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NEUROSCIENCE, NEUROTECHNOLOGY & SPORT: AN ETHICAL-EDUCATIONAL PATH BETWEEN UTOPIA AND DYSTOPIA

NEUROSCIENZE, NEUROTECNOLOGIE & SPORT: UN PERCORSO ETICO-EDUCATIVO TRA UTOPIA E DISTOPIA

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Abstract

In the field of NBIC Nanotechnology, Biotechnology, Infotechnology and Cognitive science, Neurosciences occupy vast areas of research. Technological developments in neuroscience open explorations of the brain and the NS, highlighting the connections with behaviour; recently neurotechnologies are also used in the world of sport through the use of the BCI brain-computer interface. In the context of neuroengineering, BCIs are oriented towards support systems for disabilities, but there are also non-clinical sectors, including sport, which see these neurotechnologies as a tool for applications and / or research. Several authors propose studies with the application of BCI in various sports; could sports betting be upset? Finally, the birth of Neuralink, a start-up by Elon Musk, which offers, through mini devices inserted with electrodes into the brain, to measure brain activities and / or regulate them, this opens up scenarios in need of bioethical discernment, particularly by those who work or educate, through sport. From all this a path of analysis is traced so that educational sport is not a utopia, and above all it does not become dystopia.

Nel settore delle NBIC *Nanotechnology*, *Biotechnology*, *Infotechnology e Cognitive science*, le Neuroscienze, occupano vasti spazi di ricerca. Gli sviluppi tecnologici delle neuroscienze aprono esplorazioni del cervello e del SN, evidenziando le connessioni con il comportamento; recentemente le neurotecnologie vengono usate anche nel mondo dello sport attraverso l'uso delle interfacce cervello-computer (BCI *brain-computer interface*). Nel contesto della neuroingegneria, le BCI sono orientate verso sistemi di supporto per le disabilità, ma vi sono anche settori non clinici, tra cui lo sport, che vedono queste neurotecnologie strumento di applicazioni e/o ricerche. Diversi autori propongono studi con applicazione di BCI in vari sport; le scommesse sportive potrebbero esserne stravolte? Infine la nascita di Neuralink, startup di Elon Musk, che offre *con mini dispositivi inseriti con elettrodi nel cervello* di misurare le attività cerebrali e/o di regolarle, apre scenari bisognosi di un discernimento bioetico, particolarmente da coloro che lavorano o educano, attraverso lo sport. Da tutto ciò un percorso di analisi affinché lo sport educante non sia utopia, e soprattutto non diventi distopia.

Key words

Brain-Computer-Interface; eSport; Ethic; Neuroethic.
Interfaccia cervello computer; eSport; Etica; Neuroetica.

Introduction

Convergent Technologies (TC) well define the Fourth Industrial Revolution: *Nanotechnology*, *Biotechnology*, *Infotechnology* and *Cognitive science* (NBIC); they mark a moment of our civilization which, together with the now famous globalization, make this time an epochal shift (Zamagni, 2018). Quoting Dario Di Vico (in Seghezzi, 2017), *"everything is shorter and faster at the same time and we cannot make definitive judgments precisely because we do not yet know which / how many of those transformations will be structural and how many will not"*. The term "Convergent Technologies" comes from the intersection of knowledge that was once *distinct and distant*; during the Fourth Industrial Revolution there was no new discovery capable of breaking the mold as in the case of the previous three (I°: 1784, steam engine; II°: 1870, electricity and chemistry; III°: 1970s, computer

science). NBIC technologies descend from the III Industrial Revolution, which gives way to the IV towards the end of the last century (Roco & Bainbridge, 2002). Just at that time, C.M. Christensen in his text "The Innovator's Dilemma" (1997) coins the term *Disruptive Technologies*; a disruptive technology replaces an established technology or rocks the industry with a revolutionary product that creates entirely new segments. Up to now, the presence of technology in the Sports sector, including the Paralympic, has been mainly focused on improving the athlete's equipment and performance: more sophisticated physiological tests, more precise GPS tracking techniques, monitoring of health metrics, video analysis (Dyer, 2015; Loland, 2002). We are witnessing a stabilization of the improvement of performances and therefore of the records; for several authors, any significant improvement will come from technological innovations (Berthelot, 2015; Balmer, 2011). On 11/11/2020, Forbes magazine headlines: *Five Emerging Disruptive Technologies For Entrepreneurs To Observe*; among these, we find the Neural Interface or Brain Computer Interface (BCI). This is the starting point for a literature search / review, through different databases, from Medline to SportDiscuss; the bibliographic research has focused on the critical reading of articles from the last ten years, without language restrictions.

1) The BCIs

Brain-computer interfaces (BCIs) are communication and control systems that enable their users to send commands to computers using only brain activity, which is usually measured by electroencephalography (EEG) and processed by the system; EEG measures, using electrodes placed on the surface of the scalp, or inserted in a subcutaneous position, the electrical microcurrents that reflect the synchronized activity of neurons in the brain. BCIs are divided into Invasive and Non-Invasive; the former interact directly with the brain with electrodes surgically implanted in the cerebral cortex; in the second the electrodes are positioned on the scalp by means of a helmet with sensors positioned in key points for the detection of the EEG signal.

Non-invasive BCIs with EEG use are the most common, but there are also other methodologies (Saha, 2021): fNIRS *functional near infrared spectroscopy*, (Chen, 2020), MEG *magnetoencephalography* (Boto et al., 2018), fMRI *functional magnetic resonance imaging* (Wexler et al, 1997)) and TCD *transcranial doppler ultrasound* (Alexandrov, 2000; Khalaf, 2019).

The latest commercial versions see the helmet become a simple headband with sensors, like headphones for music. They are also divided into those that "read" the brain to record its activity and decode its meaning, and those that "write" to the brain to manipulate activity in specific regions and influence their function. They are based on the *odd-ball paradigm* used in neuroscience to understand if a subject is able to distinguish and recognize a stimulus, for example, by dilating the pupil; the pupils dilate differently when particular stimuli or frequent stimuli are observed. Achieving a goal includes selecting a desired stimulus from among non-relevant ones (e.g., looking for a specific key in a set of keys, for a specific door (Strauch, 2020). In this way, it is possible to manage to write on a screen just by looking at it, or to move a bionic limb while *thinking about movement*. Thus, patients with disabilities or neurodegenerative diseases (Alzheimer's, Parkinson's, Epilepsy, Diabetic Neuropathies, Amyotrophic Lateral Sclerosis) are able to move independently and/or communicate with the outside world.

Among the earliest articles on BCIs we find Hochberg's (2006) work on quadriplegia; thereafter there was a crescendo, up to the analysis by Frost and Sullivan (2016) who traced its evolution. Blackrock Neurotech, founded in 2008, is the world leader in BCI technology and the development of neuro-implantable solutions; on November 16, 2021, the *Food and Drug Administration* (USA) defines *MoveAgain* (BCI system of this company) as revolutionary device. The Italian answer to these neuro-technologies is *Corticale*, a start-up born in the Italian Institute of Technology in Genoa, which created *Sinaps* (*Simultaneous Neural Recording Active Pixel Sensor technology*) for the observation and care of the brain (Angotzi, 2019).

The flourishing field of neurotechnology, in addition to BCI, includes also neuro-prostheses, neuro-stimulation, neuro-monitoring, as well as designs implantable devices intended to expand sensory capabilities: think of cochlear implants or even the English musician Neil Harbisson who has an antenna implanted on his head because of his *achromatopsia*, a rare disease that does not allow you to perceive colours; thanks to the antenna, colours are transmitted to the brain in the form of 360 sound waves; in 2004 he was the first in the world to have cyborg identification in the identity card. Another similar project is Elon Musk's Neuralink, which develops invasive, high-bandwidth brain-machine interfaces to connect humans and computers; during a test subject, a macaque played video game Pong neurally. BCIs were mainly created for the medical field; however, the evolution of the technique has allowed the development of neural interfaces also for video-recreational purposes or to enhance athletic performance; in this sense, Halo Neuroscience (a US for-profit company, now acquired by the Swedish *Flow Neuroscience* specialized in antidepressant BCI) has marketed HaloSport, followed by HALO2; it consists of a headset similar to conventional headphones and uses *transcranial direct current stimulation* (tDCS) in which constant low intensity currents of less than 2–3 Am are delivered to the scalp for a few minutes through surface electrodes, called *primers*, with the aim to induce changes in both sides of the motor cortex. The devices are generally used for 20 minutes before intensive training, then removed at the beginning of work. The results indicate that Halo Sport may have the potential to improve performance in a wide range of physical activities involving both physical and cognitive demands (Huang, 2019; Edwards, 2017).
In the world of sport there are many who think that some records will have truly little chance of being surpassed (see Usain Bolt 100m world record.); Geoffroy Berthelot in one of his works (op. cit., 2015), hypothesized that technological discoveries could decrease the factors that limit physical performance; I believe that neuro-technologies can also be included. Another field of use of BCIs are videogames and / or gaming: the affordable cost of neural devices, the increasingly powerful dedicated software and the increase of this new market, suggest that BCIs will be used on a large scale and, consequently a considerable amount of neural data will be managed (Gambula, 2022).

2) The eSports

Esports are "a form of sports where the primary aspects of the sport are facilitated by electronic systems; the input of players and teams as well as the output of the eSports system are mediated by human-computer interfaces." (Hamari,2017)
The Covid-19 epidemiological emergency has given considerable importance to the e-Sports sector, accelerating the spread of the discipline. The initial suspension of sporting events, on the one hand, diverted part of the public to the gaming world, on the other, also forced the sports industry to turn to digital. ESports are a competitive and organized mode of gaming, which usually (but not exclusively) involves individual players or professional teams. It is an 'umbrella' category which gathers different genres of video games according to the different titles used for the competitions. The most relevant evolution trends, according to the AESVI *Associazione Editori, Sviluppatori, Videogiochi Italiani* in the 2018 Report, are:

- 33% growth of the digital audience, especially mobile, thanks both to the better speed / connectivity of the network, and to a more widespread distribution of the hardware. Those who follow competitions outnumber those who play.
- 33% Increase in sponsorship revenues from non-endemic brands (companies whose main product does not have to do directly with esports).
- 20% More and more spaces used to organize events, in particular within trade fairs that record a strong growth in on-site physical interaction.
- 13% of players become influencers sought after by both brands and traditional sports organizations.

Thanks to the numbers provided, the sector is a condensation of economic, employment, educational, relational opportunities, intelligent and brilliant entertainment which is located on the most advanced frontier of innovation. Gaming is an economic resource; represents companies and products that compete in a global market, with extraordinary expansion potential for economy, employment and exports. (Censis, 2021)

In 2021, the global esports market was valued at just over $ 1.08 billion, an increase of nearly 50% over the previous year. Additionally, global eSports industry market revenue is projected to increase to $ 1.62 billion in 2024. Asia and North America currently represent the largest esports markets in terms of revenue, with China alone accounting for nearly a fifth of the market (Gough, 2021). In 2021, the worldwide eSports audience reached 474 million people; for 2024, more than 577 million are expected worldwide.

South Korea turns out to be the true homeland of competitive video games, as it was the first in the early 2000s to establish the first eSports Federation: The International eSports Federation (Iesf) founded in 2008 with the aim of unifying tournaments, rankings and above all regulations; in South Korea there is even a ministerial department dedicated to eSports.

Most of the authors recognize 5 categories of games:

1 Rts (Real Time Strategy)
2 Moba (Multiplayer Online Battle Arena)
3 Fps (First Person Shooters)
4 Fg (Fighting Games)
5 Sg (Sporting Games) Are virtual simulations of real sports matches; it is probably the best known category by the public and the most easily attributable to the category of real, they are virtual simulations of real sports matches.

For some time, the historic Italian newspaper "La Gazzetta dello Sport" has opened a section on esports; on 30/12/2021 it titled that the Dota2 videogame -in The International world championship- was won by the Russian Team Spirit with a of $ 18 million prize pool (Wutz, 2021).

Gabe Newell, head of the famous Valve Corporation, says that in the near future, video games will use data from people's brain signals to regulate the experience they get or vice versa the minds of players will be able to be influenced by computers (Cuthbertson, 2021). Neurogaming is a new way to play it involves the use of brain waves to operate the controls within the game.

The use of BCI based on EEG in video games already has an extensive literature: it has been extensively studied. This new technique is the result of the latest advances in video games and neuroscience. BCIs have a cost that is becoming increasingly affordable. (Rakhmatulin, 2021)

3) Ethical aspects in BCIs

At the 2014 World Cup in Brazil, a paralyzed man kicked off via a BCI-controlled exoskeleton; human beings, for the first time, can do things through thoughts, that is, without the body as an intermediary. This disembodied aspect, in the time of greatest development of studies on embodied cognition - is the first peculiarity of the BCIs that we want to emphasize; as a second point, we see that neurotechnology has led to a very significant change in the politics of the body that sees it as a network or assembly that is constantly evolving with technology. Donna Haraway's famous question (1991) takes shape: "Why should our bodies end at skin?"

BCI technology is also used for non-medical applications, such as sports and esports (Congedo, 2013; Barachant and Congedo, 2014; Vasiljevic, 2019); this may arise a number of ethical concerns that require consideration of all stakeholders involved; considering them disruptive technologies, BCIs can open new avenues for crime or new and sudden opportunities to attack the security of data, information, and even people (Killias, 2006; Ienca, 2014; 2021). In particular, the eSports world is essentially in a primordial stage and, as such, it is extremely permeable to infiltrations that can muddy the environment. Everyone now agrees that it is necessary to donate a legal umbrella to protect

eSports; as well as most of the federations and organizations operating in the sector are "self-regulating" in regard to sporting offenses, in 2016, the ESIC (Esport Integrity Commission) was born, which seeks to coordinate the activities of the sector by also giving itself a code of ethics; it deals with issues related to doping, sponsorships, athletes 'engagements -often minors- and more. At present there is no ruling on the use of BCI, also because there is no shared hazard index (Cattan, 2021; Ahn et al, 2014). The review of the literature on ethics in BCIs sees in the works of Ienca (2014; 2021) and Burwell (2017) what we believe is the best possible synthesis; according to Ienca, BCI devices operate in four phases: input, measurement, decoding and output. Each of the four phases is potentially susceptible to cybercriminal attacks through hacking. For Burwell, BCIs raise concerns about security (they can interfere and change thinking), privacy, accountability and justice (are they within everyone's reach?)

The vulnerability of BCI systems has ethical and legal implications; first of all, the so-called Dual Use Dilemma (WHO, 2005; CNR, 2019), that is, the one that you develop for purposes of utility and benefit, can be used to do good or be misused for example for criminal purposes (e.g. nuclear energy can be an energy source, or a weapon). BCIs are defined as brain reading tools; recording, decoding, modifying mental states actually means having control over the human mind. According to the Data Protection Commissioner in Italy: *We are facing a new anthropology, which requires a more effective defence of dignity from the risk of neurological reductionism, capable of canceling the conquests of freedom by now consolidated which are considered in fact acquired.* (Stanzione, 2021) With the BCI, the chapter of Neuro-rights, Digital Integrity and above all the Right to Mental Privacy begins; to have security in neural information by defending it from unwanted access and controls.

Conclusions

Advances in sports science and neuroscience offer new opportunities to design efficient and motivating sports training tools. The technical innovations so far have been dedicated to physiological and biomechanical improvement; but the motor / sport performance is multifactorial, also influenced by neurophysiological, psychological, and cognitive factors, whose value is generally underestimated (athletes with the same physical abilities, have different results). The measurement of these neurophysiological models requires the use of brain signal recording methods; BCI technology offers devices that are relatively cheap, transportable and not excessive time taken.

BCI between utopia and dystopia

In a utopian scenario, BCI gives the idea of an aid to care, and above all, new technologies guide on how to operate in life. With dystopia there is the anxiety of living with useful but vulnerable means, which have little control and little respect for the human dimension.

The current vulnerability of BCI systems has ethical implications that encourage criticism and give space to posthumanists and transhumanists projected to overcome homo faber by transforming him into homo creator; trans-posthumanism tends to support the experimental system of science and technology in all its forms. But is it possible to fully understand and realize man by limiting himself to his physical structure according to technical-scientific categories only?

The tension of primacy between knowledge and technology is ancient and has in the background the obvious consideration that anything can be used and abused; let's then add the fact that if something can be abused, it is not a sufficient reason to prohibit its use.

A recent study by the philosopher Chia Wei Fahn (2020) allows us to reach to conclusions:

The future of the posthuman lies not in unlimited efforts at technological growth, but in an interdisciplinary education that combines the humanities with scientific knowledge to teach a new and alternative way of acting. Anthropology does not need to be changed, it must be completed: Man is not only rational Homo Sapiens, nor just an architect Homo Faber nor just a utilitarian subject Homo Economicus, but he is also Homo Ludens, a man who plays, a man as he plays (Leone, 1999).

We should take into account - when we think about the happiness of being children - that for them the game is unproductive.

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