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Money And Materials Will Allow Medtech To Restore Lost Neuro Functions

by Barnaby Pickering

Medtech Insight spoke to the CEOs of Blackrock Neurotech and Pixium Vision to find out how their devices can restore lost neurological function and how devices that interface with the brain may shape the future of medicine.

Neurological conditions represent one of the last great frontiers of medicine. The brain is highly complex, poorly understood, and science ultimately has little to no answer for the "whys" or "whats" of many awful diseases such as Parkinson's and Alzheimer's.

However, there are some neurological conditions, particularly those characterized by the loss of one bodily function, such as sight or movement, that science may be able to tackle in the next decade. These conditions are typically caused by a "break in the circuit" that stops certain bio-signals from either entering or exiting the brain.

Deafness is a notable example of a condition that medicine has gone a long way towards correcting. Severe deafness that is not correctable with hearing aids can be helped with a cochlear implant. These devices bypass the non-functioning ear, and instead hijacks the cochlear nerve, electrically stimulating it to send signals to the brain, which are then processed and interpreted as sound.

But sound, and the cochlear implants that restore it, are relatively simple. Most Cochlear implants, *including those manufactured by Cochlear Limited, which has the bulk of the US market share*, have between 16 and 24 channels. This corresponds to 16-24 different audible frequencies, which is enough to interpret sound. Voices can be heard and differentiated. Moreover, the location of the implant, on the side of the head, is relatively non-invasive.

However, to restore functions like sight or motion, more channels and more invasive implants, either inside the skull or the eyes, are needed. Companies have been working on developing such implants and commercialization is relatively close.

Tackling Movement

Marcus Gerhardt told *Medtech Insight* that the inspiration for Blackrock Neurotech's technology came when he and his co-founder Florian Solzbacher were school children. Solzbacher decided that his life's goal was "to create the link between the body and an artificial bionic limb."

The two remained in contact until 2008 when the company was founded. They then began working on brain computer interfacing (BCI), a technology that had recently emerged from research labs in around 2006, when the first email was sent using it.

The *Neuroport Array* is a bundle of wires made of platinum or iridium oxide, two highly conductive and corrosion resistant metals. Hosting 100 electrodes between 1mm and 1.5mm in length, the bundle is implanted in the patient's brain and fed to the cortex.

The patient then thinks of something they want to do or something they want to say. This creates electrical signals in the brain which are in a raw, unprocessed, and noisy form. The signals then travel along the wires, and out of the head via the pedestal cap, which is installed into the skull. This cap, which looks like a complex computer cable, is the interfacing point between the patient, and the computer.

At first, the signals have no clinical benefit. However, by communicating with the patient, clinical staff can use analysis, often bolstered by machine learning, to pick out signal elements and assign them to particular thoughts or conceptions. This translates the patient's brain signals into actionable electrical ones which can be used to control computers, bionic limbs, wheelchairs and other electronic devices.

When initially working on the technology, Gerhardt explained that creating a link between human and machine seemed impossible. "While we had the vision, various constituent elements that needed to be combined to make a success of it weren't quite there."

"It required more proof-of-concept cases, and for more of these BCI pioneers to prove the fantastic impact it could have on patients," said Gerhardt.

Since then, Blackrock has seen continued success, with "31 out of the 34 BCI innovators using Blackrock technology," according to Gerhardt. The company also recently secured the US Food and Drug Administration's breakthrough designation for its NeuroPort Array BCI device. (Also see "*I Think, Therefore I Write: Breakthrough Device Turns Thoughts Into Words*" - Medtech Insight, 30 Nov, 2021.)

Blackrock's systems allow patients to not only control the outside world but perceive how the outside world affects them.

The success of Blackrock's technology has attracted widespread attention. In 2016, former US president Barack Obama fist-bumped a robotic arm controlled by a quadriplegic patient. What was most impressive about this event, however, was that the patient, who had suffered a car accident more than a decade prior, could actually feel this bump.

Restoring Vision

Pixium vision hopes to address blindness caused by age related macular degeneration. Macular degeneration is characterized by a black spot in the center of a patient's vision.

This spot will grow and become more opaque over time, forcing patients to rely on their peripheral vision, which struggles to resolve detail, as well as differentiate color.

Restoring sight has historically been viewed as an almost impossible task. Humans have evolved to have incredibly powerful eyes, with estimates of their "resolution" ranging into the many hundreds of megapixels, higher than almost any commercially available camera system, so any attempt to restore sight must feature electrical systems that contain many hundreds of channels to be useful.

Lloyd Diamond, CEO of Pixium vision explained to *Medtech Insight* the three parts of the company's flagship device, the Pixum Prima System. The first is a pair of glasses worn by a patient that contain a camera, and a digital projector. The second is a pocket processor, which connects to the glasses and transforms the camera feed into a projector feed. The final part is a wireless retinal implant. This implant measures 2mm by 2mm and is approximately 30 microns thick. In this implant, there are 378 electrodes, each with their own local electrical return path, creating what is effectively 378 artificial pixels inside the patient's vision.

When worn, the camera captures images of the patient's surroundings, converting visible light into electrical signals. These electrical signals are then processed back into light – near infrared – which is shone through the pupil onto the Prima implant.

The photovoltaic cells on the electrodes create electrical stimulation, which excites nerve cells inside the inner retina, sending signals along the optical nerve and to the brain, where they are perceived as vision.

Diamond said the stimulator can "take on the role of photoreceptor cells, but in a bionic way. We don't indiscriminately project light onto the implant. We are, in an educated fashion, targeting specific cells on the implant based on the incoming simplified images – which we generate with our proprietary algorithms."

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Naturally, the restored vision is not close to healthy, natural vision. For Diamond however, that is not yet the goal. "We're giving patients useful vision. Detailed enough to where, in a contextual setting, they are able to read and understand what they are seeing." Patients that have been implanted with the Prima system are able to read text and the speed at which they can do that is improving over time as patients become more predictive in their reading.

Diamond highlighted the example of a departures board at a train station.

"Patients could work out what train they need to take, where it goes to, and where it departs from. That's useful vision for patients with macular degeneration, because they've previously lost essentially of their independence and autonomy."

Pixium's Prima system is currently undergoing a final pivotal study in Europe, the last step for the company before it plans to apply for a CE mark and start European commercialization.

A Material Difference

For both Pixium and Blackrock, developments in material science, particularly those that impact the size of electronics, have been crucial in taking their devices from idea to reality. "Miniaturization has been key," explained Diamond. "The first generation of retinal implants were much bigger, much bulkier and had less pixels.

"You had to sew the implant onto the ocular globe and then you would have to have another component communicate with that implant somewhere else in the retinal space. We've done away with all of that. We have a two-millimeter chip that does everything."

> *"The fact you can get a chip today that does everything a much larger one did even ten years ago is phenomenal." – Marcus Gerhardt*

Gerhardt agreed. “Developments and innovations into things like polyamide, silica carbide, graphene and so on are all useful,” he explained. “The fact you can get a chip today that does everything a much larger one did even ten years ago is phenomenal.

“That is the technology advancement we benefit most from because if you think about having an implantable device, something that can transfer and analyze data all by itself really is vital. These developments are what allow us to translate ideas into clinical use.”

However, both believe that the innovations in material science, while remarkable, will take some time to consolidate themselves.

“There have been advances,” explained Diamond. “But I wouldn’t say a Moore’s law relationship is applicable to our technology. You couldn’t say, for example, that doubling the quantity of pixels would quadruple the visual improvement. We might be able to half the chip size to one millimeter and quadruple the number of pixels in the future, but we’re definitely not there yet.”

Gerhardt echoed the “not there yet” sentiment, who discussed how graphene has not yet delivered all the promises made by material scientists when it was first discovered.“A lot of things, like graphene, are talked about and everybody gets excited about them, and then it takes several years, usually decades to make it a technology we can apply to a regulated industry like medical devices,” he said.

“We get innovation and excitement, but until it finds its way into the human body, it’s going to have to jump through a variety of important hurdles put out there by the FDA covering safety, security, longevity.

“I think one has to be very circumspect about how to deploy new materials and make sure you have a product that you can commercialize in the main device area.”

Money, Money, Money

Ambitious medical developments will remain just ambitions unless their creators can build a sustainable business model alongside it.

For Diamond, this sustainability comes down to “health economic outcome work” that gives a target of less than “75 to 80 thousand euros per patient implanted.”

“There’s a precedent for payment in Europe and the US with previous generations of retinal implants targeting retinitis pigmentosa patients [which is a set of genetic disorders that causes rapid vision loss between a patient’s 30s and 50s], and that technology cost far more,” Diamond said.

"If you think about our patient population, we're intervening much later in life, however the overall cost to society is still burdensome enough to warrant the level of payment we are targeting."

Pixium Vision has seen its share price fall from a peak of almost $8 in 2014, to $0.9 as investors have shied away from the ambitious technology. For Diamond, this represents a clear distinction between the European and American appetites for risky medtech ventures.

"In Europe we've had some long-term investors that have supported us for a long time now. They took the risk and are very keen on early disruptive technologies. They aren't afraid and we're very grateful for their continued support. … There's even a small but very, very faithful retail base over the years.

"I think where you start to have some level of complication maybe, and pressure on share price, is that the markets in Europe are not as deep and as broad as the US markets, where you have a much larger institutional investment base."

This base, he explained, contains greater numbers of "specialist analysts who are able to understand the technology, go very deep in the technology and be able to give some assessment as to the potential for share price development and the value creation associated with that technology."

"In Europe, we tend to be more generalists, and conservative about investing. It's not a question of appetite, but a question on the depth and breadth of market."Blackrock Neurotech's approach to building a sustainable business model appears on the outset to be easier.

"There are 600 million people worldwide who suffer from neurological disorders," explained Gerhardt. "Our endeavor, our drive, is to impact these patients."

He pointed out that, just in the US alone, there are over 300,000 people suffering from a mix of tetraplegia and partial tetraplegia – conditions the NeuroPort Array could greatly help.

And these patients otherwise would incur massive health care costs. "A fully tetraplegic patient will incur health care costs of between three and five million dollars by the time they are 30," said Gerhardt.

"This kind of device is life changing, and therefore, it justifies why it should cost $150,000 or $250,000. But our BCI is priced similarly to a cochlear implant [between $25,000 and $30,000]. We have a social responsibility to ensure our device costs a price that is commensurate to other implantable technology.

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This approach has drawn continued interest from venture capital funds. Earlier this year, Blackrock closed a $10m financing round led by re.Mind Capital that was supported by Peter Thiel, a billionaire investor who regularly throws money behind daring medtech projects.

"We've positioned our company not just as a product, but as a platform. And we intend to create enormous cost savings and value creation," Gerhardt said. "Obviously, we're setting ourselves up to benefit from that financially, and it's great to have partners like Thiel Capital on board. Our biggest driver is to impact a large portion of those 600 million patients sustainably."