THE STIMULATION GAME

Could zapping the brain with electricity make hard effort feel easier? *Trevor Ward* undergoes transcranial stimulation before taking on some iconic Alpine climbs

In the never-ending quest for marginal gains, one WorldTour team has resorted to techniques straight from the pages of science fiction. Selected riders from Team Bahrain-Merida have been having their brains zapped with electrical currents in a procedure known as transcranial direct current stimulation (tDCS). The team claims the procedure has already achieved results. Domenico Pozzovivo used it at this year's Tour de Suisse, where he finished seventh overall, and at last year's Giro, where the 35-year-old equalled his best ever Grand Tour performance by finishing fifth.

"Normally with pro riders, all they are thinking about is their weight and diet, but Pozzovivo and [Matej] Mohoric wanted to know more about this type of treatment, especially Domenico who has a degree in sports science," says Bahrain-Merida business manager Alex Carrera. Does Vincenzo Nibali use the treatment too? "No, he said he doesn't trust the machines."


Blue-sky thinking has become ever more scientific in cycling

The 'machines' cost around £9,000 each, consist of a neoprene skullcap with a small electrical unit and up to 20 electrodes attached to it, and belong to the Istituto delle Riabilitazion Riba (IRR) of Turin, Bahrain-Merida's official sports clinic.

The treatment is all about accessing various parts of the brain and its neurons — which sounded to me worryingly like a cross between *Frankenstein* and *One Flew Over The Cuckoo's Nest*. But when IRR invited me to join a group of guinea pigs for a week of riding and neurostimulation in the Italian/French Alps, curiosity outweighed my doubts and before I knew it, I was on a plane to Turin.

The science bit

In a nutshell, tDCS targets specific areas of the brain responsible for certain functions and zaps them with a low electrical charge — "safe enough even for young children," says the consent form I'm asked to sign. By zapping the right areas, neurons can be stimulated into states of "excitability" and improve the communication between parts of the brain and the body. If applied regularly, says IRR's promotional material, the benefits can be long-term "because of changes that can be made to the brain's neural connections."

Though brain stimulation can be traced back to the ancient Greeks — they used electric rays (fish) to treat arthritis — it has only become popular in the last few decades for uses ranging from treating stroke victims and addicts to improving mental functions such as memory and learning. Its recent application in elite sport has been a natural progression in the quest for marginal gains.

As Dr Elisabetta Geda, the neuro-psychologist currently connecting electrodes to various parts of my head puts it: "It's not a performance-enhancing drug that will make you superhuman. It's something where you're changing or strengthening neural connections in your brain to aid your training. Every brain is unique and will respond differently. You may not ride faster, but maybe you will be able to tolerate pain better."

Geda is placing the electrodes in a specific pattern — "montage" — to target my dorsolateral prefrontal cortex, the part of my brain responsible for deciding just how much I'll tolerate the signals of exhaustion being sent from my body. The theory is that stimulating this area will increase my ability to overcome fatigue, something I suspect I will be much in need of during the next few days when our route is scheduled to include the Finestre, Galibier, Izoard and Agnello mountain passes. For now, I brace myself for something unpleasant as the last of the electrodes is applied. Instead, all I feel is the faintest prickling sensation that lasts just a few seconds (and is never felt again during the subsequent treatments).


One Flew Over The Finestre?

Electricity in the air

Our first day of putting tDCS to the test starts ominously. Geda has met us under darkening skies in the shadow of Roman ruins in the town of Susa at the foot of the 18km climb to the Colle delle Finestre, featuring a final eight kilometres of gravel where Chris Froome launched his spectacular solo, 80km breakaway in stage 19 of last year's Giro.

My fellow guinea pigs and I are being fitted with our skullcaps and electrodes when the first rumble of thunder is shortly followed by a flash of lightning. We run to the nearest cafe with Geda trailing in our wake and reassuring us that the electric current running through our heads will not make us any more vulnerable to a lightning strike. However, by the time we have finished our 20-minute session — "the optimal time before the brain starts asking, 'What's going on here?'" explains Geda — the storm is at its peak.

It is 90 minutes before the rain eases off and we can start riding, by which time the effects of the pre-exertion stimulation have already worn off — it normally lasts around an hour. Therefore, it is unlikely that my eventual conquering of the Finestre's relentlessly steep slopes and quagmire of rain-sodden gravel has anything to do with the enhanced firing

Photos Edoardo Melchiori, Yuzuru Sunada, Endura

of neurons between my prefrontal and primary motor cortexes.

The next day is even worse, with only one of us making it through the rain, wind, snow and sub-zero temperatures to the 2,642-metre summit of the Galibier. After climbing the Télégraphe in drizzle and zero visibility, I'm the second last to quit 10km from the top when a fierce headwind kicks up. Last man riding is Canadian Alex Hutchinson, a 63kg former elite middle distance runner and author of *Endure*, a 2018 *New York Times* bestseller about "the limits of human performance".

Brain gains

The brain's significance in endurance sports is not a new discovery. More than 100 years ago, Italian scientist Angelo Mosso confirmed that cognitive tasks could affect the body's powers of endurance. The Central Governor Theory, formulated by sports scientist and ultra-marathon runner Tim Noakes in 1998, posits that your brain subconsciously sets limits on your body's capabilities. And more recently, elite athletes have been taught by psychiatrists such as Steve Peters how to tame their "inner chimp" and conquer their mental demons.

Though the science of tDCS is slowly gaining credibility in the sporting world — several NBA, NFL and Major Baseball League stars, as well as ex-WorldTour rider Andrew Talansky, use a portable, headphones-style device called Halo Sport that retails for $399 — there are more lo-fi ways to tap into your potential.

"Changes in performance have been strongly correlated with changes in perception of effort," says Luca Angius, of Northumbria University's department of sport, exercise and rehabilitation. "When perceived effort is high, endurance performance is impaired — exercise feels harder. But when perception of effort is low, exercise feels easier and performance is improved."

To reduce the perception of effort, scientists have resorted to a variety of cunning psychological ruses in laboratory tests. These have ranged from the use of subliminal images — cyclists shown 16-millisecond videos of happy faces rode for three minutes longer than those shown sad faces; positive self-talk — a group of riders who used phrases such as "feeling good!" and "push through this!" in their training lasted 18 per cent longer than the control group; and financial incentives — volunteers' endurance magically doubled in a 1986 experiment when the "fee" rose from 0.2 francs per 20 seconds to 7.8 francs.

"Endurance magically doubled when financial incentives were offered"

Brains overiding brawn on the Col d'Izoard?

A suitable mantra could lead to an easier dispatchment of long wending climbs

In one experiment at Northumbria University in 2012, males taking part in moderate-intensity running trials had a reduced perception of effort in the presence of a female member of staff.

"These studies highlight the complexity of performance regulation and the importance of psychological factors influencing perception of effort," says Angius, adding ominously: "They also disproved the validity of the 'central governor', since if any subconscious regulator existed, none of these types of manipulation should be able to increase exercise duration."

At the end of the next day's ride — which thankfully sees us summit the

Izoard and Agnello in glorious sunshine — Geda introduces another montage, this one targeting a different part of our brains, the primary motor cortex, with the aim of improving our recovery process. It's administered at the same time as we are receiving our post-ride massage and again lasts for 20 minutes.

It's a similar protocol to Domenico Pozzovivo's during last year's Giro and this year's Tour de Suisse and should aid our sleep. We have a final big climb the next day, the Colle delle Sampeyre, so I'm hoping the treatment works. Alas, the town clock immediately across the road from our hotel ensures it doesn't. So I get up early to answer some work emails, unaware this will have a potentially negative impact on my riding.

The treatment is also said to aid recovery

Only later do I discover that sports scientist Samuele Marcora has established that perceived exertion is increased by mental fatigue. In other words, doing a cognitive task such as homework or your accounts immediately before riding your bike will adversely affect your performance. Furthermore, Marcora's experiments proved that cognitive tasks before exercise were just as debilitating as

THE ETHICAL QUESTION

If it works, is it fair?

Lecturer in sports ethics and integrity at Swansea University Dr John William Devine ponders whether tDCS is fair means or foul

On the face of it, tDCS is appealing because it seems to 'unlock' rather than 'expand' an athlete's physiological capacity — removing a barrier to full potential rather than tampering with that potential.

When examining whether an enhancement such as tDCS should be permitted in sport, three considerations are crucial: 1. Does the enhancement pose an unacceptable risk of harm? For example, is the electric charge that is applied to the brain during tDCS damaging to the rider's short or long-term health? 2. Does the enhancement create unacceptable unfairness between athletes? Is tDCS so expensive that only wealthy athletes and teams can access it? 3. Does the enhancement undermine some of the skills and capacities — the excellences — that the sport is designed to test? This third factor is perhaps the most fundamental: the spirit of the sport.

Sports communities must decide which excellences should determine the outcome of competition. In endurance cycling, the backbone of excellent performance is the ability to endure mental discomfort, fatigue and exhaustion while executing complex bike-handling skills and making decisions under pressure.

Riders who can overcome this discomfort demonstrate virtues of character such as fortitude and courage. If tDCS does in fact delay the experience of fatigue and exhaustion, these virtues become less decisive. Does tDCS thereby make cycling less a test of character, more a test of neuro-sensory meddling? That is a question for the sport to resolve.

physical tasks — a 90-minute mental task had the exact same effect on a group of cyclists' performance as doing 100 drop jumps from a height of 40cm.

Marcora, now the director of research at the University of Kent's school of sport and exercise science, says the brain can be trained to resist mental fatigue, and is currently using his research to help ultra-distance cyclists be more resistant to sleep deprivation. He has encouraging words for the rest of us who'd merely like to be able to complete that race or sportive a little faster.

"When you stop because you feel there's nothing left in the tank, the reality is that there is quite a lot of reserve," he says. "If you cycle at 300 watts for as long as you can, the reality is that from a neuro-muscular perspective you are able to do much more than that. We reach a perceptual limit, but there are things you can do to tap into your physiological capacity a little more."

Sadly, there is no magic bullet.

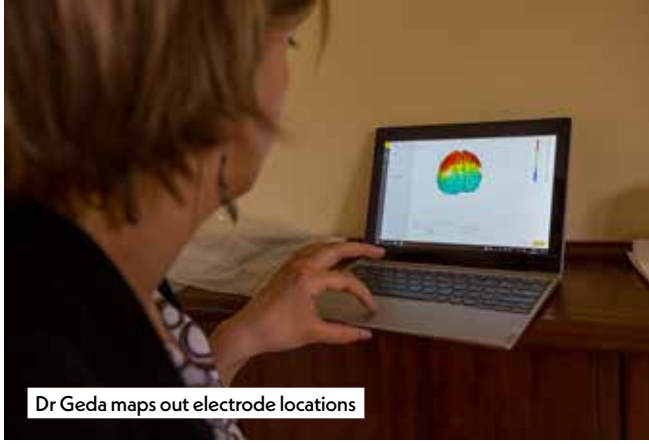
"Continuing to improve your physiological capacity through your regular training is still the most effective way. Everything you've been doing so far, keep doing it, it all has an effect."

Thankfully there are a couple of tricks with proven benefits. "Two other things can help. First, caffeine. This has an effect on the brain and reduces perception of effort. Secondly, use some psychological techniques such as motivational self-talk, imagery and goal-setting. Learn how to deal with negative thoughts by replacing them with motivational, simple statements. You can convince yourself it's not so bad."

And what does Marcora make of tDCS?

"Personally, I prefer the caffeine and self-talk, which aren't considered doping — whereas tDCS may be in the future!"

Isn't there a risk in ignoring what you perceive to be close-to-your-limit exertions? "In all the studies we've done, whether using tDCS, caffeine or self-talk, no negative effects have been reported. Perceived effort is measured on the Borg Scale from six to 20, and by using these techniques we are changing perceptions by just one point. It's not like a big change from hard effort to light, it's just enough to improve your performance in a significant way."



Dr Geda maps out electrode locations

"It's not a big change, but enough to significantly improve your performance"

Riding to the limit, and beyond, in the high Alps

Mind over mountain

During the 15km climb up to the Colle delle Sempeyre's 2,284m summit, I am trying to decipher the signals from my body. I've learned about parts of my brain I never previously knew even existed and am trying to see if I can put this knowledge to good use, and distinguish between my real and perceived suffering.

But I've dropped off the back of the group and the support van is hovering behind me, tempting me with its air-conditioned seats. I have no way of knowing if my neurons are firing more effectively or not, so resort to some self-incentivising imagery that mainly consists of a large glass of foaming beer, a hearty meal and home comforts.

But in the end it's the poor maths of the Italian Highways department that saves me. I arrive at the summit three kilometres earlier than I had expected (the sign at the bottom had said 18km to go) and this lifts my spirits more than any amount of electric currents zapping my various cortexes.

At the end of the day, we receive our final session of tDCS — again aimed at improving our recovery — though I can't be sure whether it's the electrodes or the fine wine that eventually sends me to sleep that night.

Back home in the UK, I read Hutchinson's book *Endure*. It includes a chapter about brain stimulation in which two elite US cyclists race each other after receiving tDCS. Surveying all the electronic gadgetry around them, one of them says: "You can do all this s**t, but it all comes down to two guys on a bike trying to beat each other."

Hutchinson concludes: "Brain stimulation may or may not turn out to be an effective way of accessing your hidden reserves, but... when it comes down to two guys on a bike, maybe that's the real secret weapon: believing that you have another gear."

***Cycling Weekly* was hosted by Neurofire Cycling, a collaboration between the IRR clinic and cycling tour operator Tourissimo. For information about their tours including tDCS treatment, visit neurofirecycling.com.**

PRO RIDERS ON tDCS

'Brain stimulation boosted my Giro'


'Dr Pozzovivo' is a tDCS advocate

Bahrain-Merida's Domenico Pozzovivo is known among his friends as 'Dr Pozzovivo' because of his studies in economics and sports science. During the 2018 Giro, he was given tDCS treatment during his massage after every stage — except one.

"He didn't have time and the next day he lost his podium position on the GC," says the team's business manager Alex Carrera.

But 35-year-old Pozzovivo eventually equalled his best ever Grand Tour performance, finishing fifth overall, and credits his success to the brain stimulation, saying: "Given that time is short after stages during the Giro, we used it during my massages and it's indeed had its benefits; I truly noticed an effect. The protocols that we used on me have been focused on enhancing the quality of sleep and stimulating the parts of my brain that command relaxation. After some of the very hard stages of the Giro, it's a struggle to even find the ability to be able to relax the muscles, so we experimented with various protocols and I have to say that for me my quality of sleep improved."

Vittoria Bussi is the current women's Hour record holder — she recorded 48.007km in Aguascalientes, Mexico, last September. She was also runner-up in the 2018 Italian national TT championships, and is a doctor in pure mathematics. Bussi started using tDCS at the start of this year.

"I've always believed the brain is as important as your legs and can say that my best performances are more often due to a good state of mind. I'm not saying physical fitness is not important, but somehow secondary to the serenity you can reach with your mind, especially in events where you feel under pressure.

"I decided to start using tDCS because I believe in science and think sport is a very good field of application. Also, Dr Elisabetta Geda is renowned in her field and I'm very interested in her research.

"I have been using it exclusively before races to enhance my performance. We don't have any scientific data yet but I can say for sure that it changes the perception of fatigue.

"My next goal is the Chrono Kristin Armstrong, a prestigious UCI race in the US. I plan to use tDCS during training before leaving for the US, then use it a couple of times out there and finally immediately before the race."


Bussi: seeking serenity