Mayo Clinic Q & A - AI improves brain stimulation treatments...

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SPEAKERS

Dr. Halena Gazelka, Dr. Dora Hermes, Dr. Kai Miller

D Dr. Kai Miller 00:01

Coming up on Mayo Clinic Q&A, we'll look at how artificial intelligence is being used as a tool to treat diseases of the brain.

D Dr. Dora Hermes 00:09

We use it to distinguish different types of inputs to a particular brain area in an automated fashion. And that's the important part about artificial intelligence is in an algorithm. And what this algorithm reveals, is that there's many different types of responses, a whole set of responses that describe the much more complex dynamics in the brain, or the processes in the brain. And that can actually help patients and help distinguish different types of networks.

D Dr. Kai Miller 00:35

Today, we'll look at how artificial intelligence is helping improve devices in surgical techniques in deep brain stimulation. That's a surgical procedure that involves implanting electrodes in certain areas of the brain. These electrodes produce electrical impulses that can regulate abnormal impulses. For the therapies that we deliver, usually the only symptoms that patients will have will be improvement, and the normal symptoms they have for their disease.

D Dr. Halena Gazelka 01:01

Welcome, everyone to Mayo Clinic Q&A. I'm your host, Dr. Halena Gazelka. For people with epilepsy and movement disorders such as Parkinson's disease, electrical stimulation of the brain can be part of their treatment, believe it or not. The hope is in the future that electrical stimulation may help people with psychiatric illnesses and direct brain injuries such as stroke as well. But understanding how brain networks interact with each other is complicated. So, Mayo Clinic and Google Research are using artificial intelligence to improve brain stimulation devices to treat disease. Here to discuss this interesting topic with us today are Mayo Clinic researchers, neurosurgeon Dr. Kai Miller, and biomedical engineer, Dr. Dora Hermes. Thanks for being here today Kai and Dora.

D Dr. Kai Miller 01:51

Thank you for having us.

D Dr. Dora Hermes 01:53

Thank you for having us.

D Dr. Halena Gazelka 01:54

What a fascinating topic to talk about. But maybe we should just start Kai with what is a brain stimulation device?

D Dr. Kai Miller 02:02

Many of the diseases that we think about as neurological diseases are diseases of circuitry in the brain. So, rather than coming from just one place in the brain, there are several different places in the brain that interact and the normal ways that they interact with one another are disrupted in disease. And one way we can interact with those circuits in order to have patients have improvement in their symptoms, is to put electrical stimulation devices into specific nodes in these interacting circuits and deliver electrical stimulation that shuts down part or all of the function of that given node. Some diseases that we treat for this are things people will be familiar with like Parkinson's disease, where there are tremors and abnormal electrical signatures that accompany those tremors, and also things like essential tremor, Tourette's, and epilepsy. So, as a neurosurgeon here at Mayo, I treat movement disorders like essential tremor, Parkinson's disease, and Tourette's, but also epilepsy quite a bit. And we use electrical stimulation for both of these. And people may be familiar with the term deep brain stimulation. And that is the most common type of electrical stimulation that we do.

D Dr. Halena Gazelka 03:25

So, Kai are you basically using electricity or electrical stimulation to stop activity that shouldn't be occurring in the brain?

D Dr. Kai Miller 03:35

So, that's a great question. It sounds like a simple question that you've asked. But it's actually something that's not well understood. So, when we deliver electrical stimulation, we can do it in different ways. So, we know that when we stimulate, for example, at 30 hertz, which is 30 electrical impulses per second compared with 100 electrical impulses per second, we can get actually symptoms being worse in the 30 hertz case, versus better in the 100 hertz case. And there's some mixture of exciting these cells and having them send impulses elsewhere, versus shutting the activity of these populations of cells in the brain down. And the most common type of thing that we do now is high frequency electrical stimulation. So, at something like 100 to 130 hertz, and that's really mimicking what we would do if we made a lesion or destroyed that part of the brain, but we turn it on and off, and we can actually give it a partial effect. So, it has the effect like a partial injury to that part of the brain, which helps reestablish normality in that circuit. This happened from disease states, maybe even elsewhere in the brain. And so, it's a simple question. I know an important question that you'd asked, but the answer is, there is no simple answer.

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Dr. Halena Gazelka 05:00

How did I know you were going to say that. Kai, can patients feel when their brain is being stimulated?

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Dr. Kai Miller 05:07

Yeah, in some cases they can. In other cases, they can't. I mean, for example, if you stimulate areas of the brain involved with movement or sensation, they'll feel sometimes changes in the way that they move, or they'll feel abnormal sensation. And for the case of some of the surgeries that we do. Actually, we do surgery as the patient is awake, so we can test for abnormal sensations and that kind of thing. For the therapies that we deliver for epilepsy, and also for movement disorders, usually the only symptoms that patients will have will be improvement in the abnormal symptoms they have for their disease.

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Dr. Halena Gazelka 05:47

So, let's get on to what's new about this. Dora, what is artificial intelligence or AI? And what does it have to do with brain stimulation?

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Dr. Dora Hermes 05:56

So, artificial intelligence is a set of tools, a set of mathematical and statistical tools that we can use to basically distinguish different types for, in this case, different types of brain measurements, or we can decode, we can label those automatically in an automatic fashion. So, if there's a large, yeah, it's a broad field. There's a lot we can do with artificial intelligence, or machine learning tools. And in this case, we used it to distinguish different types of inputs to a particular brain area in an automated fashion. And that's the important part about artificial intelligence. It is an algorithm, basically a mathematical computation that works on its own. So that's the important part about it here.

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Dr. Halena Gazelka 06:48

So, it sounds smart.

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Dr. Dora Hermes 06:50

Yes. So yes, you can basically, and that's why it needs to be, you know, it needs to be developed with, you know, with the insights of neurosurgeons especially such that it will actually be interpretable, that the outputs are interpretable. But it's not just a black box, that when you're labeling something that you don't know about, but you're actually getting some output back that fit, that matches your data. And that describes the data in a good fashion. And so, why that needs to be described applied to brain stimulation is important. So, the reason why we apply in this case, an AI algorithm to brain stimulation, is because previously, people only looked at like a very few features when we stimulate the brain in the manner that we did in this study. So, people only looked at one single type of response. And what this algorithm reveals is that there's many different types of responses. It's not just one type at one particular latency. But it's a whole set of responses that describe the much more complex dynamics in the brain or the processes in the brain. And that can actually help patients and help distinguish different types of networks.

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Dr. Halena Gazelka 08:01

Interesting. Dora, I'm going to ask you one clarifying question, and I may be way off base. I implant spinal cord stimulators for back pain, and it provides a constant signal, there's not an alteration. Is the point of the algorithm, and the learning part of this that the treatment can change in response to what's going on in the brain? Or am I misunderstanding?

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Dr. Dora Hermes 08:25

So, in this case, it doesn't, the stimulation doesn't change, it is constant. It's the same type of amplitude as a single pulse. So, what we did, so it's actually a really elegant way to probe brain networks, because we apply a very brief pulse of electrical stimulation. And coming back to the previous question about whether patients feel it, they generally don't in this case. It's generally, it's so short and so small that they generally don't feel it. But the good thing is that since we sent a single pulse into the brain, it has a large effect on different networks. And it affects different networks in different ways. And that's what the algorithm distinguishes. It helps us tease apart those different networks to better understand which areas to probe in order to help develop new therapies.

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Dr. Halena Gazelka 09:18

That is really fascinating. So, how do you apply this every day in your practice Kai? And how would an individual or patient know if they might be a candidate for this type of therapy?

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Dr. Kai Miller 09:33

Well, we're starting to have the ability to deliver stimulation to many different brain areas. So, for example, when Deep Brain Stimulation started, it was really just one site could be stimulated at a time. And there are now clinically available 32 channel stimulation systems for the brain. And we actually implanted the first in the world here at Mayo Clinic last summer, and If we're stimulating different areas in the brain, the brain is large and complex. And we need to know if we stimulate to different areas, are these areas interacting with one another, and if so, if we're trying to decide, let's say, I know that one particular area is important, and I have two other candidate sites where I might stimulate, and I want to know if one of those candidate sites is interacting with this one site that I know is important. So, this technique would allow us to deliver short electrical impulses separated by long periods of time, and then tease apart whether or not the response that they create in the site that we know is important is the same for both of those two, is different for those two, and whether one is, let's say statistically significant, and the other is not. And because of the types of algorithms that are out there to naively learn, or where the computer itself can learn by applying a set of rules, the algorithms that were out there prior to our study, didn't have the ability to leverage a known structure that you would already have in the data. And for the people that are maybe experts in the audience, that kind of thing, it's a new type of hierarchical clustering algorithm that didn't exist before. And basically, we take advantage of the fact that we expect that when you stimulate one brain area and measure in another, if you stimulate 10 times, that each of those stimulations should appear somewhat similar. And then if you go to a different site and stimulate 10 times, that each of those 10 should be similar. But we can actually look at shared structure between, let's say, the 10 impulses produced by stimulating one site and 10 impulses in another site, and look at similarities and differences algorithmically to tease apart both statistical significance and also the dynamics in time of the electrical response.

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Dr. Halena Gazelka 11:58

So, patients. How does this apply to your patients?

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Dr. Kai Miller 12:02

Yeah, well, at the end of the day, this is all about patients. And so, I think that the easiest way to explain it will be as we start to treat new diseases. For example, obsessive compulsive disorder, we're going to be implanting large numbers of electrodes, and only some of those electrodes will be the places that we deliver a therapy to. And we need to have a method to probe the network of regions that we've implanted, and come away with a concrete statement about how different nodes in that network are interacting with one another. And so, this provides a new important diagnostic tool to characterize those interactions so I can put in multiple electrodes that stimulate in multiple places at the same time, but with particular spatial, meaning across different areas in the brain, and temporal, meaning at different points in time, patterns of stimulation that will treat diseases that are somewhat more sophisticated and nuanced in terms of the circuit dysfunction in the brain. So, things like depression, obsessive compulsive disorder, abnormal types of seizures. And what this does is it gives us a new power tool to know what pairs of sites in the brain we should be stimulating together.

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Dr. Halena Gazelka 12:09

That is a really amazing. Dora, what do you see coming in the future for patients with brain disorders?

Dr. Dora Hermes 13:27

So, the field is shifting from seeing brain disorders, and many brain disorders as being a disorder of one particular region compared, and now they're more seeing it as a network that is abnormal. So, what we need to be able to treat network type diseases, and that's the case for epilepsy, for movement disorders. That's already been long case, but also for many neuropsychiatric illnesses, for example. And so, we need to in order to treat these network disorders, as Dr. Miller just described, we need to understand how we can probe those networks in a network style. So, distinguish multiple inputs to one brain region, and be able to combine those in order to modify a network rather than modify a single structure because we are now starting to understand better that even epilepsy doesn't always come from one brain region. Sometimes there's a network of areas involved. And this particular method allows us to probe those networks. And then I have the pleasure to be able to work with the neurosurgeons and the neurologists, to then test whether network type stimulation actually improves these diseases.

Dr. Halena Gazelka 14:37

It's very interesting. What amazing work. Much of it went above my head, but I am so thrilled that there are individuals like you working on this area. Any last thoughts for our listeners Kai?

Dr. Kai Miller 14:51

Um, I mean, I guess what I'd like to let people know is that really there is a push here at Mayo to use the traditions of the institution and the large number of patients that come to us to learn new types of therapies and bring new technologies to bear here at Mayo. And that really is a unique environment that we are able to work in, Dr. Hermes and I, in order to work with patients that had diseases, help those patients, but also learn from those patients and apply the principles that we're able to learn from working with these patients to help future patients. And that it's really only by the grace of our patients that we have that we're able to develop therapies for new patients we will have in the future. And so, I'm very grateful for the ability to work with the people who choose to do these research studies with us here at Mayo, and also to be able to work with talented scientists like Dr. Hermes, who we've brought here to Mayo Clinic.

Dr. Halena Gazelka 16:06

And allow me to say how grateful we are that both of you have joined us today to discuss this exciting topic.

Dr. Kai Miller 16:12

Thank you so much, Dr. Gazelka.

D Dr. Dora Hermes 16:14

Thank you so much for having us.

D Dr. Halena Gazelka 16:17

Thank you. Our thanks to Mayo Clinic neurosurgeon, Dr. Kai Miller, and biomedical engineer, Dr. Dora Hermes, for being here today to talk to us about brain stimulation algorithms essentially. I hope that you learned something. I know that I did. We wish each of you a wonderful day.

D Dr. Kai Miller 16:36

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