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PENN BIOETHICS JOURNAL

Analyzing the Misunderstood

The Ethics of Transgender Athletics and Analogies for Brain Computer Interfaces

Graphic by Shreya Parchure

PENN BIOETHICS JOURNAL

The Penn Bioethics Journal (PBJ) is the premier peer-reviewed undergraduate bioethics journal. Established in 2004, the Journal provides a venue for undergraduates to make contributions to the field of bioethics. Embracing the interdisciplinarity of bioethics, PBJ reviews and publishes original work addressing debates in medicine, technology, philosophy, public policy, law, theology, and ethics, among other disciplines. The biannual issue also features news briefs summarizing current issues and interviews with eminent figures in the field. Authors and the editorial staff alike have a unique opportunity to experience the peer-review process through the collaborative, rigorous review and preparation of the Journal. With an audience ranging from undergraduates to scholars in the field to the broader public seeking unbiased information, the Penn Bioethics Journal occupies a unique niche in the field of bioethics.

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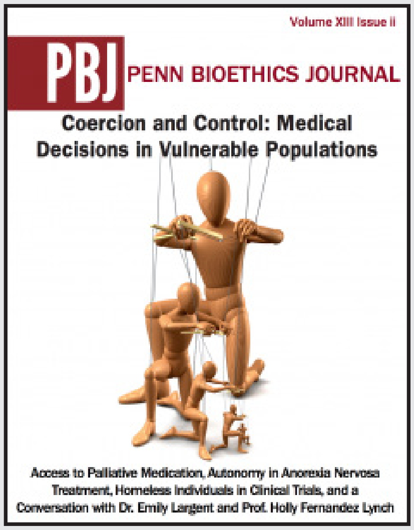

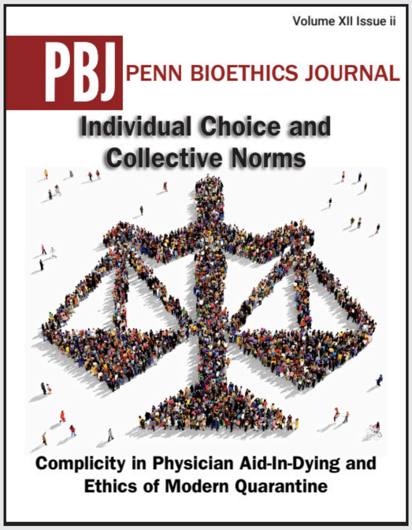

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Letter from the Editor

Rebecca Gelfer
Editor-in-Chief

Dear Readers,

It is my pleasure to present you with this issue of the Penn Bioethics Journal entitled "Analyzing the Misunderstood: The Ethics of Transgender Athletics and Analogies for Brain Computer Interfaces." The two articles in this issue explore the topics and individuals often misunderstood, from Brain-Computer Interface technologies to the complicated struggles of transgender athletes. Our first article, entitled "A Technology Unlike Any Other: BCIs and the Analogies to Understand its Ethical Implications" uses analogies to explain Brain-Computer Interfaces (BCIs) and notes the potential privacy and identity pitfalls that people with these technologies may suffer. Author Sierra Simmerman from the University of Washington-Seattle uses a framework which justifies the use of analogies in her evaluation of brain-computer interfaces.

In our second article, entitled "Ethical Issues Concerning Transgender Athletes," author Victoria Chen from the University of Alabama at Birmingham explores the conflict surrounding hormone levels and letting transgender athletes compete with others of the same gender. She uses principles of fairness and examples of different athletes to explore this controversial subject.

In this issue, the Penn Bioethics Journal also had the opportunity to interview Dr. Kenneth Foster, a Professor of Bioengineering at the University of Pennsylvania, whose research interests are in the impact of technology on society, giving him a unique insight into how technologies like BCI can be misunderstood and their potential pitfalls. Dr. Foster gives some historical context on BCI technology and discusses possible ethical ramifications of their use. He also discusses how society could view BCIs and the policies that are currently in place (and should be in place) to protect users.

Furthermore, our Bioethics-in-Brief section, which can be found on the following pages of this issue, includes news briefs that provide updates on recent developments in the field of bioethics. Our first brief highlights the historical Ireland abortion referendum, exploring the complicated meshwork of opinions in Ireland. The second brief discusses the recent research breakthrough in human-sheep embryo chimeras. This brief examines the potential medical benefits of chimeras, in context of organ transplantation, and ethical trials that may be associated with this work. The last brief covers the first successful primate cloning in China, opening a discussion about the ethics of working with primates in this fashion

Finally, I would like to thank Dr. Harald Schmidt and the entire editorial and publication staff for their hard work and dedication to this issue. I have truly enjoyed serving the PBJ community for the past year and am excited to see how this organization continues to promote undergraduate exploration in the field of bioethics. I hope that the content of this issue fosters an interest in the field of bioethics and opens your mind to previously overlooked questions.

Rebecca Gelfer
Editor-in-Chief
University of Pennsylvania C'19

Ireland Held Historical Referendum on Abortion in May 2018

In January 2018, the government of the Republic of Ireland announced that a national referendum on abortion will be held in May. Voters will be asked whether they support a constitutional amendment that prohibits abortion. In the case that they vote in favor of abortion in this historical ballot, it will put an end to Ireland's century-long ban on abortion.

Abortion has always been illegal in Ireland, which has a predominantly Roman Catholic population and is known for having a conservative culture. Only two other European countries, Malta and Vatican (both Catholic), have stricter abortion bans than Ireland (Frayer 2018). An 1861 law enacted during the British rule that outlawed abortion was kept after Ireland's independence. In 1983, the country held a referendum on abortion, in which citizens voted 67 percent to 33 percent in favor of adding a constitutional amendment known as the eighth amendment. It acknowledges "the right to life of the unborn, with due regard to the equal right to life of the mother" (Frayer 2018). On top of the original law, the amendment was intended to prevent future Irish governments from passing legislations to allow abortion.

Since the introduction of the eighth amendment, there have been two major incidents that partially changed the legal status of abortion. In 1992, a 14-year-old rape victim was initially banned from travelling to the United Kingdom for abortion. The Irish Supreme Court overturned the ruling and stated that the eighth amendment did not limit the freedom to travel (BBC 2018). This case, later called the X case, sparked controversy within the country. In 2013, an Indian woman named Savita Halappanavar died in an Irish Hospital after being denied a potentially lifesaving abortion. Although Mrs Halappanavar was experiencing severe pain and was miscarrying, staff in the hospital told her family that Ireland was "a Catholic country" and rejected their request for abortion (Dalby 2012). After the incident, the government decided to legalize abortion under special circumstances - when doctors judge that a woman life's is at risk due to medical complications, or if she is at risk of suicide. Still, it did not permit abortion in cases of rape, incest, or fetus abnormality (BBC 2018).

These incidents, combined with the country's cultural shift to the left over the last two decades, transformed Irish people's opinion towards abortion (Stack 2017). In January 2018, the Irish Times/ MRBI opinion poll showed that 56 percent of Irish voters would vote to change the Constitution to legalize abortion up to 12 weeks into a pregnancy. A majority of TDs (Irish equivalent of Members of Parliament) and Senators have also declared support to the change (Leahy 2018). In view of the change in public opinion, the government set up a Parliamentary Committee to examine the eighth amendment. The Committee published a report in December 2017 that recommended the removal of the amendment. Following that, the government committed to hold the referendum and promised that if voters support abortion, it will legislate unrestricted abortion during the first 12 weeks of pregnancy (McDonald & Sherwood 2018).

Both pro-life and pro-choice campaigns have been rallying support before the referendum takes place. On the pro-life side, the Save the English campaign launched a march named All Ireland Rally For Life in Dublin with tens of thousands of people including religious groups and politicians. Participants argued that abortion is detrimental to the rights of fetuses with disabilities such as Down's Syndrome (BBC 2018). Other anti-abortion groups, such as Youth Defense, displays graphic images of aborted fetuses to warn people of the evil sides of abortion (Gunter 2017).

On the other hand, the pro-choice campaign contended that the country's current ban on abortion does not actually prevent abortions. According to official statistics, over 3000 Irish women travelled to the UK to receive abortion annually. Experts have agreed that the abortion rate in Ireland is roughly the same as other European countries despite the ban (Frayer 2018). Moreover, women who cannot afford travelling can only take illegal pills or give birth, both of which involve a degree of risk. Apart from organizing pro-choice rallies, the campaign has also called on the 40000 Irish people living abroad to vote in the referendum. They expect these expats, who are mainly young people, to vote in favor of liberalizing abortion.

At the time this new brief is written, the referendum is expected to be held on May 25th (Agerholm 2018).

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Chimeras: Friend or Foe?

Scientists at Stanford University have, for the first time, developed a unique chimeric combination: a human-sheep hybrid. The team grew the chimeric embryos inside a surrogate composed of both sheep and human cells. After three weeks, "sheep embryos that are 0.01-percent human by cell count" were conceived, the highest ratio of human to animal cells ever obtained in chimeric studies.

These groundbreaking results have significant implications for proliferations within the field of organ transplantation, moving humans one step closer in growing a limitless supply of organs. Creating viable human organs also means finding a cure to chronic conditions like Type 1 Diabetes.


Photo courtesy of National Geographic

In the United States alone, six people are added to the national waiting list for organ transplants every hour. On an even larger scale, more than a hundred thousand people are currently in need of a new heart this year, but only about two thousand will end up receiving one. Therefore, researchers have been on the hunt for ways of artificially expanding the organ supply, utilizing chimeras in an attempt to harvest human organs in mice and rats, pigs, and, now, sheep.

To clarify, a genetic chimera refers to a single individual derived from different zygotes. In this case, researchers created an embryo combining two large, distantly related species, a milestone in the field of medical research. There are two ways to generate a chimera. The first involves introducing the organs of one animal into another. This method is often risky because an abnormal immune response in the host can cause rejection of the new organ. The second begins at the embryonic level by introducing one animal's cells into the embryo of another and letting them develop.

Scientists are building on previous, albeit controversial, research that explored animal-human hybrid embryos. A team of researchers led by Jun Wu of the Salk Institute created human-pig chimeras, piggybacking on seminal studies that had considered the embryonic method in the context of mice and rats. The Salk-led group that studied mice and rates also implemented CRISPR, a significant genome-editing tool that allowed them to delete the genes needed to grow certain organs in mice blastocysts (precursors to embryonic cells). Then, the scientists introduced rat stem cells (capable of regenerating into organs) back into the mice. What happened next shocked the research community. The stem cells flourished and the mice who survived into adulthood grew chimeric organs, some obtaining gallbladders (an organ that does not exist in rats).

Using sheep embryos is particularly advantageous because they are easily reproducible via IVF and fewer embryos are needed to be transplanted into an adult, which means fewer embryos are needed for experimentation (i.e., it's more cost effective, less wasteful, and overall, more efficient). According to Dr. Pablo Ross from the University of California, Davis, a pig chimera requires fifty embryos whereas a sheep-human hybrid needs four. The sheep also has organs (such as the lung and heart) that are similar to those found in humans.

The topic of human-animal hybrids has generated significant controversy and the ethical ramifications of chimera-farming research are plenty. Currently, the US National Institutes of Health has a moratorium on funding such research, but it is looking to lift this and replace it with a review process. Main ethical issues include risks of consciousness/self-awareness, the moral status of these hybrid beings, "and of human features in the chimeric animal due to a too high contribution of human cells" to such parts of the body as the brain and limbs (Bourret 2016). In addition, some neuroscientists like Lori Marino believe "chimeric research will only worsen the suffering of animals" (Marino 2017). Dealing with stems cells and embryonic research has also fomented controversy in political realms. There's also the possibility of viruses within the DNA of the host infecting human cells, which would make them inviable for organ transplantation purposes. However, as Dr. Ross contends, novel methods such as chimera research "offer hope to people who are dying on a daily basis" (Greshko 2017).

No one will doubt that advancing organ harvesting techniques and addressing the global organ shortage issue is an achievement of epic proportions. But, the research is riddled with controversies and everyone agrees that no approach is perfect. To conclude, exploring alternative methods to expanding the human organ supply is indeed a step in the right direction.

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First Successful Primate Cloning


Photo courtesy of The New York Times

Researchers in China have successfully cloned 2 long-tailed macaques. The cloning process was similar to that used in cloning Dolly the Sheep with one notable difference: the cells used in the primate cloning experiment were from a fetus. That is, the technique does not work with adult cells. This means that you would not be able to make clones of adult or adolescent primates but only those that are still in the embryonic phase. Furthermore, the process is not efficient as it took 60 surrogate mothers to produce 2 healthy baby macaques. Nonetheless, this was the first time nonhuman primates were cloned.

Mu-Ming Poo, the director of the Chinese Academy of Sciences Institute of Neuroscience and co-author of the study, envisions primate clones providing significant advantages in studies involving human disease. Terry Sejnowksi, a computational neurobiologist at the Salk Institute for Biological Studies, states that cloned animals eliminate the potential effects of genetic variation and can provide a more causal relationship between a treatment and its effect.

More specifically, the elimination of genetic background could allow researchers to use fewer animals in their studies. For example, research on Parkinson's Disease currently use hundreds of monkeys per experiment. By using clones, researchers could reduce this number to just 10.

However, there is still much debate as to whether or not working with primates in this fashion is ethical or even practical. Alan Trounson, a stem cell scientist at the Hudson Institute for Medical Research in Clayton, Australia, thinks that there just isn't a demand for cloned monkeys in research studies.

He says that using primates are costly and that most researchers would use other alternatives if available. Peter Dabrock, an ethicist at Friedrich-Alexander University in Erlangen, Germany, also states that there is no evidence that suggests that there are no alternatives to using macaque monkeys for research involving mental illness.

Mu-Ming Poo understands that primate research is more accepted in China than in the rest of the western world. He hopes that with more evidence, the rest of the world will see the potential benefits that cloned primates can bring to research.

Another concern of the successful cloning of primates was the question of whether or not this technique could work with humans. Dr. Mitalipov, a cloning specialist at the Oregon Health and Science University in Portland, says that this technique is "unlikely [to] be applied to humans."

That also assumes that producing human clones would be ethically permissible, which is a whole other discussion by itself. Fortunately, Mu-Ming Poo states that the ION is only interested in making genetically identical primates for research groups. They have no interest in cloning humans.

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Interview

A Conversation with Dr. Kenneth R. Foster

Dr. Kenneth Foster is a Professor of Bioengineering at the University of Pennsylvania whose research interests relate to biomedical applications of nonionizing radiation and safety aspects of electromagnetic fields. His goal in this area has been to examine technology, putting into perspective its relative risks and benefits to society. What he hopes to impart is a better perception of the social use of science.

Photo courtesy of University of Pennsylvania

Penn Bioethics Journal (PBJ): Can you talk about your career trajectory and how you developed an interest in the impact of technology on society?

Prof. Kenneth Foster (KR): I am Professor, now emeritus, of Bioengineering at Penn. Since I received my PhD in 1971 I have been interested in impact of technology on society including "soft" topics such as risk perception and misuse of technology. I have been a long-standing member (former president) of the IEEE Society on Social Implications of Technology.

My academic research over the years has touched on possible health and safety aspects of electromagnetic fields. This topic has both basic science aspects, and softer aspects related to impact of technology on society. The latter includes regulatory policy, risk perception, legal issues. I have written about all of these. Apart from my academic research, I have written articles on topics such as high-tech methods for lie detection, misuse of statistics in science, critiques of smartphone health apps. I am co-editor of BioMedical Engineering Online, which receives a considerable number of papers related to brain computer interfaces (BCIs).

I begin with a lengthy preface to add context for ethical discussion of BCIs. It is important to identify, which this otherwise meritorious paper does not, just what we mean by a BCI. Jonathan Wolpaw, one of the pioneers in this field, defined "brain-computer interfaces [as devices that] acquire brain signals, analyze them, and translate them into commands that are relayed to output devices that carry out desired actions. BCIs do not use normal neuromuscular output pathways. The main goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders such as amyotrophic lateral sclerosis [ALS], cerebral palsy, stroke, or spinal cord injury."[1]

BCIs as a distinct research topic emerged from work in the late 1980s and early 1990s by research teams led by Donchin (Univ. of Illinois)[2], Birbaumer (Tubingen Univer.)[3] and Wolpaw (Wadsworth Laboratory of NY State Health Depart.)[4] These investigators studied electrical potentials on the scalp that were elicited by visual stimuli or imagined motions by the subjects. This was followed by work in the early 2000s by Donoghue and colleagues at Brown Univ. and other research groups that recorded signals from the motor cortex of monkeys and showed that they reflected their intended motions with sufficient accuracy to operate artificial devices.[5] [6]

BCIs were initially conceived for use in assistive devices for profoundly disabled individuals, such as patients with spinal cord injury or advanced ALS who lack effective motor control but retain some semblance of normal brain function. In the simplest terms, a disabled person might be able to communicate by typing on a keyboard. Failing that, the person might think about moving part of his body and create brain signals that can be used as input to a computer that controls the keyboard. More recently, researchers have investigated other potential applications of BCIs such as neurofeedback training for treatment of ADHD or stroke rehabilitation.

The writer focuses on a tiny subset of BCIs, those using electrodes implanted in the brain. A search of clinicaltrials.gov in March 2018 found 78 clinical trials using keywords brain computer interface, the largest fraction of them involving EEG-based interfaces. A search on the same terms on Web of Science uncovered

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more than 5000 papers. However, there have been only a few human studies using BCIs with implanted electrodes, all early stage studies (mostly Phase I or pre-Phase I) that have involved very few subjects.

We don't know the potential capabilities of implanted BCIs devices or their ultimate applications. The potential market for such devices will be very limited: patients with some remaining muscle control can usually find faster and more reliable ways to communicate, for example using gaze interaction devices, that allow the user to control a computer display by eye motion.

PBJ: What ethical challenges do you believe the future of brain-computer interface technologies holds?

KR: If we are talking about implanted BCIs, the technology is in very early stages of development and any ethical analysis should be taken with a grain of salt, since we do not know what will be come of it.

Potential ethical challenges associated with BCI research can be distinguished from those that might arise when BCIs is used in nonresearch settings. For a recent commentary on research issues see Schneider et al.[7] and for nonresearch related issues see Clausen et al.[8]

> “The usual principles related to human subjects research – beneficence, respect for persons, justice – arise with BCI research, perhaps in distinctive ways.”

The usual principles related to human subjects research – beneficence, respect for persons, justice – arise with BCI research, perhaps in distinctive ways. Since BCIs are designed only to measure brain activity, their potential harms are likely to be less obvious than, say, with deep brain stimulators. However, research on disabled individuals – particularly Phase I trials that involve brain surgery (albeit minor surgery such as implanting electrode arrays in the motor cortex) needs to be carefully evaluated by IRBs.

An assistive device controlled by a BCI might be considered to be a form of semiautonomous robot, that is nominally controlled by the subject's brain but the control chain is imprecise andpotentially unreliable. If something goes wrong, at what point does the subject with the BCI become responsible? Designers of BCIs need to be careful to prevent injury to the user, following Asimov's First Law of Robots: “A robot may not injure a human being or, through inaction, allow a human being to come to harm.” It would not do, for example, to allow patients with a BCI to operate a wheelchair near the edge of a cliff or drive a bus filled with passengers.

A number of foreseeable ethical challenges related to BCIs are generically similar to those of other forms of medical technology. The author of the present paper mentions Ross Compton, whose alibi in an arson case evaporated after investigators downloaded data from his cardiac pacemaker under court order. Who would have thought that pacemakers might collect data that could be subject to legal discovery? That seems like small potatoes compared to the amount of data that Fitbit, Facebook, and Google collect from us all, but in Compton's case it was significant.

As with other devices in our connected society, we can assume that future BCIs will collect large amounts of data, and will probably include telemetry capabilities as well. Many present day implanted medical devices appear to have been developed with little concern for data privacy and security and are terribly vulnerable to hacking. Such devices, including BCIs, need to be designed with high levels of data security. What will happen if an implanted BCI suddenly decides that it is time to upgrade its software and reboot?

PBJ: What kinds of policies, if any, are currently in place to ensure that the development of BCIs proceeds in an ethical fashion? What other policy guidelines do you recommend?

KR: Human subjects research is subject to IRB approval, and manufacturers of medical devices must provide at least some proof of safety and efficacy before placing them on the market. However, medical practice is exempt from such controls; doctors can use medical devices and drugs “off label” and offer treatments that may not conform to the standard of care. The potential harms of BCIs will probably be less apparent than from devices such as deep brain stimulators (DBS's) that actively stimulate the brain. But they cannot be disregarded entirely.

In the “real world”, new medical technology is in the hands of practitioners who vary widely in experience, with patients that may or may not be representative of those in clinical studies assessing the safety and efficacy of the technology, and who provide varying levels of followup of patients. This is probably going to be a bigger source of difficulty with unregulated use of DBSs than BCIs, but there may unanticipated harms from use of BCIs as well (Schneider et al. suggested the possibility of undesirable CNS plasticity). BCI-based rehabilitation

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of patients after stroke (for example) should be done only in the context of registered clinical trials until the methodology is better understood. The proposed use of BCIs to detect consciousness in comatose patients, as suggested by at least one study[9] raises hair-raising concerns: what if the results are wrong?

PBJ: What are some societal misunderstandings of brain technology devices? How can we address these?

KF: BCI technology, particularly using implanted devices, remains largely at what one firm (Gartner, Stamford CT USA) calls the "hype" stage of innovation[10], characterized by high levels of optimism about the wonderful things the technology can accomplish but few proven applications. Only in time do viable uses of a new technology emerge, and for BCIs with implanted electrodes we have not reached that point yet.

The public seems inclined towards exaggerated views about the capability of BCIs. Some of this hype is fostered by video gamers, who are now selling BCI controllers with websites that appear to promise far more than the controllers can deliver. Some has been spread by investigators themselves, some of whom have formed companies to commercialize BCI technology and given overoptimistic projections about the development of the technology – which, for implanted BCIs, remains far from routine use with humans. Other misleading impressions have been given by the media: what viewer of an optimistic clip from a news broadcast showing severely disabled individuals doing wonderful things using BCIs will realize that these are Phase I or proof of concept studies, and that the subjects in most cases will derive no lasting benefit from their temporarily implanted BCIs?

PBJ: Is there an absolute "boundary" in BCI technologies that you think humans should never cross?

KF: If one allows science fiction into the discussion, some scary applications can be envisioned. One startup company[11] is already claiming to be developing techniques to "back up your brain" using high-tech embalming methods. Presumably this would involve using some kind of BCI to read out data from reconstituted brains. The catch: the donor must be living when the brain is donated. Not my brain thank you.

PBJ: Do you think new technologies must be understood within the context of existing ones? Must we compare BCIs to pacemakers, wheelchairs, and/or smartphones to fully grasp the ethical implications of novel technologies?

KF: It is always useful to compare new technologies with older ones, which can clarify the issues. However, the analogies that the author raises are all inapt in some way. BCIs are not pacemakers (they only collect information). They are not wheelchairs (but they may be used in control systems for wheelchairs). All technologies raise potential ethical issues, but they need to be evaluated on an individual basis.

Interview by Carolyn Chow and Shreya Parchure

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Article

A Technology Unlike Any Other: BCIs and the Analogies to Understand its Ethical Implications

Sierra Simmerman*

Brain-Computer Interface (BCI) research is a rapidly growing area of development in biomedicine. As this neuro-technology continues to be developed it is important to address the following question: what is the most appropriate way to conceptualize BCIs from the ethical point of view? This is to consider because how we understand the device will shape how it is developed and used in ethical discussions. Potential end-users and ethicists have identified nuanced issues specific to BCIs in the areas of privacy, security, identity and intimacy. To understand these issues, physicians, scientists, ethicists and patients are conceptualizing BCIs through analogies drawn from both the medical and consumer realm. Analogies such as the cardiac pacemaker, wheelchair and iPhone show a rough similarity to neural technologies in some of the issues they pose, however they have do not fully encompass the more nuanced issues raised by neural technologies. Drawing on analogies that do capture these nuances could change the way we fundamentally understand brains and computers.

Introduction

Brain-Computer Interface (BCI) is a new technology developed with the goal of replacing or restoring functional use to individuals disabled due to a neuromuscular trauma such as, but not limited to, amyotrophic lateral sclerosis, stroke or spinal cord injury. BCIs detect brain signals, analyze them, and translate them into commands that can be relayed to output devices, effectively bypassing the damaged neuromuscular area. "From initial demonstrations … researchers have gone on to use electroencephalographic, intracortical, electrocorticographic, and other brain signals for increasingly complex control of cursors, robotic arms, prostheses, wheelchairs, and other devices." (Shih 2012) BCIs are also showing potential in the commercial field as companies, like Elon Musk's Neuralink, investigate avenues for potential cognitive enhancement or consumer pleasure using BCI technology.

BCI technology comes in both implantable and non-implantable forms. For the purpose of this paper when referencing BCIs, we are implying implantable BCI technology. It has been suggested that neural technologies aren't so different from other technologies (e.g., pharmaceuticals, iPhones, cardiac pacemakers). In this paper, I will explore the most common analogies used for BCIs to show that while they are roughly related to neural technologies in terms of the kinds of issues they pose, neural technologies differ in significant ways that are un-captured by the current analogy choices.

The Meaning and Function of Analogies

According to the Stanford Encyclopedia of Philosophy an analogy is defined as a comparison between two objects, or systems of objects that highlights respects in which they are thought to be similar (Bartha 2013). Based on analogical reasoning, it is assumed that analogies are important to understanding multifaceted problems in philosophy. Analogies act as tools to set precedent and are typically evoked to help people understand some new concept or phenomenon by linking it to existing knowledge and prior experiences. People have turned to precedent technologies as their analogical source for the understanding and representing the morally important features and implications of BCI devices. In a focus group study, coded by Laura Specker-Sullivan at the University of Washington, participants evoked analogies to explain a certain feature of BCIs, comparing it to iPhones or wheelchairs (Specker-Sullivan Unpublished). Therefore, the analogies that are drawn by people, such as the participants in Specker-Sullivan's study, are not ethically benign. Rather, these representations can significantly shape our ethical analysis of BCIs.

Casuistry is the ethical approach of taking the situation being puzzled over and considering how similar or dissimilar it is from one or more cases in which the ethical judgments are clear. This approach uses paradigm cases to guide our ethical responses to situations that are relevantly similar but our ethical judgments about them are still unclear. This is why it is significant to acknowledge the consequences presented by the misuse of analogies.

Our use of analogies can both shape our ethical judgments and simultaneously define the direction of our research. According to Desnay Tan, the development of novel technologies involves emulating existing ones. She describes the steps toward the evolution of BCIs

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"… in the second phase, or emulation, the technology is used to mimic existing technologies. The first movies were simply recorded stage plays, and computer mice were used to select from lists of items much as they would have been with the numeric pad on a keyboard. Similarly, early brain-computer interfaces have aimed to emulate functionality of mice and keyboards, with very few fundamental changes to the interfaces on which they operated. It is in this phase that the technology starts to be driven less by its novelty and starts to interest a wider audience interested by the science of understanding and developing it more deeply." (Tan 2010) Analogies do have a relevant and noteworthy place in the development of new technologies and it's critical to decide which analogies to emulate throughout the research process. For example, only after we understood the heart through the analogy of a pump, was our research focused on fluid dynamics and hydrostatic pressures. In ways like this, the analogies we choose for BCIs can drive their development.

The role of analogies in science and technological development does not only come after the technology exists and is then in need of ethical appraisal, but structures the understanding and direction of the technology development from the beginning. Since analogies can shape the trajectory of BCI research, it is important to analyze which analogies will best guide such technologies. This paper will examine the relevance of three influential analogies typically evoked in BCI literature.

(1) Pacemaker

The most common analogy used to describe and investigate the ethical implications of BCIs is the BCI as a "pacemaker in the brain" (Rezai 2001). BCIs however are distinguishably different from pacemakers with regards to both their function and ethical implications.

By equating BCIs to a pacemaker, we are misrepresenting its very function, as far as we understand it. Pacemakers provide electrical stimulation and propagation whereas BCIs are currently only receiving information from electrical signals already produced by our brain. "The most commonly studied signals are the electrical signals produced mainly by neuronal postsynaptic membrane polarity changes that occur because of activation of voltage-gated or ion-gated channels" (Shih 2012). Even future BCIs are speculated to function contrary to the function of a pacemaker by interrupting the electrical signals already propagated in our brain and interrupting the electrical signals that culminate in instances of seizures, tremors or epilepsy. Therefore, the choice of this analogy is fundamentally misrepresenting a BCI's function and relationship to the body.

In addition to functional differences, pacemakers are also a source of individual data as would be BCIs. As an analogy, this raises relevant questions about what data would be recorded, why it would be used, who had access to this data, and what those who can access the data would be able to conclude about users from their data. There is also the concern that BCIs could be hacked, either making personal data public, or allowing hackers to direct BCI function.

If we choose to use the pacemaker as the precedent analogy for BCI privacy concerns, we must look to cases such as those in 2017 when Dick Cheney's pacemaker was disabled to thwart possible assassination by hacking attempts (Vass 2013). Do we have those concerns with BCIs? In addition, we see individuals who have been arrested for hacking and tampering with pacemaker data, such as Ross Compton, who was arrested for arson and insurance fraud. He was then charged based on his pacemaker data. During Compton's investigation, Electronic Frontier Foundation staff lawyer Stephanie Lacambra described this case as "the canary in the coal mine concerning the larger privacy implications of using a person's medical data" (Moon 2017). She further explained, "Americans shouldn't have to make a choice between health and privacy. We as a society value our rights to maintain privacy over personal and medical information, and compelling citizens to turn over protected health data to law enforcement erodes those rights" (Moon 2017). Cases like these lead stakeholders to question the safety and privacy of these BCIs, especially when analogized to pacemakers.

Given the privacy issues presented by a pacemaker and analogized for BCIs, it is important to ask how does that change when discussing neural data? It could be argued that neural data should be considered different from somatic data, such as a heart rate, because it is closer to what we designate as "self" and therefore should have different privacy expectations. Therefore, ethicists must investigate how neural data situates itself within our sense of self and discuss the implications of violating this different level of trust.

Combining these elements of function and privacy we can see that many of the concerns with pacemakers also apply to BCIs. Like pacemakers, BCIs utilize electrical stimulation and they may be wirelessly connected. This raises the same issues of hacking, privacy of medical data, and safety. However, unlike pacemakers, BCIs also introduce a number of novel issues, such as significant differences between somatic and neural data, the choice between physician programming and user control, and the implications of hacking a wireless device as opposed to a wired connection. The analogy of a BCI as a "pacemaker for the brain" will only illuminate the similarities and cloud the novel issues presented by BCIs. For example, if physicians continue to describe BCIs as "pacemakers for your brain" they could be misrepresenting the risk associated with BCI implantation surgery to their patients or simply miscommunicating how a BCI works. This could also then foster in a mis-association with available insurance coverage, surgical risks or data privacy regulations. This demonstrates that BCIs as pacemakers for the brain is not an apt analogy and that use of this analogy has potential long-term consequences when trying to understand risk, access and the actual function of a BCI.

(2) Wheelchairs and Prosthetic Limbs

Wheelchairs and prosthetics have been utilized in order to re-establish species typical functioning for both physical and neurological damage. One way to gain some understanding of BCIs has been to look at the insights from disability studies. Consequently, it has been natural to draw on the analogy of BCIs as assistive technologies like wheelchairs or prosthesis. This, however, is problematic because there is evidence that, unlike wheelchairs or prosthetics, BCIs might alter the identity or self-conception of its users in very profound ways.

In spite of the obvious similarities, there are important dissimilarities to recognize between wheelchairs and BCIs. Studies have shown that based on the placement of the implanted BCI electrodes, individuals have experienced personality changes or identity shifts. While this has not been conclusively shown, it does produce a risk that is not normally associated with assistive technologies.

In addition, Specker-Sullivan's research proposed that reliance on something like a BCI or a prosthetic would lead to an attachment and affinity towards that device. It is suggested that in some cases the device may even feel like it becomes a part of the user. Participants in the Specker-Sullivan study frequently made an analogy with wheelchairs to solidify this point. In the cases of both wheelchairs and BCIs, there seems to be no perceived difference in the degree of user identity melding between the two technologies. For example, a wheelchair or prosthetic may become so integrated into a person's lifestyle, that they are no longer consider it something "other" than their body. In contrast, a BCI could have more direct effects on a user's thoughts and feelings because of its direct interaction with the neural cortex. The greater physiological integration with BCIs might lead to unique issues related to identity that one cannot equate with other assistive technologies. Using the NIH "The Brain: Our Sense of Self" model (NIH 2005), we can infer that due to the closeness of the BCI to the brain, an implantable BCI seems to deviate from traditional assistive technologies. This becomes problematic when a patient's identity or even emotional state shifts and they have no way visually engage with the causal device.

Furthermore, unlike a wheelchair or a prosthetic you would be unable to remove the BCI without ex-plantation surgery, physically eliminating the user's ability to separate their identity from the device by themselves. This demonstrates that due to the physical proximity and the potential impact on identity from to direct neural interaction, BCIs and wheelchairs or prosthetics are also of limited value and accuracy when seeking a strong BCI analogy. Consequently, to address BCIs we must alter the way that we construct the patient-device relationship and reject the wheelchair to BCI analogy.

(3) iPhone

It has been proposed that, unlike most medical devices, BCIs would develop a platform for "intimate" information sharing similar to the relationship we share with our mobile phones. (Green 2015). Although this issue is similar to the privacy discussion about heart information being shared through pacemaker technology, the common analogy of the iPhone is flawed in a different way. The analogy of our iPhones is being used to liken the personal information sharing enabled by iPhones to that which is present in BCIs. However, unlike iPhones, BCIs share this interior relationship in both physical and mental ways. For instance, one participant in the Specker-Sullivan focus group study expressed concern about the idea that an external BCI wire could get caught and "tug" on the user's brain (Specker-Sullivan Unpublished). Other participants suggested that a BCI would "know" too much about the user and their personal and emotional experiences.

Our laptops and smartphones have become an integral part of modern life. Many find it hard to spend a few hours, let alone a few days, away from our device. We share our location, our sleeping patterns, our menstrual cycles and big life events through applications on our phones. This analogy of iPhones echoes the privacy concerns of the pacemaker analogy, but goes a step further into the privacy arena because of the quality of the information being shared. Unlike the information recorded by either your iPhone or a pacemaker, BCIs may access personal information that not only describes somatic information typical of all humans, but could identify unique traits, personal events or interior thoughts that are specific to each patient and their personality. This was described as a "symbiotic relationship" (Wang 2010) between the user and the device. iPhones depart from the intimate context of BCIs because the information we offer our smartphones—by agreeing to terms and conditions or choosing to post our personal information—is information that has already been filtered by the individual user. In the case of BCIs, raw brain data is recorded. This eliminates the filter that discriminates what we expose to the rest of the world and places this technology in a uniquely intimate position. These intimate interactions include universal private experiences like using the restroom or engaging in a sexual relationship. Even uniquely interior moments such as internal critical commentary of individuals around you could be collected. For example, what if your BCI registered neural data that demonstrated your silent homophobic or racist ideals? What if your BCI registered homicidal thoughts? This begs questions relating to regulation, access, identity, policing and more. This would be a tremendous step away from the intimacy and information privacy we currently operate with though our iPhones, developing an unprecedented relationship with our unfiltered neural signals. This therefore suggests that the commonly used iPhone analogy is similarly inept and even potentially dangerous in describing BCIs.

Future Directions

As seen above, the analogies that have been used by ethicists, potential end users and scientists do not fully capture the unique aspects of this technology. The analogies that we are grasping at are inept and their continuous use could produce long-term consequences. I don't believe that an appropriate and encompassing analogy exists. Instead, I would propose that BCIs fit into a new category of technology that falls outside of specific consumer or medical use analogies. As seen above, privacy concerns are changing with BCI technology because we must address security and regulation for a seemingly different type of data in the growing world of medical data. A BCI is an entirely new and more intimate technology that sits directly where we hold our sense of self and has potential personality changing side effects. This technology also has the potential power to identify information that has the ability to not only describe an individual's physical function but also their personality. Finally, for the first time, this technology plays a uniquely interior role with its users, breaching the existing social filters that allow us to control access to our most private thoughts. While BCIs exhibit similarities to existing devices such as pacemakers, wheelchairs, and iPhones, they are unmatched and unexplained by current technological and medical analogies. This situates BCI technology in an unprecedented middle ground and potentially alters the way we conceptualize the development, production and regulation of this technology. Given this, I propose the most appropriate way to conceive BCIs is as a dual market device.

A dual market device could be defined as a technology or product that has genuine applications in both the medical and non-medical market. This means that this technology is being specifically developed, regulated and ethically discussed with both of these audiences in mind. This framework would recognize the lack of precedent for these devices in either market and encourage the consideration of ethical implications for this device across both markets. Conceptualizing BCI technology as a dual market device could lead to safer and more effective regulation and develop this technology for both medical and consumer markets. Additionally, conceptualizing this device as dual market device removes the precedent expectations that cause our current analogies to fall apart and support our understanding of these devices' capabilities in context of end user's needs.

Conclusion

We are in the early stages of BCI development, which means that we are still exploring the best way to understand these devices. Literature reviews have shown that we, as researchers, ethicists and physicians reach to pacemakers, wheelchairs and iPhones to describe the ethical implications. In the Specker-Sullivan study, we see that participants also reached toward dis-analogies when asked what they understand the ethical concerns of BCIs to be. They drew connections with science fiction, medicine and the consumer market devices to articulate their understanding. For example, the 1999 movie, *The Matrix*, was a frequent reference point, as were exoskeletons and mind control games sold on Amazon, (Specker-Sullivann Unpublished). As shown in this paper, these dis-analogies with BCIs are demonstrably complicating our understanding and discussion of this technology. This acts as evidence that as researchers, physicians and ethicists, we have failed to accurately communicate the definition, function and conceptualization of BCIs. All of these analogies fall short of describing this novel technology, and as a consequence, further perpetuates both society's and researchers' misunderstanding of the significant practical and ethical implications surrounding BCIs. This suggests a need for a reconceptualization of this technology that in turn can illuminate the conversations around it.

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Article

Ethical Issues Concerning Transgender Athletes

Victoria Chen*

In an ever-changing gender landscape with regards to politics and popular culture, concerns about transgender inclusion must also be considered in the context of competitive athletics. Transgender athletes raise unique issues about fairness. Consider: Fallon Fox, the first transgender woman to compete in Mixed Martial Arts (MMA); Kye Adams, the first transgender athlete to play in NCAA Division I sports; Mianne Bagger, the first transgender woman to play in a professional golf tournament; Jaiyah Saela, the first transgender woman to play in the soccer World Cup, and Chris Moiser, the first transgender athlete to make the United States national team in duathlon (Ranker 2017). The 2016 Rio Olympics was the first Olympic game to accept transgender athletes (although no known transgender athletes competed) (Nyad 2016). As the international sporting world becomes more accepting towards transgender athletes, the question arises whether it is fair to allow them to compete, especially those individuals who transition from male to female. This paper examines the controversy surrounding transgender athletes from different ethical perspectives evaluating fairness in competition.

Background

What does Transgender Mean?

The American Psychological Association defines transgender as having a gender identity different from one's sex assigned at birth, whereas gender is defined by culture, and sex is assigned by anatomy (2015). Medical professionals can help transgender people transition by providing treatments such as hormone therapy and sex reassignment surgery. Transgender should not be confused with intersex, sometimes known as hermaphroditism, where there is atypical development of physical sex characteristics (American Psychological Association). Psychologists previously diagnosed a transgender identity as a gender identity disorder, but recently removed the diagnoses in favor of gender dysphoria in 2013 (Russo 2017).

Scientific Evidence about Testosterone and Competition

There is currently no conclusive scientific evidence backed by research on the effects of naturally produced testosterone by the body, especially in transgender athletes. The study announced by the IAAF (International Association of Athletics Federations) in 2017 is one of the very few studies that have claimed to find a clear competitive advantage created by naturally produced testosterone. "The testosterone rule – constructing fairness in professional sport" study, in 2017, reviewed existing scientific data regarding the relationship between high testosterone level and athletic performance and found no clear link between the two (Sundai 2017). Furthermore, there is no research on the effects of elevated testosterone level in transgender women on athletic ability (Jones et al. 2017).

Natural Kinds

Sporting competition relies on a philosophical notion called "Natural Kinds." This view parallels the view in biology that living beings can be rationally sorted into distinct entities, where a "natural kind" is defined by form, function, appearance, and ability to reproduce with another member of the same kind (Bird et al. 2017). In a worldview, natural kinds indicates that the universe consists of both living and non-living things sorted into natural categories. The worldview of natural kinds can be applied to humans, as historically, members of different tribes, races, and sexes were considered different natural kinds.

Applying Natural Kinds to sports is straight-forward: only those of the same "natural kind" should compete against each other. Allowing members of one natural kind to compete with members of another kind can be construed as unfair.

However, the more we have come to know about biology and humans, the more the worldview of Natural Kinds has been unable to withstand scientific inquiry. In biology, we know that membership in a tribe is not a biological fact, and that race is more of a social construct than a biological fact. Moreover, racial classification exists on a gradient. Similarly, as previously hidden sexual anomalies become better known, gender may be more fluid than we previously thought; more than 1% of babies are born with ambiguous genitalia (HRF 2014). Furthermore, many people increasingly realize that they do not fit a binary classification into one natural kind or another, but fall in between or into neither. These developments challenge the previous assumption in sports that fair athletic competition is assured when only members of natural kinds compete against one another, because this assumption excludes anyone who does not cleanly fit the stereotype of a natural gender-kind.

Perhaps even more striking is the fact that Olympic athletes are not "natural" at all (Huber 2017). Many Olympic athletes are born with natural genetic abnormalities, which give them a competitive advantage over their opponents in their respective fields (Longman 2017). In the world

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of track and field where every millisecond counts, some people are born with naturally high levels of hemoglobin, which allow their muscles to receive more oxygen, and fast twitch muscles, which lend a competitive advantage during sprints (Gaudette 2014).

Consider Michael Phelps, one of the most decorated swimmers in history. He possesses a huge wingspan, long torso and short legs, large feet, and produces less lactic acid than a normal swimmer (Siebert 2014). All of these traits coupled with his intensive training gives Phelps a huge advantage in the pool. Despite all of his genetic abnormalities, Phelps competes with normal competitors. In the case of swimmers born with webbed fingers and toes, a condition known as syndactyly, international sporting officials would be considerably more reluctant to allow them to compete (Cincinnati Children's 2016). Is there really a huge difference between these athletes? Both are using the natural advantages of their bodies to compete without the use of drugs or other enhancements. Is having a higher level of naturally occurring testosterone really so different from having higher levels of hemoglobin? No one will dispute the effects of injecting artificial testosterone on sport performance, but should athletes be punished for having bodies that naturally produce more testosterone?

Transgender Competition Policy

History and Current State of International Competition Policy

The Olympics has a long history of cheating and doping scandals. This was an especially prominent issue during the Cold War when winning medals was a matter of national pride (Bump 2014). Even in recent times, the issue is still pervasive, as the Olympics recently banned Russia from participating in the upcoming Olympics due to massive widespread cheating during the Sochi Olympics in 2014 (Chappell 2017).

Fairness concerning gender is more controversial and complex. In the early 1900s, women had to receive a certification from their medical professional certifying that they were female. In 1966, the international sports officials implemented a mandatory genital check (Padawer 2016). After complaints over the invasive technique, officials tested for the Y chromosome instead (Lindner 2016). This excluded not only intersex athletes, but (unfairly?) also those with genetic abnormalities. For example, some women are born with both the X and Y chromosome, but they are androgen insensitive. This means that they lack the ability to process testosterone. Therefore, they gain no competitive advantage from testosterone naturally produced by their bodies. However, the Y chromosome does affect other physical attributes such as height (U.S. National Library of Medicine 2017).

In 2004, the Olympic policy for transsexual athletes required a sex change surgery and hormone therapy (Reeser 2005). Based on a study that found 99% of elite female athletes had androgen (male hormone such as testosterone) levels below 3.08 nanomoles per liter (nmol/L), in 2011, the IAAF implemented a new policy (Bermon et al. 2014). They set the androgen level limit at 10nmol/L for female athletes to include outliers such as those with polycystic ovary syndrome, which creates a hormone imbalance occasionally leading to excess androgen levels (IAAF 2011). This limit allows them to use an objective measurement to differentiate between men and women in sports without sex verification procedures (Ballantyne et al. 2012). The International Olympic Committee (IOC) followed suit and implemented a similar policy.

The cases of Caster Semenya and Dutee Chand demonstrate some of the difficulties faced by the international sporting community in ensuring fairness. In 2009, Caster Semenya won the women's 800 meters Olympic gold medal by more than two seconds, a huge margin in international sports. She had to undergo a sex test and was later barred from competing (Huber 2017). The test allegedly revealed that Semenya had three times the normal testosterone expected in female athletes. After the controversy, the IAAF implemented the 2011 policy.

However, after abnormally high levels of testosterone banned her from competition, in 2015, Dutee Chand challenged the policy in the Court of Arbitration for Sport (Macur 2017). The court ruled that it was "unable to conclude that hyperandrogenic female athletes may benefit from such a significant performance advantage that it is necessary to exclude them from competing in the female category"[1]. The court gave the IAAF until 2017 to prove that naturally produced testosterone provided a clear competitive advantage, while suspending its policy implementation until then. The IAAF recently released an announcement in July 2017 about a study published in the British Journal of Sports Medicine funded by the IAAF (IAAF 2017). The study found that women with higher naturally occurring testosterone had a competitive advantage in the 400m dash, 400m hurdles, 800m run, hammer throw and pole vault, with margins between 1-5% (Bermon et al. 2017). Court of Arbitration for Sport suspended the policy for another 6 months in January 2018 after the IAAF submitted a new set of rules for review (Bull 2018). In the 2018 Olympics, the IOC did not regulate women's natural testosterone levels or have them undergo sex testing until the IAAF case is resolved (Carr 2017).

The fight over allowing hypoandrogenism concerns transgender athletes because many of the issues concerning women who produce above normal levels of testosterone will only be magnified in a transgender female.

The current IOC policy concerning transgender athletes differs for transgender men and women (IOC 2015). There are no restrictions for transgender men, who transition from female to male. For transgender females, the athlete has to declare her gender as female and stay so for at least four years. Furthermore, athletes must demonstrate that their total testosterone level is below 10nmol/L for at least 12 months prior to the competition and throughout the competition. The IOC has waived its former policy of mandating a sex change surgery for competition. However, this policy closely mimics the IAAF's policy for hyperandrogenism.

Policy in Secondary Education

The debate over transgender athletes becomes more heated at the high school level. In the United States, there

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[1] Dutee Chand v. Athletics Federation of India (AFI) & the International Association of Athletics Federations (IAAF), 3759 CAS (2014).

is no overarching sports authority for high school athletic events, leaving many states to create their own policies. State sporting authorities frequently look to the National Collegiate Athletic Association (NCAA) for regulation guidance and implementation. The NCAA requires that transgender males who receive testosterone treatments compete on male teams; transgender females are required to undergo one year of testosterone suppression before competing as a woman (NCAA 2017). Transgender males who are not taking hormones can play for whichever team they prefer. The international sporting community can provide no guidance for an appropriate policy as it is still trying to create one itself. This has led to an unequal application of regulations across state boundaries.

The current international and NCAA guidelines concerning the level of testosterone for transgender female athletes is impractical for states to implement due to a lack of resources as well as the age of the participants. All of the student athletes are minors. Before most doctors are willing to prescribe hormone therapy, they will typically ask the patient to live full-time as their self-affirmed gender for 12 months and undergo a psychosocial assessment before prescribing hormones (Unger 2016). Doctors are especially reluctant to prescribe hormones to children due to the low persistence of gender dysphoria into adulthood, 6 to 23 percent for boys and 12 to 27 percent for girls (Drescher et al. 2014). There is a low possibility that any transgender high school female athletes would fulfill the NCAA or Olympic requirements for competition.

> “The biggest ethical issue at play concerning transgender athletes is whether it is fair for them to compete with other athletes and what restrictions they could or should obey.”

Take the case of Andraya Yearwood. She identifies as a girl and plans to undergo hormone therapy to complete her transition (Smith 2017). Yearwood competed in Connecticut on her high school track team and won state titles in both the 100 and 200 meters. Under Connecticut’s rules, which prohibit discrimination based on “gender identity or expression” and allows teens to play based on their self-identification, Yearwood competed as a female (Jacobs 2017). However, was it fair?

Connecticut is not the only state with regulations concerning transgender students. California has a similar policy to Connecticut; it allows transgender students to play on the team that matches their self-identification (Michaels 2016). In Texas, a rule requires students to participate on the team that matches the gender of his or her birth certificate. Nebraska implemented a Gender Identity Eligibility Committee that is composed of a doctor, a mental health professional, a school administrator, and a Nebraska School Activities Association member. The committee decides on a case-by-case basis whether to allow a transgender student to compete in his or her self-identified gender. Indiana uses anatomical sex as the determining factor and requires students transitioning from male to female to undergo sex reassignment surgery before competing (Andrews 2017).

Fairness and Philosophical Perspectives

In sports, the question of fairness has worried leading authorities for years; they try to implement regulation to prevent cheating and doping to maintain a fair playing field for all competing athletes. This problem multiplies at a high school level where many student athletes are only beginning to realize their transgender identity and thus may not be able to start the hormone therapy or any other treatments previously required by the international sporting community. While the international community is still struggling to find a compromise, this problem has placed a heavy burden on states to implement a fair and unbiased policy for transgender athletes.

The biggest ethical issue at play concerning transgender athletes is whether it is fair for them to compete with other athletes and what restrictions they could or should obey.

Fairness could be viewed in two different perspectives. One perspective considers the amount of resources and degree of modifications on a gradient. One extreme of the gradient would be a primitive state, in which there should be no training equipment, modifications, training, etc. allowed. This would be reminiscent of the original Olympics in Greece. The other extreme, advocated by Savulescu, would be to allow everything, such as steroids and other enhancements, to gain a competitive advantage (Penaluna 2016). The current rules lie somewhere in between the two extremes. In professional sports, authorities currently ban drugs and other medical enhancements. However, could this be considered fair?

Plenty of evidence shows that athletes with access to more resources, coaching, facilities, and equipment perform much better in competitions. The results from the Rio Olympics in 2016 clearly indicate that the number of medals given to athletes of resource-dense first-world countries far outstrips those earned by athletes from third world countries with comparable populations. In fact, the United States, China and Great Britain earned the most medals (The Washington Post 2017).

An alternate view of the fairness gradient pursues the difference between correcting disability and enhancement. Bioethicists have long argued over the differences between the two as corrected disabilities could very easily become an enhancement. Sandel argues that correcting disability is returning the trait to its natural state, but societal cultural norms strongly influence the definition of “natural” (Sandel 2004). Oscar Pistorius stands as an example of the blurry divide between correcting disability and enhancement. He was born without his calf bones and had to have both of his legs amputated below the knee (Geoghegan 2015). However, he became one of the most talented Paralympic athletes the world has ever seen, even competing in the London 2012 semifinals against non-impaired athletes. Many people questioned whether his "Cheetahs", the prosthetic limbs he was wearing, gave him an unfair advantage over his opponents. Cheetah's are made of carbon fiber and store more energy than a human leg, possibly giving Pistorius a competitive edge while racing (Larwood 2010). An argument could be made that his disability became an advantage through medical enhancement. His doctors did not correct to "normal," but, rather, enhanced his natural athletic ability.

Another consideration for fairness would be how fairness affects the majority of the population versus the minority. Often, what is fair for the individual or minority is not fair for the majority and vice versa. There is often a very small intersection of fairness between the two, but to achieve fairness for both the majority and minority is incredibly difficult. For transgender athletes, especially transgender females, many people argue that allowing them to compete without restrictions with other females is unfair to the majority of "normal" females. On an intuitive level, this argument holds merit. It would seem unfair for a male to compete with a female. However, it is also unfair to discriminate against transgender athletes solely based on their gender. In the case of high school athletes, competing in sports and joining athletic teams is essential to developing healthy social relationships in school.

Future Research and Policy

Creating an inclusive policy for transgender athletes while maintaining fairness and equality is an issue facing all levels of competition, from high school to international. In order to improve the fairness of current policy, sports organizations must take into account "natural" societal standards, the gradient of enhancement and disability correction, and the amount of resources or degree of modification, while also continuing to research the effects of naturally produced testosterone and other androgens. Furthermore, with the increasing inclusion of transgender athletes, future areas of research will include policy for transgender accommodation in locker rooms and bathrooms. Achieving fairness in competitive sports remains an ever-evolving topic for debate among sporting authorities.[2]

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