Breaching the final sanctum of the mind

An analysis of the protection human rights offer against the risks posed by brain-computer interfaces to mental autonomy

Master thesis
LL.M. Law and Technology
Department of Tilburg Law School
Tilburg Institute for Law, Technology and Society
Tilburg University
June 2021

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1 INTRODUCTION

"Mental slavery is mental death, and every man who has given up his intellectual freedom is the living coffin of his dead soul." – Robert G. Ingersoll

1.1 Background

Imagine it is the year 2120. Space tourism is commonplace.[1] Cars run on artificial photosynthesis.[2] Early settlers have reached Mars and inhabit small settlements.[3] Nuclear fission – the energy source of the sun and stars – powers our cities.[4] Humans control machines with their minds.

While it remains to be seen whether the first four scenarios become a reality, the technology described in the fifth one is already among us: 100 years earlier. Brain-computer interfaces (hereafter: BCI's) detect, interpret, and translate users' brain signals[5] to command a device.[6] Although the technology is still in its early stages, BCI's have been developing at an increasingly fast pace. A recent example is the Neuralink that is in development by one of Elon Musk's companies.[7] While most of the proposed applications of the Neuralink – e.g. restoring sight, symbiosis with artificial intelligence and (technological) telepathy[8] – are (very) far from being realised[9], the technology already raises legal and ethical questions.

For example, if these chips or implants can alter perceptions, who would be responsible if it malfunctions or gets hacked and you commit a crime you did not intend to? Or would it be ethical to enhance soldiers with this technology? What about extracting pin codes or other information from abducted people?[10] These illustrative examples show the many implications of BCI's in both their current and future form. Implications that are not exclusively in the realm of science-fiction anymore; they have entered our reality.

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[1] Wendy Whitman Cobb, 'Space Tourism Is Here – 20 Years after the First Stellar Tourist, Jeff Bezos' Blue Origin Plans to Send Civilians to Space' (*The Conversation*) <http://theconversation.com/space-tourism-is-here-20-years-after-the-first-stellar-tourist-jeff-bezos-blue-origin-plans-to-send-civilians-to-space-160510> accessed 14 May 2021.

[2] 'Creating Fuel from Thin Air with Artificial Leaves' *BBC News* (12 October 2020) <https://www.bbc.com/news/business-54390932> accessed 14 May 2021.

[3] 'Mars One' (*Mars One*) <http://www.mars-one.com/> accessed 14 May 2021; James Maynard, 'NASA Offers $2.25 Million For Martian Habitat Design - How Could This Contest Help People On Earth?' (*Tech Times*, 19 May 2015) <https://www.techtimes.com/articles/54113/20150519/know-design-3d-printed-habitat-mars-nasa-2-25-million.htm> accessed 14 May 2021.

[4] Jayesh Nehiwal and others, 'Nuclear Fusion: Energy of Future' in Mohammad Shorif Uddin and others (eds), *Intelligent Energy Management Technologies* (Springer 2021).

[5] A user is the person controlling a BCI.

[6] Steffen Steinert and others, 'Doing Things with Thoughts: Brain-Computer Interfaces and Disembodied Agency' (2019) 32 Philosophy & Technology 457.

[7] 'Neuralink: Elon Musk Unveils Pig with Chip in Its Brain - BBC News' <https://www.bbc.com/news/world-us-canada-53956683> accessed 4 September 2020.

[8] Ram Sagar, '10 Mind Bending Applications Of Neuralink, According To The Team' (*Analytics India Magazine*, 30 August 2020) <https://analyticsindiamag.com/mind-bending-applications-neuralink-event/> accessed 14 May 2021.

[9] Antonio Regalado, 'Elon Musk's Neuralink Is Neuroscience Theater' (*MIT Technology Review*) <https://www.technologyreview.com/2020/08/30/1007786/elon-musks-neuralink-demo-update-neuroscience-theater/> accessed 2 September 2020.

[10] Limor Shmerling Magazanik, 'The Ethical and Legal Implications of Brain-Computer Interfaces' (*CTECH - www.calcalistech.com*, 24 May 2019) <https://www.calcalistech.com/ctech/articles/0,7340,L-3762798,00.html> accessed 3 September 2020.

1.2 Problem statement

Last year, Facebook revealed the intermediate results of a research project that it funds.[11] The results were published in a paper that provided proof of an algorithm to decode brain activity into legible words.[12] Facebook's short-term goal is to help paralysed patients to speak by reading their brain activity. In the longer term, Facebook wants to allow people to control digital devices with just their thoughts. Especially this latter application of BCI's raises questions on the risks they pose to, inter alia, mental autonomy.[13]

The potential risks that BCI's pose has led to calls of action by neuroscientists and -ethicists, urging legislators to create new laws to cover those risks. Most notably are the specific calls for new human rights in the form of so-called 'neurorights'.[14] These rights should cover the, in their opinion, gaps that the current human rights have regarding the risks posed by neurotech.[15] However, it often turns out that these gaps are merely the product of insufficient understanding of the law. Leenes calls this phenomenon the 'Flawed Law Syndrome".[16] This raises the question of whether current human rights are indeed insufficient and thus create a need for other solutions to handle the risks of BCI's or whether they are flexible enough to cover those risks. Because a study on all human rights and all risks is far too extensive for just one thesis, choices were made to narrow the scope of the research. Concerning the risks, the research will focus on risks to mental autonomy. This choice is further expanded upon and justified under section 1.5.

Now that the problem is apparent, an explanation follows on *why* it is considered a problem. With the rise of BCI's, the earlier introduced concept of mental autonomy could be at stake. Mental autonomy can have multiple definitions, which will be explored later. For now, the following definition is useful to understand what the concept encapsulates: 'the specific ability to control one's own mental functions'.[17] This ability to think freely makes us human. According to Halliburton, it is so essential to our identity that it would deprive us of personhood altogether if it were violated.[18] BCI's could pose a risk to the mental autonomy of their users by, for example, decoding our thoughts[19], manipulating brain signals (benign or malign) or incorrectly interpreting brain signals leading to unintended actions. However, what these risks are in concreto is researched in chapter 3.

[11] 'Imagining a New Interface: Hands-Free Communication without Saying a Word' (*Facebook Technology*, 30 March 2020) <https://tech.fb.com/imagining-a-new-interface-hands-free-communication-without-saying-a-word/> accessed 2 September 2020.

[12] David A Moses and others, 'Real-Time Decoding of Question-and-Answer Speech Dialogue Using Human Cortical Activity' (2019) 10 Nature Communications 3096.

[13] Mental autonomy is a major concept in this thesis and is extensively discussed further on.

[14] Rafael Yuste and others, 'Four Ethical Priorities for Neurotechnologies and AI' (2017) 551 Nature News 159; OECD, 'Recommendation on Responsible Innovation in Neurotechnology' (OECD) <https://www.oecd.org/science/recommendation-on-responsible-innovation-in-neurotechnology.htm> accessed 3 September 2020.

[15] Marcello Ienca and Roberto Andorno, 'Towards New Human Rights in the Age of Neuroscience and Neurotechnology' (2017) 13 Life Sciences, Society and Policy 5.

[16] Ronald Leenes, 'Regulating New Technologies in Times of Change' in Leonie Reins (ed), *Regulating New Technologies in Uncertain Times* (TMC Asser Press 2019) <https://doi.org/10.1007/978-94-6265-279-8_1> accessed 15 May 2021.

[17] Thomas K Metzinger, 'The Myth of Cognitive Agency: Subpersonal Thinking as a Cyclically Recurring Loss of Mental Autonomy' (2013) 4 Frontiers in Psychology <https://www.frontiersin.org/articles/10.3389/fpsyg.2013.00931/full> accessed 11 November 2020.

[18] Christian M Halliburton, 'How Privacy Killed Katz: A Tale of Cognitive Freedom and the Property of Personhood as Fourth Amendment Norm' (2009) 42 Akron Law Review 83.

[19] Andrew James Anderson and others, 'Predicting Neural Activity Patterns Associated with Sentences Using a Neurobiologically Motivated Model of Semantic Representation' (2017) 27 Cerebral Cortex 4379.

1.3 Literature review

Although the literature on BCI's is not as expansive as on the overarching field of neurotechnology, still some very vocal authors have championed the view that BCI's should be (more) regulated. Those authors are generally neuroscientists, -biologists and -ethicists who have gained respect in their fields throughout the years. E.g. one author has been in the foreground for quite some years, Ienca, a senior researcher at the Health Ethics & Policy Lab. Ienca, along with other proponents[20], suggests that BCI's pose risks that should be addressed by new legislation. Whether current human rights need to be complemented with additional clauses[21], new rights[22] (frequently called 'neurorights') need to be created altogether, or a different governance framework is needed[23], differs depending on the author. Nevertheless, their general view is that current legislation is insufficient and must be addressed in one way or another.[24] This is the earlier mentioned Flawed Law Syndrome. What becomes apparent when looking at the above sources is that it seems to be a pool of exclusively non-legal academic authors. There could be various reasons for that but discovering why that is the case is beyond the scope of this thesis. What can be said about the above observation is that there is a need for academic research, and following literature, on BCI's that is written from a legal viewpoint. While the authors mentioned above are undoubtedly experts in their respective fields, they generally lack in-depth knowledge of the legal frameworks that might encompass BCI's.

Essentially all of the above literature mentions human rights as a way to guard against the risks associated with BCI's.[25] This notion that human rights are currently the most suitable framework to prevent the risks of BCI's is one that I prima facie agree with. Especially references by authors to the link between freedom of thought and BCI's piqued my interest, which eventually led to the conception of this thesis. The concept of mental autonomy is, by most authors, regarded as being part of the freedom of thought. By delving into the literature on mental autonomy and similar terminology[26], it becomes clear that mental autonomy is inextricably linked to the freedom of thought. E.g. some authors explain mental autonomy as the 'sovereignty over our minds'.[27] Therefore, since mental *autonomy* relates to freedom of the mind, it is a logical conclusion that mental autonomy falls within the general domain of the freedom of thought.

This viewpoint is supported by one of the few legal scholars that writes about the relation between human rights and (a concept similar to) mental autonomy regarding neurotechnology. [28] Interestingly, this author also proposes a new human right to protect the autonomy of the mind, thus taking more or less the same stance as the earlier mentioned neuroscientists and -ethicists. However, by quoting former European Court of Human Rights (hereafter: ECtHR or Court) judge Loucaides, the author also explicitly states that there is very little written about the freedom of thought. He mentions that further research on the freedom of

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[20] Such as: Yuste and others (n 14).

[21] ibid.

[22] Ienca and Andorno (n 15).

[23] Magazanik (n 10).

[24] Simon McCarthy-Jones, 'The Autonomous Mind: The Right to Freedom of Thought in the Twenty-First Century' (2019) 2 Frontiers in Artificial Intelligence <https://www.frontiersin.org/articles/10.3389/frai.2019.00019/full> accessed 25 January 2021.

[25] Which are discussed in chapter 3.

[26] This research using similar terminology is justified under 1.5.

[27] McCarthy-Jones (n 24).

[28] Jan-Christoph Bublitz, 'The Nascent Right to Psychological Integrity and Mental Self-Determination' in Andreas von Arnauld, Kerstin von der Decken and Mart Susi (eds), *The Cambridge Handbook of New Human Rights* (1st edn, Cambridge University Press 2020) <https://www.cambridge.org/core/product/identifier/9781108676106%23CN-bp-30/type/book_part> accessed 7 February 2021.

thought is necessary to determine some fundamental questions on its scope and interpretation since the right is currently heavily underutilised and under-researched. This observation is made by McCarthy-Jones, who states in his paper that: 'the right to FoT [sic: read Freedom of Thought] is poorly defined. Attempts to sketch its contours have been negligible (…) unclear what counts as thought, what qualifies as a violation of the right, whether it should be absolute and, if not, what would justify its violation'.[29] This again shows the importance of the research done through this thesis and the gap in the literature filled by answering the main research question and sub-questions.

1.4 Main research questions and sub-questions

The main research question is: '*To what extent do the elements of freedom of thought contained in ECHR case law safeguard against the potential risks to mental autonomy associated with neurotechnology, more specifically brain-computer interfaces?'*.

The sub-questions used to answer the main question are as follows:
1. What are brain-computer interfaces?
2. What is freedom of thought, and what elements of freedom of thought constitute mental autonomy?
3. What can be considered a risk to mental autonomy, and what are the risks to mental autonomy currently associated with brain-computer interfaces?
4. How have the elements of freedom of thought relevant for mental autonomy been approached in ECHR case law?
5. To what extent does ECHR case law cover the risks of brain-computer interfaces to mental autonomy, and if that coverage is insufficient, what are possible solutions for that insufficient coverage?

1.5 Limitations, methodology and methods

First, the limitations of the thesis deserve attention. As mentioned in the problem statement, the scope of the thesis is demarcated to the risks that BCI's pose to mental autonomy. In my view, mental autonomy is a fundamental component of our existence. Without delving into the metaphysical interpretation of that statement, it suffices to say that the normative starting point of the thesis is that freedom of thought must protect mental autonomy. The numerous, earlier mentioned authors also support this notion in the literature review. Thus, while other concerns raised in the context of BCI's – e.g. distributive justice regarding equal opportunities to use the technology or the accountability of users performing unintended actions – are interesting, they are left out of the research to keep the scope limited to the research question.

Furthermore, the thesis likely faces a limit in the context of multidisciplinary perspectives. Whereas little is written about BCI's in a legal context, extensive literature exists in a biomedical context. That literature consists mainly of studies done regarding experimental features of BCI's, recent developments and explanations on the workings of them. While those papers are invaluable to first understand *how* BCI's work and second to determine the implications of the technology within a legal framework, I do not have a background in biomedicine. Thus, a precursory limitation of the thesis is that the deep, biomedical core of the technology might be hard to qualify for a non-biomedical scientist or scholar.

Another limitation of the thesis is the focus on the European Convention on Human Rights (hereafter: ECHR). Although the size of a master's thesis demands a narrow scope, other international human rights frameworks are suitable for analysis as well. Nevertheless, as

[29] McCarthy-Jones (n 24).

mentioned further on, the choice for the ECHR is justified. Also, while the main focus is on the ECHR and its case law, sidesteps to other human rights frameworks are not avoided *if* that is warranted.

Then, it is essential to emphasise that the concept of mental autonomy is not set in stone. Even the general term 'autonomy' has widely varying meanings depending on context and the field it is applied in.[30] In chapter 3, multiple perspectives from different authors clarify what mental autonomy should entail. Those different perspectives are gained from the literature regarding autonomy, but also regarding concepts related to it. Again, the reason is that many authors use their own or differing definitions for the concepts they discuss. That is why concepts such as mental integrity, cognitive liberty and mental self-determination are discussed besides mental autonomy. It is crucial to remember that, although the terms are different, those authors are often describing the same phenomenon or underlying notion. Therefore, the concepts used in this thesis must be understood as having the meaning that is ascribed to them by the thesis, even though different authors might define them differently.

As for the legal focus, as mentioned, the choice is made to focus solely on the ECHR and its case law. For one, the ECHR is generally regarded as the most important international treaty for human rights protection.[31] Because the treaty has been in effect since 1953, it has given birth to a broad range of case law throughout the years. This case law is an important source of information to analyse and determine the scope of freedom of thought. One point of importance is that, in this thesis, freedom of thought refers to the overarching concept of freedom of thought instead of *just* art. 9 ECHR.[32] During the literature review, it became clear that case law on the ECHR – or practically any human rights framework – regarding the 'thought' portion of the article is almost non-existent.[33] Thus, the choice was made to establish what freedom of thought is in the overarching sense, what parts constitute mental autonomy and then determine the underlying components of said autonomy. By breaking down the concepts into smaller pieces at each step, the final components are suitable to look for in the ECHR case law.

Once the risks of BCI's to mental autonomy and the scope of relevant provisions in the ECHR are clear after analysis, it is determined whether the ECHR sufficiently protects against the risks to mental autonomy. If e.g. five underlying components together constitute mental autonomy, then those individual components must all be covered by the ECHR. If that is the case, the in the problem statement mentioned supposed 'gaps' in legislation are covered by the ECHR with regards to mental autonomy. However, if that is not the case, mental autonomy is not sufficiently protected by the ECHR. If that is the result of the research, an exploration of possible solutions to remedy this insufficient protection follows. Although a complete analysis of those possibilities is outside the scope of this thesis, I want to concisely provide some possible options to provide entry points for follow-up research.

Concretely, the following methodology and methods are used to answer the research question and sub-questions. In general, doctrinal legal/socio-legal research is done. For the information on BCI's and neurotechnology in general, academic literature in those fields is used. In particular, the snowball method is utilised. With this method, one publication on a

[30] E.g. John Christman, 'Autonomy in Moral and Political Philosophy' <https://plato.stanford.edu/archives/fall2020/entries/autonomy-moral/#ConAut> accessed 7 March 2021; George Agich, 'Key Concepts: Autonomy' (2009) 1 Philosophy, Psychiatry & Psychology 267; Carlos Gómez-Vírseda, Yves de Maeseneer and Chris Gastmans, 'Relational Autonomy: What Does It Mean and How Is It Used in End-of-Life Care? A Systematic Review of Argument-Based Ethics Literature' (2019) 20 BMC Medical Ethics 76; Eric Matthews, 'Autonomy and the Psychiatric Patient' (2000) 17 Journal of Applied Philosophy 59.

[31] Irish Human Rights Commission, *European Convention on Human Rights Guide for the Civil & Public Service* (2012).

[32] This is the article on freedom of thought in the ECHR.

[33] Bublitz, 'The Nascent Right to Psychological Integrity and Mental Self-Determination' (n 28).

particular topic leads to different publications by looking at the citations of the first publication. This can either be to earlier or later publications, depending on whether one respectively looks at the bibliography of the publications or finds out how many times the publication has been cited since. Then, to evaluate the risks of BCI's, there first needs to be a definition of what risk to mental autonomy is. To determine this concept of risk, law, medical and philosophical literature is used to see what academics in those fields consider risks to mental autonomy. As for the scope of the ECHR, that is determined by doing doctrinal research of primary and secondary sources. This involves case law, drafter intentions, journal articles and written commentaries by legal scholars, among others. By consulting these, the scope of the ECHR and its application throughout the years is determined. To gather the above information, research databases such as Google Scholar, SpringerLink, SSRN and ResearchGate are used, along with specialist magazines and journals such as Frontiers, Nature Research and BioMed Central and finally, Hudoc for research on the ECHR.

1.6 Structure of the thesis

Chapter 1

The introductory chapter contains, as seen in the prior text, the background, problem statement, literature review, research question(s), limitations, methodology and methods, and the structure of the thesis.

Chapter 2

This chapter answers the first sub-question and determines what BCI's and their applications are precisely. A brief history of BCI's in the field of neurotechnology follows, then different forms of BCI's are discussed according to the level of invasiveness, signal acquisition and type, along with automation in BCI's.

Chapter 3

Chapter three explains freedom of thought and determines what mental autonomy consists of by answering the second sub-question. While a preliminary definition of mental autonomy is given under the 'problem statement' and the literature review supports that definition, there is room for improvement or expansion of that definition in this chapter. Then, the newly formulated definition is used as a framework for the rest of the thesis. Then, a summary of risks BCI's pose to mental autonomy follows, thereby answering the third sub-question.

Chapter 4

This chapter looks at the ECHR and its case law to analyse the scope, thus answering sub-question 4. Following that analysis, the final sub-question is handled, and then the main research question is answered. After the risks of BCI's to mental autonomy are clear from chapter 3 and the scope of ECHR is determined, this chapter also analyses whether the ECHR sufficiently protects mental autonomy.

Chapter 5

The conclusion summarises the main findings of the thesis, limitations faced during the research (as opposed to the predicted limitations beforehand) and final remarks.

2 WHAT ARE BRAIN-COMPUTER INTERFACES?

Before the risks of BCI's to mental autonomy are unearthed in the following chapter, it is imperative to establish what a BCI entails. That is done by answering the first sub-question. Generally, a BCI is a device that collects neuronal signals from its user as input, interprets those signals and then translates them into executable output to command a device.[34] The word 'device' refers to a wide variety of objects such as prosthetic limbs, exoskeletons, smartphones or computers. This short enumeration shows BCI's are quite varied in their forms and uses. Therefore, this chapter aims to contextualise and explain the different forms and applications of BCI's. That is important because not every form or application might be as threatening to mental autonomy as others. By discerning the differences between BCI's, it is possible to categorise them and then analyse those categories to determine risks in a later chapter. Because the objective is not to give an exhaustive overview of all the differences of every BCI but to broadly discern types and differences, a general categorisation suffices.

2.1 Brief historical overview

Although BCI's are getting more attention in recent times, the technology that enabled their development, and even BCI's themselves, is by no means new. Their inception is traceable to 1924, when German psychiatrist Berger invented electroencephalography (hereafter: EEG).[35] EEG is a non-invasive monitoring method to record brain activity.[36] In other words, Berger showed that the human brain produces electrical currents, which are subsequently measurable on the scalp using electrodes.[37] In 1968, Kamiya showed that a human subject could purposely control certain elements of EEG activity after some training.[38] He called this the 'discrimination of alpha activity', which was the beginning of neurofeedback, a field wherein users train to self-regulate their brain activity through real-time feedback about that activity.[39] Then, in 1973, Vidal coined the term – in the first peer-reviewed publication on the topic – that we still use today: Brain-Computer Interface.[40]

In the years following Vidal's inception of the name 'BCI', few noteworthy developments were made. However, that changed in 1988 when one development turned out to be seminal; the creation of the famous and widely used BCI paradigm called the 'P300-speller'.[41] Farwell and Donchin proposed a BCI that could spell letters based on Event-Related Potentials (hereafter: ERP). To explain what ERP's are, it is important to note that EEG is an exceptionally coarse measure of overall brain activity. It represents a conglomeration of all kinds of brain signals which makes it hard to isolate individual processes.[42] However, inside this collection, in the EEG, are the neural responses embedded that are associated with specific sensory, cognitive and motor events.[43] These are the events that one wants to monitor and use

[34] Steinert and others (n 6).

[35] Hans Berger, 'Über das Elektrenkephalogramm des Menschen' (1929) 87 Archiv für Psychiatrie und Nervenkrankheiten 527.

[36] The distinction between invasive and non-invasive BCI's is explained in the next section.

[37] Fabien Lotte, Chang S Nam and Anton Nijholt, *Introduction: Evolution of Brain-Computer Interfaces* (Taylor & Francis (CRC Press) 2018) <https://hal.inria.fr/hal-01656743> accessed 11 January 2021.

[38] Jonna Brenninkmeijer, 'Brainwaves and Psyches: A Genealogy of an Extended Self' (2015) 28 History of the Human Sciences 115.

[39] Lotte, Nam and Nijholt (n 37).

[40] Jacques J Vidal, 'Toward Direct Brain-Computer Communication' (1973) 2 Annual Review of Biophysics and Bioengineering 157.

[41] Lawrence Farwell and Emanuel Donchin, 'Talking off the Top of Your Head: A Mental Prosthesis Utilizing Event-Related Brain Potentials' (1988) 70 Electroencephalography Clinical. Neurophysiolgy 510.

[42] https://ebookcentral.proquest.com/lib/uvtilburg-ebooks/reader.action?docID=3339822#

[43] Ibid.

in BCI's. With a 'simple' averaging technique, it is possible to isolate and extract those events from the EEG.

With the P300-speller, a link was made between flashing rows and columns in a six-by-six grid displayed on a computer screen and the following ERP, the P300. This particular response is a positive potential that appears roughly 300 milliseconds after a person has consciously recognised a specific event, such as recognising a high-pitched sound when instructed to do so. When a low-pitched sound is heard, the P300 does not appear. Similarly, as demonstrated in the P300-speller, the P300 appears when a certain letter is recognised in a grid on a display. Through this experiment, it was for the first time possible to, albeit rudimentary, talk via brain signals after some training. It showed that BCI's could potentially enable people who were, for example, paralysed to once again communicate and interact with their environment.[44] In fact, at the time, the main driving force (and currently still a major one) for research into BCI's was for use in the medical field, especially to assist motor-impaired users.[45] That paradigm can be seen as the origin of BCI's from which the various devices and applications we know today are sprouted.

2.2 Different forms of BCI's: invasiveness, signal acquisition and types

Currently, a widely adopted definition of a BCI is: 'a system that measures central nervous system (CNS) activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output and thereby changes the ongoing interactions between the CNS and its external or internal environment'.[46] Thus, a BCI acts according to a loop of phases: signal acquisition from brain activity through a recording method, pre-processing or enhancement of the signal, feature extraction (identifying the required information), classifying or interpreting the signal and finally output on a device which gives feedback to the user, restarting the loop.

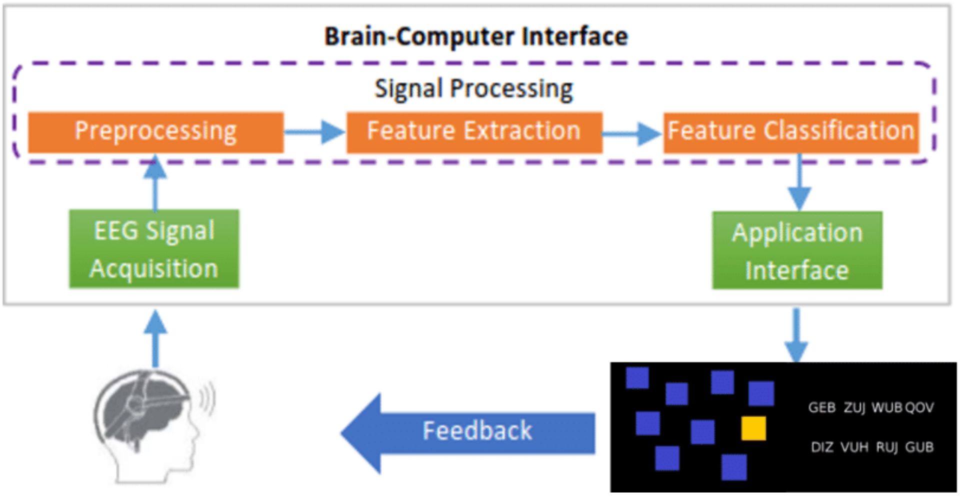

Figure 1. The BCI loop of phases[47]

[44] Lotte, Nam and Nijholt (n 37).
[45] Ibid.
[46] 'Brain–Computer Interfaces: Principles and Practice - Oxford Scholarship' <https://oxford-universitypressscholarship-com.tilburguniversity.idm.oclc.org/view/10.1093/acprof:oso/9780195388855.001.0001/acprof-9780195388855> accessed 7 February 2021.
[47] Jozsef Katona and Attila Kővári, 'Examining the Learning Efficiency by a Brain-Computer Interface System' (2018) 15 Acta Polytechnica Hungarica.

2.2.1 Levels of invasiveness and signal acquisition

BCI's use brain signals to gather information on user intentions.[48] These signals are acquirable through various recording methods, collectively known as neuroimaging. Said neuroimaging techniques are dividable into different degrees of invasiveness. Three levels of invasiveness can be distinguished: invasive, partially invasive and non-invasive. With invasive neuroimaging, electrode arrays are surgically placed directly inside the brain (intracortical). One of the main advantages over the other two categories of invasiveness is its high accuracy due to a relatively high frequency range, strong signal quality and spatial resolution. These advantages can be attributed to the fact that the electrodes are simply placed as close to the signal source as possible. Spatial resolution refers to how accurately the exact location of measured brain activity can be determined.[49] By localising where a signal originated from, it is possible to extract voluntary motor commands and then, for example, control a prosthetic limb.[50] Although developments are made to eventually control prosthetics with non-invasive BCI's[51], currently invasive BCI's are the only realistic option for that purpose.

Besides strengths, this category also has drawbacks. One of the most prominent ones is that invasive neuroimaging, as the name implies, requires surgery. Furthermore, scar tissue can form around the implanted electrodes, there is risk of infection, long-term recording stability can be jeopardised, and the process is altogether expensive.[52] Due to these advantages (high accuracy and thus ability to control prosthetics) and disadvantages (mainly surgery, cost and long term instability), the invasive method was long confined to applications within the medical field. Those applications include helping partially paralysed patients regain sensory sensation, amputees moving prosthetics, and fully paralysed people speak and interact with their environment.[53] However, with recent developments such as the Neuralink, it seems that even the invasive BCI's have expanded beyond the boundaries of medical use.[54]

Between the invasive and non-invasive BCI's is the partially (or semi-) invasive category. In this category, the most common recording method used is electrocorticography (hereafter: ECoG). With ECoG, electrical signals are recorded from electrodes placed between the scalp and the brain's surface, the cortex. Where invasive BCI's are implanted inside the brain, semi-invasive BCI's merely cover the brain with a sheet of electrodes.[55] Because these sheets can cover a substantial area of the cortex, it is possible to collect a broader range of signals simultaneously than is possible with invasive recording methods. When looking at the advantages and disadvantages of the other two levels of invasiveness, ECoG can be seen as a balanced compromise between the two. It has a higher spatial resolution, higher amplitudes,

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48 Ksenia Volkova and others, 'Decoding Movement From Electrocorticographic Activity: A Review' (2019) 13 Frontiers in Neuroinformatics <https://www.frontiersin.org/articles/10.3389/fninf.2019.00074/full> accessed 20 January 2021.

49 Teresa Jacobson Kimberley and Scott M Lewis, 'Understanding Neuroimaging' (2007) 87 Physical Therapy 670.

50 Mikhail A Lebedev and Miguel AL Nicolelis, 'Brain–Machine Interfaces: Past, Present and Future' (2006) 29 Trends in Neurosciences 536.

51 Ching-Chang Kuo and others, 'Non-Invasive BCI for the Decoding of Intended Arm Reaching Movement in Prosthetic Limb Control' (2012) 2 American Journal of Biomedical Engineering 155; Jianjun Meng and others, 'Noninvasive Electroencephalogram Based Control of a Robotic Arm for Reach and Grasp Tasks' (2016) 6 Scientific Reports 38565.

52 Joseph N Mak and Jonathan R Wolpaw, 'Clinical Applications of Brain-Computer Interfaces: Current State and Future Prospects' (2009) 2 IEEE reviews in biomedical engineering 187.

53 Ujwal Chaudhary, Natalie Mrachacz-Kersting and Niels Birbaumer, 'Neuropsychological and Neurophysiological Aspects of Brain-Computer-Interface (BCI) Control in Paralysis' The Journal of Physiology <https://physoc.onlinelibrary.wiley.com/doi/abs/10.1113/JP278775> accessed 20 January 2021.

54 'Interfacing with the Brain' (*Neuralink*) <https://neuralink.com/approach/> accessed 20 January 2021.

55 G Schalk and EC Leuthardt, 'Brain-Computer Interfaces Using Electrocorticographic Signals' (2011) 4 IEEE Reviews in Biomedical Engineering 140.

broader frequency range and lower vulnerability to disturbances (such as eye movement) than EEG.[56] In contrast to the intracortical invasive method, ECoG recordings mitigate some of the disadvantages the former is burdened with. That is because signals are acquired from the surface of the brain instead of inside the brain. This means that the potential of scar-forming, tissue damage, and risk of infection is much less present in ECoG compared to the invasive method. Nevertheless, ECoG still has disadvantages of its own. With this method, the main issues are also that surgery is required – albeit less intrusive and complex than with the invasive method – and that the cost is still high.

Finally, there is non-invasive neuroimaging. While the EEG recording method is still the most popular one since Berger invented it, there have been many different non-invasive methods developed since then. At the time of writing, the most widely used methods are EEG, magnetoencephalography (hereafter: MEG), functional magnetic resonance imaging (hereafter: fMRI) and functional near-infrared spectroscopy (hereafter: fNIRS). With the method that uses electric signals, i.e. EEG, brain activity is measured from the scalp through electrical fluctuations produced by the brain. While EEG initially consisted of placing wired electrodes on users' scalp, advancements in the field have already led to (commercial) wearable headsets that can transfer the recorded signals wirelessly to a computer.[57] For a BCI to be widely used outside of clinical settings such as hospitals and laboratories, portability is paramount. Therefore, the strength of EEG lies in, inter alia, its ease of transportation and capability to be used in daily activities. Another vital aspect of EEG is its superior temporal resolution, which indicates how often a snapshot of the brain activity is taken per second to allow real-time interactions between the brain and the output device.[58] Also, its relatively low cost compared to other recording techniques is a significant advantage. However, this recording method has distinct weaknesses as well. Those are the susceptibility to background noise, a low spatial resolution which makes it hard to localise brain activities and signals of poor quality.[59] The latter is simply attributed to the fact that the signals need to travel through the scalp, skull and many other layers before reaching the electrodes.[60] As for the other three non-invasive methods – MEG, fMRI and fNRIS – the literature review revealed that they all have one or more reasons preventing their widespread use in the (near) future. Therefore, they are included here for completeness sake but left out of further analysis.

[56] Volkova and others (n 48).

[57] See for example: 'EMOTIV EPOC X - 14 Channel Wireless EEG Headset | EMOTIV' <https://www.emotiv.com/epoc-x/> accessed 5 February 2021; 'EEG Sensors - EEG Headsets | NeuroSky' <http://neurosky.com/biosensors/eeg-sensor/biosensors/> accessed 5 February 2021.

[58] Mehdi Ordikhani-Seyedlar and others, 'Neurofeedback Therapy for Enhancing Visual Attention: State-of-the-Art and Challenges' (2016) 10 Frontiers in Neuroscience.

[59] Gopikrishna Deshpande and others, 'A New Generation of Brain-Computer Interfaces Driven by Discovery of Latent EEG-FMRI Linkages Using Tensor Decomposition' (2017) 11 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2017.00246/full> accessed 5 February 2021.

[60] Volkova and others (n 48).

Modality	Signal type	Temporal resolution	Spatial resolution	Method type	Portability
EEG	Electrical	Approx. 0.05s	Approx. 10mm	Non-invasive	Portable
MEG	Magnetic	Approx. 0.05s	Approx. 5mm	Non-invasive	Non-portable
ECoG	Electrical	Approx. 0.03s	Approx. 1mm	Invasive	Portable
ICNR	Electrical	Approx. 0.03s	Approx. 0.5mm(LFP)	Invasive	Portable
fMRI	Metabolic	1s	Approx. 1mm	Non-invasive	Non-portable
NIRS	Metabolic	1s	Approx. 5mm	Non-invasive	Portable

Figure 2. Overview of neuroimaging [61]

2.2.2 Types of BCI with regards to the 'activeness'

Now the modalities for signal acquisition are clear, one last category of classification remains. That category is best described as the 'activeness' of the BCI and consists of active, reactive and passive BCI's. Active BCI's require users to intentionally perform a mental task that is then translated in a command for the BCI.[62] A common mental task is motor imagery, in which the user imagines moving a part of his body without actually moving that part.[63] While these BCI's are operated at free will and independent of any external stimulation, they require very time-consuming training to operate successfully.[64] Then there is the reactive BCI. These types of BCI react to external stimuli resulting in brain activity.[65] One of the most common paradigms for reactive BCI's is based on the earlier mentioned P300-signal. When a user visually detects the letter she intends to pick, the signal sets in, then detected and interpreted by the BCI. Lastly is the passive BCI. This BCI reacts to unintentional affective brain activities such as drowsiness in drivers or depressed moods in patients.[66] Some BCI's can then stimulate areas of the brain to remedy these unwanted affective states.

[61] Ganesh Pandarinathan and others, 'The Potential of Cognitive Neuroimaging: A Way Forward to the Mind-Machine Interface' (2018) 4 Journal of Imaging 70.

[62] Johannes Kögel, Ralf J Jox and Orsolya Friedrich, 'What Is It like to Use a BCI? – Insights from an Interview Study with Brain-Computer Interface Users' (2020) 21 BMC Medical Ethics 2.

[63] Steinert and others (n 6).

[64] Luis Fernando Nicolas-Alonso and Jaime Gomez-Gil, 'Brain Computer Interfaces, a Review' (2012) 12 Sensors (Basel, Switzerland) 1211.

[65] Keum-Shik Hong and Muhammad Jawad Khan, 'Hybrid Brain–Computer Interface Techniques for Improved Classification Accuracy and Increased Number of Commands: A Review' (2017) 11 Frontiers in Neurorobotics <https://www.frontiersin.org/articles/10.3389/fnbot.2017.00035/full> accessed 6 February 2021.

[66] Shiv Kumar Mudgal and others, 'Brain Computer Interface Advancement in Neurosciences: Applications and Issues' (2020) 20 Interdisciplinary Neurosurgery 100694.

2.3 Automation in BCI’s

A trend that is seen with regards to the three types of BCI is automation. One of the main issues of BCI’s is that they generally require much training from the user before they can be successfully used. As mentioned above, a user has to learn how to control his brain signals through neurofeedback, a process that can take a long time. However, machine learning (hereafter: ML) and artificial intelligence (hereafter: AI) have sped up this process considerably. First, AI and ML allow enormous amounts of neural data from a user to be decoded and interpreted to make predictions about future behaviour. Second, they allow for (improved) automatic stimulation of the brain. This automation in BCI’s is quite possibly the most complicated development concerning mental autonomy.[67] With the earlier mentioned method of motor imagery, the user generates a signal which the BCI reads. However, through breakthroughs in the last decade, some BCI’s are also capable of writing to the brain. That is done through direct stimulation of areas of the brain in so-called closed-loop BCI’s. In a closed-loop system, the BCI receives continuous feedback from the brain and stimulates brain activity accordingly.[68] This means that, for example, the BCI detects that a user feels depressed and then autonomously stimulates the part of the brain responsible for positive thoughts to improve the user’s mood. Although closed-loop stimulation is still at an early stage, some applications of the technology have already left the experimental phase. One recent example of a closed-loop system – albeit experimental – is the ‘neural dust’ consisting of millimetre-sized, wireless, battery-free implants powered by ultrasound that can both record and stimulate brain activity.[69] While the capabilities of closed-loop systems, or even BCI’s in general, should not be overstated, they show that advancements in the field are happening at a breakneck pace.

2.4 Different applications

This section explains the applications of BCI’s in terms of two main functions: monitoring and stimulating. Although not individually mentioned, contemporary activities or applications one can use BCI’s for are filed under these functions, or categories. Applications that could be realised within approximately five years are included as well. Thus, envisioned speculative uses and hypotheses of BCI’s such as downloading information from the internet directly to the brain, fully immersive virtual reality and symbiosis with artificial intelligence are excluded.[70] The applications that are discussed below are essential to distinguish because a BCI on its own is merely a device comparable to a microscope or smartphone. What separates one BCI from the other is the way it is applied and how it works. Usually, the typology of BCI applications is done in line with categories such as environmental control, motor restoration, communication and entertainment. However, in this thesis, a different approach is taken. Because risks to mental autonomy are analysed, it is imperative to see the whole picture instead of specific individual activities to refrain from analysing risks only relevant to one specific section or field. For mental autonomy, it is irrelevant whether a user controls prosthetic limbs[71],

[67] To what extent that is indeed the case, is analysed in the following chapters.

[68] Steffen Steinert and Orsolya Friedrich, ‘Wired Emotions: Ethical Issues of Affective Brain–Computer Interfaces’ (2020) 26 Science and Engineering Ethics 351.

[69] Max Ortiz-Catalan, ‘Ultrasound-Powered Tiny Neural Stimulators’ (2020) 4 Nature Biomedical Engineering 144.

[70] Nuno RB Martins and others, ‘Human Brain/Cloud Interface’ (2019) 13 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2019.00112/full> accessed 7 February 2021.

[71] Jennifer L Collinger and others, ‘7 Degree-of-Freedom Neuroprosthetic Control by an Individual with Tetraplegia’ (2013) 381 Lancet 557.

exoskeletons[72], (cursors on) computers, games, TV's, lights and smart home environments.[73] Meanwhile, what is important, is *how* that control takes place. E.g. it is imaginable that an algorithm stimulating the brain to move a prosthetic arm impacts mental autonomy differently than when a user does the same through a completely self-generated brain signal. This is especially true when an intention gets misinterpreted by the BCI, and a different action follows. Therefore, applications are divided according to their function. I.e. monitoring (or reading) and stimulation (or writing).

The first group of BCI applications is related to the monitoring and reading of the brain to record brain activity and subsequently decode its meaning. E.g. researchers from Facebook's Reality Labs demonstrated the possibility to decode a small set of questions and answers in real-time from the brain using an ECoG BCI.[74] Another example is a BCI alerting epileptics when a seizure is imminent or detect when a user has a depressed mood. After the monitored brain activity is outputted, users know what is about to happen or is happening inside their head. The second group of applications takes it a step further. Deep brain stimulation (hereafter: DBS) is then applied to the brain from an implanted BCI. More precisely, when a BCI is applied to stimulate brain activity, it can already change users' moods, alleviate painful memories and trauma's and facilitate emotional expression in people with severe motor impairments.[75] Furthermore, using the same DBS technology, it is possible to reduce tremors in Parkinson's disease patients and reduce or even prevent seizures in epileptics. This is a meticulous process where a movement disorders specialist has to finetune all kinds of settings on a patient-specific basis.[76] If that process is done manually as described, it is an open-loop system. It is called that way because the loop is 'opened' by requiring a specialist to tweak the settings after a certain period. When this finetuning happens automatically due to an algorithm inside the BCI, it means it is a closed-loop system. In other words, at that point, there is essentially a decision-making device inside the brain of the users.[77]

2.5 Conclusion

To recap, there are several forms of BCI's that all use different levels of invasiveness, acquire signals in different ways and are classified in different types. These forms are also applied in multiple ways. For analysis in later chapters, the focus is henceforth placed on both open and closed-loop DBS, monitoring, automation in general and AI-assisted functions. However, this does not mean everything else discussed is not used in the analysis. Where relevant, for example, specific ways of signal acquisition or types are discussed as well. These different forms and applications used for analysis are displayed in a schematic overview relevant and referenced in the next chapter regarding the risks of BCI's.

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[72] Susan Gordleeva and others, 'Exoskeleton Control System Based on Motor-Imaginary Brain–Computer Interface' (2017) 9 Sovremennye tehnologii v medicine 31.

[73] U Masud and others, 'A P300 Brain Computer Interface Based Intelligent Home Control System Using a Random Forest Classifier', *2017 IEEE Symposium Series on Computational Intelligence (SSCI)* (2017).

[74] Moses and others (n 12).

[75] Steinert and Friedrich (n 68).

[76] Wolf-Julian Neumann and others, 'Toward Electrophysiology-Based Intelligent Adaptive Deep Brain Stimulation for Movement Disorders' (2019) 16 Neurotherapeutics: The Journal of the American Society for Experimental NeuroTherapeutics 105.

[77] Liam Drew, 'The Ethics of Brain–Computer Interfaces' (2019) 571 Nature S19.

3 FREEDOM OF THOUGHT AND MENTAL AUTONOMY

In the previous chapter, it became clear what BCI's and their applications are. Those applications were categorised as either monitoring or stimulating the brain. Especially the latter category appears relevant for (risks to) mental autonomy. However, up until now, mental autonomy has only been mentioned in an introductory or preliminary way. Therefore, this chapter explores what constitutes mental autonomy. To that end, this chapter answers the second sub-question. It does so by first dissecting freedom of thought, deciding what parts of it are relevant to mental autonomy and then arriving at a definition to be used in the remainder of the thesis. Once the formulated definition of mental autonomy is established, it is further divided into underlying core components that are used to search for, analyse and interpret the ECHR case law in the next chapter. It is important to note that those components – being mental integrity, mental privacy and agency – are only briefly touched upon in this chapter. They are fleshed out more in the next chapter, when their respective case law is discussed, to improve the readability of the thesis. To conclude the chapter, the third sub-question is answered regarding the risks BCI's pose to mental autonomy.

3.1 Freedom of thought

Ego cogito ergo sum; I think, therefore I am.[78] Descartes put into words the very thing that could, quite possibly, be the most defining aspect of what makes us human: the ability to think consciously.[79] Thus, a logical consideration is that the *freedom* of thought should be safeguarded since it protects a vital aspect of humanity. This contemplation is shared across the globe, with many human rights frameworks more or less containing said contemplation in the form of a right.[80] The drafters of one of those frameworks, the Universal Declaration of Human Rights, went as far as saying the right is the 'basis and origin of all other rights of metaphysical significance'.[81] However, as important as the right is, virtually no case law exists on the right's boundaries and on what it encompasses. E.g. art. 9 ECHR (freedom of thought, conscience and religion) case law almost exclusively pertains to the conscientious or religious portion of the right.[82] Despite the lack of case law on the matter, the law still – to a certain degree – provides guidance on what freedom of thought entails. This is best explained through the two dimensions that art. 9 ECHR is composed of: the forum internum and externum.

Whereas the forum internum is the internal dimension of the right and concerns freedom of thought, conscience and religion, the forum externum concerns the external dimension and gives the right to manifest religion or belief.[83] One peculiar detail is that an omission of 'thought' in the external dimension is observable. This is possibly because thoughts were deemed epistemologically untouchable and therefore not included in the manifestation part of the article by the drafters. Indeed, thoughts are manifestable through actions such as speaking or writing[84], but a thought on its own cannot be manifested; it is contained in the inner sanctum

[78] René Descartes, *Principia Philosophiae* (Ludovicum Elzevirium 1644).

[79] Lilit Yeremyan and Davit Harutyunyan, 'Freedom Of Thought Endangered In The 21st Century? Legal Protection From Manipulation | WISDOM' <https://www.wisdomperiodical.com/index.php/wisdom/article/view/310> accessed 20 February 2021.

[80] Art. 19 International Covenant on civil and Political rights, Art. 12(1) American Convention on Human Rights, Art. 18 Universal Declaration of Human Rights, Art. 9 ECHR and national legislation.

[81] Nolan v. Russia App no 2512/04 (ECtHR, 12 Feb. 2009), para 61; Kokkinakis v. Greece App no 14307/88 (ECtHR, 25 May 1993), para 31.

[82] Bublitz, 'The Nascent Right to Psychological Integrity and Mental Self-Determination' (n 28).

[83] Sjors Ligthart, 'Freedom of Thought in Europe: Do Advances in "Brain-Reading" Technology Call for Revision?' (2020) Journal of Law and the Biosciences <https://doi.org/10.1093/jlb/lsaa048> accessed 20 February 2021.

[84] When thoughts are expressed, they generally fall within the scope of art. 10 ECHR, the freedom of expression.

of the mind.[85] This inner sanctum, as mentioned above, is the forum internum. While the law provides a base for infringing on the forum externum through art. 9(2) ECHR, such a clause is not available for its counterpart. Thus, the forum internum is an absolute right that may never be infringed upon.[86] This means that, inter alia, governments are never allowed to interfere with this dimension of the mind through means such as indoctrination or other practices where they try to incept a particular belief in citizens.[87] In other words, the forum internum ensures one can think *what* they want.

Although the absolute nature of the forum internum is evident, what this sphere of the mind comprises eludes legal scholars and practitioners alike. Since a clear legal definition of a thought is not given, it is unclear whether this sphere protects all kinds of mental states such as dreams and emotions or whether it is restricted to the mental phenomena classified as 'thoughts'.[88] For the sake of conciseness, the metaphysical and epistemological discussion of what a thought is will be avoided. However, without precise contours of the right, it becomes hard to determine whether there has been an interference. Nevertheless, attempts to sketch conditions for interference are given in the literature. One frequently cited passage is a set of elements that constitute freedom of thought, especially regarding the forum internum. Those three elements are:

1. The right not to reveal one's thoughts or opinions
2. The right not to have one's thoughts or opinions manipulated and controlled
3. The right not to be penalised for one's thoughts[89]

Given the absolute nature of the forum internum in virtually all legal frameworks, an interference with one or multiple of the above elements means that the interference is unlawful. Accordingly, as mentioned earlier, governments not only have a negative duty to not act in a way that interferes with the forum internum, but they also have a positive duty to protect citizens from others who might interfere with the right.[90] In this case, the 'others' are, e.g. companies in the private sector such as Facebook or Neuralink. The legal basis for this positive and negative obligation is discussed in the next chapter.

When looking at the three proposed elements above, the first can be qualified as mental privacy since it relates to keeping thoughts and opinions *private*. Then, looking at the remaining two elements, the third element relates to *what* one thinks. As became clear above, this is an essential aspect of freedom of thought. However, the final element to be discussed is the second one. As opposed to *what* one thinks, this element is related to *how* one thinks. To not have one's thoughts manipulated can be divided into two components: mental integrity and agency. Although these two components are extensively discussed in the next chapter, a brief description is in order. Whereas integrity relates to the intactness or preservation of the mind, the forum internum, agency refers to the ability to act and to choose how to do so, i.e. the ability to make informed and rational choices. When thoughts are manipulated or controlled, there is an interference with the integrity and agency of the user of a BCI.

[85] E.g. art. 10 ECHR.

[86] Van der Sloot orally mentioned that one rare exception to this rule exists in the form of a derogation based on art. 15(2) ECHR.

[87] Pieter Van Dijk and others (eds), 'Theory and Practice of the European Convention on Human Rights, 5th Edition', *Theory and Practice of the European Convention on Human Rights, 5th edition* (5th edn, Intersentia 2018) <https://intersentia.com/en/theory-and-practice-of-the-european-convention-on-human-rights-5th-edition-paperback.html> accessed 5 March 2021.

[88] Jan Christoph Bublitz, 'Freedom of Thought in the Age of Neuroscience: A Plea and a Proposal for the Renaissance of a Forgotten Fundamental Right' (2014) 100 ARSP: Archiv für Rechts- und Sozialphilosophie / Archives for Philosophy of Law and Social Philosophy 1.

[89] Van Dijk and others (n 87).

[90] Susie Alegre, 'Rethinking Freedom of Thought for the 21st Century' 13.

3.2 Mental autonomy

Much was said about mental autonomy up to this point in the thesis, but always on an introductory level. Because the next section explores the risks to mental autonomy associated with BCI's, this section delves into what the phenomenon entails. Determining those risks is only possible if a fleshed-out definition of mental autonomy is available. Multiple perspectives are considered to arrive at a definition. These perspectives include etymology, philosophy and arguments presented by other authors. One final point is that the notion of free will is presupposed in the context of this thesis. Therefore, discussions such as the metaphysical possibility of autonomy in light of a deterministic universe are avoided.

The word 'autonomy' finds its roots in Ancient Greek and comprises 'autos', meaning self, and 'nomos', meaning law. Therefore, autonomy is understood to mean self-governance. As Christman puts it, the word refers to the governance of oneself through considerations, desires, conditions and characteristics that are not merely imposed externally upon one but are part of what can be considered one's authentic self.[91] If this reasoning is followed, the opposite of autonomy – being guided exclusively by external forces – seems to be oppression. Thus, it follows that autonomy is a prerequisite for a democracy where citizens choose the laws that bind them without oppression, again illustrating the need for mentally autonomous citizens. If autonomy means self-governance, it is to be supplemented with the term 'mental' to fully learn what the whole term 'mental autonomy' means etymologically. Mental derives from the Late Latin term 'mentalis', which means 'in, of, or pertaining to the mind'.[92] Hence, mental autonomy is understood as the self-governance of the mind. Describing mental autonomy as the self-governance of the mind through internal factors provides an appropriate starting point to explore the term further.

Around the year 2000 a political movement introduced cognitive liberty, or the right to mental self-determination. Cognitive liberty touches upon many aspects a definition of mental autonomy needs to describe. Neuroethicist Sententia and lawyer Boire introduced the concept as the freedom of an individual to control their own mental processes, cognition and consciousness.[93] However, as coined by the two authors, the term is too broad to be used as a mere synonym of mental autonomy. Cognitive liberty is divided into two principles by those two authors. Those principles entail, summarised, that as long as the behaviour does not endanger others, individuals should not be compelled to use technologies or psychoactive drugs that alter the mind, and the same rule applies to not being criminalised for using new mind-enhancing drugs and technologies.[94] It seems that the authors take a radical libertarian approach where, as long as others are not harmed, one should be able to alter their mind in any way they want (positive duty) and not be forced to have their mind altered (negative duty).

These two principles draw parallels to the Two Commandments for the Molecular Age in the book The Politics of Ecstasy of Leary. Those 'commandments' are: 'Thou shalt not alter the consciousness of thy fellow man' and 'Thou shalt not prevent thy fellow man from altering his own consciousness'.[95] With the latter being focused on psychoactive drugs, cognitive liberty seems to strongly focus on that aspect as well. However, besides the fact that this thesis focuses on BCI's and not drugs, the (de)criminalisation of drugs and forced administering in psychiatry is an altogether different and highly controversial matter. Thus, the part regarding drugs can already be scrapped for the definition of mental. What then remains are principles regarding

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[91] Christman (n 30).

[92] 'Mental | Origin and Meaning of Mental by Online Etymology Dictionary' <https://www.etymonline.com/word/mental> accessed 7 March 2021.

[93] Wrye Sententia, 'Neuroethical Considerations: Cognitive Liberty and Converging Technologies for Improving Human Cognition' (2004) 1013 Annals of the New York Academy of Sciences 221.

[94] ibid.

[95] Timothy Leary, *The Politics of Ecstasy* (4th edition, Ronin Publishing 1998).

technologies that directly interact with the brain, i.e. BCI's. This leads to a refinement of the principle by Bublitz, who states that cognitive liberty is 'the right to alter one's mental states with the help of neurotools as well as the right to refuse to do so'.[96] Some fundamental aspects of mental autonomy are included here. For instance, as a part of freedom of thought, if mental autonomy is the self-governance of the mind, it must safeguard the freedom to alter one's mental state through BCI's. This definition by Bublitz includes that freedom by stating both a positive and negative duty for the government.

McCarthy-Jones argues that the right to freedom of thought must be developed in such a way that the facilitation of mentally autonomous individuals is put central. That is done by safeguarding mental autonomy. He argues that Metzinger proposed that two key elements enable mental autonomy: attentional agency and cognitive agency. Whereas attentional agency refers to the ability to control the focus of one's attention, cognitive agency refers to the ability to control goal/task-related, deliberate thought.[97] These two distinctions in mental agency mirror what is going on in most active and reactive BCI's.[98] A user must either direct his attention to an external stimulus (reactive BCI) or perform motor imagery (active BCI's). Therefore, BCI's mimic the cognitive processes that constitute mental autonomy. When putting these two elements into a concise definition of mental autonomy, the one mentioned in the introduction chapter is conceived, being 'the specific ability to control one's own mental functions'. Although this was the preliminary definition used up to this point in the thesis, it is nevertheless very compelling, albeit not complete. For instance, it encapsulates the etymology of the word: self-governance of the mind. However, this definition fails to have a normative implication, as is the case with the one from Bublitz.

Now that multiple approaches by different authors on mental autonomy, or similar concepts, are discussed, a final author deserves attention. Although the author, Lavazza, calls his concept mental integrity, the underlying idea is much more akin to what I consider mental autonomy. His working definition of the concept eloquently puts into words vital parts of mental autonomy. He proposed a definition in the normative sense for mental 'integrity' as follows: 'Mental Integrity is the individual's mastery of his mental states and his brain data so that, without his consent, no one can read, spread, or alter such states and data in order to condition the individual in any way'.[99] Although his proposition is not precisely what mental autonomy entails, it is close to a complete definition. Therefore, by combining aspects of the definitions by Bublitz, McCarthy-Jones and Lavazza, the following definition of mental autonomy is henceforth used for analysis purposes:

'Mental autonomy arises from the specific ability to freely control one's own mental functions through congruence between the intended and resulting action, so that, without his explicit consent, no one can alter or manipulate his mental states'.

Now that the definition is unambiguous, the definition is split into underlying components that are researched and analysed in the next chapter. These components are the actual parts from the ECHR that (should), together, guard against the risks BCI's pose to mental autonomy. These components are cumulative; they must all be fulfilled for one to be deemed mentally autonomous. The three components, mental integrity, mental privacy and agency, all relate to a part of the formulated definition of mental autonomy. Regarding 'freely controlling one's own mental functions', all three components are relevant.[100] Mental privacy is relevant

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[96] Christoph Bublitz, 'My Mind Is Mine!? Cognitive Liberty as a Legal Concept', vol 1 (2013).

[97] Metzinger (n 17).

[98] Steinert and others (n 6).

[99] Andrea Lavazza, 'Freedom of Thought and Mental Integrity: The Moral Requirements for Any Neural Prosthesis' (2018) 12 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2018.00082/full> accessed 25 January 2021.

[100] These concepts are explained more in-depth in the next section and chapter.

because the disclosure of thoughts can have a chilling effect on what one thinks. Mental integrity is relevant since it guards the positive 'freedom to' aspect of mental autonomy, and agency is applicable here since one must be free to (choose how to) act to be an autonomous being. Then, for the 'no one can alter or manipulate his mental states' part, mental integrity is the component that relates most to it. In this context, it refers to the negative aspect of mental autonomy, to be free from any manipulation or unwanted alteration of one's mental states. For 'through congruence between the intended and resulting action', agency is relevant. That is because an agent is a being with the capacity to act (how he wants).[101] Thus, if actions do not match the intentions, one is not an agent.

3.3 Risks to mental autonomy

The previous section served to create a clear understanding of mental autonomy and culminated in a working definition. This section builds upon the last one to determine what risks to mental autonomy BCI's pose. Then, in the next chapter, the law is analysed to establish whether it can sufficiently guard against these risks. Because mental autonomy is the sum of its three underlying components, a risk to mental autonomy is when one of these concepts is threatened or infringed upon. Thus, several risks that meet that criterion are discussed below. However, these risks must not be understood as to be exhaustive. Considering that, theoretically, if the ECHR does not cover even one of the risks, it means that the ECHR cannot sufficiently protect mental autonomy. Therefore, an exhaustive overview is both a task too great for a master's thesis and unnecessary. Note that this section exclusively covers *risks* to mental autonomy. Although BCI's also possess the potential to increase autonomy substantially for, e.g. patients with locked-in syndrome[102] or benefit them in other ways[103], those considerations are left out to keep the thesis focused.

One potential harm BCI's pose to mental integrity and agency, and thus autonomy, is when they use DBS. Even more so when that stimulation of the brain is done through a combination of AI and ML in closed-loop systems. Different scholars have put forward their concerns about DBS in regards to autonomy and agency of the subject. One of those scholars suggested that the stimulation is problematic because it is 'a threat to agency – the ability to make informed and rational choices – as when a person's actions do not flow from her intentions or beliefs but rather are the result of direct brain manipulation'.[104] Notice the elements here that the definition of mental autonomy also contains. As stated in the previous chapter, attentional and cognitive agency are key elements of mental autonomy. Therefore, if DBS is used, a stimulating BCI could pose a risk to mental autonomy by undermining the user's agency since the choice of action was made by an algorithm instead of by themselves. Lavazza illustrates this by extending a real case reported by another author whereby he states that a person could go to a funeral of a dear friend and, instead of feeling sad for the loss, said something socially inappropriate.[105] The emotional response, or lack thereof, could be attributed to the closed-loop DBS intended to treat her depression. When the device detected a depressive mood, it intervened to counteract this, resulting in the BCI user feeling 'happy' at a usually sad moment.

[101] Markus Schlosser, 'Agency' in Edward N Zalta (ed), *The Stanford Encyclopedia of Philosophy* (Winter 2019, Metaphysics Research Lab, Stanford University 2019) <https://plato.stanford.edu/archives/win2019/entries/agency/> accessed 30 April 2021.

[102] Mariska J Vansteensel and others, 'Fully Implanted Brain–Computer Interface in a Locked-In Patient with ALS' (2016) 375 The New England journal of medicine 2060.

[103] Orsolya Friedrich and others, 'An Analysis of the Impact of Brain-Computer Interfaces on Autonomy' (2018) Neuroethics <https://doi.org/10.1007/s12152-018-9364-9> accessed 5 February 2021.

[104] Françoise Baylis, '"I Am Who I Am": On the Perceived Threats to Personal Identity from Deep Brain Stimulation' (2013) 6 Neuroethics 513.

[105] Lavazza (n 99).

Thus, there was incongruence between what the subject wanted to feel and actually felt due to the intervention against the subject's will. This situation perfectly illustrates how a well-intentioned technique can pose a serious threat to a user's mental autonomy; the AI merely did his job, but that job resulted in an unwanted outcome.[106] That sentence after the semicolon describes a myriad of actions – e.g. an unwanted intervention through DBS from an affective closed-loop BCI, misinterpreted prosthetic limb movement in an active BCI or loss of agency otherwise – that are quite possibly the most impactful risks to mental autonomy, since they wholly violate the definition that was given to mental autonomy in this thesis.

Risks to mental privacy deserve attention as well. Generally, (mental) privacy can be understood as the ability to determine when, how, and to what extent our thoughts are communicated to other people.[107] It is an essential component of mental autonomy because if our thoughts were exposed, we would feel pressure to think a certain way. This conformity pressure reduces the subject's autonomy in the Kantian sense since the subject can be limited in imposing his norm of conduct.[108] Kant's moral theory on autonomy was that one is free if he lives according to self-imposed laws.[109] Exposed thoughts thus lead to conformity which leads to reduced autonomy. However, a distinction must be made between mental privacy as a 'main' topic and mental privacy as a component of mental autonomy. Discourse on mental privacy as the main subject usually revolves around it in a criminal justice context, specifically non-consensual 'mind-reading' and lie detection.[110] While that is undoubtedly an interesting topic to research further, it is such a big topic that it cannot be discussed extensively in this thesis. An example is that, although mind-reading[111] of a subject through a BCI unquestionably impacts mental privacy, the same already happens, to some extent, without BCI's. People (try to) deduce what the other might think all the time.[112] Of course, BCI development could eventually allow for much more refined mind-reading than a natural person ever could. However, examining these differences here is simply unfeasible since the other two components of mental autonomy are analysed as well. Thus, this thesis considers and analyses risks to mental privacy but keeps it general since that suffices to answer the research question.

3.4 Schematic overview of initial risks

The overview is structured in certain situations or risks divided into 'expected', topical situations or 'unexpected', conceptual situations. Furthermore, the definition of mental autonomy is split up in columns, and the relevant underlying components are attached to specific parts of the definition. Then, using x marks, the overview shows how a risk might

[106] An interesting follow-up research topic could be the accountability for an unintended action performed by the user of a BCI through DBS or another malfunction.

[107] Alan F Westin, 'Privacy And Freedom' (1968) 25 6.

[108] Lavazza (n 99).

[109] Robert Johnson and Adam Cureton, 'Kant's Moral Philosophy' in Edward N Zalta (ed), *The Stanford Encyclopedia of Philosophy* (Spring 2021, Metaphysics Research Lab, Stanford University 2021) <https://plato.stanford.edu/archives/spr2021/entries/kant-moral/> accessed 9 April 2021.

[110110] E.g. Sjors Ligthart and others, 'Forensic Brain-Reading and Mental Privacy in European Human Rights Law: Foundations and Challenges' (2020) Neuroethics <https://doi.org/10.1007/s12152-020-09438-4> accessed 8 March 2021; Francis X Shen, 'Neuroscience, Mental Privacy, and the Law' (Social Science Research Network 2013) SSRN Scholarly Paper ID 2269078 <https://papers.ssrn.com/abstract=2269078> accessed 16 May 2021; Valtteri Arstila and Franklin Scott, 'Brain Reading and Mental Privacy' (2011) 156560 Trames Journal of the Humanities and Social Sciences 204; Nita A Farahany, 'Incriminating Thoughts' (2012) 64 Stanford Law Review 351; Kramer Thompson, 'Committing Crimes with BCIs: How Brain-Computer Interface Users Can Satisfy Actus Reus and Be Criminally Responsible' (2019) Neuroethics <https://doi.org/10.1007/s12152-019-09416-5> accessed 24 April 2021.

[111] This term is, at this point in time, quite misleading as becomes clear in the next chapter.

[112] Christoph Bublitz and Reinhard Merkel, 'On Crimes Against Minds: On Mental Manipulations, Harms and a Human Right to Mental Self-Determination'.

potentially infringe on a particular part of mental autonomy. It deserves mentioning that the elements are divided by elements of the formulated definition of mental autonomy, as opposed to a division based on the three components. Therefore, while a risk might for example pertain to agency, it potentially only received an x in the first column since it related to agency with regards to freely controlling one's choices instead of (in)congruence between intention and action. At the end of the next chapter, a second schematic overview is included to show whether the ECHR covers those risks or not. The two categories differ substantially in that the expected situations (generally) have less severe consequences than the unexpected situations. Furthermore, logically, the expected situations are expected to occur during normal BCI usage. Therefore, those situations deserve a bit more leeway when they infringe upon a user's right compared to the situations in the unexpected category. This distinction is vital for the notion of informed consent that is discussed in the next chapter.

Now, an explanation follows on how the situations below were established. As a starting point, literature on BCI's was examined to learn what situations might occur when one uses a BCI.[113] Along with that examination, videos were observed of actual users, using their BCI's. By observing this actual – as opposed to theoretical – usage of BCI's, it was possible to distinguish certain situations that frequently occur during that usage. Furthermore, oft-cited situations in the literature also contributed to this understanding of common situations. With those 'regular', or expected, situations uncovered, the next step was to combine them with the components of mental autonomy. When a situation potentially risked infringing on (a part of) the formulated definition of mental autonomy in this thesis, it got included in the overview. However, again, because it is impossible to discern all possible situations, the choice was made to focus on expected situations that might impact (components of) mental autonomy and are representative for all situations that might occur during regular BCI usage. Thus, while they are not meant to be exhaustive, the expected situations below provide enough variety for the purpose of and further analysis in this research. Using this approach, the inclusion of redundantly overlapping risks is prevented, keeping the thesis focused to what is important. Do note that one situation was included below to show that there are also situations that do not infringe on mental privacy, mental integrity or agency.[114]

As for the unexpected situations, those were formulated using roughly the same methods as explained above. However, the situations contained in that category are almost exclusively discussed in academic literature. That is hardly surprising given the fact that these situations are not expected during regular BCI usage or relate to, at this point in time, more conceptual risks. Conceptual means that the technology is (almost) capable of realising the situation but for now, e.g., only in a lab setting. It also means that some situations are, simply, broadly grouped for the purpose of analysis in this thesis. Because some of the situations, as of yet, have not yet materialised, they cannot be concretely discerned in specific situations as is possible with situations in the expected category. For example, brain-hacking might involve many different subcategories or -situations. The computer with the input signals could be hacked, wireless connections could be jammed thus disabling a connected device, there is the possibility of hacking the AI in closed-loop systems or an electric wheelchair might be hacked. These are all situations that have been proven to be executable.[115] However, since real-life occurrences of those hacks have barely taken place, it is more appropriate to discuss brain-hacking as a whole. Hence, the classification of such brain-hacking in the conceptual category.

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[113] Most of the cited papers in this thesis have contributed to this goal.

[114] Namely the correctly interpreted mental action to control a device. You control your own mental functions since it is your own brain signal that powers the device, not an AI for example. There is no manipulation of your brain since the motor imagery merely interprets a signal the same way it would do for a limb. Finally, because the mental action is correctly interpreted, there is congruence between the intention and action.

[115] More on that, including references to studies, in the next chapter.

Elements Activity	Freely controlling own mental functions (mental privacy, mental integrity, agency)	Freedom from manipulation/alteration (mental integrity)	Congruence between intention and action (agency)
‘Expected’, topical situations			
Monitoring/reading brain activity	X		
Correctly interpreted mental action (such as motor imagery or reaction) to control a device, e.g. a prosthetic or wheelchair			
Misinterpreted mental action to control a device			X
AI-assisted misinterpreted mental action to control a device	X	X	X
Normal functioning open-loop DBS (manually finetuned by a professional)	X	X	
Normal functioning closed-loop DBS	X	X	Possibly
Closed-loop DBS misinterpreting an intention to control a prosthesis or other device	X	X	X
Sudden loss of access to an assistive or restorative BCI through e.g. a malfunction (powering it off)	X		
‘Unexpected’ and/or conceptual situations			
Brain-hacking	X	X	X
Unintended alteration of neural processes by DBS (e.g. changing identity or affected mental state)	X	X	
Decoding mental processes	X		
Selectively erasing or altering memories	X	X	
Compulsion to provide evidence	X	X	
State surveillance through a tapped BCI	X		
Continued consent while using a BCI	X		
Incomplete information provided to BCI users about potential risks	X		

3.5 Conclusion

This chapter answered the second and third sub-questions. It considered different perspectives regarding freedom of thought and strived to formulate a definition of mental autonomy used in the remainder of the thesis. By considering all those perspectives and looking at different types of literature, it accomplished creating a definition. It also became clear that mental autonomy can be divided into mental integrity, mental privacy, and agency. Those three concepts cumulatively constitute mental autonomy and are the concepts that are analysed in the next chapter. Besides the created definition of mental autonomy, some risks were considered.

4 THE ANALYSIS AND APPLICATION OF THE ECHR

Up to this point, the chapters were mostly descriptive in nature as to lay the foundation upon which the analysis in this chapter is built. That is to say that the actual interpretation and application of the ECHR, the core of the research question as it were, is contained in this chapter. To guide the analysis, sub-question four and five are answered. All cases relating to the three elements of mental autonomy were analysed. First, relevant cases were established by searching the HUDOC[116] database using keywords.[117] Following that first collection of cases, a more refined filtering approach was used to remove the unrelated cases. Since the used keywords covered a substantial range of topics, all cases irrelevant to the definition of mental autonomy were removed from the search results. That was usually when a keyword was used somewhere in the text but as an adjective. Those cases then turned out to be on a completely different, unrelated topic. They were quickly skimmed and then discarded. A small group of cases contained the earlier mentioned elements and were suitable for analysis below. However, first the notion of dualism deserves consideration to explain the difference in perception between body and mind.

As mentioned, case law regarding the forum internum, or even the mind in general, is hard to come by. Contrast this to bodies, the other part of the equation composing a human being, on which extensive regulation, case law and doctrine exists.[118] Of course, this is mainly because, on the one hand, the inner sphere of the mind was long regarded as untouchable. On the other hand, the legal notion of 'thought' or 'mind' lacks definition in the ECHR or related works such as the travaux préparatoires. This is hardly surprising considering that a whole branch of philosophy, philosophy of mind, is dedicated to unravelling the ontology and nature of the mind. What can be observed from this apparent distinction between case law on the body and mind is that the law adheres to the dualism perspective. Dualism is one of two main categories in the mind-body problem, the other category being monism. In short, the mind-body problem is a debate on the relationship between the mind and the body, the actual, physical brain. Where dualism regards the mind and body as separate entities, monism holds that there is only one substance, essence or entity. Thus, one only needs to look at any (at least European) tort or criminal law where the distinction between mental and physical harm exists to confirm that the law subscribes to dualism.[119] This observation also clarifies why the forum internum was deemed inviolable for a long time. If mind and matter are separate, as proposed by Descartes[120], it seems logical that the mind is untouchable. However, through advances in neuroscience and -technology, such as BCI's and DBS, it becomes clear that matter (such as manipulated brain signals), at least to some degree, can influence the mind. While this thesis refrains from taking a stance in the debate around the mind-body problem, a shift in perspective from dualism to a form of monism would mean that case law on physical matters might be analogously applied to mental matters. That is why some cases relating to physical matters are included in the analysis as well.

It is important to discuss the apparent elephant in the room: users *choosing* to have their autonomy infringed upon using BCI's. The analysis below determines whether the ECHR

[116] I.e. Human Rights Documentation.

[117] Consisting of (a combination of) mental/cognitive/psychological and privacy/freedom/integrity/autonomy/self-determination/agency, and forum internum.

[118] E.g. tort and criminal law almost always refer to bodily harm and physical actions. Searching for 'physical' on Hudoc results in 3404 cases using the term. See also: Bublitz and Merkel (n 112).

[119] ibid.

[120] This concept is nowadays known as Cartesian dualism; John Cottingham and René Descartes (eds), 'On Meditation Six', *Descartes: Meditations on First Philosophy: With Selections from the Objections and Replies* (Cambridge University Press 1996) <https://www.cambridge.org/core/books/descartes-meditations-on-first-philosophy/on-meditation-six/FACFBBB88874C0F3230E0ED081F25DA0> accessed 17 May 2021.

sufficiently guards against the risks BCI's pose to mental autonomy. However, it is hard to imagine that a paraplegic feels his autonomy deeply violated when his exoskeleton, restoring his ability to walk, misinterprets his intention and performs a backward step instead of a forward one. While that is true in this particular case, this thesis has always taken a broad perspective and looked at BCI's on a more conceptual level instead of a topical one. Thus, while there are indeed cases imaginable where the substantial increase in autonomy (e.g. a locked-in patient regaining the ability to communicate) outweighs the harms posed to it, there are also numerous scenarios where the potential infringement on autonomy is severe. For these cases, the law must provide adequate safeguards, especially when such an infringement is unforeseen as can be imagined in the case of brain-hacking or unintentional alteration of neural processes by DBS, e.g. a personality change. Furthermore, even when a user decides that the benefits of a BCI outweigh the potential infringements on his autonomy, those infringements need to be consented to. Therefore, this chapter also includes a smaller section relating to the informed consent necessary to allow infringements on BCI users' mental autonomy.

4.1 The elements of mental autonomy as approached in ECHR case law

4.1.1 Mental integrity

In the words of Bublitz: "A right to the integrity of X seems to denote the **preservation of the intactness**, unity or identity of X. Alterations of these features then constitute interferences" [bold emphasis added].[121] Therefore, *mental* integrity denotes a preservation of intactness of the mind, the inner sphere. If a preserved mind is the default state, alterations, as Bublitz puts it, constitute interference. That relates mainly to the '…no one can alter or manipulate his mental states' of the definition given to mental autonomy in this thesis. While the definition above from Bublitz is not meant to be exhaustive, it suffices as an anchor to look for in case law.

Before discussing the ECHR mental integrity, a sidestep is warranted. That sidestep is to the Charter of Fundamental Rights of the European Union (hereafter: CFR, the Charter). After a troubled history since its first proclamation in 2000, the Charter has the same legal status as treaties of the EU. With the Charter, the EU has created its own 'ECHR'. While the similarities and differences between the ECHR and CFR are interesting, they are irrelevant for this sidestep. It is enough to say that the CFR respects the ECHR through art. 53 CFR, and they both protect human rights. What makes the CFR interesting is that it contains an actual right to mental integrity, something that the ECHR lacks. By expressly recognising the right to integrity as a human right, its importance is highlighted. Art. 3(1) CFR reads: 'Everyone has the right to respect for his or her physical and mental integrity'. Bublitz claims the mental part of integrity was included alongside the physical part to provide comprehensive protection, especially against novel technologies.[122] Thus, theoretically, art. 3(1) CFR should protect the integrity element of mental autonomy. However, whether that currently is the case is hard to determine. For one, this article is ridden with the same ambiguity as the ECHR when determining what *mental* and related words encompass. What meaning and scope the word should get was not extensively discussed during the drafting of the CFR. Furthermore, at the time of writing this thesis, the article has not been invoked regarding the mental portion, at least within the meaning of integrity of the forum internum as it is understood in this thesis. One might wonder why the article, lacking practical application up to this point, is included in this analysis. First off, the actual mention of *mental* integrity seems to be unique in a human rights framework. Although it is not being invoked in courts yet, the possibility to do so is there. If art. 3(1) CFR is one day

[121] Bublitz, 'The Nascent Right to Psychological Integrity and Mental Self-Determination' (n 28).
[122] ibid.

invoked with regards to the forum internum, the ECtHR could be influenced by the interpretation given to it by the CJEU. Secondly, the right to mental integrity in the CFR finds its roots in ECHR case law on psychological integrity.[123]

The ECtHR developed and protected the notion of ‘psychological’ integrity in its case law throughout the years.[124] Although art. 2 and 3 ECHR, respectively the right to life and prohibition of torture, have played a role in the case law on psychological integrity, the notion was mainly developed by interpreting art. 8 ECHR. Art. 8 ECHR is the right to respect for private and family life, where paragraph 1 states the right as follows: ‘Everyone has the right to respect for his private and family life, his home and his correspondence’. The earliest mention of physical and moral (comparable to mental in this context) integrity is observed in *X and Y v. Netherlands*, where it concerned the sexual violation of a mentally disabled girl and the applicability of art. 8 ECHR.[125] In that case, the Court established that (physical and) moral integrity include one’s sexual life and is covered by the notion of private life. Although the terms are only mentioned in one paragraph of the ruling, it paved the way for future case law regarding the concepts of physical and moral integrity.

While initially the article seems relatively narrow, the ECtHR has interpreted the notion of private life broadly throughout the years. In the case of *Tysiac v. Poland*, regarding an unexecuted abortion, the Court considered that: ‘…private life is a broad term, encompassing, inter alia, aspects of an individual’s physical and social identity including the right to personal autonomy… a person’s physical and psychological integrity’. [126] Furthermore, the Court noted that: ‘…the state is also under a positive obligation to secure its citizens their right to effective respect for this integrity’. This sentence is quite important. Here, the Court effectively says that States must ensure the protection of the personal integrity of their citizens. If art. 8 is interpreted to contain a right to mental integrity, it means that States, in the context of BCI’s, must construct, e.g., a regulatory framework to ensure the integrity of their citizens.

In *Jehovah’s witnesses of Moscow and Others v Russia*, a direct relation between integrity and autonomy is made.[127] There, the Court noted, referring to *Pretty v UK*[128], that: “The very essence of the Convention is respect for human dignity and human freedom and the notions of self-determination and personal autonomy are important principles underlying the interpretation of its guarantees”.[129] Furthermore, it noted that integrity can only be meaningful if the patient has the right to make choices according to his own views and values since that is vital to personal autonomy.[130] While this took place regarding the refusal of medical treatment, it is a fascinating case since it indicates how the ECtHR interprets integrity. Also, although this case referred to physical integrity, it is quite conceivable that the Court follows the same train of thought when it interprets mental integrity. When looking at the weight the Court attaches to patients' free choice, as irrational or unwise as it may appear to others, it is imaginable that the same is done concerning mental integrity. Due to the broad scope of art. 8, private life is not merely constrained to, e.g. a house, but also encompasses the mental sphere. Nevertheless, despite references to psychological integrity since the 1990's, the meaning of the concept

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[123] Steve Peers and others, *The EU Charter of Fundamental Rights: A Commentary* (Bloomsbury Publishing 2014).

[124] As noted by Bublitz, there are no indications that psychological and mental, in the legal context here, refer to different concepts. Thus, mental and psychological integrity are used interchangeably here.

[125] X and Y v the Netherlands App no 8978/80 (ECtHR, 26 March 1985), para. 22.

[126] Tysiąc v Poland App no 5410/03 (ECtHR, 20 March 2007), para. 107.

[127] Jehovah's Witnesses of Moscow and others v Russia App no 302/02 (ECtHR, 10 June 2010).

[128] Pretty v the United Kingdom App no 2346/02 (ECtHR, 29 April 2002).

[129] Jehovah's Witnesses of Moscow and others v Russia App no 302/02 (ECtHR, 10 June 2010), para. 135.

[130] Ibid, para 136.

‘psychological’ is not extensively explained.[131] Despite that, there are some indications of the Court's interpretation of 'psychological' or 'mental'.

In *Bensaid v. UK*, the Court regarded mental health as being a part of psychological integrity.[132] In paragraph 47 of that case, the ECtHR argues that private life is a broad term not susceptible to exhaustive definition. Therefore, it notes that mental health must also be regarded as a crucial part of private life associated with moral integrity. However, mental health seems narrow if it is understood as the sole interpretation of mental integrity, especially in light of mental integrity as a building block for mental autonomy. Fortunately, the Court has touched upon other elements contained within psychological integrity. For example, in *Jalloh v Germany*, the ECtHR ruled that using a medicine resulting in a person vomiting (police suspected him of swallowing drugs) constituted a violation of his physical and mental integrity under art. 3 ECHR because of the anxiety and mental suffering he experienced.[133] While this is an extreme situation, as demonstrated by the fact that it constitutes an infringement on the right of prohibition of torture, it indicates that mental integrity refers to, inter alia, mental suffering, anxiety, indignity and humiliation from forced, unwanted medical interventions and other forms of degrading treatment.[134] In other words, the Court considered mental integrity to encompass a broad spectrum.

In *Karakó v. Hungary*, the Court’s consideration from *Von Hannover v. Germany* was reiterated that personal integrity and identity are protected by art. 8 while adding that its protection extends to reputation.[135] Another example is *Axel Springer AG v. Germany*. There the Court counted reputational harm as harm to psychological integrity.[136] If reputational harm, harm not much connected to intactness of the mind initially, is included in mental integrity, it means the Court uses a broad interpretation. Therefore, although the exact scope of the right is not clear, it is now apparent that it is broad. That means that mental integrity as a component of mental autonomy could, and very likely would, fall under the scope and protection of art. 8 ECHR. However, as mental autonomy seeks to protect the forum internum unconditionally, protecting mental integrity through art. 8 is problematic. That this unconditionality is present in art. 9 but not in art. 8 ECHR becomes clear in *Kokkinakis v Greece*. There, the Court mentioned that, unlike the second paragraphs of art. 8, 10 and 11 that cover all rights mentioned in the first paragraphs of those articles, that of art. 9 only refers to ‘freedom to manifest one’s religion or belief’.[137] That means that, while the rights contained in art. 8 may be infringed upon, the freedom of thought may not. That is why art. 8 might not be appropriate for mental integrity.

To elaborate, the second paragraph of art. 8 ECHR deserves attention. While the inner sphere of the mind is protected absolutely in art. 9(1) ECHR, the freedom of thought, conscience and religion, the right to private life can be legitimately interfered on. Paragraph 2 provides the possibility for restriction of the right. For interferences to be legitimate, they must be in accordance with the law (meaning accessible and foreseeable), pursue a legitimate aim and be necessary in a democratic society. The latter requires a pressing social need and that the interference was proportionate to the aim pursued. Concretely, if the above conditions are met, states are allowed to interfere with a right to private life by, for example, medically treating someone against their will. Another example would be state surveillance through a tapped BCI. That states can perform such an interference can be illustrated by drawing a parallel to the

[131] Bublitz, ‘The Nascent Right to Psychological Integrity and Mental Self-Determination’ (n 28).
[132] Bensaid v the United Kingdom App no 44599/98 (ECtHR, 6 February 2001).
[133] Jalloh v Germany App no 54810/00 (ECtHR, 11 July 2006).
[134] Peers and others (n 123).
[135] Karakó v Hungary App no 39311/05 (ECtHR, 28 April 2009), para 22.
[136] Axel Springer AG v Germany App no 39954/08 (ECtHR, 7 February 2012), para. 83.
[137] Kokkinakis v. Greece (App. 14307/88) Jud. 25 May 1993, para. 33.

tapping of mobile phones.[138] Already back in 1978, the Court ruled that German legislation on secret surveillance was justified because its interference with art. 8 ECHR was 'necessary in a democratic society and in the interests of national security and the prevention of disorder or crime'.[139] While those laws must comply with strict requirements such as foreseeability[140] and accessibility[141], that does not change the fact that an interference can be legitimate. Even more so because the surveillance or tapping is covert, and the Court explicitly said in *Szabo and Vissy v Hungary* that the foreseeability requirement does not mean that citizens should know beforehand if and when their communication is intercepted. This looming threat of infringement on the integrity of BCI users is something that is, as demonstrated by the case law, not alleviated by the ECHR.

To put it differently, the (as of yet) hypothetical scenario of tapping a BCI illustrates the problem with BCI's and the protection of mental integrity as a part of mental autonomy under art. 8. One aspect of mental integrity was the preservation of intactness of the mind. If that intactness can be interfered upon, justified or otherwise, without consent, it violates the very essence of the concept: freedom from manipulation. Therefore, if mental integrity is to be absolutely protected, it needs to be protected under the umbrella of freedom of thought through art. 9 ECHR. However, it is as of yet not clear whether the ECtHR acknowledges mental integrity as a part of art. 9 due to the lack of case law. This means that presently, following the analysis above, mental integrity could only be realistically protected by art. 8 and thus is not adequately protected by the ECHR since mental autonomy requires inviolable mental integrity.

Nevertheless, despite its possibility for interference, it is important to propose a reconceptualisation or broadening of art. 8 to safeguard mental integrity if the ECtHR decides to regard the right as relative instead of absolute (under art. 9) in the future. Because, if the public debate also points toward a need for the right to be relative (e.g. in light of prevention of terrorism), this thesis can dynamically change its stance and conclude that the ECHR adequately protects mental integrity. Therefore, the right should be developed by the Court through art. 8 case law to explicitly provide normative protection from unauthorised alteration of one's brain (signals) that results in direct harm to the victim. Then, States have a negative obligation to refrain from manipulating citizens on the one hand, while they must take measures to prevent that manipulation of citizens by other actors. This broadening should not pose many problems when considering the discussed legal cases above, demonstrating the already broad interpretation of art. 8 ECHR. Interferences are then legitimate when the conditions mentioned above are met and the rights of citizens are adequately balanced against the rights of others (e.g. mental integrity as contained in art. 8 ECHR against public interests such as national security).

4.1.2 Mental privacy

This section researches whether mental privacy, as opposed to physical privacy, is adequately protected under the ECHR. Keep in mind that actual 'brain-reading' is not (yet) possible. However, reading brain signals and drawing inferences about certain mental states or about (a limited set of) things the user is thinking about is possible. Privacy is well established in the case law of art. 8 ECHR. The previous section already established that the ECtHR interprets the scope of the right expansively. While one could argue that thoughts are merely another form of 'information' as it is regularly protected under art. 8, the fact that these thoughts

[138] Do mind that tapping and surveillance by states is an expansive topic. As such, it is only mentioned concisely here to demonstrate that states can potentially tap BCI's; legitimately.

[139] Klass and others v Germany App no 5029/71 (ECtHR, 6 September 1978), para. 60.

[140] Kruslin v France App no 11801/85 (ECtHR, 24 April 1990), para. 30; Valenzuela Contreras v Spain App no 27671/95 (ECtHR, 30 July 1998), para. 46.

[141] Malone v The United Kingdom (Article 50) App no 8691/79 (ECtHR, 26 April 1985), para. 66; Roman Zakharov v Russia App no 47143/06 (ECtHR, 4 December 2015), para. 242.

are situated in and originate from the forum internum warrants a special status. Again, because art. 8 is a relative right, providing a possibility for interfering with a subject's privacy. However, perhaps here a case could be made for a more nuanced approach than the rigid normative outlook that mental integrity must be absolute. Quite possibly, the right to mental privacy does not have to be absolute in its totality. That is due to the classification of 'thoughts'. If brain signals acquired through a BCI are classified as thoughts altogether, then absolute protection of mental privacy under art. 9 ECHR is warranted. However, that seems currently unlikely. From the limited (indirect even) case law on the subject, it seems that the Court has a narrow interpretation of the forum internum. For example, in *İzzettin Doğan and others v. Turkey* the Grand Chamber ruled that for a belief – situated within the forum internum, falling under art. 9 ECHR – to be protected under the ECHR, it must: 'attain a certain level of cogency, seriousness, cohesion and importance'.[142] So, according to the Court, only thoughts that reach a certain weighty threshold are to be protected by the right. An example is the intention to vote. In *Russian Conservative Party of Entrepreneurs and others v. Russia* and later in *Georgian Labour Party v. Georgia*, the Court notes that an intention to vote is a thought confined to the forum internum, and its existence cannot be proved or disproved until it is manifested (through voting).[143]

Therefore, Ligthart et al. accurately note that if brain-reading reveals information about an element covered under art. 9 such as a political preference, the absolute protection of the right guards the subject against this brain-reading. Nothing changes for thoughts relating to those protected concepts. However, that does not answer whether remaining 'thoughts' fall under the scope of art. 9. These can be anything from thinking about what groceries to buy to what one's opinion of someone is. Essentially, thoughts that do not reach the high criterion of the Court. Perhaps, if BCI's advance enough to accurately distinguish *actual* words or sentences instead of rougher brain signals related to a cortical area, it might be acceptable to declare that interferences regarding thoughts can be justified in specific cases. E.g. the location of a ticking timebomb from the mind of a confirmed terrorist.

However, since precise brain reading is currently impossible and a whole batch of signals gets recorded without any regard to the sensitive content it might contain, it is best to qualify all thoughts as inviolable by putting them under art. 9 ECHR for now. The arguments for this decision echo the ones given in the previous section regarding mental integrity. I.e. the possibility for states to legitimately infringe on the right. Since brain data relates directly to one's inner life and personhood and it is not yet possible to distinguish accurately between thoughts, thoughts as a whole need to be protected absolutely.[144] To classify thoughts as legally inviolable is also supported by bioethicist Wolpe, who states: "*The skull should be designated as a domain of absolute privacy. No one should be able to probe an individual's mind against their will… We should forgo the use of the technology under coercive circumstances even though using it may serve the public good*".[145] This also ensures that users of BCI´s know their ´thoughts´, as a whole, remain private, which prevents the hypothesised self-imposed conformity that could reduce their autonomy if this was not the case. Furthermore, in *Eweida & Others v United Kingdom* – one of the very few cases where a breach of a positive duty under

[142] İzzettin Doğan and others v Turkey App no 62649/10 (ECtHR, 26 April 2016), para. 68.

[143] Russian Conservative Party of Entrepreneurs and others v Russia App no 55066/00 and 55638/00 (ECtHR, 11 January 2007), para. 76; Georgian Labour Party v Georgia App no 9103/04 (ECtHR, 8 July 2008), para. 120.

[144] Ienca and Andorno (n 15).

[145] Paul Root Wolpe, 'Is My Mind Mine? Neuroethics and Brain Imaging', *The Penn Center Guide to Bioethics* (Springer Publishing Co 2009) <https://repository.library.georgetown.edu/handle/10822/953170> accessed 24 April 2021.

art. 9 ECHR was found – the Court confirmed that art. 9 obliges States to secure the freedom of thought of its citizens.[146]

4.1.3 Mental agency and informed consent

An agent is one who acts. Therefore, agency is the capacity to act. This merely refers to the *ability* to act and to choose how to do so (i.e. the ability to make informed and rational choices). Despite its close relation to autonomy, they are not the same. Autonomy was self-governance. Thus, when an agent is acting according to her own beliefs, motives or intentions, she is autonomous. One classic example of one who acts but is not autonomous is when an agent gets robbed. While it is true that he chooses an action and acts – he hands over his wallet on his own – his motive is not his own. It is clear that the agent did not *want* to hand over his wallet, but external pressure – an intimidating person with a knife – compelled him to act in a certain way. Consider some of the given possibilities such as brain-hacking, misinterpreted intentions by closed-loop DBS and the sudden loss of an assistive or restorative BCI because of a malfunction. These three scenarios illustrate how agency can be threatened by BCI's by losing the ability to choose how to act, experiencing incongruence between intention and action and losing the ability to act (at least partially). This section examines case law to determine whether the ECHR adequately protects the agency of BCI users while taking the notion of informed consent into account.

Perhaps the quintessential example of losing agency in BCI's, is when a BCI gets hacked. However, different types of brain-hacking can be distinguished. Although the example below relates primarily to mental privacy, akin to a computer being hacked containing written thoughts or sensitive information, it is a good entry point to illustrate how malicious actors can affect BCI users.

The first kind of brain-hacking is not merely a hypothetical situation. A study done to test different kinds of attacks on BCI's demonstrated that certain information could be extracted from EEG signals with a success rate higher than random guesses.[147] Such information consisted of faces of persons the users know, their pin codes, debit card numbers, what bank they use, and their home location.[148] For this study, the P300 signal corresponding to a specific stimulus was detected to determine if that stimulus corresponded to the users' sensitive information. Concretely, the users got shown different months, and when they saw their month of birth, a P300 signal got evoked and detected. This allowed the researchers to extract the information. This type of brain-hacking seems quite rudimentary and theoretical compared to more sophisticated hacks since it requires hacked external stimuli. However, such a hack is easier than one thinks. The study hypothesised that manipulating input signals is accomplishable through 'ordinary' malware on computers of users. When (consumer) BCI's get more popular, the chance of infecting a user's computer through widely distributed malware increases considerably. Another problem mentioned in the study is that EEG data is currently not anonymised. Due to the relatively early stage that BCI development is in, brain data is hard enough to manage as it is (e.g. due to the complexity and size). However, the fact remains that the unfiltered, raw EEG data gets transferred from, e.g. a lab computer to a user's private computer. If this raw data falls into a hacker's hands, quite some information can be distilled from it already, considerably infringing on the user's (mental) privacy.

The above type of brain-hacking demonstrated how malevolent actors might access information of BCI users. While this does impact agency to some extent (e.g. knowing one is

[146] Eweida & Others v United Kingdom App nos 48420/10, 59842/10, 51671/10 and 36516/10 (ECtHR, 15 January 2013), para. 84.

[147] Ivan Martinovic and others, 'On the Feasibility of Side-Channel Attacks with Brain-Computer Interfaces' (USENIX 2012).

[148] ibid.

hackable might make him act differently), a different kind of brain-hacking impacts agency far more. That is when changes in the user's decision-making are made by hacking a closed-loop DBS BCI.[149] According to Haselager, the mere usage of a BCI already introduces uncertainty for the user on whether he intentionally acted or not in case of incongruence.[150] The user might question if he made a mistake with the mental imagery necessary for the action. When this incongruence results from a misinterpreted intention by AI in DBS or interference from a hacker, the user's agency is even more diminished. In other words, the user cannot act or choose how to act, which impacts his agency. What makes this type of brain-hacking even more insidious is that the user does not know his brain functions are altered. Before the ECHR is scoured regarding brain-hacking, another concept needs to be discussed first. That concept is free and informed consent.

Free and informed consent is a widely known and respected notion in the medical field. One of its first mentions in legislation is in art. 7 of the International Covenant on Civil and Political Rights, a treaty from the United Nations adopted in 1966. The ECHR recognises the principle implicitly through art. 3 and 8, while art. 5 of the Convention on Human Rights and Biomedicine and art. 3(2) CFR do so explicitly. This compact enumeration shows the importance placed on the concept. For consent to be valid, three conditions require fulfilling. An individual must have decision-making capacity in the legal and factual sense, the consent must be free, and it needs to be informed.[151] Already at this first condition, problems arise. This decision-making capacity is the essence of DBS BCI's. In those devices, the AI is the factual decision-maker when detecting a particular signal and decides to respond. While this consent problem does not manifest before implantation of the BCI, there is a risk with continued consent. If a BCI radically changes mental states, as an intended effect or negative side effect, the user is initially unable to give his consent on changes to or the termination of his treatment.[152]

Besides the capacity to act, consent needs to be given freely and informed. In *V.C. v. Slovakia*, the Court ruled that the individual must be informed regarding her health status, the proposed procedure, and its alternatives for consent to be valid.[153] That case concerned a woman sterilised after consenting during child labour. Because of the circumstances the consent was obtained in, the Court ruled that the consent was invalid. That was mainly because the woman did not decide of her own free will after considering all relevant issues and after reflecting on the implications.[154] In the context of BCI's, users must be thoroughly informed about all the different risks and implications of using the technology. This includes the tempering of high expectations. Clausen observes that users tend to 'overhype' the capabilities of BCI's, which can lead to them accepting much higher risks of usage than they otherwise would.[155] Furthermore, each BCI is currently tailored to a specific condition or situation. Even researchers and doctors cannot foresee every effect a BCI can have.

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[149] Marcello Ienca and Pim Haselager, 'Hacking the Brain: Brain–Computer Interfacing Technology and the Ethics of Neurosecurity' (2016) 18 Ethics and Information Technology 117.

[150] Pim Haselager, 'Did I Do That? Brain–Computer Interfacing and the Sense of Agency' (2013) 23 Minds and Machines 405.

[151] Wannes Buelens, Coralie Herijgers and Steffi Illegems, 'The View of the European Court of Human Rights on Competent Patients' Right of Informed Consent. Research in the Light of Articles 3 and 8 of the European Convention on Human Rights' (2016) 23 European Journal of Health Law 481.

[152] W Glannon, 'Stimulating Brains, Altering Minds' (2009) 35 Journal of Medical Ethics 289.

[153] VC v Slovakia App no 18968/07 (ECtHR, 8 November 2011), para. 112.

[154] Ibid.

[155] Jens Clausen, 'Conceptual and Ethical Issues with Brain–Hardware Interfaces' (2011) 24 Current Opinion in Psychiatry 495; Glannon (n 152).

For example, the security of medical devices[156] is barely touched upon by clinicians simply because their knowledge is lacking on the matter.[157] While 'there are increasing efforts to raise awareness…of cybersecurity vulnerabilities on patient safety', there still is no 'widespread curricula for allied health professionals'.[158] Other reasons might be that they know about a risk but refrain from informing about it if the chance of it occurring is extremely slim. However, the normative outlook here is that all risks require disclosure. Lee and Lai suggest that, e.g. a risk of paralysis should be disclosed even if the chance is far below 1%.[159] Kiener also notes that individual perspectives require consideration.[160] He gives the example of a pianist who is likely to be especially concerned about a (minor) paralysis of his hands. While one counterargument for disclosing all risks is that this could unnecessarily frighten users, the discussed risks in this thesis show the considerable impact they can have if they were to manifest. Potential adverse side effects such as unintentionally altered identities and mental states are such a grave interference on a user that they warrant disclosure before using BCI's. Therefore, users *should* be informed of *all* potential implications and risks of BCI's. However, it cannot be determined if that is currently the case based on the available data, although the literature suggests that is not the case.[161]

Nevertheless, assuming the fiction that all those implications and risks are accurately explained to the user, he can then make the informed decision to accept those risks. Thus, most infringements on agency (as well as mental integrity and mental privacy) can be justified by the user's informed consent. However, the same cannot be said for continued or different consent (since each new or changed treatment needs consent) where the capacity to act is compromised. In that case, Glannon suggests turning off the BCI, request consent from the user and then turn the BCI back on (or not, depending on the user's decision).[162] However, if the capacity to act is not restored by turning off the BCI due to, e.g. a permanent alteration, it is unclear what should happen next. Such a situation is debated among bioethicists, scholars and scientists with no clear outcome in sight.[163] One clear thing is that the agency and autonomy of the user are permanently harmed in such a case.

Then, the final piece regarding informed consent. Informed consent quite possibly cannot be used for the potential risk of brain-hacking and a few other risks in the 'unexpected' category. This is because users do not know when they are hacked, and their decisions are not originating from themselves. Users already cannot detect their unintended altered behaviour or even their changed identity, as observed by Goering et al.[164] They note that family members

[156] U. S. Government Accountability Office, 'Medical Devices: FDA Should Expand Its Consideration of Information Security for Certain Types of Devices' (U S Government Accountability Office 2012) <https://www.gao.gov/products/gao-12-816> accessed 29 April 2021.

[157] Jeffrey Tully and others, 'Connected Medical Technology & Cybersecurity Informed Consent - A New Paradigm (Preprint)' (2019) 22 Journal of Medical Internet Research.

[158] ibid.

[159] Danny WH Lee and Paul BS Lai, 'Risk Disclosure and Informed Consent: Practice Caveats in the Post Montgomery Era' (2020) 24 Surgical Practice 75.

[160] Maximilian Kiener, 'Artificial Intelligence in Medicine and the Disclosure of Risks' (2020) AI & SOCIETY <https://doi.org/10.1007/s00146-020-01085-w> accessed 29 April 2021.

[161] Christine Grady, 'Enduring and Emerging Challenges of Informed Consent' (2015) 372 New England Journal of Medicine 855; Eran Klein and Jeffrey Ojemann, 'Informed Consent in Implantable BCI Research: Identification of Research Risks and Recommendations for Development of Best Practices' (2016) 13 Journal of Neural Engineering 043001.

[162] Glannon (n 152).

[163] Sara Goering and others, 'Staying in the Loop: Relational Agency and Identity in Next-Generation DBS for Psychiatry' (2017) 8 AJOB Neuroscience 59; Philipp Kellmeyer and others, 'The Effects of Closed-Loop Medical Devices on the Autonomy and Accountability of Persons and Systems' (2016) 25 Cambridge Quarterly of Healthcare Ethics 623; Haselager (n 150).

[164] Goering and others (n 163).

and friends are required to notice the change in behaviour since the user cannot do so.[165] Therefore, States must take measures to prevent brain-hacking and other involuntary alterations of the brain as much as possible. While many technical principles and solutions are suggested, such as anonymising brain data[166], implementing a 'kill-switch' to cut off connections, 'antivirus' for BCI's and keeping a person in the loop (i.e. manually deciding whether to prevent or accept actions from a DBS BCI before application)[167], this thesis cannot realistically propose a single solution due to the complexity of the matter. However, what it can do, is establishing the legal basis for those possible solutions. States must adopt regulatory measures necessary to ensure doctors fully inform BCI users of the risks and implications before the device is implanted or used. That follows from, inter alia, *VO v. France*[168], *Trocellier v. France* (inadmissible, but relevant considerations)[169] and *Csoma v. Romania*.[170] If states fail to adopt those regulatory measures and a foreseeable risk does materialise without the individual being informed, the state may be directly liable for that lack of information. Furthermore, interferences must be prevented or penalised.[171] That means that measures must be taken to prevent, inter alia, brain-hacking.

To summarise this section, agency is infringed upon by BCI's. While users' informed consent covers most situations, brain-hacking and some other risks in the 'unexpected' category still pose a substantial risk to agency. States are obliged to adopt measures such as technical standards that all BCI's need to adhere to regarding security to prevent this threat to user's agency and ensure doctors inform users of all risks. However, at this point, there do not seem to be any measures on EU level specifically relating to BCI's or neurotechnology in general. Furthermore, it is improbable that users are, at this point, being fully informed about all the risks proposed in this thesis, while the consequences can be grave if those risks manifest. Thus, the informed consent can then not be relied upon for the infringement on the agency of the user, since the user was simply not fully informed. Therefore, agency is currently not fully protected by the ECHR.

4.2 Conclusion: risks covered?

While pinpointing exact risks is hard since different applications and situations can have different risks, this thesis tried to formulate both 'expected' or topical risks and 'unexpected' or conceptual risks. After carefully analysing relevant ECHR case law and presenting arguments on possible interpretations the Court gives to provisions, it is now time to answer the fifth and final sub-question: '*To what extent does ECHR case law cover the risks of brain-computer interfaces to mental autonomy and if that coverage is insufficient, what are possible solutions for that insufficient coverage?*'. Below, risk coverage is discussed globally for each of the three components that together constitute mental autonomy. After that, the chapter concludes with some suggestions on going forward after the conclusions of this thesis.

Risks to mental integrity

A problem that surfaced is that the very essence of a BCI violates mental integrity since it takes over the user's mental functions or entirely. A solution is informed consent. Since informed consent is a possible justification for all three components but was discussed under the section on agency in this chapter, it is discussed under the agency heading below. Following the analysis of the ECHR above, it turned out that the Court interprets art. 8 ECHR quite broad.

[165] ibid.
[166] Ienca and Haselager (n 149).
[167] Kellmeyer and others (n 163).
[168] Vo v France App no 53924/00 (ECtHR, 8 July 2004), para. 89.
[169] Trocellier v France App no 75725/01 (ECtHR, 5 October 2006), para. 4.
[170] Csoma v Romania App no 8759/05 (ECtHR, 15 January 2013), para. 42.
[171] Buelens, Herijgers and Illegems (n 151).

The Court's values in the analysed cases indicate that it could regard mental integrity as a principle or right worth protecting under the scope of the article. However, if mental integrity is regarded as an absolute right as this thesis intends, the ECHR currently fails to protect mental autonomy against the risks BCI's pose adequately. That is because the right, under art. 8, can be legitimately interfered upon through paragraph 2 of the article. Concretely, risks such as state surveillance through tapped BCI's are not covered. Nevertheless, if public debate points toward the need for the right to be relative (e.g. for national security), it merely requires a reconceptualization or slightly different interpretation of art. 8 to accomplish that goal. In that case, art. 8 needs to be developed to provide explicit protection from unauthorised alteration of one's brain (signals). That way, both a negative and positive obligation exists for the State to safeguard the right as mentioned in that section.

Risks to mental privacy

One peculiarity regarding mental privacy was the legal classification of thoughts. Looking at art. 9 ECHR, the protection threshold conceived in *İzzettin Doğan and others v Turkey* for a particular thought seemed quite high. If brain-reading reveals a thought that reached the high threshold, i.e. vote intention or religious beliefs, it is protected absolutely. However, because actual brain-reading is not yet possible, it is extremely difficult to differentiate between a thought reaching that threshold and a trivial one. That is why, for now, all thoughts require protection under art. 9 ECHR. At least until it is possible to distinguish thoughts accurately. Thus, if the Court agrees with this reasoning, mental privacy is adequately protected. If they do not, mental privacy is currently inadequately protected.

Risks to agency and the possible justification through informed consent

Two examples of risks to agency were the possibility of brain-hacking and misinterpreted intentions by closed-loop DBS. Early on, it was established that almost every application of BCI's, legitimate or illegitimate, infringes on the user's agency. However, when the user is fully informed of all the potential risks and freely consents to using a BCI nevertheless, most infringements can be justified. That justification hinges on the complete informing of the users by, e.g., their treating physicians in medical settings.[172] That means the users need to be informed about cybersecurity risks as well. The literature review showed that that is unlikely to be the case at the moment. Thus, informed consent is probably usable for the expected risks – since physicians likely know those medical risks and inform the users about them – but it is unusable for unexpected situations. Furthermore, due to the complexity of some risks (e.g. the user not knowing his mental state is altered), consent is hard to rely on regardless. Thus, the risks in this category are, just as in the other two categories, also not (fully) covered by the ECHR. This leads to the conclusion that the ECHR does not adequately protect against the risks BCI's pose to mental autonomy.

4.3 Concluded risk overview

Elements / Activity	Freely controlling own mental functions (mental privacy, mental integrity, agency)	Freedom from manipulation/ alteration (mental integrity)	Congruence between intention and action (agency)	Consent to infringement realistically given (full information) and/or acceptable	Conclusion

[172] Although informed consent is a concept mostly confined to the medical field, it certainly is recommendable to be used regarding consumer BCI's as well.

'Expected', topical situations					
Monitoring/reading brain activity	X			X	Risk to autonomy, but (able to be) justified through consent
Correctly interpreted mental action (such as motor imagery or reaction) to control a device, e.g. a prosthetic or wheelchair					No risk to autonomy
Misinterpreted mental action to control a device			X	X	Risk to autonomy, but justified through consent
AI-assisted misinterpreted mental action to control a device	X	X	X		Risk to autonomy
Normal functioning open-loop DBS (manually finetuned by a professional)	X	X		X	Risk to autonomy, but justified through consent
Normal functioning closed-loop DBS	X	X	Possibly	X	Risk to autonomy, but justified through consent
Closed-loop DBS misinterpreting an intention to control a prostheses or other device	X	X	X	Possibly	Risk to autonomy, maybe justified through consent but cannot be said certainly
Sudden loss of access to an assistive or restorative BCI through e.g. a malfunction (powering it off)	X			X	Risk to autonomy, but justified through consent
'Unexpected' and/or conceptual situations					
Brain-hacking	X	X	X		Risk to autonomy
Unintended alteration of neural processes by DBS (e.g. changing identity or affected mental state)	X	X			Risk to autonomy
Decoding mental processes	X			X	Risk to autonomy, but justified through consent
Forced selectively erasing or altering memories in case of violent criminals	X	X			Risk to autonomy

Requested selectively erasing or altering memories (e.g. in case of a trauma)	X	X		X	Risk to autonomy, but justified through consent
Compulsion to provide evidence	X	X			Risk to autonomy
State surveillance through a tapped BCI	X				Risk to autonomy
Continued consent while using a BCI	X			X	Risk to autonomy, but justified through consent IF altered state can be reversed, otherwise no consent possible
Incomplete information provided to BCI users about potential risks	X				Risk to autonomy

4.4 The way forward

After answering the research question and concluding that the ECHR fails to protect mental autonomy, exploring potential solutions remains. Do mind that this is merely an entry point for further research. However, I found it important to add possible solutions to tackle the problem since the thesis would have felt unfinished if it only established the current shortcomings of the ECHR and left it at that. Furthermore, despite the breakneck speed at which BCI's develop, it is still not receiving much academic or political attention.[173] Thus, having read all the papers and perspectives this year, I considered it wise to propose suggestions while everything is still fresh in mind. Hence, the suggestions below.

4.4.1 Ethical and technical principles

One possible solution is to draft ethical and technical principles that must be adhered to while developing BCI's. The Organisation for Economic Co-operation and Development (OECD) already proposed such principles regarding responsible innovation in neurotechnology.[174] Although these principles touch upon many important areas, they could be complemented with more ethical considerations. For example, making mental autonomy the underlying notion all BCI development must respect. Also, more concrete technical principles such as the one proposed by Lavazza, where he notes that BCI's must detect unauthorised alterations and stop those alterations, are desirable.[175] Alternatively, perhaps veto control should always be possible in DBS BCI before they are allowed. This could also prevent certain accountability issues if users first accept or deny a particular action before the AI executes the

[173] Even in the year that I wrote this thesis, several breakthroughs in the field were made. E.g. Sumner L Norman and others, 'Single-Trial Decoding of Movement Intentions Using Functional Ultrasound Neuroimaging' (2021) 0 Neuron <https://www.cell.com/neuron/abstract/S0896-6273(21)00151-3> accessed 30 April 2021; John D Simeral and others, 'Home Use of a Percutaneous Wireless Intracortical Brain-Computer Interface by Individuals With Tetraplegia' (2021) IEEE Transactions on Biomedical Engineering 1; Choong Yeon Kim and others, 'Soft Subdermal Implant Capable of Wireless Battery Charging and Programmable Controls for Applications in Optogenetics' (2021) 12 Nature Communications 535; Yaoyao Jia and others, 'A Trimodal Wireless Implantable Neural Interface System-on-Chip' (2020) 14 IEEE Transactions on Biomedical Circuits and Systems 1207.
[174] OECD (n 14).
[175] Lavazza (n 99).

command. By developing these principles and ensuring developers adhere to them, the possibility of infringements is drastically reducible. Furthermore, it means that governments are fulfilling their positive obligation under the ECHR to protect users – as much as possible – from manipulation.

4.4.2 New right of mental autonomy

The origin of this thesis's research topic can be traced back to calls from neuroscientists that the current human rights are insufficient regarding the risks posed by BCI's. Therefore, some authors proposed the creation of new neurorights to protect against these new risks. As is now clear, the human rights in the ECHR are, in their current form, indeed insufficient. However, a set of entirely new rights, such as the four neurorights proposed by Ienca is unnecessary.[176] That is because, as discussed in the next section, our current rights merely need a reconceptualised scope. Nevertheless, it is interesting to propose a single new right: the right to mental autonomy. This right should be absolute because it contains all three components that are necessary to be deemed an autonomous being, i.e. mental integrity, mental privacy and agency. The formulated definition in chapter 3 could be a starting point for the formulation of such a right.

4.4.3 Reconceptualising article 9 ECHR

With the normative outlook of this thesis that mental autonomy should be inviolable, the best current solution is to reconceptualise article 9 ECHR. Much was said about considerations for classifying mental autonomy, or its components, as absolute. While art. 3(1) CFR certainly is an option for protecting mental integrity, time will tell to what extent the other components of mental autonomy fall under its scope as well. Therefore, if interferences are to be deemed unjustifiable, art. 9 is the only realistic option. This argument is also supported by human rights lawyer Alegre who champions practical relevance of the article.[177] If the Court establishes that all thoughts matter (at least until actual differentiation in recorded 'thoughts' is possible) and the whole forum internum must be protected, it will likely do so under that article. To do that, it only needs to broaden its interpretation of what a thought entails and let go of the high threshold formulated in *İzzettin Doğan and others v Turkey* for thoughts it uses now. That threshold should be low enough so that it encompasses all thoughts, save the most trivial ones, for now. Since there has not yet been a case where the Court considered the possibility of a violation of the forum internum regarding thoughts, a reinterpretation is not unlikely when such a case does present itself.

4.4.4 Different legal perspective regarding the mind-body problem

This last suggestion is relatively novel, and it is impossible to oversee the consequences it would have. Nevertheless, it is an interesting thought experiment. This chapter mentioned that the law adheres to the dualism perspective regarding the mind-body problem. That means that it regards mind and matter as separate. However, were the law to subscribe to monism, a whole new world opens up. If a monistic view is used, all cases relating to e.g. bodily harm, self-determination, and bodily autonomy are directly applicable to matters regarding the mind. Because mind and matter are then the same. While parallels have been drawn to the physical counterpart of the mind, having the case law directly apply to the mind would be revolutionary. However, it is impossible to foresee all possible implications such a radical paradigm shift would have. Therefore, for now, it remains a topic worth philosophising about.

[176] Ienca and Andorno (n 15).
[177] Alegre (n 90).

5 CONCLUSION AND RECOMMENDATIONS

5.1 Findings

BCI development happens at a breakneck pace. Consider the real-time decoding of a set of questions and answers, the ability for paralysed patients to regain sensory sensations or the control of prosthetics whose movements are almost indiscernible from physical limbs. While BCI's have the potential to alter our lives for the better, their use also comes with risk. To minimise or prevent these risks, the law must provide adequate safeguards. According to a group of, mainly but not limited to, neuroscientists, human rights currently fail to do so. This thesis was conducted in response to their calls. To that end, it aimed to determine whether current human rights sufficiently protect against the risks BCI's pose to mental autonomy, an essential part of what makes us human. By answering the research question, it filled the gap in the academic literature on whether human rights in their current form are indeed incapable of protecting mental autonomy or not.

First, it was established what a BCI exactly entails. This was crucial to determine the technological scope of the thesis. During the research, it became apparent that one particular development in the field deserved additional attention: automation. In particular, closed-loop DBS, where AI automatically detects and subsequently stimulates certain mental states or conditions. That stimulation was one of the two broad application categories, the other being monitoring. It was interesting to discover that, although their taxonomy seems complex, BCI's are reducible to mainly two application categories. It is worth mentioning that the thesis is limited with regards to automation. Because of constraints associated with a master's thesis, it was unfeasible to extensively discuss all facets of automation in BCI's.

After a rough typology of BCI's was established, it was imperative to determine what mental autonomy, as part of freedom of thought, actually is. Because, despite its significance throughout the thesis, the concept is ambiguous. Even the general term 'autonomy' has vastly different meanings. Furthermore, the literature review showed that authors use many different terms while generally describing the same underlying concept. Thus, chapter 3 served to formulate a definition of mental autonomy by looking behind the semantic curtain. It showed that mental autonomy relates to two of the three parts that constitute freedom of thought. Although the remaining part was left out of the thesis, further research could be interesting to determine to what extent one can be penalised for having certain thoughts. Then, the research culminated in the formulation of a new definition, namely: *Mental autonomy arises from the specific ability to freely control one's own mental functions through congruence between the intended and resulting action, so that, without his explicit consent, no one can alter or manipulate his mental states*. This definition can serve as a more grounded, centralised foundation for further research. Next, the research showed that mental autonomy, and its definition, are divisible into three underlying components, i.e. mental integrity, mental privacy and agency. This division was unexpected since, beforehand, there were no indications that mental autonomy, a part of freedom of thought, contained subparts itself.

Chapter 3 finished with risks to mental autonomy. These were split into 'expected' or 'unexpected' situations and are displayed in a schematic risk overview. One limitation was that some risks could be a topic for a more elaborate research as such, due to their many implications and consequences. E.g. the concept of brain-hacking. A limit was the unfeasibility of discussing this notion in-depth. Thus, brain-hacking and human rights could be interesting for further research. Another limitation related to the above was the impossibility of exhaustively mentioning all risks. However, this limitation was overcome because an exhaustive list of risks was unnecessary for analysis in the next chapter since a representative group of risks was enough to determine whether the ECHR provides enough protection against them.

While chapters 2 and 3 were more descriptive, the final substantive chapter contained the actual analysis. A note on the mind-body problem was necessary to justify the parallels drawn to physical counterparts (e.g. bodily integrity) of the mind in the analysis. One interesting observation was that the law takes a dualistic stance in the mind-body debate. It regards the mind as an entity separate from the body and thus inviolable. However, research showed that this view is outdated. The very fact that this thesis was necessary to determine if human rights protect against the *influence* of *physical* technology on *mental* autonomy shows that the 'mind' *can* be affected by matter, at least to some extent.

First, the Court's interpretation of mental integrity was discussed. This concept refers to the preservation of the intactness of the mind. If mental integrity is to be protected, it must guard BCI users from manipulations/unintended alterations and allow users to freely control their own mental functions. Art. 3(1) CFR was discussed because that article *directly* refers to mental integrity; a unique first occurrence. Although its practical relevance is not yet demonstrated, it was an important article to show that legislators value the concept. While the EU drafted the CFR, it has a symbiotic relationship with the ECHR from the CoE. Thus, were the article to be invoked in a case, it stands to reason that the ECtHR adopt a similar interpretation regarding the concept.

The earliest mention of physical and moral integrity was observed in *X and Y v. Netherlands.* In that case, the Court also noted that the State has a positive obligation, besides a negative one, to guarantee the effective protection of the right. In the context of this thesis, it means States need to take measures to protect mental integrity. Another case, *Tysiac v. Poland*, showed the broad interpretation the Court gives to art. 8 ECHR. After that, the analysis of two cases resulted in the finding that the ECtHR considers integrity and autonomy to be intertwined, requiring protection under art. 8.[178] After that, multiple cases displayed what the Court might regard as 'psychological' (roughly the same as mental) integrity. The interim conclusion was that mental integrity falls under the scope of art. 8. However, as mental autonomy seeks to protect the forum internum unconditionally, that article was problematic as the analysis of art. 8(2) ECHR shows that States can legitimately infringe on their citizens' right to private life. This was especially problematic for the potential of state surveillance through a tapped BCI. Hence, mental integrity is inadequately protected by the ECHR since it requires absolute protection. However, the thesis added guidance on a reinterpretation of art. 8 ECHR in case public debate pointed toward a need for mental integrity to be relative, e.g. in matters of public security. Then, the thesis could retroactively regard mental as *adequately* protected by the ECHR.

Regarding mental privacy, the ability to determine to what extent information about our thoughts is shared, the findings echoed much of the findings on mental integrity. One addition compared to mental integrity was the extensive consideration of brain-reading. If brain-reading reveals sensitive thoughts that reach the high threshold of thoughts formulated in *İzzettin Doğan and others v. Turkey*, they fall under art. 9 ECHR already. However, since actual brain-reading is not yet possible, all 'thoughts' or brain data should fall under art. 9 for now. To accomplish this, the ECtHR must release its high threshold of thoughts. However, whether they will do so remains to be seen.

Finally, mental agency and informed consent were analysed. Referencing studies that proved the current ability of brain-hacking, the concept was extensively discussed. Because even interfering with the correct functioning of a BCI can have grave consequences for the user. Furthermore, such interferences affect the capacity of an agent to act in the way that he wants. On the non-malicious but nonetheless impactful side, there was the situation of closed-loop DBS. By taking over (a part of) the decision-making of the user, his agency is violated.

[178] Pretty v the United Kingdom App no 2346/02 (ECtHR, 29 April 2002); Jehovah's Witnesses of Moscow and others v Russia App no 302/02 (ECtHR, 10 June 2010).

However, that violation is justifiable through free and informed consent. As became clear through the research, informed consent might justify certain infringements on the agency, privacy or integrity of the user, but it requires that their treating specialist informs her of all the potential risks. As it turned out, that is very unlikely. Since there is a positive obligation, following from case law, on States to safeguard the freedom of thought of its citizens, States are obliged to e.g. draft legislation and establish procedures to determine when that right has been breached. Because that is not yet the case and considering the above, agency is also not (fully) protected under the ECHR, which means the ECHR inadequately protects all three components. Hence the final conclusion that the ECHR does not, in its current form, sufficiently protect against the risks BCI's pose to mental autonomy.

5.2 Recommendations

The recommendations were given in the previous chapter under section 4.4. They consist of four suggestions that can be used together or separately to ensure that the ECHR adequately protects mental autonomy. Those suggestions are drafting ethical and technical principles, creating a new right to mental autonomy, reconceptualisation of art. 9 ECHR, and finally, a shift in legal perspective regarding the mind-body problem.

6 BIBLIOGRAPHY

Agich G, 'Key Concepts: Autonomy' (2009) 1 Philosophy, Psychiatry & Psychology 267

Alegre S, 'Rethinking Freedom of Thought for the 21st Century' (2017) 13

Anderson AJ and others, 'Predicting Neural Activity Patterns Associated with Sentences Using a Neurobiologically Motivated Model of Semantic Representation' (2017) 27 Cerebral Cortex 4379

Arstila V and Scott F, 'Brain Reading and Mental Privacy' (2011) 156560 Trames Journal of the Humanities and Social Sciences 204

Baylis F, '"I Am Who I Am": On the Perceived Threats to Personal Identity from Deep Brain Stimulation' (2013) 6 Neuroethics 513

Berger H, 'Über das Elektrenkephalogramm des Menschen' (1929) 87 Archiv für Psychiatrie und Nervenkrankheiten 527

'Brain–Computer Interfaces: Principles and Practice - Oxford Scholarship' <https://oxford-universitypressscholarship-com.tilburguniversity.idm.oclc.org/view/10.1093/acprof:oso/9780195388855.001.0001/acprof-9780195388855> accessed 7 February 2021

Brenninkmeijer J, 'Brainwaves and Psyches: A Genealogy of an Extended Self' (2015) 28 History of the Human Sciences 115

Bublitz C, 'My Mind Is Mine!? Cognitive Liberty as a Legal Concept', vol 1 (2013)

Bublitz C and Merkel R, 'On Crimes Against Minds: On Mental Manipulations, Harms and a Human Right to Mental Self-Determination' (2014)

Bublitz JC, 'Freedom of Thought in the Age of Neuroscience: A Plea and a Proposal for the Renaissance of a Forgotten Fundamental Right' (2014) 100 ARSP: Archiv für Rechts- und Sozialphilosophie / Archives for Philosophy of Law and Social Philosophy 1

Bublitz JC, 'The Nascent Right to Psychological Integrity and Mental Self-Determination' in Andreas von Arnauld, Kerstin von der Decken and Mart Susi (eds), *The Cambridge Handbook of New Human Rights* (1st edn, Cambridge University Press 2020) <https://www.cambridge.org/core/product/identifier/9781108676106%23CN-bp-30/type/book_part> accessed 7 February 2021

Buelens W, Herijgers C and Illegems S, 'The View of the European Court of Human Rights on Competent Patients' Right of Informed Consent. Research in the Light of Articles 3 and 8 of the European Convention on Human Rights' (2016) 23 European Journal of Health Law 481

Chaudhary U, Mrachacz-Kersting N and Birbaumer N, 'Neuropsychological and Neurophysiological Aspects of Brain-Computer-Interface (BCI) Control in Paralysis' (2020) The Journal of Physiology <https://physoc.onlinelibrary.wiley.com/doi/abs/10.1113/JP278775> accessed 20 January 2021

Christman J, 'Autonomy in Moral and Political Philosophy' <https://plato.stanford.edu/archives/fall2020/entries/autonomy-moral/#ConAut> accessed 7 March 2021

Clausen J, 'Conceptual and Ethical Issues with Brain–Hardware Interfaces' (2011) 24 Current Opinion in Psychiatry 495

Collinger JL and others, '7 Degree-of-Freedom Neuroprosthetic Control by an Individual with Tetraplegia' (2013) 381 Lancet 557

Cottingham J and Descartes R (eds), 'On Meditation Six', *Descartes: Meditations on First Philosophy: With Selections from the Objections and Replies* (Cambridge University Press 1996) <https://www.cambridge.org/core/books/descartes-meditations-on-first-philosophy/on-meditation-six/FACFBBB88874C0F3230E0ED081F25DA0> accessed 17 May 2021

'Creating Fuel from Thin Air with Artificial Leaves' *BBC News* (12 October 2020) <https://www.bbc.com/news/business-54390932> accessed 14 May 2021

Descartes R, *Principia Philosophiae* (Ludovicum Elzevirium 1644)

Deshpande G and others, 'A New Generation of Brain-Computer Interfaces Driven by Discovery of Latent EEG-FMRI Linkages Using Tensor Decomposition' (2017) 11 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2017.00246/full> accessed 5 February 2021

Drew L, 'The Ethics of Brain–Computer Interfaces' (2019) 571 Nature S19

'EEG Sensors - EEG Headsets | NeuroSky' <http://neurosky.com/biosensors/eeg-sensor/biosensors/> accessed 5 February 2021

'EMOTIV EPOC X - 14 Channel Wireless EEG Headset | EMOTIV' <https://www.emotiv.com/epoc-x/> accessed 5 February 2021

Farahany NA, 'Incriminating Thoughts' (2012) 64 Stanford Law Review 351

Farwell L and Donchin E, 'Talking off the Top of Your Head: A Mental Prosthesis Utilizing Event-Related Brain Potentials' (1988) 70 Electroencephalography Clinical. Neurophysiolgy 510

Friedrich O and others, 'An Analysis of the Impact of Brain-Computer Interfaces on Autonomy' (2018) Neuroethics <https://doi.org/10.1007/s12152-018-9364-9> accessed 5 February 2021

Glannon W, 'Stimulating Brains, Altering Minds' (2009) 35 Journal of Medical Ethics 289

Goering S and others, 'Staying in the Loop: Relational Agency and Identity in Next-Generation DBS for Psychiatry' (2017) 8 AJOB Neuroscience 59

Gómez-Vírseda C, de Maeseneer Y and Gastmans C, 'Relational Autonomy: What Does It Mean and How Is It Used in End-of-Life Care? A Systematic Review of Argument-Based Ethics Literature' (2019) 20 BMC Medical Ethics 76

Gordleeva S and others, ‘Exoskeleton Control System Based on Motor-Imaginary Brain–Computer Interface’ (2017) 9 Sovremennye tehnologii v medicine 31

Grady C, ‘Enduring and Emerging Challenges of Informed Consent’ (2015) 372 New England Journal of Medicine 855

Halliburton CM, ‘How Privacy Killed Katz: A Tale of Cognitive Freedom and the Property of Personhood as Fourth Amendment Norm’ (2009) 42 Akron Law Review 83

Haselager P, ‘Did I Do That? Brain–Computer Interfacing and the Sense of Agency’ (2013) 23 Minds and Machines 405

Hong K-S and Khan MJ, ‘Hybrid Brain–Computer Interface Techniques for Improved Classification Accuracy and Increased Number of Commands: A Review’ (2017) 11 Frontiers in Neurorobotics <https://www.frontiersin.org/articles/10.3389/fnbot.2017.00035/full> accessed 6 February 2021

Ienca M and Andorno R, ‘Towards New Human Rights in the Age of Neuroscience and Neurotechnology’ (2017) 13 Life Sciences, Society and Policy 5

Ienca M and Haselager P, ‘Hacking the Brain: Brain–Computer Interfacing Technology and the Ethics of Neurosecurity’ (2016) 18 Ethics and Information Technology 117

‘Imagining a New Interface: Hands-Free Communication without Saying a Word’ (*Facebook Technology*, 30 March 2020) <https://tech.fb.com/imagining-a-new-interface-hands-free-communication-without-saying-a-word/> accessed 2 September 2020

‘Interfacing with the Brain’ (*Neuralink*) <https://neuralink.com/approach/> accessed 20 January 2021

Irish Human Rights Commission, *European Convention on Human Rights Guide for the Civil & Public Service* (2012)

Jia Y and others, ‘A Trimodal Wireless Implantable Neural Interface System-on-Chip’ (2020) 14 IEEE Transactions on Biomedical Circuits and Systems 1207

Johnson R and Cureton A, ‘Kant’s Moral Philosophy’ in Edward N Zalta (ed), *The Stanford Encyclopedia of Philosophy* (Spring 2021, Metaphysics Research Lab, Stanford University 2021) <https://plato.stanford.edu/archives/spr2021/entries/kant-moral/> accessed 9 April 2021

Katona J and Kővári A, ‘Examining the Learning Efficiency by a Brain-Computer Interface System’ (2018) 15 Acta Polytechnica Hungarica

Kellmeyer P and others, ‘The Effects of Closed-Loop Medical Devices on the Autonomy and Accountability of Persons and Systems’ (2016) 25 Cambridge Quarterly of Healthcare Ethics 623

Kiener M, ‘Artificial Intelligence in Medicine and the Disclosure of Risks’ (2020) AI & SOCIETY <https://doi.org/10.1007/s00146-020-01085-w> accessed 29 April 2021

Kim CY and others, ‘Soft Subdermal Implant Capable of Wireless Battery Charging and Programmable Controls for Applications in Optogenetics’ (2021) 12 Nature Communications 535

Kimberley TJ and Lewis SM, ‘Understanding Neuroimaging’ (2007) 87 Physical Therapy 670

Klein E and Ojemann J, ‘Informed Consent in Implantable BCI Research: Identification of Research Risks and Recommendations for Development of Best Practices’ (2016) 13 Journal of Neural Engineering 043001

Kögel J, Jox RJ and Friedrich O, ‘What Is It like to Use a BCI? – Insights from an Interview Study with Brain-Computer Interface Users’ (2020) 21 BMC Medical Ethics 2

Kuo C-C and others, ‘Non-Invasive BCI for the Decoding of Intended Arm Reaching Movement in Prosthetic Limb Control’ (2012) 2 American Journal of Biomedical Engineering 155

Lavazza A, ‘Freedom of Thought and Mental Integrity: The Moral Requirements for Any Neural Prosthesis’ (2018) 12 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2018.00082/full> accessed 25 January 2021

Leary T, *The Politics of Ecstasy* (4th edition, Ronin Publishing 1998)

Lebedev MA and Nicolelis MAL, ‘Brain–Machine Interfaces: Past, Present and Future’ (2006) 29 Trends in Neurosciences 536

Lee DWH and Lai PBS, ‘Risk Disclosure and Informed Consent: Practice Caveats in the Post Montgomery Era’ (2020) 24 Surgical Practice 75

Leenes R, ‘Regulating New Technologies in Times of Change’ in Leonie Reins (ed), *Regulating New Technologies in Uncertain Times* (TMC Asser Press 2019) <https://doi.org/10.1007/978-94-6265-279-8_1> accessed 15 May 2021

Ligthart S, ‘Freedom of Thought in Europe: Do Advances in “Brain-Reading” Technology Call for Revision?’ (2020) Journal of Law and the Biosciences <https://doi.org/10.1093/jlb/lsaa048> accessed 20 February 2021

Ligthart S and others, ‘Forensic Brain-Reading and Mental Privacy in European Human Rights Law: Foundations and Challenges’ (2020) Neuroethics <https://doi.org/10.1007/s12152-020-09438-4> accessed 8 March 2021

Lotte F, Nam CS and Nijholt A, *Introduction: Evolution of Brain-Computer Interfaces* (Taylor & Francis (CRC Press) 2018) <https://hal.inria.fr/hal-01656743> accessed 19 January 2021

Magazanik LS, ‘The Ethical and Legal Implications of Brain-Computer Interfaces’ (*CTECH - www.calcalistech.com*, 24 May 2019) <https://www.calcalistech.com/ctech/articles/0,7340,L-3762798,00.html> accessed 3 September 2020

Mak JN and Wolpaw JR, ‘Clinical Applications of Brain-Computer Interfaces: Current State and Future Prospects’ (2009) 2 IEEE reviews in biomedical engineering 187

‘Mars One’ (*Mars One*) <http://www.mars-one.com/> accessed 14 May 2021

Martinovic I and others, ‘On the Feasibility of Side-Channel Attacks with Brain-Computer Interfaces’ (USENIX 2012)

Martins NRB and others, ‘Human Brain/Cloud Interface’ (2019) 13 Frontiers in Neuroscience <https://www.frontiersin.org/articles/10.3389/fnins.2019.00112/full> accessed 7 February 2021

Masud U and others, ‘A P300 Brain Computer Interface Based Intelligent Home Control System Using a Random Forest Classifier’, *2017 IEEE Symposium Series on Computational Intelligence (SSCI)* (2017)

Matthews E, ‘Autonomy and the Psychiatric Patient’ (2000) 17 Journal of Applied Philosophy 59

Maynard J, ‘NASA Offers $2.25 Million For Martian Habitat Design - How Could This Contest Help People On Earth?’ (*Tech Times,* 19 May 2015) <https://www.techtimes.com/articles/54113/20150519/know-design-3d-printed-habitat-mars-nasa-2-25-million.htm> accessed 14 May 2021

McCarthy-Jones S, ‘The Autonomous Mind: The Right to Freedom of Thought in the Twenty-First Century’ (2019) 2 Frontiers in Artificial Intelligence <https://www.frontiersin.org/articles/10.3389/frai.2019.00019/full> accessed 25 January 2021

Meng J and others, ‘Noninvasive Electroencephalogram Based Control of a Robotic Arm for Reach and Grasp Tasks’ (2016) 6 Scientific Reports 38565

‘Mental | Origin and Meaning of Mental by Online Etymology Dictionary’ <https://www.etymonline.com/word/mental> accessed 7 March 2021

Metzinger TK, ‘The Myth of Cognitive Agency: Subpersonal Thinking as a Cyclically Recurring Loss of Mental Autonomy’ (2013) 4 Frontiers in Psychology <https://www.frontiersin.org/articles/10.3389/fpsyg.2013.00931/full> accessed 11 November 2020

Moses DA and others, ‘Real-Time Decoding of Question-and-Answer Speech Dialogue Using Human Cortical Activity’ (2019) 10 Nature Communications 3096

Mudgal SK and others, ‘Brain Computer Interface Advancement in Neurosciences: Applications and Issues’ (2020) 20 Interdisciplinary Neurosurgery 100694

Nehiwal J and others, ‘Nuclear Fusion: Energy of Future’ in Mohammad Shorif Uddin and others (eds), *Intelligent Energy Management Technologies* (Springer 2021)

Neumann W-J and others, ‘Toward Electrophysiology-Based Intelligent Adaptive Deep Brain Stimulation for Movement Disorders’ (2019) 16 Neurotherapeutics: The Journal of the American Society for Experimental NeuroTherapeutics 105

‘Neuralink: Elon Musk Unveils Pig with Chip in Its Brain - BBC News’ <https://www.bbc.com/news/world-us-canada-53956683> accessed 4 September 2020

Nicolas-Alonso LF and Gomez-Gil J, 'Brain Computer Interfaces, a Review' (2012) 12 Sensors (Basel, Switzerland) 1211

Norman SL and others, 'Single-Trial Decoding of Movement Intentions Using Functional Ultrasound Neuroimaging' (2021) 0 Neuron <https://www.cell.com/neuron/abstract/S0896-6273(21)00151-3> accessed 30 April 2021

OECD, 'Recommendation on Responsible Innovation in Neurotechnology' (OECD) <https://www.oecd.org/science/recommendation-on-responsible-innovation-in-neurotechnology.htm> accessed 30 April 2021

Ordikhani-Seyedlar M and others, 'Neurofeedback Therapy for Enhancing Visual Attention: State-of-the-Art and Challenges' (2016) 10 Frontiers in Neuroscience

Ortiz-Catalan M, 'Ultrasound-Powered Tiny Neural Stimulators' (2020) 4 Nature Biomedical Engineering 144

Pandarinathan G and others, 'The Potential of Cognitive Neuroimaging: A Way Forward to the Mind-Machine Interface' (2018) 4 Journal of Imaging 70

Peers S and others, *The EU Charter of Fundamental Rights: A Commentary* (Bloomsbury Publishing 2014)

Regalado A, 'Elon Musk's Neuralink Is Neuroscience Theater' (*MIT Technology Review*) <https://www.technologyreview.com/2020/08/30/1007786/elon-musks-neuralink-demo-update-neuroscience-theater/> accessed 2 September 2020

Sagar R, '10 Mind Bending Applications Of Neuralink, According To The Team' (*Analytics India Magazine*, 30 August 2020) <https://analyticsindiamag.com/mind-bending-applications-neuralink-event/> accessed 14 May 2021

Schalk G and Leuthardt EC, 'Brain-Computer Interfaces Using Electrocorticographic Signals' (2011) 4 IEEE Reviews in Biomedical Engineering 140

Schlosser M, 'Agency' in Edward N Zalta (ed), *The Stanford Encyclopedia of Philosophy* (Winter 2019, Metaphysics Research Lab, Stanford University 2019) <https://plato.stanford.edu/archives/win2019/entries/agency/> accessed 30 April 2021

Sententia W, 'Neuroethical Considerations: Cognitive Liberty and Converging Technologies for Improving Human Cognition' (2004) 1013 Annals of the New York Academy of Sciences 221

Shen FX, 'Neuroscience, Mental Privacy, and the Law' (Social Science Research Network 2013) SSRN Scholarly Paper ID 2269078 <https://papers.ssrn.com/abstract=2269078> accessed 16 May 2021

Simeral JD and others, 'Home Use of a Percutaneous Wireless Intracortical Brain-Computer Interface by Individuals With Tetraplegia' (2021) IEEE Transactions on Biomedical Engineering 1

Steinert S and others, 'Doing Things with Thoughts: Brain-Computer Interfaces and Disembodied Agency' (2019) 32 Philosophy & Technology 457

Steinert S and Friedrich O, ‘Wired Emotions: Ethical Issues of Affective Brain–Computer Interfaces’ (2020) 26 Science and Engineering Ethics 351

Thompson K, ‘Committing Crimes with BCIs: How Brain-Computer Interface Users Can Satisfy Actus Reus and Be Criminally Responsible’ (2019) Neuroethics <https://doi.org/10.1007/s12152-019-09416-5> accessed 24 April 2021

Tully J and others, ‘Connected Medical Technology & Cybersecurity Informed Consent - A New Paradigm (Preprint)’ (2019) 22 Journal of Medical Internet Research

U. S. Government Accountability Office, ‘Medical Devices: FDA Should Expand Its Consideration of Information Security for Certain Types of Devices’ (U S Government Accountability Office 2012) <https://www.gao.gov/products/gao-12-816> accessed 29 April 2021

Van Dijk P and others (eds), ‘Theory and Practice of the European Convention on Human Rights, 5th Edition’, *Theory and Practice of the European Convention on Human Rights, 5th edition* (5th edn, Intersentia 2018) <https://intersentia.com/en/theory-and-practice-of-the-european-convention-on-human-rights-5th-edition-paperback.html> accessed 5 March 2021

Vansteensel MJ and others, ‘Fully Implanted Brain–Computer Interface in a Locked-In Patient with ALS’ (2016) 375 The New England journal of medicine 2060

Vidal JJ, ‘Toward Direct Brain-Computer Communication’ (1973) 2 Annual Review of Biophysics and Bioengineering 157

Volkova K and others, ‘Decoding Movement From Electrocorticographic Activity: A Review’ (2019) 13 Frontiers in Neuroinformatics <https://www.frontiersin.org/articles/10.3389/fninf.2019.00074/full> accessed 20 January 2021

Westin AF, ‘Privacy And Freedom’ (1968) 25 6

Whitman Cobb W, ‘Space Tourism Is Here – 20 Years after the First Stellar Tourist, Jeff Bezos’ Blue Origin Plans to Send Civilians to Space’ (*The Conversation*) <http://theconversation.com/space-tourism-is-here-20-years-after-the-first-stellar-tourist-jeff-bezos-blue-origin-plans-to-send-civilians-to-space-160510> accessed 14 May 2021

Wolpe PR, ‘Is My Mind Mine? Neuroethics and Brain Imaging’, *The Penn Center Guide to Bioethics* (Springer Publishing Co 2009) <https://repository.library.georgetown.edu/handle/10822/953170> accessed 24 April 2021

Yeremyan L and Harutyunyan D, ‘Freedom Of Thought Endangered In The 21st Century? Legal Protection From Manipulation | WISDOM’ <https://www.wisdomperiodical.com/index.php/wisdom/article/view/310> accessed 20 February 2021

Yuste R and others, ‘Four Ethical Priorities for Neurotechnologies and AI’ (2017) 551 Nature News 159

Axel Springer AG v Germany App no 39954/08 (ECtHR, 7 February 2012)

Bensaid v the United Kingdom App no 44599/98 (ECtHR, 6 February 2001)

Csoma v Romania App no 8759/05 (ECtHR, 15 January 2013)

Eweida & Others v United Kingdom App no 48420/10, 59842/10, 51671/10 and 36516/10 (ECtHR, 15 January 2013)

Georgian Labour Party v Georgia App no 9103/04 (ECtHR, 8 July 2008)

İzzettin Doğan and others v Turkey App no 62649/10 (ECtHR, 26 April 2016)

Jalloh v Germany App no 54810/00 (ECtHR, 11 July 2006)

Jehovah's Witnesses of Moscow and others v Russia App no 302/02 (ECtHR, 10 June 2010)

Karakó v Hungary App no 39311/05 (ECtHR, 28 April 2009)

Klass and others v Germany App no 5029/71 (ECtHR, 6 September 1978)

Kokkinakis v. Greece App. 14307/88 (ECtHR, 25 May 1993

Kruslin v France App no 11801/85 (ECtHR, 24 April 1990)

Malone v The United Kingdom (Article 50) App no 8691/79 (ECtHR, 26 April 1985)

Pretty v the United Kingdom App no 2346/02 (ECtHR, 29 April 2002)

Roman Zakharov v Russia App no 47143/06 (ECtHR, 4 December 2015)

Russian Conservative Party of Entrepreneurs and others v Russia App no 55066/00 and 55638/00 (ECtHR, 11 January 2007)

Trocellier v France App no 75725/01 (ECtHR, 5 October 2006)

Tysiąc v Poland App no 5410/03 (ECtHR, 20 March 2007)

Valenzuela Contreras v Spain App no 27671/95 (ECtHR, 30 July 1998)

VC v Slovakia App no 18968/07 (ECtHR, 8 November 2011)

Vo v France App no 53924/00 (ECtHR, 8 July 2004)

X and Y v the Netherlands App no 8978/80 (ECtHR, 26 March 1985)