go directly to where signals come from. And so, when we want to talk and move, presumably, things get routed through our motor cortex and out down to our spinal cord to talk and move and do we're trying to get

directly at the source of that so we can listen to it. But it was unknown before this study what we would get if we recorded from the cortex of someone who's had a stroke, right next to that area, this was new, and we weren't really sure what we were gonna get. And we still have tons to learn, in terms of making sense of what we are recording, but we are very happy to say that we could make enough sense of it that he could control the brace so that he would try to open the hand and we could detect that trying type of signal and then learn to use it to actually open the hand up.

Dr. Weisman:
You have the first study that targets people who've had strokes for this type of technology. What made you choose to test this technology on stroke patients?

Dr. Serruya:
Right, so it was important for me and our colleagues at Jefferson to go for a condition that affects more people for a couple reasons. So one is that there are so many more people affected by this kind of hemispheric stroke that causes hand weakness, leg weakness, some people, as we know, difficulty with communication, perception, cognition, and so, it just is relevant to a large number of people, but also, not only does it affect more people, but because of that, you can attract more resources and interest, so we can sort of advance the technology that will help, we hope, the people with less common conditions; because, since we did the original work at Brown University almost sixteen years ago, there have been other groups that have expanded on this work, maybe 20, 30+ people have had these implantable brain computer interfaces and there's people today that have them, but without exception, they rely on this gigantic team and all this equipment and it really is not available to the average person and so, one way to move the whole translation enterprise forward is to show that it's relevant to a much more common condition and it can do something concretely to benefit them.

Dr. Weisman:
For those just tuning in, you're listening to *NeuroFrontiers* on ReachMD. I'm Dr. David Weisman, and I'm speaking to Dr. Serruya about his research focusing on the combination of brain interface and robotic braces to help stroke patients restore functionality.

So let's just keep diving into your research, Dr. Serruya. Can you tell us about the different components involved in this technology?

Dr. Serruya:
Right. So, there are different components, so part of it is the brain sensor, which also can be used for stimulation, and as people listening to this may know, there are a lot of devices out there that are fully implantable. so, There are deep brain stimulators for essential tremor and the tremor Parkinson's disease. There are devices like the NeuroPace for epilepsy and other types of implants that are in use by many, many human beings, including children. So there is a way to make a device safe and fully-implanted. This device is a little different than those in the sense that almost all of those devices I mentioned are stimulating; they're generating an electric current to modulate some part of the brain, whereas, in this one, we were recording activity, his own brain makes and using that to trigger something else. So there's at least one man who had a stroke in Cleveland who had an implanted functional electrical stimulation system. So the orthopedic and plastic surgeons there implanted tiny wires in his arm with a stimulator in his chest and he can move that paralyzed hand through electricity in that arm. So one could imagine connecting these two kinds of technology, so a sensor in the brain that beams signals out without any wire sticking through the skin to, say, your iPhone, that is, kind of, a supercomputer and then that sends signals, in turn, to a stimulator in the chest and the arm and moves it again. And there are lots of variations in this so one could have stimulators in the spinal cord, there may be ways to actually use optogenetics, so we use light and shine light to parts of the spinal cord, and I have colleagues that working with at Penn who are working on making all of the aspects of this made of cells, making it biological. So, just like people who have had a heart valve problem and they may get either a metal valve or a porcine valve made of pig tissue, we may actually be able to make electrodes and batteries out of cells from the person. And these kind of living electrodes, living amplifiers, living radios, they may sound like science fiction, too, but in a sense, they're just building naturally off of techniques that surgeons have been using for a long time and putting them together in a principled way. So, all those things are options, and we want to make all of those available. And there may be different things that work for different people.

Dr. Weisman:
What advice do you have for young medical students who may be interested in your field?

Dr. Serruya:
Thomas Edison I think was the one who said, "Genius is 1% inspiration, 99% perspiration", so I think a lot of this is perspiration and persistence, it's getting lots of advice from different people, but also keeping your own council. I think one thing that I learned, and I give credit to you, too, is sort of, running these things by people and sort of saying, well, you know, "What makes me happiest? What gives me most joy in the day?" If so many parts of our working day is going to be challenging and difficult with whatever kind of mundane aspects or bureaucratic or administrative or who knows what, then what bigger pictured are we plugged into? What are some unique things that we can contribute? So, I think that's important. And I mean, in 2021, as a medical student and a college undergrad and a

graduate student neuroscience, all of human knowledge is literally at your fingertips and some of that is the internet, but some of that is also reading manuscripts, including original ones, going back, you know, a century or more. So, there's an enormous number of resources that people can explore and then you connect yourself to laboratories and companies doing cool and interesting things, realizing that these are all a huge team effort

Dr. Weisman:
Well, this has been a fascinating look at some of the latest technology and research that can help stroke patients and I wanna thank my guest, Dr. Serruya, for joining me to discuss this research and where it's going in the future. Dr. Serruya, terrific having you on the program. Thank you so much.

Dr. Serruya:
My pleasure. Thank you.

Dr. Weisman:
I'm Dr. David Weisman, to access this and other episodes in our series, visit ReachMD.com/NeuroFrontiers, where you can Be Part of the Knowledge. Thanks for listening.