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Neuro-Doping – a Serious Threat to the Integrity of Sport?

Verner Møller · **Ask Vest Christiansen**

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Abstract The formation of the World Anti-Doping Agency (WADA) in 1999 was spurred by the 1998 revelation of widespread use in professional cycling of erythropoietin (EPO). The drug was supposedly a real danger. The long-term consequences were unknown, but rumor said it made athletes' blood thick as jam with clots and other circulatory fatalities likely consequences. Today the fear of EPO has dampened. However, new scientific avenues such as 'neuro-doping' have replaced EPO as emergent and imagined threats to athletes and to the integrity of sport. In this paper, we analyze the alleged threat from 'neuro-doping' in the following steps: First, we outline an understanding of 'neuro-doping' in a narrow sense, which we then put into context by looking at the phenomenon in a broader sense. Second, we highlight examples of societal perceptions of sport and science in order to shed light on where the concern for 'neuro-doping' comes from. Third, we address the more general fear of technology as a root for this concern. Fourth, we examine the evidence for the performance enhancing capacities of 'neuro-doping', where after we look at the obstacles for a ban on this technology. We conclude the analysis by stating that at present 'neuro-doping' cannot be considered a threat to the integrity of sport. Finally, however, we put this conclusion into perspective by examining what the most reasonable response would be *if* in the future neuro-stimulation techniques becomes an effective performance-enhancing mean in sport.

Keywords Neuro-doping · Doping · Sport · Integrity of sport · Performance enhancement

V. Møller · A. V. Christiansen (✉)
Department of Public Health, Aarhus University, Dalgas Avenue 4, 8000 Aarhus C, Denmark
e-mail: avc@ph.au.dk

Introduction

Rigorous anti-doping efforts have been part and parcel of elite sports since the turn of the twenty-first Century. This marks a change of attitude in the Western world to the use of advances within the medico-technological field for performance-enhancing purposes. In the 19th and first half of the twentieth Century scientific attempts to boost athletic performances were viewed positively with only few expressing concerns about scientific performance enhancing means' potential health damaging effects [1]. During the second half of the twentieth Century doping remained a minor concern spurred by occasional tragedies such as Danish cyclist Knud Enemark Jensen's death from heatstroke at the 1960 Rome Olympics, British cyclist Tom Simpson's amphetamine related death during the 1967 Tour de France, and eye-popping scandals such as the exposure of the Canadian sprinter Ben Johnson during the Seoul Olympics in 1988. The change of attitude by the end of the twentieth Century, which in 1999 lead to the formation of the World Anti-Doping Agency (WADA), was caused by the 1998 revelation of widespread use in professional cycling of a newly developed, highly potent drug, erythropoietin (EPO), that could stimulate the body's production of red blood cells and thus increase

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athletes' endurance significantly. The drug was supposedly a real danger. The long-term consequences were unknown, but rumor said it made athletes' blood thick as jam with clots and other circulatory fatalities likely short-term consequences. For instance, a number of sudden deaths in young athletes was – albeit unsubstantiated – linked with EPO use [2]. Today, twenty years after the foundation of WADA, the fear of EPO and other drugs have dampened. Known users from the EPO heydays are still alive and healthy, and previous fears that this potent drug would kill the athletes who used it have declined with the absence of EPO-related deaths. However, fear of the unknown persists. Hence, new scientific avenues such as gene therapy and brain stimulation have replaced EPO as emergent and imagined threats to athletes and to the integrity of sport. In this paper, we will focus on the following: First, we will outline an understanding of 'neuro-doping' in a narrow sense, which we will then put into context by looking at the phenomenon in a broader sense. Second, we will highlight examples of societal perceptions of sport and science in order to shed light on where the concern for 'neuro-doping' comes from. Third, we address the more general fear of technology as a root for this concern. Fourth, we examine the evidence for the performance enhancing capacities of 'neuro-doping', where after we look at the obstacles for a ban on this technology. We conclude the analysis by stating that at present 'neuro-doping' cannot be considered a threat to the integrity of sport, by which we mean that it does not distort fair play by its limited performance enhancing capacities. Finally, however, we put this conclusion into perspective by examining what the most reasonable response would be if in the future neuro-stimulation techniques becomes an effective performance-enhancing mean in sport.

What Is Neuro-Doping?

As we understand it in the context of this article, the so-called 'neuro-doping' differs from other forms of doping in that it is not an invasive measure.[1] No pills or needles are involved. Instead, 'neuro-doping', or 'brain doping' as it is also called, uses brain stimulation techniques to improve athletes' performance ability. If advances in brain stimulating techniques have opened yet another path for sport to potentially exploit, it is tempting to think of this as a new type of doping. However, as obvious as this may be, the use of the term *neuro-doping* is, strictly speaking, premature. At present, it would be more correct to label the phenomenon: 'performance enhancing electronic brain stimulation', because there is no such thing as doping per se. Doping is most often understood as the use of banned substances or methods to improve athletic performance. Until 2004, caffeine was on the World Anti-Doping Agency's (WADA) list of prohibited substances and the use of it was thus regarded as doping. In 2004 caffeine was taken off the list and consequently it was no longer perceived as a doping means, despite evidence for caffeine's performance enhancing properties is much stronger today than it was when prohibited [4]. Those who currently use of the term 'neuro-doping' appear to use it synonymously with a specific type of a 'performance-enhancement measure'. While it may be convenient to apply such a common sense approach, it is inaccurate if we apply WADA's definition, as the caffeine example illustrates. Doping is by definition what WADA at any given time deems as an anti-doping rule violation, as set forth in the code article 2.1–2.10 [5]. Electronic stimulation of the brain is not prohibited by WADA, ergo is the term neuro-doping misrepresenting the phenomenon in a sport context. For this reason, we will in this paper refer to it with inverted commas, 'neuro-doping'.

So why is it that not only laymen and journalists, but also people familiar with WADA's official doping definition, employ the term neuro-doping (without inverted commas) and call for WADA to proactively ban these emerging techniques to manipulate the brain, in the same way that the agency previously introduced a ban on gene-doping before any evidence of athletic use of this emerging therapy had occurred [6]?

To clarify the discussion we will distinguish between a broad and a narrow understanding of 'neuro-doping'. First, we will outline and discuss the narrow understanding and then follow up with examples of 'neuro-doping' understood more broadly to put the former into perspective.

[1] For the present discussion, we are interested exclusively in non-invasive brain stimulation techniques. Thus, we do not consider for example Deep Brain Stimulation (DBS). DBS certainly is invasive as it involves the placement in the brain of a medical device, which sends electrical impulses to specific targets in the brain for the treatment of diseases such as Parkinson's disease, essential tremor and dystonia (see [3], Deep Brain Stimulation)

Neuro-doping in a narrow sense, is, as most of the traditional doping products, a result of medico-technical research that targets diseases. The blood-brain barrier is the brains self-protection mechanism. This mechanism makes deliverance of foreign substances to the brain difficult and is a major obstacle for the invention of medicine that can cure brain diseases such as Parkinson's and Alzheimer's [7]. Therefore, researchers have begun to look for alternative avenues to influence brain functioning. Electromagnetic field treatment in mice with Alzheimer's disease has shown positive results in terms of both cognitive-protective and cognitive-enhancing effects [8].

We are not experts in this field of medical research, so we refrain from entertaining a discussion of the prospects of these observations in mice. For our purpose, it suffices to note that scientists experiment with electronic stimulation of the brain in order to cure cortical diseases and that this research has proven strong enough to attract interest from athletes and athletes support personnel in search for new avenues of performance-enhancement.

According to Davis [9], two main techniques are currently available: Transcranial magnetic stimulation (TMS) and transcranial current stimulation (TCS). TMS techniques applies magnetic currents to an electro-magnetic device attached to the head. This generates a magnetic field that induces an electrical current in the subject's brain. This stimulation triggers action potential in neurons in the targeted area. If for example TMS is applied over the motor cortex, the subject can experience involuntary finger twitches. The technique can produce lasting alterations of the brain's functioning, which makes it potentially useful in stroke rehabilitation, and treatment of Parkinson's disease, depression, migraine etc. The TCS techniques are different in that they use very low levels of constant current delivered to targeted areas of the brain. TCS were invented with the same purposes as TMS but are more convenient as they are cheaper and more portable. The most common of these techniques 'transcranial direct current stimulation' (tDCS) is in principle very simple. Electrodes with anodes and cathodes are attached to the scalp's surface in which 1–2 mA runs that facilitate depolarization and hyperpolarization of neurons. The positioning of the electrodes' anodes and cathodes determines how the currents flow and what part of the brain are affected thereby stimulating and inhibiting brain activities. The TCS techniques have been shown to have therapeutic effect on neurological patients. Moreover there is evidence that they can improve concentration and reaction and learning time [10]. With this clarification of 'neuro-doping' in the narrow sense, we can now return to our question on why there is a call to ban it. To answer this, it is helpful to look at 'neuro-doping' in a broad sense, that is other ways of brain stimulation, as such phenomena has been known for quite some time. Research has found that listening to motivational music after intense exercise can help athletes recover faster [11]. More importantly, it has also been shown that performance can be manipulated by music. A cycling study found that if a piece of music of the research subjects' liking was played at a 10 % higher tempo performance output increased, whereas if it was played at a 10 % lower tempo the performance output decreased [12]. Therefore, listening to music during exercise seems to aid athletes during both training and recovery. In spite of this, no one seem to be concerned about the suggested performance-enhancing effects of music during training and recovery. It is true that headphones are banned in cycling and other sports but this is usually explained as a security measure and not because of the performance-enhancing effect of music, and the topic has never really been a cause for concern.

Another example of a method to increase performance by electronic devices is the use of radio-communication in cycling, introduced in the 1990's by the Motorola Cycling Team that had American Lance Armstrong on its roster. The introduction of radios made it possible for team directors to warn riders of dangers ahead, but also to give them tactical advice and motivational pep-talks in critical moments. The International Cycling Union (UCI) have tried to ban this kind of radio communication in races because of complaints from cycling enthusiasts and broadcasters that it impacted the spectacle negatively, but the radios' potential performance-enhancing effect were never addressed [13].

A final type of 'neuro-doping' in the broader sense worth mentioning is hypnosis. Although not transmitted by an electronic device hypnosis is a forceful way to manipulate people's brains. A study of the effects of hypnosis on three male collegiate basketball players' ability to score showed an increase from baseline in all subjects under hypnosis, with all returning to baseline after coming out of the hypnosis [14]. Other studies have shown positive effects on several other sports

including soccer [15], athletics [16] and golf [17]. Despite such findings of the performance-enhancing effects of hypnosis, to the best of our knowledge, no one has yet publicly called for a ban on sports hypnosis. Hypnosis is apparently another type of 'neuro-doping' that does not cause concern.

The reason why music, radio communication and hypnosis are not rendered controversial the same way as TMS and TCS cannot be that they are electronic, because the same is true for music devices and radios. Nor can it be that they manipulate the brain because that can also be true for music devices and radios and is definitely true for hypnosis. Further, the objections to TMS and TCS are not rooted in their more potent performance-enhancing capabilities because the evidence in this respect it is not much stronger than for the other phenomena mentioned.[2] So, in order to understand the cause of the concern, one has to look for reasons outside the foundational pillars of anti-doping: performance-enhancement, health and the spirit of sport, and direct attention toward societal perceptions of sport and science.

[2] Neuroethicists and others have attempted to draw a morally defensible line between different types of interventions, related to what we here refer to as 'neuro-doping' in its narrow and broad sense. The elevated concern for 'neuro-doping' could thus be explained by the extent to which such interventions exhibit a greater potential to compromise autonomy and disrupt identity. In their article "Moral Enhancement: Do Means Matter Morally?" Farah Focquaert & Maartje Schermer argue that indirect means (e.g. education) are morally preferable to direct means (e.g. change of brain structure and function). Although the latter are presently largely hypothetical (for inducing moral enhancement), the reason why they are morally inferior, the authors argue, is first that "direct, passive interventions limit an individual's capacity for continued rational deliberation and autonomous choice. […] Second, direct, passive interventions may induce such radical and/or abrupt psychological changes, with little or no link to an individual's narrative life story, that the continuity of one's narrative identity is threatened ([18], p. 149). However, while such arguments may have academic resonance and help discriminate between different types of interventions, they are not only rather sophisticated, but also unrelated to sport/athletes or any other arguments previously forwarded by WADA (or any other NADOs) and thus hardly constitute a core component in the call for a ban on 'neuro-doping' [6]. Another point concerns the unknown aspects of new technologies. While it is true that music and radio does not have any adverse effects worth worrying about, we do not know the long-term effects of 'neuro-doping', and this in itself – as we will discuss below – could cause concern. Such concern, however, is in line with a general fear of the unknown, dehumanizing aspects, which science is often portrayed to embody by reactionaries. When it comes to manipulating the brain, the concern hereof is perhaps best captured in Mary Shelly's *Frankenstein*, originally published in 1818 – a time where one could only vaguely see the contours of science' Promethean potential (see the section "The fear of Technology").

Societal Perceptions of Sport and Science

One standard argument against doping is that sport should not be about who has the best physician. Sports results should be based on the individual athlete's skills and decision-making and for sport to be meaningful, victory must therefore ideally represent superior athletic abilities [19]. In light of this, it is noteworthy that hypnosis does not cause controversy even though hypnotherapists openly offer to assist athletes online. Especially if it is true, that hypnosis brings an athlete in a condition so that the hypnotist can control her. If we imagine that an athlete's performance can be improved under remote control, the athlete is not responsible for the performance and outcome of the competition and would thus be contrary to the understanding of sport that anti-doping is based upon. The obvious reason why hypnosis worry neither the public nor the sports' governing bodies is that they do not take hypnosis seriously. We may have seen people do weird things under hypnosis in TV shows, heard about patients going through surgery with no anesthesia other than the verbal assistance provided by a hypnotist at the bedside, or less spectacularly be freed from their smoking habit after hypnotherapy. Yet it appears that most modern minds regard hypnosis as a placebo treatment and associate it with 'witchcraft', healing, mysticism occultism – things that simple-minded people find amazing even awe-inspiring as they do with other Uri Geller-like magical tricks.

An illustrious parallel example appeared in 1996 when Danish cyclist Bjarne Riis won the Tour de France. Until 1993, Riis had been a more or less anonymous rider whose job in the race it was to shield his team captain from wind so the captain would spend as little energy as possible until the decisive part of the race began at which point Riis' job was over. Riis climbing ability was by professional cycling standards mediocre at best. This all changed from 1993 onwards when he suddenly managed to follow the favorites on the most demanding climbs. In the following years, his performance gradually improved. In 1996, while leading the race, Riis gave an interview on Danish television about the unexpected improvement of his competitiveness in which he readily explained his extraordinary improvement as a result of his collaboration with a skillful healer with insight in the workings of acupuncture. This healer, Riis 'revealed', triggered a point in the knees called 'three miles extra'. Before and after stages Riis had

needles placed in these distinct points to stimulate the energy flow and this had caused a significant increase in Riis' power. TV-viewers even saw the healer put the needles in ([20], p. 135). It was an obvious 'admittance' of the use of a performance-enhancing technique. Despite acupuncture's transformative effect that Riis was living 'evidence' of, his admission did not inspire any calls for acupuncture to be banned. Eastern healing techniques are something people are free to believe in but rational minds rarely take an interest in Eastern holistic medical techniques, and much less see them as truly potent. For good reasons, one might say. Indeed, later we learned that it was not acupuncture needles but syringes with EPO that did the trick in Riis' case. Nevertheless, the fact that Riis conned the public with his acupuncture hoax neither means that acupuncture could not potentially benefit athletic performances nor that hypnosis does not have the performance-enhancing capacities the abovementioned studies have found. This example indicates that it is not so much athletes' search for ways to get a competitive advantage over their opponents and the unlevel playing field this may produce, but new scientific ways to enhance performances that is cause for concern.

The Fear of Technology

Modern science is a fairly recent endeavor. The direction was set in the fifteenth Century when philosophers and researchers began to undermine previous conceptions based on biblical and Aristotelian writings and undertake experimental research. It was not until the eighteenth Century, though, that science and technology started to change the material conditions in what became known as the industrialized world. Ever since there has been a divide between progressives who embraced new inventions and reactionaries who rejected them as dangerous. The Luddites in England, whose name has become emblematic for those who oppose new technologies in general, feared and fought against the factory machines, which they saw as a threat to their livelihood, or rather what they perceived as their adverse effects. Because, as the economist Tom Lehman has observed,

> [t]he modern Luddite impulse appears not to be overtly anti-technology per se, even though that tendency may be latent among some. Critics expressing fears about modern technology are generally careful not to reject the technology itself for fear of losing their audience altogether. ([21], p. 266)

In this point by Lehman we find inspiration for a likely explanation why electronic music and radio communication devices do not cause the same concern among people as TMS and TCS. Around the turn of the twentieth Century in the early days of radio broadcasting radio-phobia was indeed an issue. Some people thought radio waves and related broadcasting and receiving technology could undermine human health. Since then radios became an integrated part of almost everybody's life. Hence, people cannot easily be mobilized to oppose radio technology anymore (and listeners' current change to streaming and digital audio broadcasting (DAB) has nothing to do with the fear of radio waves, but rather with supply and accessibility). But this does not mean that radiophobia is dead and buried. Even though radio and television have become an integral part of daily life, radiophobia reappeared when cell phones were invented. Not long ago it was feared that the radio waves transmitted to and from cell phones could cause brain cancer, not least in children [22]. Experiments confirmed that high dosages of cell phone radiation could cause brain cancer in rats and this of course did not dampen the concern among 'technophobes'. The convenience of cell phones convinced the less concerned that the benefits of having one outweighed the risks. As the use of the cell phone spread without any increase in registered brain tumors that can be attributed to cell phone use, the fear of cell phone radiation has faded.

When technology emerges, progressives take them onboard immediately and if they are useful enough more hesitant people follow suit and after a while, the new invention becomes an integrated part of society. Contrary to televisions and cell phones, new technology like TMS and TCS are not invented with the general population as the target group but with the purpose to solve specific medical problems. This means that people will not be introduced to them as readily, making it more likely that related concerns about the damage they can do in the wrong hands will last longer. In addition, the TCS helmet inspires vivid Frankenstein-like images of a person whose brain is wired up to computers, giving the impression of a much more potent and invasive technology. With this in mind, it is understandable why

ideas about a new and potentially dangerous kind of performance enhancement has evolved with the invention of TMS and TCS and why there has been a call to define it as doping. Another aspect that adds to the concern is of course stories about the efficacy of the new technology.

The Potency of Science

In his book *Homo Deus*, Israeli historian Yuval Noah Harari refers an article from the popular-science magazine *New Scientist* written by a female journalist who had been allowed to visit a military training facility to test a TCS helmet developed with the purpose of helping soldiers to make decisions faster. At first, she tried a battlefield simulator without the helmet and found she was way too slow to decide on target, aim and shoot not to be overwhelmed by the enemy forces. This changed instantly after she was wired up with a TCS helmet. She did not feel any different except for

> a slight tingle and a metallic taste in the mouth. Yet she began picking off the virtual terrorist one by one, as coolly and methodologically as if she were Rambo or Clint Eastwood. 'As twenty of them run at me brandishing their guns, I calmly line up my rifle, take a moment to breathe deeply and pick the closest one, before tranquilly assessing my next target. In what seems like next to no time, I hear a voice call out, "Okay that's it!" The light comes up in the simulation room… In the sudden quite amid the bodies around me, I was really expecting more assailants, and I am a bit disappointed when the team begins to remove my electrodes… "How many did I get?" I ask the assistant. She looks at me quizzically. "All of them".' ([23], pp. 335-336)

It goes without saying that such stories spark interest among progressives who want to improve their performances by enhanced brain functioning. Equally unsurprising is it, that profit seeking entrepreneurs have started to produce TCS helmets for personal use to meet the demand. A demand that will only be further fertilized if (academics, e-sport athletes and) sportspeople vouch for them by advertisement or use. And some sports people have begun to explore the efficacy of tDCS. The US Ski and Snowboard Association (USSA) established a collaboration with Halo Neuroscience in San Francisco with the purpose of testing whether tDCS can make it easier for ski jumpers to hone their skills and thus improve their performances. A study conducted by Halo Neuroscience, in which seven elite Nordic ski jumpers practiced jumping onto an unstable platform four times per week in two weeks, yielded remarkable results. Four athletes out of seven received brain stimulation. The three others were given placebo treatment. The athletes subjected to treatment increased their jumping force by 70% and their co-ordination by 80%, compared with the three who had received the sham procedure [24]. The study Reardon refers to is unpublished. Halo Neuroscience has produced a 'do-it-yourself' tDCS device and wants of course to convince people who want to enhance their capacities to buy its products. The laboratory tests were probably designed to do just that. Hence, there is reason to be skeptical about the results. Recent meta-studies, have challenged the perception that tDCS has performance-enhancing effects in the sport domain. When findings were compared for effects on different parameters the positive effects were at best minuscule and even these modest effects were in all likelihood outcomes of publication bias as null-findings are rarely submitted and even more seldom published [25]. So far only one meta-study [26] has confirmed a positive effect of tDCS and this result is grossly influenced by a few low quality studies with unusually large effect sizes [25]. So, there is every reason to take claims that 'neuro-doping' is the next big thing in the athletic performance-enhancement toolbox with a pinch of salt.

Even if we were to take the stories affirming the efficacy of the technology at face value, there is no reason to fear that 'neuro-doping's' performance enhancing capacities is a threat to the integrity of sport. The above example of the journalist targeting computer animated terrorists, may make the TCS helmet look like an impressive and effective technology, but strictly speaking all the helmet did was to work as a noise cancelling device:

> the thing that made the earth drop out from under my feet was that for the first time in my life, everything in my head finally shut up... My brain without self-doubt was a revelation. There was suddenly this incredible silence in my head" ([23], p. 336).

The helmet shut out unnecessary distractions and let the journalist focus on her task. Disregarding the likely contribution from the placebo effect, this is probably the best-case scenario of what the technology in question can do to healthy individuals. There is a quote, often attributed to an anonymous Navy seal – a Special Forces unit in the U.S. Navy, saying: "Under pressure, you don't rise to the occasion; you sink to the level of your training. That's why we train so hard."[3] A lot of training (in the army and in sport) is aiming at teaching the soldier/athlete to focus on what is relevant. In (simulated) combat, an untrained journalist will obviously experience more distractions than a trained soldier will. In that way, what the TCS technology does to our focus is comparable to what noise-cancelling headphones are doing to people working in open office spaces. Their effect on performance are pre-modern in the sense that they do not alter the athlete's physiology, like modern drugs such as EPO and anabolic steroids do. In a similar fashion to noise-cancelling headphones, the TCS helmet does not alter the athlete's physiology, but shuts out distractions and let her do her best. But not better than that. Letting athletes perform their best (but no better) can hardly be seen as representing a threat to the integrity of sport.[4]

However, the potency of the tDCS devices in sports contexts is not the primary concern here. Should the alleged positive effects of electric transcranial stimulation techniques be false or impossible to exploit in real sports contexts, concerns about this kind of 'doping' vanishes. But so long as it is still not determined whether TMS or TCS techniques has performance-enhancing effects, marginally or significantly, it is still worthwhile to consider what the right response to it would be.

Obstacles for a Ban

Welsh neuroscientist Nick Davis, who has conducted experiments with tDCS, has voiced that: "Like any new and potentially performance-enhancing measure, the safety and the ethics of using brain stimulation must be carefully considered" ([9], p. 649). Davis states this as if it were a matter of course. He does not explain why any new performance-enhancing measure should be so considered, nor does he tell whose responsibility it is to consider it. Davis takes the common sense approach that ethical and health concerns are and should be the underpinnings of anti-doping based on a solid fundament of reason. But this is not the case and 'neuro-doping' is an ideal phenomenon to show why. Davis suggest that it should be up to each sport to determine "whether neuro-doping poses a risk to the ethos" ([9], p. 651). He mentions shooting as an example. 'Neuro-doping' can reduce tremor, which is a crucial factor in this sport. Thus, the governing body must decide if such techniques should be banned or allowed, he maintains. As reasonable as this suggestion may sound, there are a few problems related to it.

First, the shooting sport's governing body does only have undisputed authority in the matter so long as WADA has not deemed TMS and TCS techniques doping. If WADA decides to include 'neuro-doping' on its list of banned performance-enhancing means, the International Shooting Sport Federation (ISSF) must conform, to maintain its status as an Olympic sport. Second, Davis' suggestion, that each sport must consult its own ethos is not of much help here. He may be in line with Wikipedia that says, "In modern usage, ethos denotes the disposition, character, or fundamental values peculiar to a specific person, people, corporation, culture, or movement." However, as stressed above even if the ethos of shooting is different to that of swimming, which is different to that of team handball, there is no way that each sport can decide for themselves, what to include on the list, and what not to. Rather, one has to consider the ethos of the sports movement, and here it will fall under what in anti-doping is referred to as the *spirit of sport*, and that is thought to be universal. (We will refrain from entering into the discussion of the critique that the spirit of sport has been subjected to. For more on this, see for instance [28]). The core of the problem is that there is no objective way to determine whether TMS or TCS are against the ethos of sport or not. Technophobes will probably argue that 'neuro-doping' is against the sport's ethos and should be banned, whereas technophiles could argue that TMS and TCS are simply new tools to aid people's ability to concentrate and focus regardless of their tasks and that they

[3] The origin of the quote could probably be attributed to the Greek poet Archilochus: "We don't rise to the level of our expectations, we fall to the level of the training."

[4] We are aware of the simplicity in reducing tDCS to simply a noise-cancelling device. There are for instance studies that have shown an effect on aggressive behavior. Thus sessions of bilateral prefrontal cortex tDCS has been shown to reduce self-perceived aggressiveness in men with high aggression potential [27]. However, for the present context we are concerned solely with TMS or TCS and their effect on performance, hence the analogy to a noise-cancelling device.

ought to be embraced by sport so it does not become antiquated.[5]

Third, at present it is impossible to determine the safety of these new techniques. To judge from experiences the adverse effects of their use seem negligible [29]. However, the techniques are so recently developed that potentially long-term effects have yet to be revealed. So again, vigilant reactionaries will probably argue that they should be banned as a matter of precaution whereas progressives may argue that if the techniques have been deemed unsafe by the authorities they would not have been approved for use in ill, impaired, and weak people. Hence, the progressives may claim, they are unlikely to cause any damage to young, healthy athletes.

Finally, if ISSF decides to ban TMS and TCS techniques there is, Davis admits, "no known way to detect reliably whether or not a person has recently experienced brain stimulation" ([9], p. 650). Today the only available detection technology is magnetic resonance spectroscopy (MRS) which "can detect changes in the concentration of neurotransmitters and related metabolites" ([9], p. 650). To enforce this testing procedure is unrealistic as it would be not only costly and cumbersome, but probably also imprecise and involve a significant risk of producing false positive and false negative results in unacceptable numbers.

Have the Courage to Use your Own Reason

By way of conclusion, we can say that since there is nothing to suggest that TCS, TMS or similar techniques are effective in enhancing performance, doping authorities do not need to be concerned. At present, 'neuro-doping' is more a figment of the imagination among sport philosophers and technophobes than any real threat to sport, and it likely will continue to be so for the foreseeable future. It has not been proven to have significantly more potential than music-stimulation, pep talks and other known ways to affect behavior by stimulating brain activity, it does not alter the athletes' physiology, and speculation about what to do can thus cease.

That said, let us put this conclusion into perspective with a thought-experiment that illustrates the inbuilt problem in anti-doping that the discussion of 'neuro-doping' accentuates.

As unlikely as it may be, if electronic brain manipulation techniques should become genuinely effective performance-enhancing tools for athletes, the associated problems mentioned above push for a re-thinking of anti-doping in its entirety. *If* athletes could make significant improvements in their performance by the use of TMS or TCS, and this involved a degree of risk of brain-damaging effects, the default reaction of WADA would surely be to ban it. However, if there is no way the use of neuro-doping can be detected, a ban would hardly make sense. If a performance-enhancing technique is available and it results in improvements comparable to those produced by traditional drugs (anabolic steroids, EPO, Growth Hormone, stimulants, etc.), which can be tested for, athletes would most likely stop using the testable drugs in favor of the new technique. This has been the situation in anti-doping since the beginning. When a test method for a potent drug has been established, athletes have moved on to new drugs or variants of the drug that there is yet no test for, which has meant that anti-doping scientists had to develop test for the new drug of choice in the well-known game of catch-up. In keeping with this, one might object to our claim, that it would not make sense to ban the use of 'neuro-doping' because it cannot be detected, with reference to the fact that this was indeed the case when for instance EPO was invented. There was no test for this potent drug. Still, when the authorities became aware of its use in sport, it made sense to ban it because otherwise there would not have been developed a test for it. But this objection does not take into account that it is principally impossible (at least in this thought-experiment) to ever develop a reliable test for neuro-doping.[6] It is not even possible to instigate an indirect control measure like the maximum hematocrit levels introduced in cycling and cross-country skiing before the EPO-test was developed. Under these circumstances, the only chance to sanction

[5] Should Davis be interpreted more gently, it could be argued that what he refers to is not the broad idea of the ethos of sport but something narrower. Namely that for every new technology that emerges, each sport need to determine whether that technology stimulates, impedes or is indifferent to the testing of the relevant athletic skills in that sport. However, that is a different and more mundane question than assessing those technologies' impact on the ethos of sport, or the spirit of sport, and inclusion or not on the list of banned drugs, substances and methods.

[6] An anonymous reviewer pointed out that in the future it may be possible to develop a test that can detect the use of 'neuro-doping'. We acknowledge that this is of course possible. However, this is indeed a thought-experiment, and to illustrate the potential consequences of potent 'neuro-doping', it is an explicit premise for the thought-experiment that it is *not* possible to develop such a test.

neuro-dopers would be to catch them in the act, with the helmet on their head, which would only be possible if anti-doping authorities per default were allowed to force their way into the athletes' place of residence at any time. A scenario that immediately comes across as a gross violation of athletes' privacy rights. (Yet it reflects the exceptional case when an anti-doping police raid exposed cross-country skier Max Hauke in his hotel room while he was in the middle of a blood transfusion in preparation for a race at the Nordic World Ski Championship [30]).

The thought-experiment exemplifies how there is a totalitarian risk embedded in the anti-doping mind-set. This however, is not unique to sport or anti-doping, but is a general trait that characterizes many problems that arises with modernity. Whether it is epidemics, traffic problems, lifestyle diseases or doping, the handling of those problems follows a movement from registration over control to prevention ([31], pp. 49–52). As touched upon in the introduction, from the birth of modern sport and until the 1950s there was a certain acceptance of doping. Journalists and sporting authorities did little more than registered that athletes doped. However, in the period from the 1930s to the 1950s the wish to oppose the use gradually evolved. List, rules and regulations were introduced allowing the authorities to control doping to a certain degree. The fundamental idea was to act and remove the problem when it arose. However, the sense that the problem was on the rise, let to the idea that authorities should not only find and sanction those who doped, but prevent its use in the first place. With the introduction of out-of-competition testing in the 1990s and the whereabouts-system in the 2000s the decisive step was taken. The original aim to deal with cases when they arose, altered to an ideal of eliminating the very preconditions for the problem to occur in the first place. It is noteworthy that the move from registration to control implies an active and conscious decision. However, when that has been made, the move from control to prevention follows with historical necessity. It is in the idea of complete prevention that the totalitarian potential is embedded.

This is the reason why, since the beginning of anti-doping, the requirements forced upon athletes have ballooned whereas the respect for their privacy rights have deflated. The development has been propelled by ingenious athletes' constant attempts to find ways to get around the control system. But the current level of control seems to be at the breaking point. It is hard to imagine that legal authorities would continue to back anti-doping in the event that necessary random raids of athletes' place of residence were introduced to protect the integrity of sport from neuro-doping.

Consequently, if neuro-doping existed in the way described in the thought-experiment, there would be just two possible solutions. One would be to accept neuro-doping while upholding the ban on all other types of doping. Nevertheless, if neuro-doping is as effective as the other types of doping, such distinction would be irrelevant if not inconsequential. The other, more consistent and reasonable solution would be to discontinue the paternalistic approach that has driven anti-doping hitherto and instead consider changing the policy in accordance with the motto of the Enlightenment. That is, make athletes aware of the risks involved in the various kinds of performance-enhancing measures an encourage them to use their reason without direction from others. Should the outcome of such an approach be that some talented athletes decide to opt out of elite sport because they do not want to run the risks involved to be competitive, little would be lost. Should some decide to embrace all the performance-enhancing means modernity has endowed humankind with and die as a result, lessons will be learned and if the governments decide that this is unacceptable, the most reasonable solution will be to ban professional sport removing the temptation for athletes to pursue richness through a lucrative but potentially fatal career in sports.

Compliance with Ethical Standards

Conflict of Interest The authors have no conflict of interest.

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