The London School of Economics and Political Science

Why (not) enhance the brain?
A mixed-methods exploration of the acceptability and desirability of neuroenhancement

Imre Bárd

A thesis submitted to the Department of Methodology of the London School of Economics and Political Science for the degree of Doctor of Philosophy, London, January 2023

Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

I declare that my thesis consists of 68 135 words.

Statement of co-authored work

Chapter 3: The survey described in the chapter was co-designed with a team of researchers engaged in the NERRI project. My supervisor, Prof George Gaskell and I took a leading role in the survey's conceptualisation. I was responsible for the survey design, its implementation, and data analysis.

Chapter 6: The concept for this study was developed together with Carl H. Smith and Lesley Ann Daly. The interview topic guide was developed together with Lesley Ann Daly, who also conducted 9 of the 36 interviews. I conducted the rest of the interviews, performed transcription, thematic analysis and wrote 100% of the chapter.

Signed:

Imre Bard
31 January 2023

ACKNOWLEDGEMENTS

Over the course of this PhD, I had lost a parent, became a parent myself, and learned first-hand what it's like to be a medical cyborg by necessity. Turbulent years indeed. Birthing this document has taken far longer than I – or anyone else - would ever have dared to imagine but I am immensely grateful for all the support and kindness I have received along the way.

First and foremost, I extend my endless gratitude to my Mom, and to my partner in life, Izabella. Without their unwavering love and support, I would most certainly be nowhere. Alice, I hope you will not be too embarrassed, should you ever come to read this work when you grow up.

I am also grateful to Prof Peter Reiner, who has become a mentor to me not only in academia but on how one should aspire to lead a meaningful life.

I also want to give a nod of appreciation to fellow travellers Martin Dinov, Lesley-Ann Daly, and Carlos Sainz Martinez. I owe a lot to the considerate support of Dr Louise Hickman and Prof Alison Powell.

Thank you to all my former colleagues on the NERRI project, and to my interviewees who volunteered their time to share their thoughts and perspectives with me.

I also want to thank my examiners, Prof Martin Bauer and Prof Steve Fuller for their careful, detailed and thoughtful reading of my thesis and for their supportive suggestions on improving it.

Finally, I would like to say thank you to my supervisors, Prof George Gaskell, for his caring support and who so perfectly modelled the art of being an *undisciplined* social scientist, and to Dr Flora Cornish and Prof Patrick Sturgis, for their patient guidance, especially during the last 100 yards of this unusually long journey.

ABSTRACT

Neuroenhancement, the prospect of enhancing mental and cognitive capacities, raises important ethical questions that have been widely debated in academic and public spheres. However, little is known about how values shape people's attitudes towards this phenomenon, and how these attitudes vary across contexts and countries. This thesis addresses this gap by using a mixed-methods approach to empirically investigate the views of the public in five countries: Austria, Germany, Hungary, the United Kingdom, and the United States, and the perspectives of neuroenhancement users. The thesis consists of three main empirical studies.

The first study analyses data from a representative multi-national survey that included two contrastive vignette experiments and a series of attitude questions. The study identifies two value orientations – the Societal-Restrictive and the Individual-Permissive stances – that underpin people's views on neuroenhancement. The study also reveals the diversity and complexity of reasoning about neuroenhancement among different segments of the public, using cluster analysis methods and open-ended qualitative survey responses.

The second empirical component of the work is an exploratory micro-study of a UK brain hacker collective. The findings highlight the heterogeneity of personal motivations for involvement in brain hacking. This work reveals that in contrast to the productivity-oriented pursuit of pharmacological neuroenhancement, brain hackers pursue a wider range of goals and are motivated by broader, more ambitious values.

The third empirical chapter is based on repeat interviews conducted with users of a sensory augmentation device. It offers insights into the Proactionary Milieu, which is characterized by a culture of openness to risk, innovation, and self-experimentation in pursuit of a vision of voluntary cyborgisation and enhancement. The study tracks user experiences over time, uncovering motivations, experiences, and reflections on the successes and failures of the practical pursuit of transhumanism.

The thesis argues that public attitudes towards neuroenhancement are not monolithic, but rather reflect the interplay of personal and social values and goals, as well as moral and practical considerations.

TABLE OF CONTENTS

FIGURES AND TABLES **8**

INTRODUCTION **10**

Stumbling on Transhumanism *10*
Overview of thesis *12*

PART I – SETTING THE SCENE **14**

CHAPTER 1 – A REVIEW OF THE LITERATURE 15
What is Neuroenhancement? *15*
How did Neuroenhancement Become 'A Thing'? *19*
An Overview of Neuroenhancers *25*
Public Attitudes to Neuroenhancement *33*
Conceptual Framework *36*
CHAPTER 2 – METHODS AND METHODOLOGY 40
The NERRI Project *40*
On RRI and Public Engagement with Neuroenhancement *41*
Operationalising the Concept of Mobilisation and Mutual Learning *44*
From Public Dialogue to Public Ethics – Thesis Part II *46*
Qualitative Exploration of the Proactionary Milieu – Thesis Part III *56*

PART II – NEUROENHANCEMENT AND THE PUBLIC **61**

CHAPTER 3 – NEUROENHANCEMENT IN NATIONAL DISCUSSIONS 62
What's in a name? *62*
The Evolution of Media Coverage on Neuroenhancement *63*
Policy activity on Neuroenhancement *67*
Summary *70*
CHAPTER 4 – POINTS OF VIEW ON NEUROENHANCEMENT 71
Education & Employment Experiments *72*
Reasoning about neuroenhancement *82*
Interim conclusions *92*
Claims about Neuroenhancement *93*
From claims to value orientations *94*
Binocular Values *95*
Considering value scales in the context of the experiments *96*
Deriving points of view via cluster analysis *99*
Arguments by cluster *106*
Bridging investigations *111*

PART III – PROACTIONARY MILIEUS **113**

CHAPTER 5. BRAIN HACKERS AN EXPLORATORY ACCOUNT OF THE PRACTICE OF DO-IT-YOURSELF BRAIN STIMULATION 114
The Emergence of Brain Hacking *114*
Interviewees *116*
Science and brain hacking *121*
Brain stimulation practices *122*
Smart drugs vs brain stimulation *122*
Ethics and enhancement *123*
CHAPTER 6. "I WANT TO BE A CYBORG" A STUDY OF VOLUNTARY CYBORGISATION 125
We are all cyborgs *125*
Cyborg Nest Ltd., and its Founders *127*
The North Sense *128*
How did users find out about the North Sense? *129*

Motivations – Why did users decide to purchase the device? ... *130*
Concerns – What worries did users have about the device? ... *133*
How have others responded to the North Sense? ... *134*
Effects – What is the North Sense experience like? ... *135*
Experimentation and the Freedom to Choose ... *138*
Vision meets reality ... *139*
CHAPTER 7 - CONCLUSION ... 141
Are there points of view on neuroenhancement? ... *141*
The Proactionary Milieu ... *144*

BIBLIOGRAPHY ... **149**

APPENDIX A ... **186**

APPENDIX A1. CODING FRAME WITH EXAMPLE COMMENTS. ... 186
APPENDIX A2 - COUNTRY LEVEL REGRESSION ANALYSES ACROSS EDUCATION AND EMPLOYMENT CONTEXTS ... 190
APPENDIX A3. CONDITIONAL DISTRIBUTION OF CODES BY COUNTRY IN THE EDUCATION CONTEXT. ... 231
APPENDIX A4. CONDITIONAL DISTRIBUTION OF CODES BY COUNTRY IN THE EMPLOYMENT CONTEXT. ... 233
APPENDIX A5. PROPORTION OF ARGUMENTS IN EACH CLUSTER, SORTED IN DESCENDING ORDER OF OVERALL FREQUENCY. EDUCATION CONTEXT. ... 235
APPENDIX A6. PROPORTION OF ARGUMENTS IN EACH CLUSTER, SORTED IN DESCENDING ORDER OF OVERALL FREQUENCY. EMPLOYMENT CONTEXT. ... 237

APPENDIX B ... **239**

APPENDIX B1. BRAIN HACKERS – INTERVIEW TOPIC GUIDE ... 239
APPENDIX B2. BRAIN HACKERS INTERVIEWS ... 240
Nik ... *240*
Thomas ... *260*
Ray ... *271*

APPENDIX C ... **288**

APPENDIX C1. NORTH SENSE INTERVIEW TOPIC GUIDE ... 288
APPENDIX C2. NORTH SENSE - PARTICIPANT INFORMATION ... 290
APPENDIX C3. NORTH SENSE INTERVIEW SAMPLE - PT02 ... 291

FIGURES AND TABLES

Box 1. Education and Employment Vignettes – English language versions.
Box 2. Claims about neuroenhancement.

Figure 1. Schematic representation of NERRI survey flow.
Figure 2. Elbow plot of k-means algorithm.
Figure 3. Press coverage of neuroenhancement between 2000-2021 expressed as a yearly percentage of total coverage.
Figure 4. Line chart of average values on *'Would you do the same?'* plotted by SR/IP scale category based on tertile split.
Figure 5. Clustered bar chart of the proportion of clusters in each country.

Table 1. Proportion of commenters and non-commenters from each country.
Table 2. Keywords used in news searches.
Table 3. Number of articles yielded by search, and number of articles retained after filtering.
Table 4. Education context regression coefficients of experimental manipulations on 5 response variables.
Table 5. Employment context regression coefficients of experimental manipulations on 5 response variables.
Table 6. Education context regression coefficients of experimental manipulations and demographic indicators on 5 response variables.
Table 7. Employment context regression coefficients of experimental manipulations and demographic indicators on 5 response variables.
Table 8. Distribution of codes by country for codes where proportions differed significantly across countries.
Table 9. Mean, standard deviation, and percentage in agreement with claims on neuroenhancement.
Table 10. Claims loading on societal restrictive and individual permissive components.
Table 11. Cross tabulation of support for Societal-Restrictive and Individual-Permissive values.
Table 12. Multiple linear regression coefficients with experimental factors and SR / IP scales as predictors.
Table 13. Mean, standard deviation, median and % in agreement with 14 claims on NE cross tabulated with cluster membership.
Table 14. Condition distribution of gender and cluster membership.
Table 15. Conditional distribution of cluster allocation by age group.
Table 16. Binary logistic regression of age group and allocation to the 'Anti' cluster.
Table 17. Conditional distribution of cluster allocation by nationality
Table 18. Mean and standard deviation of "Would you do the same?" experimental variable in education and employment contexts for each cluster.
Table 19. Codes above 3% frequency in each of the four clusters, sorted by descending frequency. Education context.
Table 20. Codes above 3% frequency in each of the four clusters, sorted by descending frequency. Employment context.

Image 1. The North Sense device. Copyright Cyborg Nest Ltd.

Introduction

Stumbling on Transhumanism
In the Summer of 2006, I was an undergraduate student in Philosophy at the University of Vienna. As I strolled the department hallways a few weeks before the summer holidays set in, I came across a large poster that featured an image of the android Maria from Fritz Lang's classic movie, *Metropolis (*Lang, 1927). The poster donned a bold caption which asked:

Is technology the future of human nature?

It was a call for essays on the 50th anniversary of the establishment of the Forschungszentrum Karlsruhe[1] a prominent German research centre that is also home to a leading technology assessment institute. The essay competition invited applicants to engage with questions concerning the relationship between humanity, nature, and technology and to investigate the meaning of our growing ability to use scientific advances to shape, mould and optimise ourselves, from antidepressants and plastic surgery to gene therapy and nanorobots.

In retrospect, it strikes me as a remarkable choice to use the android Maria as the visual representation of our possible future relationship with technology. Lang's movie is a classic about class struggle between deprived workers and powerful elites, where technology, in many guises, acts as an oppressive force. What were the organisers of the competition suggesting with this image? Did they seek to imply a vision of a future in which our technological advancements lead us to a point where we create machines nearly indistinguishable from ourselves, or perhaps that we may alter ourselves so significantly that we begin to resemble machines? Was there an allusion to how technology can function as a means of social control, perpetuating the interests of a small elite?

Until then, I had not engaged with questions concerning the Philosophy of Technology and my interests had been elsewhere, mainly in the Philosophy of History. I was fascinated by the thesis put forward by Karl Löwith that much of German Philosophy of History from the 18th and 19th-centuries was born out of two issues passed down from mediaeval Theology. On the one hand, from the eschatological orientation of history, and on the other, from the 'problem of evil', that is, from the theodicy question (Löwith, 2011). The eschatological interpretation of history views all events as leading up to a single, final event, which is thought to hold the key to understanding the meaning of history as a whole. The problem of evil concerns how an infinitely good God, as postulated by Christian Theology, can be reconciled with the apparent evil we confront in the world. In a sense, these questions are about the perennial challenge of articulating some conception of human freedom and purpose in the face of overwhelming evidence to the contrary.

[1] Since then it has been rebranded as the Karlsruhe Institute of Technology (KIT).

As I encountered the notions of human enhancement, and that of transhumanism in particular, I first viewed them against the background of this theoretical interest. In such a light, they seemed to embody a radical and, in many ways, utterly pragmatic response to abstract concerns articulated in the form of technological liberation and emancipation. Contrary to other figures in my Philosophy curriculum until then, transhumanists were not concerned with theoretically resolving, explaining, or justifying the existence of human limitations, pain, suffering, and death. They were not looking to chart a path of human flourishing *despite* human limitations, or to defend human freedom in the face of scientific naturalism. Instead, they sought to use technologies to transcend and abolish those limitations as quickly as possible. I was both appalled and completely amazed.

As I immersed myself in the topic, a new world of concepts, questions and perspectives opened. I was filled with the restless excitement of having stumbled upon something significant that was profoundly intellectually exciting. After all, it was about nothing less than the future of humanity, and somehow it all seemed imminent, just on the cusp of transforming everything. I encountered cyborgs, posthumans, the notion of the singularity, cryonics, and a host of other ideas. I worked frantically to meet the Karlsruhe essay competition's looming deadline as I tried to take in all I could find in the university library and online. I spent my nights listening to the archives of Changesurfer Radio, where techno-progressive sociologist James Hughes interviewed leading figures in the space and advocated for his version of a 'democratic transhumanism for a radically better future'. I was completely drawn in.

It would be an all too perfect conclusion to this brief introductory narrative if I could claim that my burgeoning exploration of human enhancement had also secured me the prize money that accompanied the essay competition. It did not, although the contribution was selected for inclusion in a curated volume of entries published several years later (Grunwald & Hartlieb, 2012). More importantly, that fortuitous encounter with a poster in the university hallway defined my subsequent interests and research career trajectory. It led me to pursue Cognitive Science, and Science and Technology Studies as my undergraduate specialisations. It led me to undertake a Master's degree in the social study of biomedicine, and to embark on this doctoral work.

Following my undergraduate dissertation in Philosophy, I felt the need to complement the theoretical perspective with a more empirical understanding of the realities of enhancement-related practices. Where was enhancement happening, and how? Thanks to a generous scholarship from the Austrian Federal Ministry of Science and Research, I could pursue an MSc at the LSE's BIOS Centre. At the LSE, I could get involved in empirical work looking at enhancement 'on the ground'. Gradually, my interest had shifted from trying to articulate a concise position about the rightness or wrongness of enhancement and critiquing the desirability of transhumanist visions of the future, towards the socially constructed meanings of enhancement in the present, and towards the ways in which people come to think and reason about it.

A pivotal moment along this transition occurred during my collaboration with Prof Ilina Singh, shortly after my Master's studies. In 2012 I was working with Prof Singh on an exploratory study of UK students' experiences with, and attitudes towards pharmacological cognitive enhancement. We developed an online survey to assess the practice's prevalence and to gauge students' views on its moral acceptability, and we also conducted a series of focus groups (Singh et al., 2014; Vagwala et al., 2017). The studies took place when mild, non-invasive electrical brain stimulation started to gather significant attention as a potentially safe and effective means of non-pharmacological cognitive enhancement (Fitz & Reiner, 2014). In order to gauge how students would respond to this technology, we had prepared a short description along with some images illustrating the use of electrical stimulation electrodes. We asked students in focus groups whether they saw any unique ethical concerns with using it, and whether they might be interested in trying the technology. This question was raised towards the end of each session when we had already discussed pharmacological enhancement in detail. It may have been an artefact of our research but a striking observation for me at the time was that several of our student respondents who had previously held seemingly principled objections against the practice of enhancement appeared open and interested once we swapped the method from psychostimulant pharmaceuticals to electrical brain stimulation. In other words, even if their previous arguments were not based on pragmatic considerations like safety or efficacy but on moral grounds, like cheating, the new technology seemingly overwrote those concerns. This was not a general pattern in our data, but I was deeply surprised by this encounter. In a way, it led me to the question concerning the factors that shape people's views of the moral acceptability and desirability of neuroenhancement, which forms the basis of this thesis.

Shortly after this work on smart drugs, I was fortunate to participate in developing a proposal for a multi-national EU project called *Neuroenhancement – Responsible Research and Innovation (NERRI)*. Once our consortium was awarded the grant, I contributed to the project's UK effort for over three years. Learning from and collaborating with colleagues from multiple countries and disciplines, and having my working days revolve around neuroenhancement was an invaluable experience that led to a greater appreciation of the phenomenon's richness and complexity. Parts of the present thesis draw directly on data gathered during the project, while other parts have been greatly enabled by my proximity to the field, which the NERRI project afforded.

Overview of thesis

The subsequent parts of the thesis are structured in the following way.

Part I sets the stage for this study by explicating the concept of neuroenhancement. It offers an account of the social phenomenon's transition from a peripheral concern to an object of intense study and engagement. This chapter also introduces the specific types of neuroenhancers on which my empirical work has concentrated. Additionally, it synthesises existing scholarship on public attitudes towards neuroenhancement, highlighting these studies' varied methods and outcomes. Finally, it offers a detailed account of the theoretical and methodological approach pursued in this thesis, including details of the instruments, sampling procedures, and methods of analysis used in the empirical components of the work.

Part II focuses on the general public's attitudes towards neuroenhancement and draws on a large-scale online survey conducted within the NERRI project. The survey investigated how citizens in 11 countries view the prospect of neuroenhancement in general and in two familiar contexts of application: higher education and employment. The survey used a combination of closed and open-ended questions and two vignette-based experiments. The chapter describes my analyses of a subset of this data that includes respondents from three EU Member States (Austria, Germany, and Hungary), the United Kingdom, and the United States. The work combines multiple qualitative and quantitative methods of analysis to explore the factors that shape public attitudes. The chapter argues for the fundamental importance of value orientations that inform different points of view on the propriety of neuroenhancement.

Part III draws on qualitative interviews and focuses on neuroenhancement users to uncover their perspectives and describe the Proactionary Milieu, in which enhancement-related practices are seen as a worthy undertaking, even if they carry risks. The thesis includes a micro-study conducted with users of Do-It-Yourself neurostimulation devices. It represents my first attempt at studying the views and practices of a group of neuroenhancement users. However, after initial successes, I encountered difficulties recruiting enough participants. Nevertheless, the study contributed to my understanding of the Proactionary Milieu. As I was keen to explore users' perspectives beyond the already studied and familiar ones, I sought another suitable group. Through a fortunate series of events, I could gain access to the user base of a new type of sensory augmentation product that was just being released to the commercial market for the first time. This access afforded a unique opportunity to study an entirely new group of enthusiastic neuroenhancement users. The second chapter in Part III describes a longitudinal interview study that explored the expectations, experiences and reflections of individuals who had decided to use a sensory augmentation device called the North Sense.

The thesis concludes with a final chapter to draw together the findings and contributions of the work.

Part I – Setting the Scene

Chapter 1 – A review of the literature

"Worry about enhancement? Why not worry instead about apple pie?"
(Parens, 1998a, p. 1)

From the ubiquity of caffeinated beverages to the endless stream of advertisements for nutritional supplements, wearable devices and other brain-boosting gadgets, games, and products the practice of neuroenhancement is perhaps more pervasive than ever before. Yet, the notion of using advanced technologies of various kinds to deliberately improve upon, augment, and perhaps radically extend our capacities remains a deeply controversial issue. It is a topic that has many people baffled, some enthused, and a few outraged, but hardly anyone is unmoved when they are asked to consider the possibility of stretching human capacities beyond current limits.

This thesis is a study of neuroenhancement and it draws on a combination of quantitative and qualitative methods to study the phenomenon in two distinct spheres: the general public, considering data from five countries, Austria, Germany, Hungary, the United Kingdom and the United States; and the particular milieu of users of neuroenhancement technologies who hail from across the world.

This chapter sets out to accomplish five sub-tasks to lay the scene for the subsequent parts of the work. First, it will introduce the phenomenon of neuroenhancement and address definitional complexities related to the concept. Second, it will offer a brief account of how neuroenhancement emerged as a noteworthy phenomenon on which the public's opinions are regularly sought. How did the topic migrate from fringe futurist discussion boards to the front pages of mainstream magazines? How did it come to engage national and international ethics councils and technology assessment bodies? In short, how did neuroenhancement become 'a thing' at a particular point in time? What were its antecedents, or to borrow a rather Kantian term, what were the conditions of possibility for the emergence of the neuroenhancement debate? Third, the chapter will introduce the specific neuroenhancement methods that are addressed by the studies in this thesis, pharmacological cognitive enhancement, non-invasive electrical brain stimulation, and sensory augmentation. Fourth, the chapter reviews the empirical literature on public and stakeholder attitudes towards neuroenhancement, which is the immediate literature my work intends to contribute to. Finally, the chapter outlines those gaps and shortcomings in current discussions that the thesis seeks to address.

What is Neuroenhancement?

The term neuroenhancement forms a subcategory of a broader concept, that of *human enhancement*. The 'neuro-,' prefix implies that the enhancement in question is somehow pertaining to the brain or the nervous system. Most discussions of enhancement grapple at length with the issue of defining the term properly and carving out a specific scope for the types of activities, practices, or interventions that the label should denote. This is not an easy task, for, as Nick Bostrom and Julian Savulescu suggested: *"In a sense, all technology can be viewed as an enhancement of our native human capacities, enabling us to achieve certain effects that would otherwise require more effort or be altogether beyond our power"* (Bostrom & Savulescu, 2008).

From that perspective, enhancement is the most common of human pursuits. However, the contemporary debate and controversy over enhancement does not extend to technologies of all sorts, from power drills to pocket calculators. Rather, it is more narrowly circumscribed and pertains mostly to advanced technologies resulting from biomedical research.

The idea of neuroenhancement is rooted in the assumption, or hope, that progress in biomedical research might make it possible to not only treat diseases and ameliorate suffering, but also to improve upon healthy, normal functioning (Wiesing, 2009). In a certain sense, enhancement might appear as an unanticipated effect of medical research. As scientists pursue their work trying to unlock treatments for debilitating diseases, they may uncover interventions that benefit the healthy too. For example, developing a treatment for Alzheimer's disease might turn out to bring memory benefits for those unaffected by the condition as well. Consequently, one of the central issues vexing scholars of enhancement has been the relationship between therapeutic interventions aimed at addressing some health deficit, and those that seek to enhance upon an otherwise 'normal', non-disease state. This is at the heart of Juengst's definition, according to which *"The term enhancement is usually used in bioethics to characterize interventions designed to improve human form or functioning beyond what is necessary to sustain or restore good health"* (Juengst, 1998, p. 29). However, as noted by Paul Root Wolpe, enhancement denotes a boundary condition between whatever a culture and its medical professionals consider to be worthy of treatment, and whatever lies outside that scope. As such, the notion of enhancement is inextricably wound up with beliefs about health, normality, and disease, which are culturally and historically fluid and shifting (Wolpe, 2002). Wolpe's observation also foregrounds the fundamental role of social values in negotiating the contours of enhancement.

As Eric Parens observed (Parens, 1998b), there are at least two distinct types of discussions taking place about enhancement. The first type is related to the goals of medicine, in which the treatment/enhancement distinction plays a central role because the discussion revolves around identifying what should be part of a just system of healthcare and what types of interventions doctors could be expected to carry out. What are the boundaries to the duty of care? In this context, the notion of species-typical functioning, as articulated by Norman Daniels is a key reference point. According to Daniels, species-typical functioning refers to the statistically derived range of capabilities that are generally exhibited by most members of a species. This concept is supposed to provide the basis for determining what society owes to its members in terms of healthcare. On this account, the scope of medicine extends to restoring individuals' capabilities to this species-typical range or preventing their decline, but enhancement beyond species-typical capacities falls outside this scope (Sabin & Daniels, 1994). However, the concept has been criticised, for the distinction between treatments and enhancement on this basis might appear arbitrary, it could valorise 'the normal' in ways that are harmful to those who have disabilities, and in some cases it is not even clear how we could define what species-typicality means for certain psychosocial traits (Juengst, 1998; Silvers, 1998). In addition, we are already familiar with a variety of practices that draw upon the knowledge and toolkit of medicine, but are non-therapeutic, such as cosmetic surgery, sports medicine or military research to extend human capacities and performance. Thus, there are precedents for dealing with the application of knowledge, infrastructure and technologies rooted in medicine, applied for non-medical purposes. However, such criticisms notwithstanding, the question concerning the level of physical and mental well-being and capacities that society owes its members remains unresolved.

Moreover, ideas about the proper scope of medicine are also shifting. In recent decades medicine has gradually extended its scope and remit into new domains of everyday life, and many characteristics and behaviours got medicalised, or pharmaceuticalised, as their management became feasible with the help of drugs and other medical interventions (Coveney et al., 2019; Williams et al., 2011). What used to be viewed as common, if undesirable traits – for example shyness, baldness, decreased sexual performance, or age-related memory loss – have been recast in a medical framework (Conrad, 2007; Moynihan et al., 2002). While this trend has been observed and described for many decades, a more recent development is the shift from curing disease towards an emphasis on "managing normality" and optimising health and well-being with biomedical means, which signals the increasing role afforded to individuals in taking control of their own health as a valuable asset (Rose, 2007). As several scholars have noted, medicine, at least for those who can afford its services, has already become a means of fulfilling personal desires and aspirations with a view to improving quality of life beyond any therapeutic orientation (Buyx, 2008; Karsch, 2015; Kettner, 2006). Such trends are also clearly expressed in social groups like the Quantified Self movement, whose members use internet enabled devices and sensors to track their vital signs, such as heart rate, and aspects of their daily lives including sleep, exercise, diet and mood, with the aim of optimising these activities (Swan, 2012). Aspects of this practice are rapidly acquiring mainstream adoption as tracking technologies become ever more pervasive and integrated into more and more consumer electronics products (Sharon & Zandbergen, 2017). From this perspective, enhancement measures can be seen as providing a further modality for realising lifestyle preferences.

As a result of this ambiguity, some believe that the term 'enhancement' is so lacking in conceptual clarity that we ought not use it all. They suggest instead that we should focus on the risks and benefits associated with any intervention irrespective of whether it is therapeutic, preventative or enhancing (Harris, 2007). Others have proposed to radically expand the notion of enhancement arguing that instead of limiting its meaning to direct biological interventions on the human body, we should consider enhancement within a population health framework to encompass all manner of policies and practices that serve to improve human flourishing (Cabrera, 2015).

But the issue of enhancement stretches far beyond the question of what may be expected of doctors and systems of healthcare. The second type of enhancement-related conversation identified by Parens is not about the proper scope of medicine at all, but about broader issues related to the goals of society and ideas about the good life. In this sense, enhancement touches upon fundamental questions related to the meaning of social practices that might be upset or transformed by the introduction of technological augmentations. The prospect foregrounds the issue of how we morally value the means we employ in the pursuit of our goals, and whether enhancement might lead to a more hollow, shallow, and inauthentic existence. Finally, enhancement might lead to an exacerbation of societal pressures, unfairness, and inequality (Parens, 1998b). Thus, while the notion of enhancement is to some extent continuous with familiar, age-old practices humans have pursued to improve themselves since time immemorial, there is a novelty with regard to the degree to which interventions enabled by new technologies might transform human capacities. The more radical the enhancement proposition, the more subversive its implications may be and the more directly we confront fundamental questions concerning the meaning of humanness. Cherished notions of what it means to be human and what sort of existence we should aspire to are upset by the possibility of overcoming current limitations. Implied within the idea of radical enhancement is a view of humanness that many might find deeply unsettling, destabilising, and troubling. Taking the enhancement project seriously means reckoning with the materiality and manipulability of the human form. This has animated a lot of the theoretical clash between techno-progressive proponents and bioconservative opponents of enhancement. Antagonists argue that 'human nature' possess a form of binding normativity that precludes technological modifications aimed at improvement (Kass, 2004). On this account, human enhancement would impinge upon our intrinsic nature and fundamentally upset the social and political order (Fukuyama, 2002). Pursuing enhancement is the expression of a morally questionable 'drive to mastery' that fails to recognise the giftedness of the natural world that in some fundamental sense lies beyond our control (Sandel, 2007). Adherents tend to argue the opposite, that enhancements might in fact help to level out the inherently unjust natural distribution of capacities (Buchanan et al., 2001), and that they could lead to a more, rather than less dignified existence where the most valuable human traits were elevated (Bostrom, 2005b), meaning that we have a moral obligation to enhance (Harris, 2007).

Over the course of the evolution of the neuroenhancement discussion, several new areas of concern have been incorporated. While discussions during the 1990s were centred around modulating mood, during the early 2000s cognitive enhancement took centre stage. Subsequently, in an influential article in 2008 Tom Douglas put forward the possibility of moral enhancement, referring to biological interventions to modulate psychological mechanisms that would influence morally relevant behaviour (Douglas, 2008). Arguably, the notion of technologically manipulating morality was not first advanced by Douglas. One might argue that much of the history of psychiatry is comprised of a series of attempts at applying technologies of various kinds to improve and control traits or behaviours that were perceived to be morally problematic (Shorter, 1997). The novelty of Douglas' contribution lay in its proposition that *wanting to be better morally* is something that even opponents of cognitive enhancement might reasonably recognise as a desirable goal. Building on Thomas' intervention, Savulescu and Persson developed an argument for the necessity of moral enhancement, premised on the notion that human moral psychology was fundamentally ill-equipped to deal with the challenges of a highly technological 21st century civilisation. In their view, human morality was adapted to conditions that prevailed tens of thousands of years ago, wherefore, our biologically ingrained moral intuitions were unfit for our current predicament. Yet, they recognised that the biomedical enhancement of morality carried the risk of undermining freedom and morality itself, which is an outcome they also want to avoid (Persson & Savulescu, 2012). Finally, introducing yet another aspect to the discussion on neuroenhancement, Jon Danaher advanced the notion of biomedical epistemic enhancements, that is, *"enhancements to the ability of humans to acquire knowledge, both theoretical and practical"* (Danaher, 2013, p. 85).

In summary, neuroenhancement may target aspects of human cognition, emotion, morality, and epistemic ability. It is a dynamic and multifaceted concept with contested boundaries that sits at the intersection of technological developments and cultural norms and values. It may be seen as a continuation of age-old human pursuits aimed at the betterment of our condition, or as a radical departure and a step too far that challenges core values.

How did Neuroenhancement Become 'A Thing'?

It is somewhat difficult to pinpoint the exact emergence of discussions about the propriety of human enhancement in general, and of neuroenhancement in particular. As described above, all forms of technology use can be seen as attempts at enhancement, and we may consider humanity's 'self-retouching impulse' to be an expression of a deep seated desire to transform our bodies in pursuit of some idea of improvement (Thévoz, 1984). Moreover, every culture has myths, religious or spiritual traditions expressing some notion of self-transcendence. The origins of the philosophical discussion about the morality of neuroenhancement in the Western tradition may be traced to Socrates' worries about the impacts on memory of the proliferation of a new type of technology: writing (Jowett, 1892). Fuller argues that the notion of human perfectibility arose from a dynamic conception of the human species first introduced in the theological writings of John Duns Scotus (Fuller, 2011), while Bostrom highlights the birth of the natural sciences during the 16th and 17th centuries as ushering in an understanding of the world, and thus of humanity, as malleable and manipulable objects that can be understood and improved upon with the aid of reason and science (Bostrom, 2005a). Elise Bohan offers a rich and detailed account of the history of ideas related to the notion of enhancement as a hallmark of transhumanist thought (Bohan, 2018). Here, I will only give a cursory overview of important developments during the latter half of the 20th century. My emphasis will be on events from around 1990 onwards, as the most decisive period for the emergence of neuroenhancement as a salient topic.

Advances during and shortly after the Second World War in domains like nuclear technology, cybernetics, and molecular biology gave rise to intense discussions and concerns about the appropriate application of science and technology. There was a sense, in Hannah Arendt's words, that humanity's newfound technological prowess might leave us *"unable to understand, that is, to think and speak about the things which nevertheless we are able to do"* (Arendt, 1958). At a prominent symposium organised by the Ciba Foundation (later Novartis) in the 1960s some of the world's leading thinkers and scientists, such as J.B.S. Haldane, Julian Huxley, Francis Crick and Gregory Pincus pondered over the issues raised by humankind's growing ability to interfere into natural processes. They sought to chart a responsible path into the future (Wolstenholme, 1963). At the event Julian Huxley - who coined the term 'transhumanism' - spoke of the rise of a new philosophy, which was informed by natural sciences and took the transformation of the human species as its target. He christened this emerging philosophy *evolutionary humanism*. It was meant to capture the idea of humanity taking control of its own evolution with the means of science and technology and advances in the 1960s made it seem like realizing this prospect was within reach.

The birth of the class of nootropic substances like piracetam, which were meant to enhance learning and memory without side-effects also occurred during this decade and the lifestyle use of pharmaceuticals was becoming widespread (Rasmussen, 2008; S. Rose, 2002). The decade also saw the rise of the psychedelic movement with the consumption of drugs like LSD and psilocybin emerging as forms of self-discovery and spiritual growth as part of a counterculture revolution. Reflecting on the growing use of prescription psychotropic drugs by normal or mildly neurotic individuals, and of the growing use of psychedelic drugs, Klerman introduced the notions of pharmacological Calvinism and psychotropic hedonism in 1972. He described these as two opposing value orientations. While the Calvinist rejects drug use for non-therapeutic ends – most notably to modulate mood – as morally bad, the hedonists, primarily associated with young people, prioritise personal pleasure. Klerman predicted that further advances in drugs development would only amplify this gulf in society (Klerman, 1972).

This was also a period of intense and controversial research into invasive neurosurgical methods and electrical brain stimulation. The studies of Jose Delgado at Yale and of Robert Heath at Tulane University provided the foundation for modern day invasive methods like deep brain stimulation, but also serve as testimony to the (ab)use of science to propagate deadly stereotypes against sexual and ethnic minorities, as brain stimulation research sought to' suppress violence' in Blacks, and 'cure' homosexuality (Horgan, 2005). For many researchers, their forays into the neural bases of behaviour were underpinned by the desire to fundamentally transform the human condition by establishing physical control over the mind, which was perceived as the gateway to a 'psycho-civilised society' (Delgado, 1969). The stakes of this research were aptly summarised in the title of a long-form article in the New York Times from 1970, which read: *Brain researcher José Delgado asks – What kinds of humans would we like to construct?* (Scarf, 1970).

In addition to advances in pharmacological and invasive technological interventions on the brain, burgeoning cultural movements emerged that spread the idea of a coming transformation of humankind. Although a somewhat marginal figure at the time, Iranian-American futurist thinker Fereidoun M. Esfandiary, or FM-2030, advocated the view from the early 1970s that a transition from human to posthuman was already unfolding and could be accelerated by actively supporting the advancement of science and technology. In his Up-Wing Priorities, he wrote emphatically:

> *We want to spread a daring new optimism crystallizing from the obvious fact that for the first time in all the eons of life we are no longer blackholed within this microplanet – no longer trapped within fragile terminal bodies – that we are emerging as a triumphant new species – extraterrestrial and immortal.* (Esfandiary, 1981, p. 72)

Inspired by advances in computing and artificial intelligence research, the emergence of nanotechnology and other technological developments, a new intellectual movement called transhumanism began to take shape in California by the mid-1980s, originally organised via the early Internet (MacFarlane, 2020). Transhumanist thinkers like Max More argued that science and technology should be deliberately employed to overcome and transcend the limitations of human biology. Transhumanists put forward visions of a future in which radically altered post-humans enjoyed indefinite lifespans and vastly improved sensory, cognitive and affective capacities (Kurzweil, 1990). At the time, such views were relegated to burgeoning online discussion boards and other fora frequented mostly by committed futurists, science fiction fans, and tech-enthusiasts, but their ideas soon reached broader dissemination.

As the cursory overview so far suggests, throughout the 20th century technological developments in biology, pharmacology, neuroscience, and computer science continually pressed on the issue of human enhancement. However, the topic of neuroenhancement, that is, the application of various technologies to the brain and nervous system reached greater prominence during the 1990s. One of the reasons driving this change, was that in 1989 US President George H. W. Bush designated the 1990s the Decade of the Brain, and there were enormous expectations about advances in our scientific understanding and intervention capability associated with this move (Goldstein, 1990).

Discussions about enhancement started to reach wider audiences as ideas and expectations about the potential of neuroscience grew. A number of developments drove neuroscience's rise to prominence during the 1990s. Among these was the proliferation of functional magnetic resonance imaging, which came to be seen as a tool for localizing and understanding previously elusive brain functions (Dumit, 2004). This technology allowed researchers to peer into the brain and observe it in action, at a much higher resolution than ever before. Moreover, theories about neurotransmitter activity and chemical signalling in the brain held the promise of precisely targeting specific receptors to achieve desired behavioural outcomes. The development of a novel class of drugs called selective serotonin reuptake inhibitors (SSRIs), such as Prozac, which promised to accurately target and manipulate specific chemicals in the brain was a major milestone in this regard (Shorter, 1997). In his highly influential book 'Listening to Prozac', psychiatrist Peter Kramer described how the drug allowed certain patients who did not meet clinical criteria for any psychiatric condition to achieve desired psychological states. Kramer coined the term *cosmetic pharmacology* to describe such enhancement use of drugs and his book formulated a novel set of questions about the modification of personality via pharmaceuticals, and the use of medicine to achieve states that are 'better than well'. Kramer proclaimed that the availability of these enhancement technologies prompted us to think about normative questions about how they should be used (Kramer, 1993). Furthermore, the work of Eric Kandel, who later went on to receive the Nobel Prize in Physiology and Medicine for his work on the biological basis of memory, and that of Tim Tully on the genetic underpinnings of memory, greatly contributed to an expectation that potent pharmacological agents would soon be available to modulate brain function and improve memory.

Responding to these developments, the first academically oriented project studying enhancement was conducted by the Hastings Center for Bioethics between 1995 and 1997. Given the importance attributed to cognitive enhancement in present day discourses it might seem peculiar that the project paid scant attention to that topic. Instead, it focused primarily on adequately defining the meaning of the term 'biomedical enhancement', as well as addressing some of the ethical and philosophical issues surrounding the concept, such as those of authenticity and complicity with suspect norms that enhancement practices might propagate (Parens, 1998a). At the same time, the transhumanist movement underwent a period of intense 'institutionalisation' with the founding of the World Transhumanist Association in 1998 by Nick Bostrom and David Pearce, which played a significant role in raising the profile of the movement as a serious actor in debates about science and policy.

Beyond the rise of mood modulating psychopharmacology, and neuroimaging, the 1990s was also characterized by growing concern in the US about the rise in the number of children being prescribed psycho-stimulant medications for the treatment of attention deficit hyperactivity disorder (ADHD). Several factors may have contributed to this sudden increase in ADHD incidence and subsequent psychostimulant medication, including changes in diagnostic criteria, changing expectations about children, and institutional pressures on physicians and educators (Diller, 1996). By the end of the 1990s concerns were widespread about the over-prescription of psychostimulant drugs and their potential for abuse (Singh, 2002). One of the first surveys measuring the prevalence of off-label psychostimulant use was published in 2000 and it found that on one US college campus 16% of students had used psychostimulant medications 'for fun' (Babcock & Byrne, 2000). Although this survey was interested in recreational use and it only mentioned the purported cognition enhancing effects of psychostimulants in passing, the 16% figure for prevalence became a frequently cited piece of evidence, contributing to a false perception of an ‘epidemic’ of cognition enhancing drug use (Zohny, 2015).

The Human Genome (HUGO) Project, that aimed to map and sequence the entire genetic code of humans, as well as to identify and analyse the functions and variations of genes also contributed to raising expectations about the near-term potency of medical technologies. The first draft of the genome was ceremoniously unravelled by Bill Clinton in 2000, saying *"Today, we are learning the language in which God created life. With this profound new knowledge, humankind is on the verge of gaining immense, new power to heal."* (Clinton, 2000). HUGO was also the first large science project to have a dedicated, embedded work stream addressing the ethical and societal implications of the technology, for its scale and potential impact was perceived to represent a radical shift in the contract between science and society. This development gave rise to a new type of research dedicated to the ethical, social, and legal implications/aspects of emerging technologies and raised the profile of disciplines like bioethics and technology assessment.

Subsequently, a number of important reports and books appeared on the subject of enhancement. This increased interest was partly driven by the completion of the Human Genome Project and accompanying expectations about its transformative potential, as well as by the emergence of discourses around converging technologies. The US National Science Foundation (NSF) issued a report in 2002 under the title *Converging Technologies for Improving Human Performance*. This document achieved some notoriety for it embraced a very optimistic and bold view about the near-term applicability of advances in nanotechnology, biotechnology, information technology and cognitive science for the purposes of improving human performance in a wide variety of domains including cognition and behaviour (Roco & Bainbridge, 2002). The NSF report emerged at a time when controversy over the use of embryonic stem cells was sweeping across the world, with particularly strong repercussions in the US (Thompson, 2013), which had enacted restrictive policies on federal research in that domain. The optimistic outlook of Roco and Bainbridge’s report attracted criticism, in the US and Europe alike, for its seemingly technocratic approach to the question of human enhancement (Nordmann, 2004). The US President’s Council on Bioethics published its landmark report, *Beyond Therapy - Biotechnology and the Pursuit of Happiness* in 2003, in which the Commission set out to investigate the ethical challenges of the dual use potential of biotechnologies to make people “look younger, perform better, feel happier, or become more “perfect.” (Kass, 2003). The report’s opening letter summarises the view adopted by the Commission, which was chaired by conservative bioethicist Leon Kass:

> *“We want better children - but not by turning procreation into manufacture or by altering their brains to gain them an edge over their peers. We want to perform better in the activities of life - but not by becoming mere creatures of our chemists or by turning ourselves into tools designed to win or achieve in inhuman ways. We want longer lives - but not at the cost of living carelessly or shallowly with diminished aspiration for living well, and not by becoming people so obsessed with our own longevity that we care little about the next generations. We want to be happy - but not because of a drug that gives us happy feelings without the real loves, attachments, and achievements that are essential for true human flourishing.”* (Kass, 2003, p. 17)

In response to these developments a broader intellectual debate emerged in the public and a number of books by prominent thinkers appeared, which took issue with the challenge of human enhancement with strong arguments presented on both sides of the debate (Agar, 2005; Buchanan et al., 2001; Habermas, 2003; Hughes, 2004; Kurzweil, 2005; Stock, 2003).

The period also saw two important institutional developments. First, hopes attached to the prospect of neuroscience delivering powerful new brain interventions led to the birth of neuroethics, an interdisciplinary spin-off of bioethics, which set out to investigate the ethical aspects of advances in neuroscience (Illes & Raffin, 2002). From the earliest days of the discipline, neuroenhancement was amongst its central and most discussed topics (Farah et al., 2004). Second, the early 2000s was a time of institutionalisation for techno-progressive thought as well with the founding of the Institute for Ethics and Emerging Technologies (IEET) in 2004 with James Hughes as its director, and the establishment of the Future of Humanity Institute at Oxford University, under the leadership of Nick Bostrom. The latter institute was enabled by one of the largest grants to the university donated by successful technologist James Martin. Martin himself espoused transhumanist views and values and considered the 21st century to be a make-or-break period for humanity, where advances in technology will either eliminate our species or elevate it far beyond its current form (Martin, 2006). Since its establishment the Future of Humanity Institute has become a leading voice in discussions about the ethics and governance of emerging technologies and has significantly raised the profile of techno-progressive perspectives.

Starting in the mid-2000s technology assessment bodies at national and European levels began to take notice of the enhancement phenomenon as well and started funding projects to map policy relevant issues. A major focus of these efforts was directed at cognitive enhancement, as the management of a nation's cognitive resources emerged as an important factor in maintaining growth and competitiveness in the transition to knowledge-based economies (Beddington et al., 2008).

The debate about neuroenhancement took a distinctive turn and began to attract more significant public attention in late-2007 with the publication of a comment paper in Nature by Barbara Sahakian and Sharon Morein-Zamir. The article claimed that the *"off-label and non-prescription use [of cognition enhancers] by the general public is becoming increasingly commonplace"* (Sahakian & Morein-Zamir, 2007). The drugs in question were mainly ADHD medicines (methylphenidate, mixed amphetamine salts) or narcolepsy medication (modafinil). The article highlighted some of the most important questions around the use of enhancers in academic and professional contexts, including cases where enhancement use might be encouraged. Sahakian and Morein-Zamir brought attention to the phenomenon of students' and academics' use of pharmacological cognitive enhancers and portrayed it as an already established and growing phenomenon, albeit without providing any empirical data to support their claim, apart from anecdotal evidence. The article took it for granted that cognition enhancement was widespread or that it would soon be so, and that enhancing drugs were truly efficacious and could provide benefits to the healthy. Prompted by this article, Nature conducted an informal online survey in 2008, which revealed that among the journal's readers one in five respondents had used drugs for non-medical reasons to stimulate their focus, concentration, or memory (Maher, 2008). Thereafter, the use of cognition enhancing drugs in academic environments began to almost entirely dominate discussions about neuroenhancement. This represents a qualitative change compared to the early phases of the debate in the late-90s, which revolved around cosmetic psychopharmacology, authenticity and a broader set of philosophical and anthropological questions related to the proper place of technologies in fashioning ourselves. After Nature's intervention, issues around performance, coercion and fairness began to take centre stage.

Coinciding with the first wave of European-funded projects (Coenen et al., 2009) a group of distinguished scientists published a call in Nature, urging society and the research community to embrace the use of safe cognition enhancers and to develop guidelines for their responsible use (Greely et al., 2008). Although governments and funding bodies had not taken up the recommendation that research should directly address the effects and side-effects, risks and benefits of cognition enhancers in healthy individuals, the American Academy of Neurology issued guidelines to physicians on how to respond to requests from healthy patients to obtain such enhancing drugs. It concluded that while physicians were under no obligation to prescribe drugs off-label to healthy individuals, it was still ethically permissible to do so, provided that physicians adhered to the bioethical principles of respect for autonomy, beneficence, and non-maleficence (Larriviere et al., 2009). Subsequently, frameworks were proposed for the paediatric use of enhancers as well, which took a more restrictive stance (Graf et al., 2013; Singh & Kelleher, 2010). However, starting in 2010 social scientists began questioning the legitimacy of the debate about neuroenhancement by pointing out that it was built on non-existent empirical data to support the idea that cognition enhancing drugs were indeed beneficial to the healthy, and that their use was actually widespread (Partridge et al., 2011). On closer inspection, both claims turned out to be questionable. As a result, some have called the discussion about cognition enhancing drugs a phantom debate (Quednow, 2010).

Although pharmacological enhancement has largely dominated discussions about neuroenhancement over the past two decades, the early 2010s saw the emergence of new candidate technologies, such as transcranial electrical brain stimulation, which drew attention to a novel set of questions, namely consumerization and DIY practices, which lay outside previous discussions about the legitimate use of medical technologies (Santarnecchi et al., 2013; Walsh, 2013).

Rapid advances in neurotechnologies during the late 2010s and especially the prospect of interfacing the human nervous system with computers and machine learning systems in fast, reliable, and safe ways, have directed renewed interest at the prospect of new avenues for neuroenhancement with more radical effects (Rainey & Erden, 2020; Royal Society, 2019).

Questions concerning neuroenhancement gain further salience against the background of significant growth in research funding devoted to neuroscience all over the world. Between 2013 and 2020 funding for neuroscience by the National Institutes for Health doubled, from around $5b annually to over $10b and several large scale, collaborative neuroscience initiatives have been launched (Adams et al., 2020). The Human Brain Project, the European Union's Future & Emerging Technologies Flagship effort was launched in 2013 with a €1b budget over the course of a 10-year period. The project's aim was "to achieve a multi-level, integrated understanding of brain structure and function through the development and use of information and communication technologies." Beyond theoretical neuroscience this work is expected to drive innovation in areas including neurorobotics, neuromorphic computing and brain simulation. The United States launched a similarly ambitious project called the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative. With funding from DARPA, the NIH and the NSF, the project's aim is to support the development and application of new technologies to achieve a dynamic understanding of the brain in action. Similarly, China and Japan are actively pursuing large-scale neuroscience research projects (Cyranoski, 2018; Hamzelou, 2015) and in 2010 Israel launched its own Brain Technology hub to foster and accelerate the translation of neuroscience and neurotechnology research into viable products and services. Besides national and international projects financed from public funds there are also privately funded initiatives, such as the non-profit Allen Institute for Brain Science, launched in 2003 by Microsoft co-founder Paul Allen, as well as ventures funded by corporate giants like Facebook or serial entrepreneurs such as Elon Musk and Bryan Johnson, whose companies intend to bring non-medical consumer neurotechnologies to the mass market, explicitly targeting the enhancement of normal capacities.

Over the course of 25 years, since the founding of the World Transhumanist Association, the fundamental idea of using neuroscience-based technologies to augment human capabilities has migrated from the fringes to the mainstream (Bohan, 2022) and has become the subject of countless articles, documentaries, public lectures, and popular science books. Moreover, neuroenhancement has become the topic of Hollywood blockbusters, such as Limitless (Burger, 2011), Lucy (Besson, 2014), and Transcendence (Pfister, 2014), as well as widely popular series, including Black Mirror (Brooker, 2011), Limitless (Sweeny, 2015), or Years and Years (Davies, 2019). Importantly, many of these works do not portray enhancement as a fantastical fiction similar to the superhero genre, but rather as a topic of near-future fiction, where various types of enhancements appear as plausible extrapolations of the present. Even though the promises associated with the Decade of the Brain and other large initiatives have largely remained unfulfilled, the notion that (neuro)science is progressing in the direction of enhancement appears to be increasingly taken for granted.

An Overview of Neuroenhancers

The studies presented in this thesis involve three different types of neuroenhancement methods: pharmaceutical cognition enhancers, non-invasive electrical brain stimulation, and sensory augmentation technology. The sections below will offer a brief overview of each class.

Pills and pharmaceuticals

The use of stimulants to boost performance is probably as old as old as humanity itself. Pollan argues that coffee played a major role in the intellectual achievements of the Enlightenment and helped usher in a spirit of rationalism (Pollan, 2021), Freud was a famously avid user of cocaine (Karch, 1999) and the German army was powered through the Second World War by a stimulant called Pervitin, which is a type of methamphetamine (Ohler, 2015). Scholars have documented the extensive use of potent stimulants during the first half of the 20th century (Rasmussen, 2008). Despite such an intimate familiarity with this type of substance, rising rates of prescription stimulants during the 1990s and growing concerns about their off-label use have been at the centre of discussions about pharmacological neuroenhancement. These discussions have primarily focused on prescription drugs intended for the treatment of attention-deficit hyperactivity disorder, such as methylphenidate and Adderall, and modafinil, which is a drug for the management of narcolepsy. This section will first give a brief overview of these two types of substances and what we know about their neuroenhancing effects, and then summarise available data about their prevalence for neuroenhancement purposes.

The chemical substance methylphenidate, was first synthesised in 1944 and it came on the US market as Ritalin in 1955, marketed by Ciba (later Novartis) for the treatment of mild depression and narcolepsy. In 1961 it was indicated for a childhood disorder that was called hyperkinetic syndrome at the time, which may be seen as a precursor to what we currently label attention-deficit hyperactivity disorder. Ever since then, it has periodically grabbed the attention of the public, causing worries about the medication of children and the pathologisation of childhood behaviour (Singh, 2002). As described previously, concerns were raised during the 1990s about the rising rate of psychostimulant medication prescribed for children (Diller, 1996), and soon thereafter worries about the abuse of these drugs by students took centre stage in neuroethics discussions of enhancement, although data about both efficacy and prevalence of use were largely absent at the time (Quednow, 2010). Methylphenidate and amphetamines are tightly controlled substances with annual quotas, but their production has been steadily increasing since the mid-1990s (Schleim & Quednow, 2017).

A meta-analysis of the cognition enhancing effects from 2010 indicated no consistent effects of methylphenidate on cognitive function, with the exception of a slight improvement in memory (Repantis et al., 2010). Subsequent meta-analyses have suggested that the drug may have a broader range of effects. For example, studies that combined methylphenidate with other stimulants in their analysis found evidence of effects on inhibitory control, episodic memory, and processing speed accuracy (Ilieva et al., 2015; Marraccini et al., 2016). The most recent study suggests that the cognitive component of "recall" may be most responsible for the observed enhancement in memory (Roberts et al., 2020). Additionally, there is evidence that methylphenidate has an effect on inhibitory control in healthy adults. This finding is not unexpected, given that methylphenidate is used to treat attention-deficit hyperactivity disorder, which is characterized by high impulsivity and low inhibitory control. However, previous studies of the effects of prescription stimulants on inhibitory control in healthy participants have reported only small effects (Smith & Farah, 2011). A rigorous study assessing Adderall, a drug comprised of mixed amphetamine salts, on a large battery of tests found that despite no observable, or at best marginal effects on most measures of cognitive performance, participants nevertheless *perceived* their performance to have been enhanced (Ilieva et al., 2013). In summary, methylphenidate can improve inhibitory control in healthy individuals and has positive effects on memory but it remains unclear whether these effects would translate to increased productivity or academic achievement and the effects of methylphenidate are generally small to moderate and likely temporary (Repantis et al., 2021; Roberts et al., 2020).

In comparison, modafinil is a relatively recent drug that was first synthesised in the late 1970s by the French drug company L. Lafon and physicians started to prescribe it for narcolepsy patients in 1983. Early experiences with the drug in the treatment of idiopathic hypersomnia were very positive and the French army used modafinil during the Gulf War in 1991. The drug subsequently underwent clinical trials in Canada during the late 1990s and was increasingly used in the treatment of a variety of neurological and psychiatric conditions (Billiard & Broughton, 2018). Studies investigating the effects of modafinil have demonstrated benefits rather clearly. In studies where the drug was only administered once, significant improvements were observed with regard to alertness, even in subjects without sleep deprivation. However, the strongest effect was seen in subjects who were sleep deprived. In those conditions, modafinil had a persistent positive impact on executive function, and memory performance and alertness were also significantly enhanced, although increasing the severity of sleep deprivation progressively diminished but never eliminated the effects of the drug (Repantis et al., 2010). Based on current evidence, the enhancing effects of modafinil are most pronounced when the drug is taken occasionally as opposed to regularly, under (moderate) sleep deprivation, and it works by increasing alertness, but not necessarily attention. Modafinil is a prescription only pharmaceutical and while it is generally considered to be safe, like all pharmaceuticals it has side effect risks that include nervousness, headache, anxiety, nausea, and in rare cases, serious skin conditions. Nevertheless, in comparison to psychostimulants like methylphenidate, modafinil has a lower risk of producing cardiovascular effects and has lower abuse potential, for it doesn't activate dopamine systems in the brain, hence, its effects are not euphoric (Roberts et al., 2020).

Studies of prevalence suggest that students, but also some other groups, such as academics and surgeons, use substances to enhance their cognitive performance (Franke et al., 2013; Maher, 2008; Smith & Farah, 2011). However, the precise extent of this practice remains somewhat difficult to ascertain. Early estimates of the student use of enhancers have ranged from 5-35% depending on the method of assessment and the definition of what constitutes neuroenhancement use. Different studies used different lists of substances that were included under the category of enhancers, which makes the findings somewhat difficult to compare (Ragan et al., 2013).

More recent and methodologically robust estimates had found much lower prevalence rates. A 2018 study investigated the relationship between pharmacological neuroenhancer use and resilience in a representative sample of German adults (n=1128). The questionnaire included two separate lists of substances: the first list encompassed freely available substances, like ginkgo biloba or caffeine tablets, while the second list included prescription drugs, such as methylphenidate or modafinil, and illicit substances such as cocaine or amphetamines. The lifetime prevalence for any substance used for neuroenhancement was 38.8%. However, the lifetime prevalence of prescription stimulants was 4.3%, and 10.2% for stimulating illicit drugs. The authors also found a relationship between stress and neuroenhancer use, as coping with stressful situations was a frequent motive for the use of stimulants or mood modulating prescription drugs. A similarly rigorous study in a Swiss sample found comparable figures amongst the general public. Lifetime prevalence of using a prescription or recreational drug for neuroenhancement was 4%. Half of these respondents used the substances within the past year and the strongest predictors of enhancer use were life-time diagnosis of a mental disorder, experience with professional psychological consulting, stress, being a student, perceived poor health and the life-time use of the illegal stimulants cocaine and amphetamine (Maier et al., 2016). Other researchers have found similar prevalence figures in France and Romania, where across two sites 12-month prevalence of methylphenidate use was below 1% (Brumboiu et al., 2021). In Brazil 12-month prevalence amongst students was 4.2% but reached 14% for students in law (de Oliveira Cata Preta et al., 2020). A large scale, representative study conducted by a German health insurance company in 2009 found that the lifetime prevalence of prescription neuroenhancer use without a medical indication was 4.7% amongst the working population, while approximately 2% were regular users. The study included psychostimulants, dementia medications, antidepressants, and beta blockers as neuroenhancers (DAK-Report 2009). A follow-up from 2015 showed that lifetime prevalence had increased to 6.7%, but the proportion of regular users stayed the same, at 1.9%. The study also showed that those in precarious working conditions were more likely to use enhancers (DAK-Report 2015). Finally, a repeated assessment from 2018 showed that lifetime prevalence had decreased to 5.5% or workers, while the proportion of regular users was 1.8% (DAK-Report 2019).

In summary, the rate of pharmacological neuroenhancer use is rather low, and a consistent pattern emerging from studies is that a primary driver of this type of enhancer drug use is stress and coping with pressures and performance demands.

Non-invasive electrical brain stimulation

The application of electricity in medicine has a long, rich and diverse history that spans the use of torpedo fish against headaches in ancient Rome, through 'animal electricity' therapies in the 19th century, to the infamous electroshock treatment in the 1950s, all the way to present day interest in Brain-Computer Interfaces and different forms of neurostimulation (Elliott, 2014; Pancaldi & Bertucci, 2001; Parent, 2004; Rowbottom & Susskind, 1984; Shorter & Healy, 2007). In recent years there has been a growing amount of neuroscience research dedicated to neuromodulation technologies, which comprise the use of applied electricity to influence brain function – emotion, cognition, and behaviour – in a targeted manner.

A non-invasive technology called transcranial electrical stimulation (TES) has garnered much academic and popular interest (Adee, 2017; Wexler, 2016b). This deceptively simple method involves passing low-intensity currents between electrodes placed strategically on the scalp. There are a few different forms of TES depending on the type of current used in the stimulation: transcranial direct current stimulation (tDCS), alternating current stimulation (tACS), and random noise stimulation (tRNS). Among these, tDCS is the most well researched method. In comparison to other non-invasive brain stimulation techniques like electroconvulsive therapy, TES uses a much lower level of current. While most tDCS studies use between 0.5 and 2 mA, ECT typically uses between 500 and 900 mA (American Psychiatric Association, 2008). The technology is investigated both in cognitive neuroscience research to understand brain mechanisms, and for the neuropsychiatric treatment of conditions like depression, Alzheimer's, and stroke rehabilitation (Nitsche et al., 2008). Some findings suggest that it may also enhance or optimize brain function in healthy people and the method has even been described as an all-purpose cognitive enhancer, due to its favourable effects on learning ability (Fitz & Reiner, 2015; Kadosh, 2013; Looi & Kadosh, 2015). Transcranial electrical stimulation has been demonstrated to achieve rapid improvements in working memory performance in older adults (Reinhart & Nguyen, 2019), as well as greatly increased learning efficacy in both healthy and brain-damaged individuals (Herpich et al., 2019).

Beyond the world of academic research several companies have brought cheap brain stimulation kits to the commercial market. The first product, released in 2013 targeted video gamers[2] with the catchy slogan, *Overclock your brain!* Since then, several others have entered the market, and although some of the newer entrants had already failed and the companies folded, there are over a dozen companies selling neurostimulation products directly to consumers (Coates McCall et al., 2019). The commercial availability of electrical brain stimulation was initially heavily criticised

[2] See https://www.foc.us

and some have described it as *“an example of how market goals may overcome ethics by threatening users’ and gamers’ health and imposing high social risks”* (Santarnecchi et al., 2013, p. 713). Informal online groups have also sprung up where people exchange knowledge and experience in anonymous forums[3]. The simplest versions of the technology can be built by anyone with a basic understanding of electrical components, using nothing but commercially available equipment. Therefore, groups of ‘brain hackers’ emerged, who experiment with do-it-yourself (DIY) devices to manipulate their affective states and cognitive performance. This is a somewhat controversial practice because neuroscientists are still researching the long-term effects and precise mechanisms of action of different types of brain stimulation. The community of neurostimulation researchers expressed caution and frustration over the phenomenon of brain hacking and the rapid commercialization of the technology (Bikson et al., 2013; Walsh, 2013). However, as a gesture of support towards the DIY community, a group of researchers issued an open letter outlining the potential risks of the DIY practice, emphasising especially that any enhancement of brain function in one area might come at the cost of reduced function in another (Wurzman et al., 2016). Although uncertainties remain with regard to ensuring the safety of non-clinical, at-home use of brain stimulation devices, a large review study published in 2022 and co-authored by several of the most distinguished researchers in the field concluded that neuroenhancement using transcranial electrical stimulation is safe if the appropriate protocols and guidelines are followed. The authors also noted that in case of deviations from such protocols, for example through more frequent use, or stimulation at higher voltage settings – referred to as ‘dose’ – cannot be characterised as safe, and they recommended that devices be engineered with certain risk-management procedures in mind that would make them tamper-proof (Antal et al., 2022).

The fact that the technology can be replicated with commercially available components poses quite a challenge for policymaking (Fitz & Reiner, 2015) and a variety of regulatory proposals have been put forward. The Nuffield Council on Bioethics’ 2013 report on Novel Neurotechnologies recommended that transcranial electrical stimulation devices should be considered medical devices and thus be unavailable to consumers even when their manufacturers refrain from attaching diagnostic or therapeutic claims to their products (Baldwin et al., 2013). An influential report on the regulation of Cognition Enhancement Devices published by a working group at the Oxford Martin School argued for a more liberal, consumer-oriented approach that would not impose a high regulatory burden on low-risk devices such as TES (Maslen, Douglas, et al., 2015; Maslen et al., 2014). In the US, the Food and Drug Administration stated that it would not be enforcing medical device regulations against low-risk wellness products, even though they do have the authority to regulate such devices but whether TES falls into the low-risk category is a bit uncertain (FDA, 2019). The most recent regulatory recommendation by neuroethics scholars suggested that an independent working group should be set up to monitor the evidence on potential harms and likely benefits, which would act as a clearing house for regulatory agencies like the US FDA and the Federal Trade Commission (FTC) (Wexler & Reiner, 2019).

In the United States, transcranial electrical stimulation is currently classed as an ‘investigational device’, not yet approved for the treatment of any medical condition. In fact, the devices can be brought to the commercial market only because manufacturers do not make any health-related claims about the device, marketing it instead as a wellness product, which further highlights the fleeting boundary between treatment, lifestyle interventions for wellness, and neuroenhancement.

[3] Such as http://www.diytdcs.com

Commercial companies emphasise in their information material that their kits are not medically licensed, nor are they suitable or intended for the treatment of any medical condition, which exempts them from having to test the safety and efficacy of their products prior to marketing, beyond the level expected of consumer electronics in general.

In Europe, the revised Medical Device Regulation, which came into force in May 2020 explicitly states that "equipment intended for brain stimulation that apply electrical currents or magnetic or electromagnetic fields that penetrate the cranium to modify neuronal activity in the brain" that are marketed for non-medical purposes will need to comply with additional regulatory requirements (European Union, 2017), essentially pulling TES into the regulatory purview of medical technologies. A few devices have received clearance from European regulators and the method has been approved for the treatment of depression (Thomson, 2019).

In light of the scientific, commercial, media and lay interest in the subject, brain stimulation is certainly a noteworthy phenomenon of inquiry. Yet, at the time of my data collection, the academic literature on neuroenhancement was mostly preoccupied with the off-label use of psychostimulants and other prescription medications that are intended for the treatment of ADHD, narcolepsy, or other conditions. Neuroenhancement use involving such drugs is often described as the inappropriate (ab)use of pharmaceuticals by healthy people (Racine & Forlini, 2010). Hence, the discussion takes place largely in a medicalised context with all its connotations, most notably the comparison of enhancement-oriented practices with the purportedly more legitimate aim of medical treatment. The dominance of pharmaceuticals in the discussion is partly due to the fact that not many other technologies seemed capable of delivering meaningful benefits to healthy users in an accessible way (Ragan et al., 2013). Brain stimulation emerged as a possible alternative, and as such it offered an opportunity to investigate attitudes and practices related to neuroenhancement in a different, non-medicalised context. This is further supported by the fact that in comparison to psychostimulants, which are illegal to possess without a prescription, brain stimulation devices can be legally bought, sold and used.

Sensory augmentation

The last type of neuroenhancement technology this thesis engages with is that of sensory augmentation. Sensory augmentation refers to a form of human enhancement that is aimed at extending the normal sensory capacities of humans. This might be realised through enhancing an existing sense into ranges beyond current limits, or by adding entirely new senses (Jebari, 2015).

Despite the importance of perception and the senses within neuroscience, philosophy, and our everyday lived experience, it is a largely ignored subject as a form of neuroenhancement. To some extent, this lack of attention may be explained by the fact that clinically relevant technological breakthroughs have been more pronounced – or at least more readily anticipated – in other domains, such as psychopharmaceuticals, neurosurgery, and brain imaging, which have largely preoccupied scholars in neuroethics and related fields addressing neuroenhancement. The most notable exceptions are cochlear implants and, to a lesser extent, visual prosthetics, which have attracted some attention in the literature (Hansson, 2015; Komesaroff et al., 2015; Sparrow, 2005) while the topic of sensory enhancement is discussed even more rarely (Jebari, 2015; Wolbring, 2013).

Yet, there are multiple avenues through which perception modification technologies are likely to become widespread over the coming years. First, with the ageing of the population in developed countries, the rate of sensory deficiencies, particularly those related to vision and hearing, is expected to increase significantly. For example, currently incurable conditions, such as age-related macular degeneration is predicted to affect 288 million people worldwide by 2040 (Wong et al., 2014), and the World Health Organization (WHO) predicts that by 2050 over 900 million people will have disabling hearing loss (World Health Organization, 2019). Meeting this medical need presents a strong incentive for continued medical research as well as corporate innovation. At the same time, the military is likely to be another key driver of advances in sensory technologies. A report from late 2019 by the US Department of Defence's Biotechnologies for Health and Human Performance Council identified four potential military use-cases emerging from scientific advances over the next 30 years. Two of these use-cases pertain to sensory enhancement, namely ocular and auditory augmentations (Emanuel et al., 2019).

Trends in technology development, such as the growing miniaturization of sensors and other components, ever faster data connectivity and increasing processing power act as enabling forces for powerful wearable technologies ranging from smart glasses to AI-enabled hearing aids (Ovanesoff, 2019). However, at present, sensory augmentation technologies exist in more rudimentary forms in two distinct types.

The first category are sensory substitution devices, which translate information from one sensory modality into another (Renier & De Volder, 2013). This concept goes back to the work of neuroscientist Paul Bach-y-Rita who was investigating brain plasticity in the 1960s, by studying whether it was possible for congenitally blind individuals to acquire the sense of vision. Together with colleagues, he conducted a series of ground-breaking experiments, which demonstrated the phenomenon of sensory substitution and established a new field of research. Bach-y-Rita's and colleagues' novel experimental setup consisted of a TV camera, a monitor, an electronic commutator device, and an array of 400 vibrating metal pins arranged in a 20 × 20 grid, which was attached to the back of a modified dentist chair. The camera captured images of objects placed in front of it and the commutator device converted the visual signals into patterns of vibrations that a person sitting in the chair could feel in their lower back. The location of the vibrating pins was mapped unto the location of pixels on the monitor, and the strength of the vibration was proportional to the luminance of pixels on the screen, such that brighter pixels produced a stronger vibration (Bach-y-Rita et al., 1969). This was the first sensory substitution device, which came to be known as the Tactile-Vision Substitution System (TVSS). After a few hours of training, users seated in the chair could recognize a range of objects, and judge their absolute size and distance based on the patterns of vibrations in their lower back (Bach-y-Rita et al., 1969). Importantly, subjects experienced the location of objects to be in front of them, despite the stimulus being presented to their backs (Guarniero, 1974). Bach-y-Rita also reported that upon zooming of the camera's lens subjects instinctively moved their head and body backwards, as if the object on the screen was moving toward them (Bach-y-Rita, 2002). Although there had already been a number of devices as early as the 1910s that relied on the concept of representing visual information as sound or touch, these were developed only in the context of allowing the blind to read and were considered reading machines (Koestler, 2004). In contrast, Bach-y-Rita's experiments opened a much broader horizon by asking whether humans could learn new sensory systems.

Building on this type of research, other devices have been developed that aim to translate between sensory modalities. In 2015, Scott Novich and David Eagleman presented a sound-to-touch sensory substitution device called the Versatile Extra-Sensory Transducer (VEST) (Eagleman, 2015), intended to assist individuals with impaired hearing. It comes in the form of a vest, which can be worn underneath one's clothing and translates sounds picked up via a microphone into patterns of tactile stimulation along the torso (Novich, 2015). With some training, deaf individuals can use the device to recognize spoken language. More recently, the company co-founded by Eagleman and Novich released the Neosensory Buzz, a wristband that also translates environmental sounds into vibrational patterns. According to the company's website, with practice the associations between sounds and vibrations become automatic and "a new sense is born"[4].

However, despite bold visions with regard to the potential of sensory substitution-based technologies, their uptake as assistive technologies to date has been extremely limited. Critics have argued that fundamental imbalances with regard to the cortical area available to tactile and auditory processing as compared to vision make it unlikely for these modalities to truly compensate for the lack of sight. Moreover, sensory substitution devices are incapable of capturing the hedonic aspects of the sense modality being substituted for, which might further explain their limited use (Spence, 2014, 2018).

Although sensory substitution emerged in the context of restorative and assistive technologies, since the early days of this research there has been interest in applying it for augmentation purposes (Webster et al., 1987). It has been proposed that the principle of sensory substitution may be extended to feed new kinds of information to the nervous system, thereby allowing for the acquisition of new senses. To illustrate the concept, a German research group developed a wearable device to deliver tactile stimulation around the waist to signal the direction of north, giving wearers constant information about their orientation in space. Through a series of experiments they demonstrated that *"newly acquired sensory information can have profound effects on performance and perceptual experience"* (Nagel et al., 2005, p. 15). Similarly, the VEST developed by Novich and Eagleman has been proposed as a model for creating non-invasive devices to extend human perception and extract features from a variety of high-dimension data by leveraging neuroplasticity and the brain's remarkable pattern recognition ability (Novich, 2015). Yet, so far, these ambitious claims remain to be realised and adopted in practice.

Besides the domain of sensory substitution, the second area of sensory enhancement, is the DIY practice of a group of biohackers, sometimes referred to as *grinders*. They take a pragmatic approach to transhumanism (Warwick, 2016) and experiment with technologies in pursuit of upgrading their sensory capacities (Doerksen, 2018). Their activities take inspiration from body modification (Myers, 1992) and their ethos is expressed succinctly on the biohack.me website, an important online resource of the community:

> *Grinders practice functional (sometimes extreme) body modification in an effort to improve the human condition. We hack ourselves with electronic hardware to extend and improve human capacities. Grinders believe in action, our bodies the experiment.*[5]

---

[4] See https://www.neosensory.com
[5] See https://wiki.biohack.me/Who_We_Are

The most widely discussed sensory enhancement is the implantation of rare earth magnets into the body. The procedure involves making an incision on a person's finger and inserting a small, approximately 3 × 1 mm, Neodymium or Alnico magnet wrapped in a layer of biocompatible coating, such as medical grade silicone (Hameed et al., 2010). The purpose of getting a magnetic implant is to enable a person to sense electromagnetic fields. This occurs due to the fact that strong electromagnetic fields cause the implanted magnet to move or oscillate slightly, in synchrony with the field. This stimulates mechanoreceptors in the skin and causes a vibro-tactile sensation (Harrison, 2015). The intensity of the vibration is proportional to the frequency of the electromagnetic field, allowing implantees to 'feel' and differentiate between various sources and to sense when wires or electrical appliances are live. The practice started to become more widespread in the late 2000s and early 2010s (Norton, 2006). The implantation itself is usually performed in piercing or body modification studios. However, the magnetic implant also comes with a variety of risks, such as corrosion and infection at the implantation site if the protective sheath is breached or degrades. In addition, first-person accounts report that over a few years' time the magnet's power weakens and the acquired perceptual capabilities of the user fade, before disappearing altogether (Robertson, 2017).

In Part III, I will describe an interview study conducted with users of a type of sensory augmentation device called North Sense, which sits at the intersection of these two areas. Conceptually, it builds on the phenomenon of sensory substitution and attempts to convey a new piece of information to users, namely, their orientation in space with regard to cardinal directions. At the same time, its experimental nature and the moderately invasive form of its attachment to the body via subdermal piercings places it in the vicinity of DIY practices.

Public Attitudes to Neuroenhancement

Given the controversial nature of using emerging science and technology to improve human capacities, there is an increasing emphasis on and repeated calls for the involvement of broad segments of the public in discussions and deliberation about the acceptability, desirability and governance of neuroenhancement (Dijkstra & Schuijff, 2016; Felsen & Reiner, 2017; Nadler & Reiner, 2011). In response, a number of works emerged studying the public's attitudes towards the practice. This body of work presents a complex but quite mixed picture of sentiments towards the prospect of enhancement and depending on which piece of research one looks at, one might get a slightly different sense as to the public's take on the topic. To add further complexity to the issue, there is great methodological variety in empirical studies of public attitudes, as researchers have used interviews, focus groups, media analysis, and online experiments to name just a few approaches.

One type of research has relied on large scale representative surveys that ask broad questions about attitudes towards enhancement technologies of different kinds. For example, a 2016 study by Pew Research found that 69% of the US public was very worried or somewhat worried about the use of 'brain chip implants for much improved cognitive abilities', with 34% being very or somewhat enthusiastic about that prospect (Funk et al., 2016). In contrast, a 2019 comparative international survey looking at 11 countries (Brazil, South Africa, Poland, Spain, Greece, South Korea, Sweden, USA, Netherlands, Germany and France) carried out by the SIENNA Project reported a more balanced result, with 55% in favour and 43% opposed to the notion of 'using technology to make people more intelligent' (Prudhomme, 2020). In the sample Brazil showed the highest approval at 75% in favour, while France had the lowest, with only 35%, suggesting considerable national differences in acceptability. Similar figures were observed for the prospect of using technology to improve people's moral values, and to allow people to choose a particular emotion. Yet another, large multi-national survey conducted in 16 countries by Kaspersky Labs has found that nearly half of adults (46.5%) believe that people should be free to enhance their own body with human augmentation technology (Kaspersky Labs, 2020). While in the most recent 2021 survey conducted by Pew in the US, 56% of respondents said that "widespread use of brain chips to improve cognitive function would be bad for society", with only 13% considering it to be a good idea, and only 20% say they would want such an implant themselves. According to this most recent survey 63% of respondents believed that brain chip implants to more quickly process information represented meddling with nature and was a line that should not be crossed, while 35% held that it was analogous to how humans had always tried to better themselves (Rainie et al., 2022).

More targeted research looking at particular stakeholder groups and applications has also emerged. Studies on university students' attitudes suggest that neuroenhancement is looked at through the lens of different 'comparators', such as illicit street drugs, pharmaceuticals, or more familiar enhancers, like coffee and that those participants who believed enhancers to be harmless, and those who felt they knew enough to use them safely, tended to have more positive attitudes, while those who felt that enhancer use was unfair had more negative attitudes (Champagne et al., 2019). Students in one study deemed the use of enhancers to increase study performance to be morally less acceptable than traditional forms of academic misconduct, such as cheating in exams, fabrication, or plagiarism (Dubljević et al., 2014). A focus group study found that participants believed enhancement was a matter of personal and individual choice, albeit one that also results from tremendous social pressures to perform that might press some to search for quick fixes. Students expressed both tolerance for the personal choices of others with regard to enhancement, but also spoke of concerns related to peer pressure and of fears of being at a disadvantage if they chose not to use enhancers (Forlini & Racine, 2009). Another focus group study conducted with British university students found a complex moral ecology of individual, peer and environmental factors interacting to shape attitudes to enhancement, and that contrary to the intense coverage of pharmacological cognitive enhancement in the popular media, where it is often depicted as a widespread and growing phenomenon, there is actually low use and low knowledge of pharmacological enhancers among UK students, with substantial resistance to the practice based on normative reasons (Vagwala et al., 2017). Investigating the differences in attitudes between users and non-users, research has found that both groups systematically overestimate the cognitive-enhancing effects of the substances (Finger et al., 2013; I. Ilieva et al., 2013), but their views reveal a sharp discrepancy in terms of the assessment of risks. Non-users generally have strong concerns regarding the safety of enhancers, while users are more concerned about addiction, and sometimes deploy arguments for the substances' safety that downplay potential health risks by contrasting enhancers with riskier street-drugs, and by pointing toward neuroenhancers' acceptance within the medical establishment as a grounds for less concern. By labelling neuroenhancer use as harmless they find its application to be morally and socially acceptable (DeSantis & Hane, 2010). In addition, the riskier the substances, the more respondents object to their non-medical use on moral grounds (Scheske & Schnall, 2012). Related to this result, a set of findings point toward a preference for natural over artificial enhancers and toward interventions that might be closer to treatment than to enhancement (Bergström & Lynöe, 2008). Studies about the acceptability of pharmacological cognitive enhancement have found that practices that show alignment with cultural values centred on healing, personal effort, and productivity increased acceptability (Coveney et al., 2019; Sales et al., 2019), while applications that seemed misaligned with such norms lead to rejection of the practice as a form of cheating or unfair advantage (Bjønness, 2019; Coveney et al., 2019).

Healthcare providers and physicians have also become an important group to study as they are both gatekeepers and are themselves exposed to high pressures and demands that might increase the likelihood of enhancer use. Banjo, Nadler and Reiner conducted an online survey of US and Canadian primary care physicians and found that this group was more comfortable to prescribe enhancer drugs to older patients, where the intervention could be construed as a form of restoration, while for younger adults, neuroenhancement was viewed as unnecessary. Safety issues were of high concern for physicians, however, almost half of responders mistrusted the safety claims issued by pharmaceutical companies (Banjo et al., 2010). Regarding physicians themselves being obligated to use enhancers, Maslen and colleagues found clear and strong public objection against the idea that people in professions with high responsibility, such as pilots and surgeons, might have a moral obligation to enhance their performance (Maslen, Santoni de Sio, et al., 2015).

Lastly, starting in the mid-2010s the contrastive vignette technique (CVT) emerged as a powerful methodology in experimental neuroethics to investigate public attitudes in a more controlled and rigorous manner (Burstin et al., 1980; Fitz et al., 2014). This method allows researchers to present richer, more nuanced descriptions of neuroenhancement practices embedded into certain social situations and contexts of application, and it enables researchers to systematically manipulate individual variables within these depictions of neuroenhancement to investigate how they might impact upon the public's views (Reiner, 2019). This avenue of research has proven to be very productive in uncovering how a host of factors, ranging from the type of enhancer, the targeted trait, the level of effort required for the enhancement, the amount of peer pressure, the cost of the technology, and a number of others shape public attitudes (Cabrera et al., 2015; Dinh et al., 2020; Fitz et al., 2014; Specker et al., 2017). Research has found that US respondents were significantly more likely to approve of neuroenhancement and accept its risks if the aim was restorative rather than enhancing, irrespective of whether the method was pharmacological or neurostimulation. They found evidence for the hypothesis that attitudes towards the risks and benefits of enhancement are different according to the perceived prosocial nature of the individual's occupation who is using the enhancer. The risks are deemed more acceptable if the subject's occupation is considered more prosocial, such as finding a cure for cancer as opposed to developing new weapons. The study also showed that societal and peer pressure were more bothersome for technological enhancement modalities compared to those that also rely on effort. Irrespective of the technology in question, respondents reported a rather high likelihood of using an enhancer in the workplace. Furthermore, in terms of fairness the study showed that the public embraces meritocratic views and cherishes hard work and effort over unearned benefits (Fitz et al., 2014). A subsequent study investigated public attitudes to restorative and enhancing uses of pharmaceuticals across twelve cognitive, affective and social domains and found respondents were significantly more comfortable with interventions towards the norm (restoration) than with interventions above the norm (enhancement) (Cabrera et al., 2015). Another experiment conducted with the US general public sought to determine the effect of framing metaphors and context of use on opinions towards neuroenhancement and found that metaphoric framing influenced whether participants thought it was acceptable to use neuroenhancement by other people, but it didn't affect their attitudes towards their own use. In general, participants were more likely to support the use of enhancement by others than by themselves, and even more so when the use of enhancement by others was framed with a 'fuel' metaphor than with a 'steroid' metaphor. Respondents supported the use of enhancement by employees more than by students or athletes and participants who worked in more competitive environments were found to be more willing to take enhancers (E. C. Conrad et al., 2019). In a similar experiment, Dinh, Humphries & Chatterjee examined whether acceptability of neuroenhancement was malleable. They aimed to replicate and extend their previous study by using metaphors which were internally driven, revealing inner capacities. They confirmed the hypothesis that opinions about neuroenhancement are indeed malleable, although the metaphors did not influence acceptability judgments about the use of neuroenhancement by others, they affected whether the participants would consider using the technology themselves. Those exposed to the 'key' metaphor, which described enhancement as a way of unlocking capacities in the brain were more willing to consider enhancement than those who encountered a Pandora's box vignette (Dinh et al., 2020).

An important conclusion that emerges from this line of research is that the public's views are malleable and vary as a function of how the topic is presented (Forlini, 2020). To some extent, this is not surprising because neuroenhancement is a rather novel phenomenon that most respondents likely had not engaged with or pondered over extensively prior to being asked about the subject. Moreover, the existence of framing and context effects is among the most well documented in social psychology (Schwarz & Sudman, 1992). Research has shown that views about neuroenhancement are also context-dependent and characterised by a significant level of ambivalence, where respondents hold seemingly conflicting normative standpoints as they struggle to formulate an opinion (Forlini & Hall, 2016). In response, it has been suggested that researchers should increase the realism and validity of the ways in which the public's attitudes are sought. For example, this may be achieved by introducing finer distinctions between the contexts of enhancer use, their effects, and trade-offs. According to this view, neuroenhancement is a 'disunified kind' that doesn't allow for highly general moral evaluations to be made (Veit et al., 2020). While I agree with the assertion that neuroenhancement is a highly complex phenomenon, as I will try to argue in the next section, I believe that research thus far has paid too much attention to the specification of the object – that is, neuroenhancement – and too little attention to the different ways in which different subjects might come to appreciate it.

Conceptual Framework

The perspective of the thesis is informed and inspired by Social Representation Theory, which grew out of the seminal works of Serge Moscovici, who studied the reception of psychoanalysis in France in the 1950s (Moscovici, 2008). Through a systematic study of social survey data and media analysis, Moscovici described three distinct ways in which social groups in French society have responded to the new field of knowledge, psychoanalysis. The communist, Catholic and urban-liberal milieus identified by Moscovici used characteristic ways to represent psychoanalysis, each group emphasising, suppressing and adapting the form and content of communication about the subject according to their broader set of values and goals. Moscovici labelled the type of communication characteristic of the communist press as *propaganda*, for it sought to militate readers against the supposedly imperialistic, Western intellectual influence. The communicative strategy characteristic of the major secular, liberal newspapers, was characterised as *diffusion*, for this milieu diffused information about psychoanalysis without much commentary, adopting a fairly neutral position. The Catholic church's relationship to psychoanalysis was as one of *propagation*, for they sought to reconcile certain aspects of this new form of knowledge with their own particular system of beliefs and commitments. Moscovici's studies revealed how different milieus adapted the scientific language and concepts of psychoanalysis, resulting in new forms of common sense.

Two fundamental mechanisms are at work in the construction of social representations: (1) anchoring, which allows for the classification of new phenomena by comparing and relating them to existing categories, and (2) objectification, which can be described as the process of reifying and concretising the object of the social representation. Through these processes, social representations become naturalised and come to be seen as 'taken-for-granted' elements of the social world (Hakoköngäs & Sakki, 2016). Social representation theory is a form of weak social constructionism and it proceeds from the starting point that people's representations of reality are not oriented towards veracity but rather that they serve social, emotional and pragmatic goals or projects (Jovchelovitch, 2008).

Since Moscovici's pioneering work, the theory has been used in a large number of studies to address representations of science and the integration of expert knowledge into the common sense of various groups (Kronberger, 2015) and a particularly influential elaboration of the theory was advanced by Martin Bauer and George Gaskell in the late 1990s. Emerging from an extensive research project about biotechnology and the public, Bauer and Gaskell defined social representation as a logical triplet of subject, object and project (Bauer & Gaskell, 1999). This model highlights how the representation of any object, psychoanalysis, biotechnology, or neuroenhancement takes shape against the background of larger *projects*, which are perceived to be at stake. For example, biotechnology may be conceived of in relation to worries about the environment, as the solution to world of hunger, as the expansion of corporate power over processes of life, or simply as the extension of traditional agriculture etc. depending on the wider framework of reference against which it comes to be understood and represented (Bauer & Gaskell, 1999). Similarly, the phenomenon of neuroenhancement can be understood against the background of different larger projects that particular groups might care about. Therefore, Social Representation Theory is well suited to capture and interpret the richness of "voices and images of public concern" about scientific developments, but also of hopes and expectations in relation to new domains of innovation. For the purposes of this thesis, the conceptual vehicle of the *project of representation* as articulated by Bauer and Gaskell is especially productive. In discourses about neuroenhancement, we are ultimately dealing with notions of 'futures-for-us' (Bauer & Gaskell, 2008) as the technology is envisaged to transform fundamental aspects of what it means to be human, impacting upon a range of social practices.

This thesis is situated in empirical descriptive ethics (Hämäläinen, 2016; Sugarman & Sulmasy, 2001) understood as the branch of ethics which draws on social scientific methods to study ethical decision-making in practice. Studies in descriptive ethics draw on a range of familiar social science methods from interviews and focus groups to surveys and experimental research, while emerging methods even involve the use brain scans and other physiological measurements to understand moral behaviour. My specific aim is to contribute to the literature on public and stakeholder perspectives on neuroenhancement described in the previous section, with the aim of advancing it in two distinct ways.

First, both large-scale survey-based assessments of neuroenhancement, as well as experimental approaches utilising moral dilemmas and the contrastive vignette technique, suffer from a similar limitation. They tend to treat the public as an undifferentiated mass.

The first type of study – large scale surveys – provide high-level snapshots of opinion in relation to neuroenhancement technologies that are not contextualised within relatable life-world contexts of application but are usually described at a rather high level of abstraction, such as "a technology to increase intelligence". Hence, the findings from these investigations give us a measure of general acceptability without providing any insight into the ways in which people understand and interpret the technologies they are asked about, and perhaps more importantly, we learn little about their reasons and the perspectives that inform the judgments of different segments of the public. Arguably, one might counter that the goal of such large-scale survey research is not to uncover nuanced perspectives but to track the evolution of overall sentiment in relation to an object over time, or to gather comparative data across geographies, or to provide an estimate of the segmentation of attitudes on the basis of demographic characteristics, or other traits, etc. On this view, the in-depth exploration of nuanced perspectives would be considered the proper domain of qualitative work. This is where a mixed-methods approach, such as the one pursued in this thesis, combining multiple types of data and analysis can provide distinct advantages over either purely quantitative or purely qualitative efforts.

A similar problem applies to experimental studies relying on the contrastive vignette technique, which reveal the average difference in terms of an outcome measure between a small number of carefully crafted scenarios that depict neuroenhancement use in context. These studies offer valuable insight into the set of factors that the public *on average* might consider to be relevant for their decision-making and ethical assessment. Nevertheless, we learn little about the underlying *points of view* that motivate such judgments. Here, my use of the notion of points of view is inspired by Sammut's work and is understood to represent an underlying perspective that individuals take in relation to a subject, which perspective then informs their behaviour and attitude judgments in specific social situations and encounters (Sammut, 2010). A point of view represents a person's *"outlook towards some object or event relative to others within the social field"* (Sammut, 2010:127). The study of reasons and arguments plays a central role in this context, as these are seen as providing justifications for specific ways of relating to the object in question. Once we adopt this stance, it is difficult to speak of *the public's* views on any subject, as long as we may assume that different ways of relating to that subject are conceivable, and the last few decades of research on the social study of science has demonstrated that different groups make sense of scientific developments based on their value commitments and broader world view (Durant et al., 1998). In addition, Thurstone's insight is also relevant:

> *It is quite conceivable that two men may have the same degree or intensity of affect favourable toward a psychological object and that their attitudes would be described in this sense as identical but that they have arrived at their similar attitudes by entirely different routes.* (Thurstone, 1967, p. 21)

Applying this to the case of neuroenhancement, it is likely that in a survey on the acceptability of some neuroenhancement measure the numerical value given by two respondents might be equal, even though they hold fundamentally different perspectives with regard to why they chose that value. I contend that if we are to take seriously the notion of stakeholder involvement, public engagement and democratically aligned technology governance, calls for which are regularly reaffirmed (Dijkstra & Schuijff, 2016; Forlini, 2020; Stilgoe et al., 2014), then we should endeavour to devise ways to uncover a diversity of perspectives, which do not treat the public as a monolith. This is what I attempt to do in Part II of this thesis, with the help of data gathered during a 3.5-year long EU research project that sought to engage members of the public in diverse settings to understand their views and perspectives. Drawing on this empirical data, I will try to argue that pre-existing value orientations and the points of view from which respondents come to evaluate any particular scenario of neuroenhancer use are significant, and hitherto neglected, factors that shape public judgments.

The second distinct contribution that the thesis hopes to make is to the study of neuroenhancement users. Thus far, our understanding of the perspectives, motivations, and experiences of neuroenhancement users is extremely limited. This is partly due to the fact that despite a rich and nuanced academic discussion about the phenomenon of enhancement, in reality, there are not many technologies available to deliver on the aspiration. As described in the review above, the majority of user studies had looked at students engaging in pharmacological cognitive enhancement, which is a pursuit that seems primarily driven by competitive motives, stress, and coping with multiple demands on one's time. As such, this type of use does not quite seem to approximate the sorts of visions that have been expressed in transhumanist and techno-progressive milieus since at least the late 1980s. There seems to be a gulf between the vision of a technologically enhanced humanity as it emerges from transhumanist writings, and the current reality with regard to neuroenhancement, which appears to be constrained to the abuse of prescription pharmaceuticals. Critical voices contend that the ongoing preoccupation with student pharmacological cognitive enhancement in neuroethics is in fact a bubble and is indicative of a phantom debate that creates an aura of urgency around an issue that is neither new, nor as significant as some portray it to be (Schleim & Quednow, 2017). While I believe there is truth to this criticism, I don't agree that the entirety of the neuroenhancement phenomenon would be exhausted by pharmacological cognitive enhancement. As MacFarlane convincingly argued, over the last decades a new social movement had emerged around the proactionary pursuit of technological human enhancement, which is animated by the conviction and desire to actualise some latent potential in humanity through its radical technological upgrading and transformation (MacFarlane, 2020). While MacFarlane pursued a multi-sited ethnographic investigation of this emerging social movement, my emphasis in this thesis project was on exploring the specific enhancement-related practices and experiences of small groups of users, in the hope of characterising the Proactionary Milieu. This is what Part III of the thesis attempts to do.

Chapter 2 – Methods and Methodology

Moving on from an overview of the phenomenon of neuroenhancement and the current landscape of public attitude studies, this chapter will describe the methodological approach pursued in this thesis. I will describe the various methods that have been applied, including the sources of data that underpin the empirical work and the details of data collection and analysis. The first empirical study draws on a large-scale survey, which includes two contrastive vignette experiments along with closed and open-ended questions, while the final two studies are based on semi-structured qualitative interviews.

As mentioned in the Introduction, part of the data analysed in this thesis was gathered during the course of a 39-month European research project. I was involved in this effort from the early stages of proposal development, through to the project's completion. Therefore, the first section will offer background information about the project and explain how the survey's constructs emerged from preliminary work.

The NERRI Project

In 2011 the European Commission issued a call for proposals under the Science in Society Work Programme, inviting research organisations, businesses and civil society organisations to submit, what the EU had termed, 'Mobilisation and Mutual Learning (MML) Action Plans on Societal Challenges'. The call specified three such societal challenges that the EU sought to address: synthetic biology, 'human enhancement' technologies, and healthy and active ageing. According to the call, these developments represent complex phenomena connected to science and technology that can attract conflicting opinions by the public. Therefore, the aim of the projects should be to connect various perspectives and jointly explore the issues at stake in order to *"develop innovations that encompass societal needs and concerns"* (European Commission, 2011, p. 8). Furthermore, the call specified that at least 10 EU Member States would need to apply as a consortium in order to be eligible for funding. The call also briefly defined what Mobilisation and Mutual Learning Action Plans mean. According to this, *"An MML Action Plan aims to create mechanisms to address Societal Challenges where science and technology are involved, bring together a wide range of actors, pool partners' knowledge and experience, develop mutual understanding and joint solutions"* (European Commission, 2011, p. 3). With regard to human enhancement, the call specification offered the following interpretation:

> *Using the insights coming from the cognitive sciences, as well as from robotics, the life sciences and ICT, human enhancement technologies are being developed to not only enhance the physical abilities of humans, but also their cognitive and emotional abilities and performance. To what extent is society ready and prepared to accommodate the transformative impacts that the envisaged developments may have? The MML should elaborate on a European research agenda and explore policy issues that will need to be addressed in order to ensure that this field develops in accordance with fundamental values such as human dignity, equality, individual freedom and solidarity. (European Commission, 2011, p. 13)*

The winning project on the topic of enhancement was called *Neuro-enhancement: Responsible Research and Innovation (NERRI).* It was led by Ciência Viva, the Portuguese National Agency for Scientific and Technological Culture, which was established in 1996 to promote public awareness of science and technology. The NERRI project consortium was comprised of 18 partner institutions from 11 European[6] countries and included several universities across Europe with expertise in the social sciences and law, research foundations focused on the life sciences, NGOs, such as a patient organisation for rare genetic disorders, and the European Brain Council, as well as science museums with experience in conducting public-facing science outreach. The project's mandate was to facilitate Europe-wide societal dialogue on the issues raised by neuroenhancement.

To the best of my knowledge, this call was the first time that the EU introduced the MML concept, which has since been used in a number of efforts that intended to engage relevant societal stakeholders to address the challenges of various areas of scientific research or technological innovation. Therefore, part of the NERRI project's work revolved around articulating some conception of what Mobilisation and Mutual Learning should mean and look like in practice. This was all the more challenging, because the 2011 call for proposals and the NERRI project were part of a wider shift towards Responsible Research and Innovation (RRI) as the EU's emerging approach to science governance.

On RRI and Public Engagement with Neuroenhancement

The notion of Responsible Research and Innovation (RRI) has gained prominence in policy circles in the European Union and to some extent in the United States in the early years of the 2010s (Owen et al., 2012, 2013; von Schomberg, 2013). RRI can be seen as an effort to address two key issues related to the governance of science and technology: public participation in decision-making and the ethical and societal implications of scientific and technological innovation. By promoting RRI, advocates hope to ensure that these concerns are considered during the development of new technologies and that the public is actively engaged in the process, such that the benefits of innovation can be maximised.

Since the launch of the Human Genome Project in 1988 the study of ethical, legal and societal implications/aspects (ELSI/ELSA) related to emerging technologies has become an integral part of large scientific projects, and a series of related centres and institutions were established. Although the concept originated in the United States, it was quickly adopted in Europe as well, where between the late 1990s and early 2010s a large number of ELSA studies were supported by the European Commission, particularly on the topics of genetics/genomics, and nanotechnology. However, this type of work became the subject of criticism as well, for it was seen to be primarily an academic undertaking whose audiences were other academics, without achieving real impact on policy-making (Yesley, 2008). Even though the European approach (ELSA) sought to develop a broader mandate and institutionalise a form of critical normative reflection on science and technology, while also working towards better embedding science in society, it was the subject of criticism for emphasising only a small number of issues and prioritising harms and risks construed in a narrow way. RRI has been put forward, mostly in a top-down manner by large research funders, as a more pragmatic approach that carries forward some elements of the ELSI/ELSA agenda, while putting more emphasis on channelling innovation towards socially desirable ends and grand challenges (Zwart et al., 2014). RRI aims to foster innovation that is beneficial to

[6] Austria, Belgium, Denmark, Germany, Hungary, Iceland, Italy, the Netherlands, Portugal, Spain, and the UK.

society, and this is best achieved when stakeholders and the public are involved in the process from the beginning (Stilgoe et al., 2013).

At the same time, RRI may also be viewed as a progressive response to an earlier approach to science communication, often referred to as the 'deficit model' of the public understanding of science. The deficit model was motivated by the perceived need to uncover and correct 'flaws' in public interpretations of science and technology, which were seen to underlie misunderstandings and opposition to scientific pursuits. Rooted in a cognitive deficit model this approach sought to educate the public to facilitate support for science (Irwin & Wynne, 1996). Subsequent research brought evidence pointing to a lack of a correlation between factual knowledge about science and support for it (Durant et al., 1998). For example, in relation to the controversy surrounding genetically modified organisms in food, studies revealed that researchers and the public draw on different, and incommensurable, notions of risk. While scientists think in terms of mono-dimensional risk assessments, 'lay' people take a much broader array of factors into consideration, including culturally situated ideas about the good life and the value of certain practices, which are not captured by scientific evaluations (Marris, 2001). Such recognitions have led to a shift towards a more dialogue-based approach that was articulated in an influential UK House of Lords report already in 2000 (UK House of Lords, 2000). The move "from PUS to PEST", that is, from public *understanding* of science to public *engagement* in science and technology (Holden, 2002) no longer viewed the public as an uninformed mass that needed to be educated. Rather, it emphasised the importance of dialogue and upstream involvement to ensure that societal values and scientific pursuits were aligned (Wilsdon & Willis, 2004).

The RRI approach builds on the ideas underpinning PEST and recognises that the evaluation and translation of contemporary scientific developments into society call for an integrated approach to governance, one that ventures beyond considerations of risks and benefits to take into account the broader context of technological innovation, the values it expresses, and the visions of the desirable society it embodies (ter Meulen, 2012). The shift towards public engagement has been particularly pronounced in the United Kingdom, where the National Co-ordinating Centre for Public Engagement (NCCPE) was established in 2008 with funding from Research Councils UK and the Wellcome Trust. Since then, the NCCPE has worked with a large number of universities and research organisations on delivering public engagement strategies. In 2010 research funders issued the Concordat for Engaging the Public with Research, which laid out the importance of public engagement as well as a set of principles for how research organisations should undertake such activities (Research Councils UK, 2010).

Hence, a vision of public and stakeholder engagement and dialogue has been central to the RRI approach and is viewed as one of the principal mechanisms by which the notion of responsible innovation is to be implemented. The concept is rooted in ideas about participatory democratic governance (Gutmann & Thompson, 2000; Habermas, 1999; Rawls, 1971), which is understood to entail inclusive and deliberative processes of decision-making. However, critics have pointed out that over time the commitment to public engagement and stakeholder involvement has become proceduralised and institutionalised. The practice of public engagement often takes precedence over the goals of reflexivity and deliberative *decision-making* it was initially meant to serve (Jones, 2014). Moreover, the idea of anticipatory governance, which seeks to align societal goals and interests with potential future developments in science and technology, has attracted criticism as well. For example, Fuller views such exercises as essentially equivalent to public relations mechanisms by which ‘the public’ is provided with a frame of reference to better accommodate innovations that are coming their way, no matter what (Fuller, 2009). The same criticism has been levelled against ELSA/ESLI and it might hold even more so with regard to RRI.

Regarding the topic of enhancement, the dimension of anticipation is particularly relevant and problematic, as we are dealing with an area of innovation that is in many ways promissory and hypothetical, which makes its evaluation uniquely challenging and risks devolving into ‘speculative ethics’. According to Nordmann, ethical formulations in this vein take the shape of if-and-then statements:

> *An if-and-then statement opens by suggesting a possible technological development and continues with a consequence that demands immediate attention. What looks like an improbable, merely possible future in the first half of the sentence, appears in the second half as something inevitable. And as the hypothetical gets displaced by a supposed actual, an imagined future overwhelms the present.* (Nordmann, 2007, p. 32)

This type of argumentation often seems to be at play in discussions about enhancement, where both proponents and opponents in the academic discourse assume that the development and arrival of enhancement technologies is inevitable. As such, the mere hypothesised possibility of enhancement technologies gets depicted as a call to policy action in the present. To some extent, the MML call by the European Commission, in response to which NERRI was formed, can be seen as an instance of this, for it construed the hypothetical possibility of transformative human enhancements as sufficient grounds for exploring policy issues in the present. Thus, it is a particular challenge for public engagement to draw the boundary between mere speculation and meaningful thinking about an area of promissory science.

Moreover, recent research on the degree to which such activities achieve their primary goal, that of better decision-making, suggests that the method needs refinement. Public engagement does not have much policy impact because the public in dialogue exercises expresses a different 'imaginary' of science compared to that of the policymakers, and policymakers often do not see the public as offering the kind of expertise they expect or require. Furthermore, dialogue events are not tied in with the right policy networks to be able to exert any influence (Smallman, 2018). Recently, deliberative mini-publics have emerged as a potential method to overcome some of these difficulties, but their embedding into actual processes of decision-making still remains uncertain (Ada Lovelace Institute, 2021; Steel et al., 2020).

Beyond the lack of efficacy to influence policy level decision-making, scholars have drawn attention to some methodological limitations as well. A fundamental challenge is that ‘the public’ is not a pre-existing natural category, but rather, it has to be brought into existence through communicative acts (Hansen, 2010). As a result, dialogue events often engage self-selected members of the public who meet willing scientists in settings framed by proponents of public engagement. Therefore, while, dialogue events take the ‘ideal public sphere’ as their model, they nevertheless fail to implement even an approximation of it, given that the events are hardly representative of ‘the public’. Moreover, some research suggests that we should question whether ‘the public’ as a general category desires involvement in participatory governance at all (Sturgis, 2014).

Operationalising the Concept of Mobilisation and Mutual Learning
These challenges notwithstanding, members of the NERRI project consortium set out to operationalise the concept of Mobilisation and Mutual Learning and apply it to the notion of neuroenhancement. Within the context of the project, the MML notion was translated into Mutual Learning Exercises, which denoted public events designed to bring together a variety of stakeholders in order to facilitate an interactive learning process. By exposing participants to different perspectives, MLEs aimed to foster in-depth dialogue where the traditional format of experts interacting with lay audiences could be overcome and innovative formats of engagement could be explored. The project ran more than sixty such MLEs on the subject of neuroenhancement, which took the form of focus groups, workshops, debates, games, exhibitions, film screenings, theatre plays, a hackathon, and Science Cafés. The events involved researchers, ethicists, teachers, students, military officers, medical professionals, people with disabilities, entrepreneurs, and members of the public from all walks of life. The events ranged from 8-person focus groups to 500 or more attending exhibitions or other live events, and from hour-long group discussions to workshops and activities spanning several days.

An MLE explores the possible impacts of neuroenhancement on different aspects of social life. It engages with the hopes and fears, the aspirations and worries that are elicited by this prospect. These open-ended questions were tackled through distributed and deliberative modes of reflection, where the purpose was not to achieve agreement or to foster societal integration or acceptance of neuroenhancement, but rather to uncover, express and broaden the issues at stake. (Zwart et al., 2017). Across the European Union, the project encountered a variety of perspectives ranging from small pockets of enthusiasm for neuroenhancement to the shocked and appalled reaction of patients suffering from psychiatric and neurological conditions, who learned about the notion of enhancing healthy abilities.

This work resulted in a qualitative appreciation of various perspectives and issues of interest and concern to the public. These have been grouped into 9 salient ‘points of view’ by a small team of NERRI researchers, which included George Gaskell, Helge Torgersen, Jürgen Hampel, Agnes Allansdottir, Nicole Kronberger, and myself.

Restoration: A common perspective across MLEs emphasised the primacy of treatment and the duty of care over attempts at enhancing healthy functioning. Pathological causes such as brain damage, dementia or old age can impair cognitive functions, and therapeutically restoring them was perceived to be acceptable and desirable, especially as societies increasingly face aging populations. However, this was sharply distinguished from enhancing normal abilities, which was perceived as the misuse of resources and of medicine. This perspective echoes arguments from the normative discussion about enhancement reviewed in the previous chapter, and especially the distinction between treatment and enhancement.

Natural limits: A frequent initial disposition to the idea of neuroenhancement was suspicion or sheer rejection. As justification, the inherent ‘unnaturalness’ or discordance with ‘human nature’ was often evoked. Some people differentiated ‘natural’ means of increasing brain performance from ‘artificial’ ones, where natural was perceived to be acceptable, while ‘artificial’ was not. Substances originating from plants, in contrast to ‘artificial’ pills containing chemically synthesized substances, were judged natural and perceived to be less damaging. The notion of naturalness also emerged in relation to the idea that brain was already in a naturally balanced state that would be upset or disrupted by neuroenhancement methods, potentially leading to negative implications. Adherents of this stance tended to support alternative approaches of enhancing mental capabilities such as a healthy lifestyle with good food, enough sleep and sufficient exercise over artificial approaches such as pharmaceuticals or brain stimulation methods.

Natural transgression: This view express various degrees of optimism, from mild curiosity about some less invasive enhancements to enthusiasm for radical technologies that alter the core of human nature. This view contrasts with the one form Natural Limits, which holds that human nature has a normative force that constrains our actions. Instead, this view regards the current set of human traits as mere products of random evolutionary processes, which often generate suboptimal outcomes. Therefore, the human form and its limitations have no moral weight and should be viewed as both transitory and accidental. According to this view, enhancement is the next logical stage in human cultural evolution, the manifestation of our "natural" drive for self-transcendence or the unavoidable continuation of technological progress. On this account, enhancement is often portrayed as a value in itself, or an intrinsic good that is not only desirable for the relative benefits it may confer on its users, but also because it facilitates the development of human potential and the surmounting of natural barriers. Technologies exist on a continuum without any obvious cut-off point at which something becomes impermissible due to its enhancing effects.

Consequentialist reasoning: For this perspective, enhancement is fundamentally a matter of examining the efficacy of the intervention at hand (how large and lasting are the desired effects) and its safety (how large and lasting are the undesired effects). Consequences are evaluated both from the perspective of the individual, and from the perspective of broader collectives and society at large. Both desired and undesired effects may be uncertain, and those adopting a consequentialist line of reasoning may come to different conclusions about neuroenhancement depending on the relative weighting of risks and benefits.

Challenging authenticity: The authenticity of individual accomplishment and achievement of those who use neuroenhancers was often contested by the public. For some, enhancers are seen as a way to conceal one’s genuine capacity and to perform beyond one’s real capabilities. Thus, it is unclear whether their accomplishment is really their own. Adherents of this perspective also invoked the distinction between ends and means, sometimes considering neuroenhancement to be an inappropriate means for the pursuit of ends that may otherwise be worthy. Enhancement alters the significance of social practices by turning them into a technological competition instead of a display of real human capabilities and excellence. This also destabilises the ascription of achievement to individuals. In the end, neuroenhancement is seen as a form of cheating, albeit not simply because it would go against a rule or prescription of some sort, but because of its inauthentic nature.

Pressure and coercion: This perspective frames neuroenhancement as a response to societal pressure and articulates the concern that it will enable institutions to exert more pressure and demand more from individuals, who will have no other choice but to cope with the use of enhancers. Instead of adapting institutions to human needs, capacities, and limitations, neuroenhancement operates in the opposite direction, modifying humans by technical means for institutional benefit. Therefore, neuroenhancement is also seen as a tool that facilitates the ever-increasing acceleration of life with harmful effects.

Undermining solidarity
Neuroenhancement was sometimes perceived as a strategy for enhancing one's competitive advantage over others, intensifying rivalry in education and work settings. This would effectively undermine solidarity, as each individual would prioritise their own pursuits neglecting the needs of others. On this view, neuroenhancement would represent an overdrive of individualisation in an increasingly competitive world.

Alternatives to neuroenhancement
This perspective suggests that contrary to the assumption that success in life is dependent on individual performance, which may be enhanced technologically, in reality, a host of other factors, such as socioeconomic status, parental resources and connections, and social capital are what determine how one fares in life. Therefore, this view diminishes the significance of neuroenhancement depicting as a pursuit that is not worth taking, because it is not what ultimately matters.

These perspectives were distilled from the range of MLEs conducted during the NERRI project. However, as described in the previous section, public engagement activities have limitations and generalising from these observations would be unwarranted. Moreover, the perspectives distilled above are the result of a variety of engagement activities that often addressed somewhat different aspects of the broader neuroenhancement phenomenon. Hence, building on the insights gathered from MLEs an online survey was developed with the aim of gathering a more robust understanding of the public's views about neuroenhancement in the participating European countries and the United States of America. A 2018 article published in the journal Neuroethics (Bard et al., 2018) includes a subset of quantitative analyses performed on the full dataset of 11 countries that were included in the NERRI survey. The analyses presented in this thesis will only consider partial data, looking at five countries: Austria, Germany, Hungary, the United Kingdom, and the United States. However, I will offer a more in-depth analysis that includes the full set of response variables collected in the survey experiments along with qualitative data.

From Public Dialogue to Public Ethics – Thesis Part II
As described previously, the purpose of the survey was to take the insights derived from a diverse set of public dialogue events and gather data about public views in a more standardised format.

The survey was comprised of two main components:

- two experiments focused on the public's views about neuroenhancement in an educational and employment context;
- a series of broader attitude questions related to neuroenhancement.

Figure 1 shows a schematic representation of the survey flow.

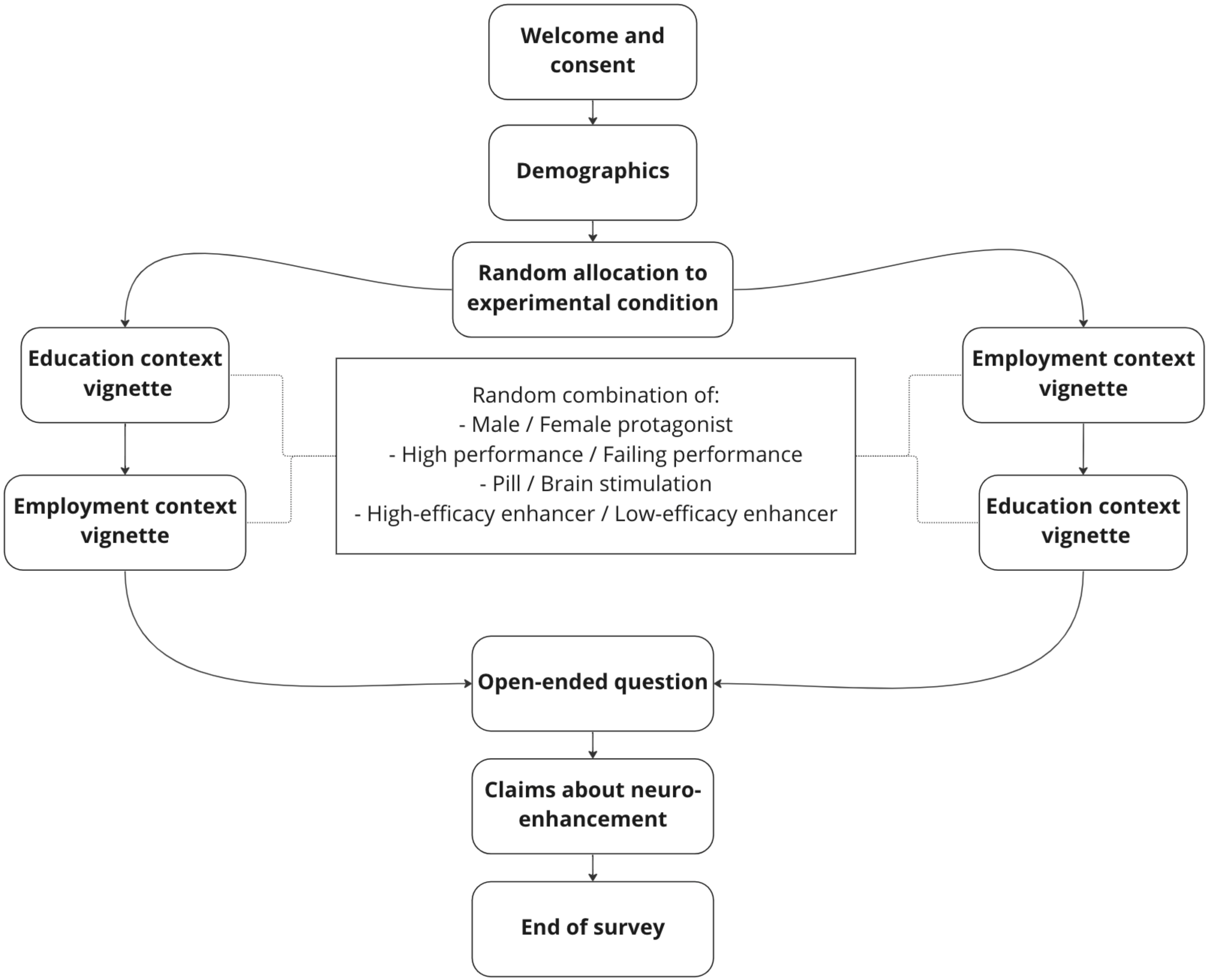

Figure 1. Schematic representation of NERRI survey flow.

The experiments employed the contrastive vignette technique (Burstin et al., 1980), which powerfully combines the causal analysis of experimentation with the large sample sizes typical of survey research. Broadly speaking, a vignette is a short account of a situation in which a protagonist with certain characteristics faces a dilemma and choses one of two available courses of action. In its simplest form the contrastive technique involves presenting minimally different versions of a single vignette to respondents and asking all participants the same set of questions. The minimal contrasts allow experimenters to investigate how a single factor influences people's responses.

An advantage of using vignettes for our study is that only a minority of people in our public consultation events had heard about neuroenhancement. As such, asking respondents for a judgement on it without providing them with some information about the topic would not have yielded meaningful results. With vignettes, it is possible to give an accessible and non-technical account of NE, embedding the technology in contexts familiar to respondents.

Experiments – Education and Employment

As outlined in Chapter 1 it has been established in the literature that therapeutic interventions on the brain are generally not seen as problematic by the public, while use by non-clinical groups appears more contested. Respondents were presented with two vignettes, one featuring neuroenhancement in education, the other in employment. The order of presentation of the two contexts was randomised. The experiments were designed to assess whether the type of enhancing technology, its efficacy, the gender of the user, and the user's current level of performance shape attitudes to neuroenhancement.

Efficacy has been shown to be an important factor modulating attitudes towards enhancement (Sattler et al., 2013). It was also a key question in the qualitative consultation exercises during NERRI, where a recurrent issue raised by participants was how well neuroenhancement actually works. This suggests that both pragmatic and moral assessments may be predicated on such basic facts about the interventions. We hypothesized that a smaller (10%) improvement compared to a larger (50%) improvement would elicit different responses, with higher efficacy making enhancement more acceptable, because more significant benefits might outweigh perceived risks and other considerations.

In relation to the *performance* of the protagonist, earlier studies established that lower performance correlates with higher levels of support (Sattler et al., 2013). We hypothesised that, with the prospect of a serious loss as a result of failing an examination or losing one's job, there would be greater propensity to accept the possible risks of enhancement (Tversky & Kahneman, 1979).

Furthermore, a scenario where a protagonist is acting to avert such a loss might be perceived as a quasi-therapeutic intervention (Cabrera et al., 2015), and thus seen as more permissible. In NERRI public consultations, discussions often revolved around 'pills' and 'electrical brain stimulation' as two available neuroenhancement methods. The public can draw on a great degree of life-world experience in relation to pills, and a significant proportion of the neuroethics discussion has also focused on this form of neuroenhancement. Electrical brain stimulation devices were recent developments at the time of data collection but the method was attracting considerable attention just as we were preparing for data collection. As brain stimulation was emerging as a novel form of neuroenhancement, we decided to include it in our study, since its potential neuroenhancing effects (Kadosh, 2013), commercial availability, and uptake in the DIY community (Jwa, 2015) have sparked new kind of debates and proposals about the regulation of such cognition enhancing devices (Maslen, Douglas, et al., 2015). We sought to investigate whether contrasting these two *technologies,* the more familiar, pharmacological intervention with the less familiar, technological one, would influence attitudes.

We also investigated whether the *gender* of the person engaging in neuroenhancement would affect responses. The analysis of experimental effects is subsequently complemented by the inclusion of sociodemographic characteristics to assess whether these correlate with certain attitudes. Each factor had two levels; gender (male/female); type of enhancer (pill/device); enhancer efficacy (10% or 50% improvement), and current performance (good/failing). The 16 vignettes each present a short story in which the protagonist confronts a problem, which leads to a decision to use a neuroenhancer. Having read the vignette, respondents answer the same set of questions, capturing the outcome variables of interest. Respondents were not aware of the other conditions. The hypotheses relating to the four factors are tested with different versions of the vignette. As respondents see only one vignette this acts against the 'good subject' effect, the desire to conform to mainstream expectations on moral issues (Nichols & Maner, 2008). Communicating possible risks as well as benefits was deemed important to make the scenarios more realistic and life-like. For employment, the risk was described as 'occasional insomnia', similar to Fitz et al.'s study (Fitz et al., 2014). For education, the risk was described as 'some people get a headache after the effect wears off', similar to Sattler's study (Sattler et al., 2013). Box 1 below shows the different versions of the education and employment vignettes.

Employment:

(GENDER Paul/Jack/Emily/Sarah) is in his/her mid-30s and works full-time at a big company. Recently, his boss told him that last year his work successfully (PERFORMANCE met / failed to meet) the company's expectations. (Paul is determined to get a promotion. / This raised Paul's fears that he could lose his job.) He recently came across the idea of using (TYPE OF ENHANCER a pill / device) that promises to (somewhat / substantially) increase a healthy person's concentration and memory, by about (ENHANCER EFFICACY 10% / 50%). (for device only: It delivers tiny electrical currents to stimulate certain areas of the brain using small sticky pads attached to the outside of the head for about 15 min.) In some people, the pill / device can cause occasional insomnia, but there are no known long-term side effects. He decides to give it a try.

Education:
(GENDER Emily/Jack/Sarah/Paul) is in his/her early twenties and studying full-time at university. His/Her results so far have been (PERFORMANCE good / below average). S/he is currently preparing for his/her examinations. (While s/he feels overwhelmed with how much work s/he has to do, she is aiming for the top grade. / She feels overwhelmed with how much work she has to do and fears that she may fail the exam.) Recently s/he heard about a (TYPE OF ENHANCER pill / device), which promises a (ENHANCER EFFICACY small / significant improvement in the speed of learning in healthy people, but still about 10% / by about 50%). (for device only: It delivers tiny electrical currents to stimulate certain areas of the brain using small sticky pads attached to the outside of the head for about 15 min.) Some people get a headache after the effect wears off, but there are no known long-term side effects. She decides to give it a try.

Box 1. Education and Employment Vignettes – English language versions; first names were adapted to local equivalents.

Respondents were randomly allocated a vignette from both contexts and asked 5 questions (+1 trap question) after each presentation. Responses were recorded on an 11-point scale, ranging from −5 to +5. The five questions were:

- Can you sympathise with [vignette protagonist]'s decision?
- Will [vignette protagonist]'s decision give him/her an advantage over his colleagues/fellow students?
- Do you think most people would decide like [vignette protagonist]?
- Do you think the benefits outweigh the risks?
- In [vignette protagonist]'s shoes, would you make the same choice?

Each question was designed to address a different aspect of the phenomenon, progressing from the assessment of the more affective dimension of sympathy, through benefits, implicit norm, and competitive advantage, to the individual's decision to act in a similar manner.

Each vignette is a depiction of a situation involving a dilemma, and in half of these the protagonist is in a state of distress and concern. The first question gauges the degree to which respondents can understand and relate to a struggling and a high achieving protagonist's situation and to their decision to use an enhancer. Sympathy is usually understood as an immediate, unthinking and emotional response in relation to a person's situation, usually one that involves suffering or some plight (Lishner et al., 2011). Answering this question involves an involuntary adoption of the perspective of the person described in the story. While respondents may disagree with the choice for some reason or other, they may still be able to sympathise with the protagonist's circumstances.

The second question provides insight into the degree to which respondents view the neuro-enhancement as giving a positional advantage to the protagonist, which is a concern that is discussed at length in the neuroethics literature, and it also emerged during public consultations.

Recognising that neuroenhancement is a rather new phenomenon around which clear norms have not yet crystallized, question 3 is eliciting an assessment about the degree to which survey respondents view believe that neuroenhancement is widely endorsed in society.

The fourth question invites participants to perform a risk/benefit assessment. As explained in Chapter 1, some techno-progressive thinkers argue that such calculations are the only sensible way to approach the assessment of enhancers (Harris, 2007), and during public dialogue events we repeatedly encountered a hunger for facts about neuroenhancers that would provide a basis for making such determinations.

Finally, we assumed that respondents could imagine themselves in the same predicament as the protagonist, and to be able to decide whether they would support their choice or not. We also assumed that this question, inviting a participant script (Abelson, 1976), would induce a more active involvement in the situation than a question asking about the extent to which they approve or support the choice or approve/disapprove of NE in general – a non-participant script.

Following their responses to the second vignette, respondents were invited to describe in their own words why they answered as they did.

Claims about Neuroenhancement

After experiments 1 & 2 respondents were asked to read the following definition of neuroenhancement, which was intended to provide a neutral account of NE introducing some key ideas without influencing respondents to lean either way in their assessment.

> *Scientists are learning more about how our brains work – how we remember, how we think, how we feel and how we perceive the world. This research is driven by the desire to understand the brain and to find treatments for conditions like Alzheimer's, Parkinson's, stroke, and depression. It is hoped that this work will result in new ways of intervening in brain functions to improve the mental abilities and sensory capacities of patients. At the same time, such research might also bring about ways of enhancing the capacities of "healthy" people as well (for example: improve concentration or increase memory). This is called neuro-enhancement. The stories you read on the previous pages are just two examples of many possible situations. Some are optimistic about neuro-enhancement and think that we will be able to improve our abilities. Others are doubtful because the brain is very complex and so little is known about how it functions.*

Building on the points of view described earlier, which had been identified on the basis of analysing recurrent themes encountered during the public dialogues, we distilled fourteen commonly mentioned claims about neuroenhancement and the use of technological interventions in human achievement. These claims may be seen as the results of a bottom-up approach to identifying moral and other considerations thought to be of relevance by the public.

In the survey, the following instructions were presented. "Here are some views that people have expressed about neuroenhancement of healthy individuals, and its wider implications for society. Please read the statements below and show how much you agree or disagree with them, using the scale provided (−5 to +5).

1. People should be content with their talents and abilities and not use artificial means to improve their performance
2. It is an expression of human nature to try to overcome the limitations of our body and mind
3. People's achievements should come from their own effort and not from pills and devices
4. I can imagine neuro-enhancement opening up fascinating new opportunities
5. Some people will use neuro-enhancers to cope with increasing demands in life
6. As life gets more pressured, neuro-enhancement may be the only way out
7. It is essential that public authorities oversee and control neuro-enhancement
8. Only people with a medical problem should have access to neuro-enhancement
9. People need to be protected from pressures to use neuro-enhancers
10. If a neuro-enhancer is safe, it should be available as a consumer product
11. Neuro-enhancement should never be used on children
12. Neuro-enhancement should be available to all those who might want it
13. Neuro-enhancement will increase competition between people
14. Neuro-enhancement will threaten social cohesion

Box 2. Claims about neuroenhancement

Responses to these claims were recorded on an 11-point scale, from Strongly disagree (−5) to Strongly agree (+5), which were subsequently recoded into a scale from 0-10.

First, I used Principal Component Analysis to investigate, whether latent variables could help explain survey-takers pattern of responses to the claims. Subsequently, I used the k-means algorithm (Forgy, 1965) to cluster this data and to investigate whether patterns of similar responses emerge from data that represent distinct points of view on the phenomenon of neuroenhancement. Clustering is the process of grouping data points in such a way that similar entries get allocated to the same group, while dissimilar entries get allocated to different groups (Steinley, 2006). The k-means algorithm is one of the most popular unsupervised clustering techniques that is often used in the context of market research for purposes like customer segmentation (Syakur et al., 2018) but clustering methods have been used to investigate public attitudes in relation to technology as well, including views on online platforms and privacy (Hermes et al., 2020, 2021) and stem cell research (Gaskell et al., 2012).

The k-means algorithm works by grouping the observations in a dataset into a predefined number (k) of clusters in an iterative manner, whereby k centroids are initialised randomly in the dataset, and each observation is assigned to the nearest centroid. In a next step, the centroids are updated on the basis of the mean of all points within each cluster, and these steps get repeated until no further updates are necessary, which means that each data point has been assigned to the centroid with the smallest mean distance. As k-means is a somewhat heuristic method, the algorithm is usually run with an increasing number of clusters, until an ideal cluster solution is found. The elbow method is often used to help determine the number of clusters, where the optimal number is deemed to be the one where the sum of squared distances starts to decrease linearly. This is visually represented by a 'break' in a plot of cluster, similar to an elbow joint. See Figure 2 for the elbow plot.

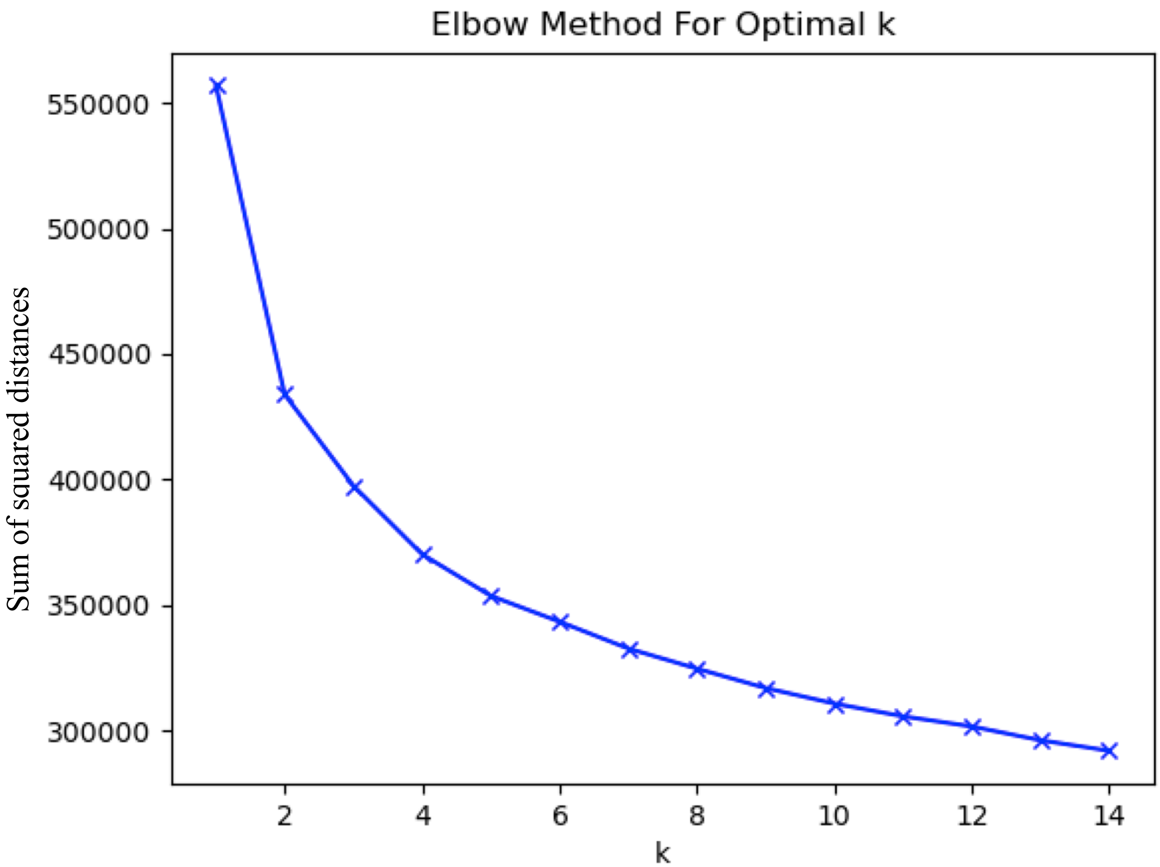

Figure 2. Elbow plot of k-means algorithm.

The plot did not yield a straightforward point for the optimal number of clusters, so I performed the algorithm with clusters ranging from 2-6, and decided on a 4-cluster solution based on optimal interpretability and in line with the elbow plot. The k-means algorithm produces an allocation of each individual respondent in the database to one cluster, along with a measure of how far away each individual is from the centre of the given cluster. This is an indication of how 'typical' any given respondent is of the cluster they have been assigned to. A one-way ANOVA test revealed that the group means across all 14 variables are statistically significantly different at the $p < 0.001$ level of statistical significance, indicating that the views of respondents in each cluster are significantly different from each other. In addition, I used binary logistic regression to investigate the relationship between cluster membership and demographic characteristics such as gender, age, level of education and nationality, as well as to analyse the relationship between cluster membership and qualitative comments.

Qualitative Analysis of Open-ended Comments

As so often happens in research, similar ideas are developed by multiple groups simultaneously as they explore the adjacent possible (Björneborn, 2020) and usually the first team to publish gets to claim credit for the idea. The design of the NERRI survey was greatly inspired by the work of Prof Peter Reiner's group at the University of British Columbia who had published a series of excellent contrastive vignette-based studies about neuroenhancement investigating public attitudes towards the phenomenon in US samples (Cabrera et al., 2015; Fitz et al., 2014). We wanted to explore the use of this experimental approach in combination with qualitative inquiry to understand how the public reasons about enhancement as a function of the type of vignette they had been exposed to. The idea was to include open-ended questions, which would then be coded into discrete categories to investigate whether the public mobilised different perspectives based on the experimental manipulations. This difference would be expressed as a difference in code frequencies for the experimental conditions. In fact, our team had published a paper looking at attitudes towards gene editing for enhancement, where we applied a version of this method (Gaskell et al., 2017). Nevertheless, the proper articulation of the technique as a fleshed-out research method must be credited to Cabrera and Reiner (2018).

The qualitative data gathered in the survey was coded in an iterative manner, whereby entries from the 5 countries included in the present sample were merged in a new database, retaining a unique identifier for each respondent. The entries were sorted in a random manner, such that the data from all countries was mixed. Then, I extracted a subset amounting to approximately 15% of the entire dataset and this pool of responses was used to generate the first version of the coding frame. This helped ensure that the coding frame would be appropriate to the entire dataset instead of being overly influenced by the perspectives expressed by respondents in any individual country. I proceeded to categorise the contents, arguments, statements and viewpoints that the free-text entries contained following a conventional content analysis methodology(Hsieh & Shannon, 2005; Saldaña, 2021). I took each individual response to be the unit of analysis and proceeded to code each distinct argument or statement separately. Codes were reviewed multiple times, with several rounds of consolidation and relabelling in an attempt to minimise overlaps between them. My aim was to arrive at categories that represented the essence of the expressed ideas succinctly, while still fulfilling the purpose of coding as a data reduction technique. Codes were quantitised using a binary method such that the presence or absence of each code was recorded for each individual with a 1 or a 0 for all codes (Onwuegbuzie, 2003). Hence, if a person made multiple points or arguments in their comment, each of them was captured. Appendix A1. contains the final version of the coding frame with example statements.

A $\chi 2$ test revealed that there was no difference between the proportion of comments received on the two enhancement contexts and in both cases almost exactly two-thirds of respondents had provided an explanation of their assessment, $\chi^2(1,5332) = .058$, $p = .809$.

The entire corpus was comprised of 334 375 characters (with spaces), which amounted to a total of 55,173 words. The average number of words per comment was 15.3. The shortest comment was made up of just a single word, while the longest piece of text entered by a respondent was 202 words long.

I used χ^2 tests to investigate how balanced the sample of commenters vs non-commenters was. There was no statistically significant difference in any of the investigated contexts between the proportion of respondents who left a comment and the randomly allocated experimental condition. However, significantly more respondents from the UK and the USA left a comment compared to other countries. From Austria, Germany and Hungary 56.6%, 59.8%, and 65% respectively left a comment, while from the UK and the US the proportions are 76.3% and 80.3% respectively. See Table 1. below.

Conditional distribution of commenters by country							
		Country					**Total**
Did the respondent leave a comment?		Austria	Germany	Hungary	UK	USA	
No	Count	462	433	374	255	206	1730
	% within Country	43.40%	40.20%	35.00%	23.70%	19.70%	32.40%
Yes	Count	603	643	695	823	838	3602
	% within Country	56.60%	59.80%	65.00%	76.30%	80.30%	67.60%
Total	Count	1065	1076	1069	1078	1044	5332
	% within Country	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 1. Proportion of commenters and non-commenters from each country.

In Austria, there was no statistically significant difference in the proportion of those who left a comment as a function of possessing a tertiary degree, and equally, no difference with regard to age group. However, the perspectives of women were somewhat overrepresented amongst the Austrian comments ($p < 0.001$), as only 42.8% of men left a comment, while 57.2% of women did, with the overall gender ratio in the sample being 48.1% for men and 51.9% for women. A similar pattern was evident for Hungary, where the level of education and age group were not different between commenters and non-commenters, while women were somewhat overrepresented ($p < 0.001$). In the Hungarian sample the proportion of men/women was 46.4% / 53.6%, while amongst the commenters this ratio was 42.2% / 57.8%.

For Germany, none of the demographic indicators differed between respondents and non-respondents. In the case of the UK, the proportion of men and women was also significantly different. In the UK sample the ratio of men/women was 48.5% / 51.5%, while amongst the commenters this ratio was 46.4% / 53.6%. For the US the proportion of university educated respondents was slightly higher than in the overall sample. In the total sample the proportion of respondents with a degree was 30.2%, while amongst commenters this proportion was 31.6%.

Recognising that the differences in proportion are rather small and that samples in this study were not carefully matched, and that the primary interest was not to compare the views of pre-defined demographic groups, but rather, to investigate whether the experimental manipulations would be associated with different types of arguments, I decided to now adjust the sample usig weights (Gary, 2007). Is there anything systematic that may be said about non-commenters? In order to answer this question, I compared the mean responses of commenters and non-commenters on the key experimental outcome measure, whether the respondent would act the same as the protagonist depicted in the vignette. There was no difference between the groups in the case of the US, however, for the other 4 countries, non-respondents gave a higher mean score in the employment context, but not in the education context. This result is statistically significant at the 5% level of statistical significance and the mean difference is approximately 0.3 points on the 11-point scale. I must admit, I am somewhat at a loss with regard to the interpretation of this difference, but I am disclosing it for the sake of transparency.

Design and Respondents

The survey was developed using the Qualtrics web platform. The vignettes and the accompanying questionnaire were designed by the NERRI research group. Translation from English into the national languages was undertaken by members of the research group. Assiduous attention was paid to ensuring comparability of meaning of words and phrases.

The vignettes underwent qualitative piloting in focus groups conducted by the Austrian team. Subsequently, the draft survey was piloted on 200 respondents in the UK. Field work was conducted between January and February 2016 by the commercial company Respondi, which coordinates double opt-in access panels of respondents for online surveys. In each country quota samples of persons 18 years and above, approximating the national profile of age groups, gender, and level of education (tertiary or not) were selected, N = 5,333.

The questionnaire design included two trap questions to automatically disqualify respondents speeding through the survey; approximately 400 per country on average. Demographic information was collected at the beginning in order to ensure quotas were appropriately filled.

In the survey, the experimental vignettes were the first block of questions, followed by respondents' level of agreement with claims about NE. The rationale for this ordering was to ensure that the effects of the experimental treatments (gender, technology, efficacy and performance) would not be influenced by the substantive content of the claims about NE. In other words, the claims might introduce respondents to arguments about NE that they had not previously encountered and these arguments might set the context for responding to the vignettes. Were this to have occurred it would not be possible to claim that changes in responses to the vignettes could be confidently attributed solely to the experimental treatments. However, with this ordering of the questions, it is possible that the experimental treatments created a context effect for responses to the claims. This will be investigated in detail In Part II when I describe the results.

Qualitative Exploration of the Proactionary Milieu – Thesis Part III

Chapters 5 and 6 in Part III of the thesis describe interview studies conducted with two different groups of neuroenhancement users. Chapter 5 offers an exploratory account of the practice of brain hacking, understood as the use of Do-It-Yourself or commercially available neurostimulation devices for the purposes of neuroenhancement. The study describes interviews conducted with 3 members of a brain hacking collective and explores the motivations animating their practice, as well as their experiences with brain stimulation, and their views on neuroenhancement.

Semi-structured interviews were judged to be the most appropriate method, because my primary research interest concerned personal motivations, views, attitudes and practices as opposed to interactions or group dynamics (Lamont & Swidler, 2014). The interviews were conducted in April 2015. I was introduced to the first interviewee by a mutual acquaintance at a futurism-themed public event, who was aware of my research interest and could connect me to the first informant. Subsequent interviewees were recruited via chain-referral sampling, whereby the first informant suggested the second, who in turn suggested the third contact. However, no further interviewees were available, which makes this project an exploratory micro-study. Interviewees were assured of anonymity and confidentiality and informed about the purposes of the study - to explore the views, practices and experiences of DIY brain stimulation users - and its exploratory nature. One interview was conducted at an informant's home, while the other two took place on the interviewees' university campuses. Interviews lasted between 30 minutes and 1 hour. The interview topic guide is reproduced in Appendix B1.

Although there are no pre-defined rules and criteria for sample size in qualitative research, and sometimes in-depth analyses of single-subject interviews are reported (Patton, 2002), projects tend to have more informants than the present sample, which is a weakness of the project. In addition, interview-based qualitative research often draws on the notion of 'saturation' as the criterion for determining when additional subjects are no longer recruited. This concept emerged from Grounded Theory (Bowen, 2008) and refers to the point where additional informants would fail to lead to new insights and theory generation. In the case of this project, saturation was certainly not reached because further interviewees were simply not available, even though their views would most likely have enriched my understanding of the phenomenon. Nevertheless, the interviews yielded a surprisingly rich set of insights into the practice of 'brain hacking' that are aligned with and comparable to existing findings from studies undertaken by Jwa (2015) and Wexler (2015; 2018), and they can be interpreted within the framework of technological human enhancement advocacy (MacFarlane, 2020). Given the small sample size and exploratory nature of the study, I have chosen to present the data in the form of individual profiles of the three interviewees in order to adequately foreground the nature of their motivations and experiences, and to highlight commonalities among their views.

Chapter 6 also reports of a qualitative study, however, in this case, I used repeat interviews to investigate the experience of a group of sensory augmentation users. Although interviewing is one of the most frequently used techniques in qualitative research (Bryman, 2004; Holstein & Gubrium, 1995) scholars rarely take advantage of collecting data at more than one time point. While researchers are invited to consider how many subjects to interview, the question of how many times a subject should be interviewed receives far less attention (Vincent, 2013). The emerging practice of Qualitative Longitudinal Research (QLR) offers important advantages compared to single interviews, most notably that the incorporation of temporality into the research process allows for the documentation of change and follow-up questions can take into account the information already shared by interviewees, thus leading to richer accounts and a fuller understanding of interviewee perspectives (Saldana, 2003). There are no clear guidelines or established practice with regard to the frequency of data collection or the time between points of data collection in QLR and researchers have demonstrated a wide variety of approaches with regard these aspects of their studies (Holland et al., 2006). The present research might be characterised as a piece of QLR because it was designed with the aim of interviewing respondents at two time points in order to capture the evolution of their experiences with the North Sense sensory augmentation device, which is based on the notion of sensory substitution and provides wearers with a directional cue in the form a tactile vibration that signals the direction of north. The device has to be attached to the body using transdermal piercings, which hold it in place on the body.

Interviews were conducted remotely using Skype and the conversations were audio recorded and subsequently transcribed verbatim. Interview durations ranged from 25 to 90 minutes. In total, there were 23 subjects of whom 12 were available for a second interview, and one of these subjects opted to share their second reflections via email instead of another conversation.

Data collection took place between July 2017 and Aril 2018, with an average of 6 months between the two data collection moments. This interval was selected on purpose, as I wanted to ensure that respondents had sufficient time to gather experience with the device and to take into account individual differences with regard to the stage respondents were in at the time of the first interview.

Interviewees were recruited via email. Cyborg Nest Ltd., the North Sense device's manufacturer agreed to send out an invitation to the individuals who had purchased their product to participate in an independent research study exploring their views and experiences. The invitation included a link to a Qualtrics form hosted under my LSE account where subjects could express their consent to participate. The identity of study participants was not shared with CyborgNest. The form asked respondents to provide their first name, age, gender and email address, and asked them to identify the stage they were currently in with regard to the North Sense.

Those who signed up via the form were subsequently contacted by email with further details about the study's processes, aims and methods, as well as a link to another online form where they could indicate their availability for an online interview if they wished to participate in light of the extended information.

At the start of each interview, subjects' verbal consent was also taken, after explaining to them again the study processes, including their right to withdraw at any time, the confidential and anonymous handling of their data, and the study's complete independence of Cyborg Nest. Participants received no compensation.

In total, there were approximately 250 North Sense devices sold worldwide. My initial expression of interest form received 46 responses, and interviews were conducted with a total of 23 subjects, which amounts to over 9% of the entire population of North Sense users. The other 23 respondents who had signed up but were not interviewed did not respond to follow-up emails to schedule an online meeting. However, the sample compares quite favourably to similar research undertaken by Wexler (2018), which was conducted among the owners of tDCS devices who were contacted in a similar fashion via the manufacturer's newsletters to complete an online survey. That study achieved a 3.9% response rate. As will be described below, most interviewees had a strong sense of commitment and of participating in a unique experience sometimes described as being 'pioneers' in a new domain and were therefore very enthusiastic and supportive of contributing to the study. In contrast, the owners of electrical brain stimulation might not share this self-identification, which may, at least partially, explain lower response rates.

Interviewees came from across the world with 1 respondent each from Austria, Canada, France, Germany, Hungary, Spain, Ireland, Israel, Mexico, the Netherlands, and Poland, 3 respondents from the UK, and 9 from the United States. With regard to gender, 17 respondents identified as male, 5 as female, and 1 as trans. The respondents' age ranged from 19 to 62, with a mean age of 31.9 years. All respondents were either employed or in full-time education at the time of the interviews. Respondents' occupations and study programs spanned a wide range of fields with an emphasis on scientific and technical domains, such as computer programming, geophysics, mathematics, IT system administration, human- computer interaction research, data science, consulting, technology journalism, but there were other professions as well, including a social worker, a barista, and a few respondents who described themselves as creatives active at the interface of technology and the arts.

Interviewees fell into three discrete categories based on where they were in the process of using the North Sense. Stage 1 respondents had already ordered the device but had not had the anchoring system nor the device itself attached to their body. Stage 2 users had already had the anchoring system put in place but were in the process of healing and had not started using the North Sense yet. Finally, respondents in Stage 3 had both the anchoring system and the device in place at the time of the interview. Appendix C1 shows a summary of user trajectories encountered throughout the project. Over the course of conversations, it became apparent that there was a Stage 4 category of users as well, those who had already discontinued the use of the device for some reason. With regard to other forms of body modification, six individuals in the sample had magnetic implants and 4 of them had an RFID chip, one person was using an insulin pump for diabetes, another was receiving testosterone treatment as part of their transition, and one person was using an intrauterine device for contraception.

A topic guide was used during the interviews, which included several questions on the core topics of interest. The interview process considered the respective stage of the respondent and the topic guide was adjusted accordingly. The main difference was that respondents who had already started using the device at the time of the interview were asked about their experiences with the device, while the others were not. See Appendix C2 for the interview topic guide.

Stage 1 respondents were asked about their feelings with regard to the next step in the process, the mounting of the anchoring system. In addition, Stage 2 respondents were asked about their experience with the process of attaching the anchors, while Stage 3 respondents were asked to describe and reflect on their experiences with the North Sense itself in terms of daily use, perceptual effects, the nature of the sensation they get from the device, and any other thoughts they wished to share.

The follow-up interviews were somewhat less structured than the first and began by simply asking the respondent to provide an update on where they were in the North Sense journey and to say whatever they felt was most important. Then, they were asked questions from the topic guide that addressed their current stage. Interviews generally closed with discussions about broader questions triggered by the North Sense experience.

In the coding and analysis of the data I mostly followed an inductive and interpretative approach to thematic analysis which involved reading and re-reading the transcripts, developing codes based on major topics and issues and grouping data extracts together, and connecting congruent codes to generate themes (Boyatzis, 1998). However, the analysis was to some extent guided by the broad themes identified in the topic guide, which might situate the project somewhat more in a hybrid approach (Fereday & Muir-Cochrane, 2006). Coding was performed using Atlas.ti for Mac version 9.1.2.

Part II – Neuroenhancement and the Public

Chapter 3 – Neuroenhancement in National Discussions

Part II of the thesis will describe the findings from a large multi-national survey conducted within the framework of the NERRI project. The survey included contrastive vignette-based experiments situating neuroenhancement in education and employment contexts, as well as an open-ended question, where respondents could explain the reasoning behind their judgments. It also used closed questions about attitudes towards enhancement that were derived from public engagement activities conducted during the project. However, before turning to the study's findings, this short chapter will situate the work with respect to national discussions about neuroenhancement at the time of data collection. Therefore, the first section will offer a brief overview of the state of public discourse about the phenomenon in each of the 5 countries surveyed in this part of the thesis. The purpose of this section is to contextualize and ground my own empirical data.

In order to paint a picture of the public salience of neuroenhancement I am drawing on two key indicators. First, I have performed basic news searches on the LexisNexis platform using a set of keywords related to the theme of neuroenhancement, covering the period between 2000 and 2021. Where available, I also draw on existing secondary analyses of the subject. In addition, I investigated the degree of professional and policy activity on the topic, expressed in the form of studies or documents issued by professional organizations, technology assessment bodies, bioethics commissions, and similar organisations.

My objective is to provide a birds-eye view of the level and nature of public awareness and interest in neuroenhancement in each country. This will help to situate my own data and to highlight some of the similarities and differences across the countries. Before turning to the analysis though, it seems pertinent to add a note about the translatability of the term 'neuroenhancement' itself.

What's in a name?

During the late 1990s and early 2000s the word 'neuro' attained broad usage as a prefix, showing up in a number of contexts from niche academic domains like neuro-aesthetics, neuro-theology and neuro-philosophy to a whole host of other areas some of which claim to have direct relevance for various social practices, like neuro-education, neuro-law, neuro-economics, neuro-marketing, etc. In all these cases, the neuro-, prefix denotes the incorporation of insights and methods from the neurosciences into the relevant domain. For example, neuro-marketing uses brain-based information to understand consumer preferences (Murphy et al., 2008), while neuro-education seeks to exploit the potential of neuroscience for education policy and practice (Ansari et al., 2012). However, the cultural proliferation of neuroscience as an authoritative source of understanding and intervening into human life extends much further into everyday contexts, thus, we find neuro-drinks, neuro-trainers, neuro-therapies and a host of other products, services and activities that seek to promote and distinguish themselves by foregrounding some form of association with the brain and the nervous system (Rose & Abi-Rached, 2013).

The term neuroenhancement carries a certain intuitiveness in English that suggests some improvement, augmentation or enhancement of that which falls under 'neuro', i.e., the brain and the nervous system. However, it translates poorly into both German and Hungarian. The German expert academic discussion has largely adopted neuroenhancement (Schöne-Seifert et al., 2009;

Viertbauer & Kögerler, 2019; Wagner, 2017), while its literal translation into German (Neuro-Verbesserung) and the equivalents of 'cognitive enhancement', such as 'kognitive Verbesserung', 'kognitive Steigerung' or 'kognitive Leistungssteigerung' are absent from public discourse. In Hungarian academic discussions on enhancement the term is usually translated as a form of 'performance enhancement' (teljesítményfokozás).

In addition, both neuroenhancement and cognitive enhancement are rather neutral in comparison to some of the other terms that are used to denote the phenomenon in other languages. For example, 'brain doping' ((Ge)Hirndoping) is very common in German and signifies inappropriateness, 'brain boosting' is sometimes used in English and has some positive connotations, while in Hungarian the most appropriate term is 'mental performance enhancement' (Hungarian: szellemi teljesítményfokozás'), which also situates the practice in the vicinity of doping. In addition, enhancement is sometimes described with terms related to particular interventions, such as 'brain zapping' for the use of electrical brain stimulation, or 'smart drugs' (German: 'smarte Pille'; Hungarian: 'okos drog') for pharmaceuticals.

The Evolution of Media Coverage on Neuroenhancement

For Austria, Germany, the United Kingdom and the United States I used LexisNexis, which is one of the most robust news aggregators for social science research, while for the construction of the Hungarian corpus I relied on Arcanum Digitheca, the highest quality periodical database in Hungary.[7] Table 2 shows the keywords I used for each search. First, I performed the queries using the relevant keywords for each language, and then used LexisNexis' customization features to restrict results to the relevant geography, language, time period, and sources. In order to account for the growing prominence of online media in people's news consumption habits, I included three types of data sources for each country: newspapers, web-based publications, and magazines.

	English	German	Hungarian
Keywords	"cognitive enhancement" or neuroenhancement or neuro-enhancement or "brain doping" or "brain boosting" or "brain enhancement" or "brain zapping" or "smart drug*" or "smart pill" or "brain hacker" or "brain stimulation"	"cognitive enhancement" or neuroenhancement or neuro-enhancement or gehirndoping or hirndoping or "kognitive Leistungssteigerung" or "geistige Leistungssteigerung" or "mentale Leistungssteigerung" or "smart Pill" or "smart drug" or "smarte Pille" or "brain hacker" or "Gehirnstimulation" or "Hirnstimulation"	"Agyi teljesítményfokozás" or "agydopping" or agyfényesítés or "kognitív képességfokozás" or "kognitív teljesítményfokozás" or agyfokozás or agystimuláció or mentális teljesítményfokozás agy-dopping mesterséges képességfokozás művi képességfokozás

Table 2. Keywords used in news searches

[7] See https://adt.arcanum.com/en/

After removing duplicate articles, I performed a simple review of the corpus, including the article title and body to determine whether the text was actually discussing neuroenhancement or if the contents were unrelated. Table 3 shows a summary of the total number of articles downloaded, and the number of articles retained in the corpus.

The very large number of excluded articles from the UK is due to three main reasons. The proportion of duplicates was higher than in the case of the other countries, a significant portion of articles were about the ‘brain boosting’ effects of various foods, over-the-counter dietary supplements and behaviours like sleep, exercise, or brain training. Moreover, a large number of articles discussed therapeutic interventions for neurological and psychiatric conditions, like Alzheimer’s, Parkinson’s, depression, and others. To some extent, the same was true for the United States, but here, the proportion of articles promoting the use of various nootripcs and supplements was higher. However, the same was not the case for the Austrian, German and Hungarian corpus, where the proportion of excluded articles unrelated to neuroenhancement was smaller.

Country	**Number of articles matching keywords**	**Retained article count**
Austria	53	30
Germany	1562	423
Hungary	85	17
United Kingdom	5309	629
United States	2569	224

Table 3. Number of articles yielded by search, and number of articles retained after filtering.

I excluded articles which were entirely unrelated to the topic of neuroenhancement and the keyword match was spurious, as well as those articles that discussed brain optimization or improvement methods that did not rely on pharmaceuticals, brain stimulation, neural implants, brain-computer interfaces, or other emerging technologies discussed under the heading of neuroenhancement. The most common article type described the purportedly beneficial effects of all kinds of behavioural interventions like better sleep, a healthier diet, regular exercise, and cognitively challenging activities, such as crossword puzzles or brain training video games. Similarly, a very large proportion of articles reported on the beneficial cognitive effects of certain foods, ranging from chocolate and beer to fish, blueberries and flavonoids. The dominance of ‘brain health’ and coverage of such ‘common’ techniques for enhancement confirms the findings of earlier studies, which have suggested that brain optimization was an increasingly prominent topic in the media (O’Connor & Joffe, 2015). The proportion of excluded articles was much higher for the UK and the USA than for the other 3 countries, which may suggest that the keywords I used more tightly corresponded to the phenomenon of interest in Austria, Germany and Hungary, or that coverage of familiar brain optimization methods through lifestyle and behavioural choices has higher salience in the UK and the US.

Figure 3 below presents the distribution of neuroenhancement coverage over time between 2000 and 2021, expressed as a yearly percentage of the total. This type of representation allows us to identify the ebb and flow media attention directed at the topic and to situate the early 2016 data collection presented in this thesis.

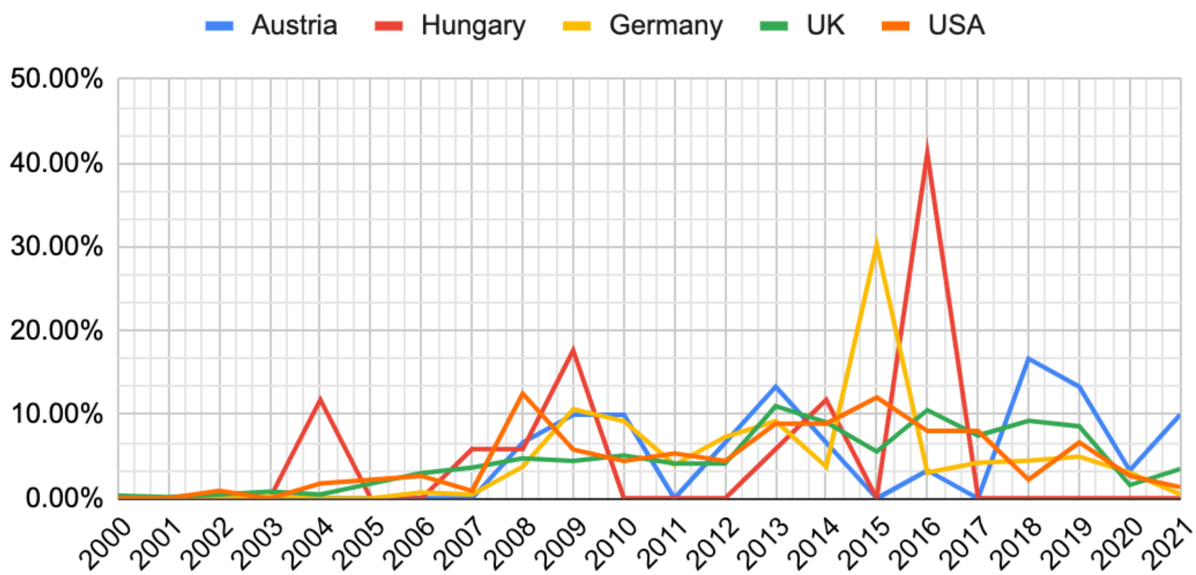

Figure 3. Press coverage of neuroenhancement between 2000-2021 expressed as a yearly percentage of total coverage.

It is notable that in both Austria and Hungary, the topic of neuroenhancement has received very low coverage. In Austria, coverage is generally rare. In 2009 articles reported of brain doping citing the recently published papers in Nature (Maher, 2008), while the small peak in 2013 reported of the NERRI project's launch, and about recent cognitive enhancement research using electrical brain stimulation. Finally, the peak in 2018 covered a variety of enhancement topics, including brain doping via drugs, Elon Musk's company Neuralink, as well as the resurgence of psychedelics research as a form of neuroenhancement.

In Hungary, coverage is so rare that a tiny number of articles can lead to peaks. In 2004 articles reported of students using stimulants to aid their studies, in 2009 also coinciding with the wave of attention spurred by Nature's coverage of the phenomenon a handful of Hungarian articles in a magazine covering culture and science reported of the broader phenomenon of enhancement, including the potential of deep brain stimulation, and the topic of moral enhancement. Finally, the peak in 2016 surfaces a variety of topics, with the use of brain enhancement methods in sport being most prominent.

Importantly, for both Austria and Hungary, coverage is primarily of developments taking place elsewhere, such as the UK or the USA, without linking the phenomenon to local demographics, institutions or activities.

The two peaks in Germany in 2009 and 2015 are related to the publication of large-scale, representative public health studies conducted by the health insurance company DAK-Gesundheit, which has over 5.5 million individuals covered. The reports sought to assess the extent of pharmacological neuro-enhancement among the German working population. The first report in

2009 had found that 4.7% of respondents had used pharmaceuticals at least once during the 2008 calendar year to cope with work (Krämer & Nolting, 2009), while the update from 2015 suggested that the proportion of workers using pharmaceuticals in relation to their work demands had risen to 6.7% and the use of enhancers to increase well-being was more common (4.7%) compared to performance enhancement (3.3%) (DAK Forschung, 2015). In these years, coverage sharply increased as several media outlets reported of the findings in a rather concerned and alarmist tone that framed the phenomenon as a form of doping at the workplace. The periods in-between also primarily frame the phenomenon as substance abuse and doping and problematise the practice as a 'brave new world' that raises serious ethical questions. Only a comparatively small amount of coverage (approximately 10% of the total) is devoted to other methods, such as brain implants, psychedelics, or brain stimulation. A small number of long form articles also engage with the deeper significance and implications of brain research and interventions for our understanding of humanness.

Coverage of neuroenhancement is most prevalent in the United Kingdom, which is perhaps not surprising given the prominent role that UK institutions and researchers have played in raising the profile of neuroenhancement, and the amount of relevant academic research that is carried out on related topics. Remarkably, over 15% of articles mention Cambridge professor, Barbara Sahakian's name, who published the first article in Nature that directed significant attention at smart drug use. Coverage of neuroenhancement in the British media is rather constant, with an emphasis on students' use of smart drugs, academic doping and cheating, until 2013-14 when there is a rise and coverage stabilises again at this higher level. During this period, mentions of electrical brain stimulation sharply increase. In addition, the prospect of banning smart drugs at universities or installing drug testing policies is also discussed and some outlets report rather exaggerated figures of prevalence, suggesting that 20% of students are using drugs to increase their academic performance. In addition, reports of more extreme forms of neuroenhancement via brain implants are also common and increase in frequency after 2013.

Finally, in the United States coverage first peaks in 2008, which coincides with Nature's publication of its first survey conducted among academics, which received broad coverage in US media, and also with a call from highly prominent US academics under the lead authorship of Stanford law professor Hank Greely, also published in Nature, which suggested that we should chart a path towards the responsible use of neuroenhancing drugs by the healthy (Greely et al., 2008). This was widely reported in the media as an 'OK' that academics had provided to the practice and outlets from the New York Times to University Wire foresaw a coming era of academic drug use. The second peak in US coverage occurred during 2015 when an increase in coverage of electrical brain stimulation took place. Exaggerated reports of student prevalence are also common, with some articles suggesting that over a third of students use enhancers.

Policy activity on Neuroenhancement

This section will briefly review the extent of the policy salience of neuroenhancement in each country.

Austria

Although questions related to human augmentation occasionally appear at niche events in Austria, such as the European Forum Alpbach, a yearly Summer seminar series addressing science, politics and culture, the Ars Electronica Festival, one of the world's largest media art festivals, or university lectures and seminars, the topic of neuro-enhancement is best described as a non-issue (Kastenhofer & Torgersen, 2015). The lack of public and academic interest in this topic is evident in the dearth of specialized reports and small media coverage as seen above. Neuro-enhancement was addressed briefly in a 2015 report of the Austrian Addiction Prevention Strategy by the Ministry of Health (Österreichische Suchtpräventionsstrategie Strategie für kohärente Präventions- und Suchtpolitik, 2015), which considered neuro-enhancement to denote the consumption of psychoactive substances of all kinds with the aim of increasing mental performance. The report argued for preventive measures and public awareness campaigns to highlight the health risks associated with neuro-enhancement, it called for action against the illegal trade of these substances but cautioned against stigmatizing or criminalizing the use of medications to improve quality of life for those with serious impairments. Thus, the defining framing of the phenomenon is through the lenses of drug abuse, addiction, and health risks. Although a member of the Austrian Bioethics Commission suggested the topic for discussion in 2012, it was ultimately deemed irrelevant[8].

Germany

In Germany, neuroenhancement has much more prominent visibility, with several academic projects investigating the phenomenon. The Institute of Science and Ethics, which was set up by the Federal Ministry of Education and Research issued a booklet outlining the state of the ethical discussion on enhancement already in 2002 (Fuchs, 2002), which shows that it has been on the radar of policymakers for a long time. Following the first wave of international attention directed at neuroenhancement in the wake of Nature's coverage of pharmacological cognitive enhancement, in 2008 the German government commissioned a technology assessment study to investigate the issue. The study came to a largely sceptical conclusion, arguing that current discussions in bioethics about issues related to fairness, autonomy and other concerns presuppose the existence of potent and risk-free neuroenhancers that is currently not supported by the scientific evidence. It also concluded that the phenomenon should be considered in the context of already familiar discussions around doping (TAB, 2020). As already mentioned, the German discourse was heavily influenced by the publication of the DAK studies, which provided high quality evidence about the extent of neuroenhancement use in the general population. This type of data does not exist for most countries to this day. In addition, in 2016 the Federal Institute for Occupational Safety and Health also undertook a small investigation of the phenomenon and found around 1.3% lifetime prevalence of neuroenhancer use.

---

[8] Personal communication with Dr Helge Torgersen.

Hungary

In Hungary, policy action directed at neuroenhancement may be characterised as entirely non-existent. Although a very small number of bioethicists have published on the topic, no learned institute, think tank, or government agency had commissioned publicly available studies on the subject.

United Kingdom

In the United Kingdom, the level of policy activity and interest in neuroenhancement is quite high. In 2005 the UK Government's Foresight programme under the Office of Science and Technology commissioned a report on Brain Science, Addiction and Drugs with the title Drugs Futures 2025 (Government Office for Science, 2005). The report sought to answer the question: "How can we manage the use of psychoactive substances in the future to best advantage for the individual, the community and society?" It addressed cognition enhancers and offered a set of policy choices whereby the UK could capitalise on the business opportunity in this domain and suggested that public conversations should be launched to solicit societal views. In 2007 the British Medical Association's Ethics Department issued a discussion paper which offered a comprehensive overview of the scientific basis (or lack thereof) of different enhancement methods including nutrition, pharmaceuticals, brain stimulation and genetic selection and manipulation (British Medical Association, 2007). The primary aim of the document was to serve as a starting point for further debate among doctors, scientists, policymakers, and members of the public, although this initiative was not taken forward.

In 2008 the Academy of Medical Sciences published a report on brain science, addiction and drugs, building on earlier work in the Drugs Futures project. The Academy set out to "consider, in consultation with experts and the public, the societal, health, safety and environmental issues raised by 'Drugs Futures 2025?'". It was intended primarily for policymakers in Government, research funders, regulatory authorities, universities, NHS trusts, patient groups and other relevant bodies. The project included a significant public consultation component, whereby over 500 members of the public had a chance to express their concerns and opinions (Horn, 2008).

In 2012 a report from a joint workshop hosted by the Academy of Medical Sciences, the British Academy, the Royal Academy of Engineering and the Royal Society was published under the title Human enhancement and the future of work. In comparison to the earlier reports, which addressed the enhancement-phenomenon in more general terms, this report focused on the context of work in particular, looking at both cognitive and physical enhancement.

In 2013 the Nuffield Council on Bioethics produced a substantial report on Novel Neurotechnologies, which looked at key ethical considerations in relation to transcranial brain stimulation, deep brain stimulation, brain-computer interfaces and neural stem cells. While the report's primary focus was not on enhancement applications of these technologies, it did address that topic where it was relevant and suggested that ethics committees monitor research proposals looking at non-medical uses of novel neurotechnologies to ensure their value and quality, and recommended that the evidence about such enhancement uses should be available via a public register (Baldwin et al., 2013).

In 2015 ScienceWise published a short report summarizing research into public attitudes to human enhancement, which highlighted that data from the UK on this topic was scarce and much of it focused on pharmaceutical cognitive enhancement. These indicate low prevalence, but eagerness on the side of the public to be consulted, especially when it comes to policy relevant discussions. The report calls for further research, particularly comparative studies looking at the opinions of the public and those of policy makers (Stupple-Harris, 2015).

Finally, the Royal Society published a major report on neural interfaces which addressed enhancement but also recommended that the UK take steps to ensure its leadership in the field of technologies for the enablement of human-machine merger. It proposed regulatory sandboxes as a way of gathering evidence on the efficacy of new types of devices. While the report emphasised potential benefits of the technology overall, enhancement was discussed as a possible risk to be addressed (Royal Society, 2019).

Although it is beyond the scope of this thesis to undertake a thorough investigation of this phenomenon, it is worth noting that a very significant portion of neuro-enhancement related activities in the United Kingdom has been funded by the Wellcome Trust, an independent charitable organization focused on medical and health research, that is among the world's wealthiest non-profits. Importantly, the Wellcome Trust places great emphasis on public engagement and has supported education and outreach projects on topics related to neuro-enhancement, which likely brought the phenomenon close to a larger proportion of average citizens than in the other countries investigated in this thesis. For example, already in 2004 the Wellcome Trust funded a theatre company to develop a touring production around advances in neuroscience, covering memory enhancement and similar interventions, and in 2011 it supported the creation of a facilitated classroom debate for 13-16 year-olds that explored the ethical implications of using drugs for cognitive enhancement.

United States of America

One might say that the international policy and ethics discussion about neuroenhancement emerged because of two significant interventions from US institutions. On the one hand, the already mentioned NBIC reports, which painted a radically optimistic vision of enhancement (Roco & Bainbridge, 2002), and the US Presidential Commission for the Study of Bioethical Issues' counter, Beyond Therapy, which laid out the restrictive, conservative case against such interventions (Kass, 2003). However, since then, there have only been a small number of comparable reports or signs of engagement by federal organisations. In 2009 the American Academy of Neurology put out guidelines to physicians on how they should respond to requests from healthy patients to obtain neuroenhancnig drugs. It concluded that while physicians were under no obligation to prescribe drugs off-label to healthy individuals, it was still ethically permissible to do so, provided that physicians adhered to the bioethical principles of respect for autonomy, beneficence, and non-maleficence (Larriviere et al., 2009). In 2015 the Presidential Commission released a report on novel neurotechnologies, which also covered cognitive enhancement and put forward a few recommendations, such as the continued prioritisation of treatment over enhancement, and it advised research funders to support studies on the prevalence, benefits, and risks of novel neurotechnologies in order establish the ethical use of such technologies for the augmentation or enhancement of neural function. It also called on policymakers to ensure equitable access, and on professional organizations to issue guidance to clinicians, employers and the general public on the risks and benefits of such neural technologies. Finally, a report published by a research arm of the Department of Defence in 2019, laid out possible visions of future cyborg enhancements to military personnel (Emanuel et al., 2019).

Summary

In summary, both the media discourse and the level of policy activity differ across the countries investigated in this thesis. Hungary is somewhat of an outlier, in the sense that there has been very little public discussion and no professional or policy activity directed at neuroenhancement whatsoever. In Austria, salience is also low, the small number of articles that appear generally report about developments related to neuroenhancement in the UK and the US, while locally, the phenomenon is viewed mostly as a substance abuse issue. In Germany, the UK and the US, media engagement and policy activity has been intense since the early 2000s but the types of actors and their form of engagement seems to differ. Although the relevant ethics committees in each country have addressed enhancement, there is an emphasis in Germany on approaching the topic as a matter of public health, as suggested by the role played by health insurers, Government occupational health institutes, and the overall tenor of media coverage, which often describes neuroenhancement as a concerning sign of workplace pressures. In the UK, while learned societies and academics have continually engaged with the topic of enhancement, some reports emphasised the importance of the country seizing the economic opportunities that go along with scientific and technological innovation in the domain of pharmaceuticals – in the early stages of the debate – and more recently with regard to human-machine interfaces as well. In addition, there is a very strong emphasis on public involvement and dialogue in the UK, which is less characteristic of the other countries in the sample. Finally, in the US there has been decreased policy attention directed at enhancement since the first wave of reports in the early 2000s, but it is the only country where a professional medical organisation had issued guidance on dispensing neuroenhancers to healthy adults, and several major technology companies and venture capital firms have openly embraced R&D goals that points towards neuroenhancement.

The data presented in the next chapter were collected in early 2016, that is, during a period where media coverage of neuroenhancement was low in Austria and Hungary, of medium intensity in the UK, and right after peaks in the USA and Germany.

Chapter 4 – Points of View on Neuroenhancement

Following the brief overview of the salience of neuroenhancement in five national contexts, this chapter will dive into the results of the NERRI survey. As described in Chapter 2, the survey was developed with the aim of investigating the general public's attitudes towards neuroenhancement using a combination of contrastive vignette experiments that depict the technology in familiar life-world contexts, open-ended questions about respondents' reasoning about the practice's acceptability, and traditional attitude statements intended capture broader attitudes towards enhancement. The broad attitude statements were derived from the public dialogue events carried out during the NERRI project. Data collection for the survey took place during the months of January and February in 2016.

The depiction of neuroenhancement in the education and the employment context experiments had a similar structure. They presented a vignette in which a protagonist faced a situation in which they decided to use a neuroenhancer to advance their goals. The experiments varied four factors:

- Gender: male / female;
- Performance: low performance and risk of failing at their exam or job / good performance and the desire to achieve more;
- Enhancer efficacy: low efficacy providing ~10% improvement / high efficacy yielding ~50% improvement;
- Technology: pill / brain stimulation device.

A random combination of the above four variables was assigned to each respondent for both contexts. Respondents expressed their opinion on five response variables, which gauged the degree to which they could sympathise with the protagonist's decision, whether they perceived the enhancement to confer an advantage, whether they believed most people would decide in a similar way to the protagonist, whether the benefits of the enhancement outweighed its risks, and finally, whether respondents themselves would decide to do the same, were they to find themselves in the protagonist's shoes.

This chapter will present the findings of the study in several interlinked steps that successively build on each other. First, I will describe the results of the experiments, focusing only on the degree to which the four experimental factors described above affected responses in each of the contexts. Next, I will consider the role of respondent demographics in combination with experimental factors. This will be followed by an investigation of country-level differences, focusing on the effects of the experimental manipulations. Then, I will consider the open-ended text respondents provided in response to the second vignette they had seen. I will present an overall picture of the distribution of arguments and points that were expressed. The next section will explore country level differences with regard to the arguments. Subsequently, I will investigate whether and how the arguments differed as a function of the experimental conditions. The next section will turn towards the analysis of broader attitude statements about neuroenhancement and explore the overall pattern in the data. I will then turn to multivariate methods to investigate, whether there are any latent variables underlying the responses, and I will consider these in the context of the two experiments. Finally, I will use cluster analysis methods to segment respondents into opinion groups and explore whether certain types of arguments are more characteristic of these groups.

Education & Employment Experiments

The pattern of responses across all five variables measured in the survey appears to be quite similar in both contexts. Gender is never a relevant factor in respondents' considerations, while the vignette protagonist's baseline level of performance is a relevant factor in most cases, and the applied neuroenhancer's level of efficacy is always highly significant. Whether the intervention was a pill, or a brain stimulation device proved to be a relevant factor for some response variables, but not all. Below, I will consider the effect of experimental manipulations on each question in the two contexts.

Avoiding failure vs getting ahead - The effect of baseline performance

In the education context, respondents can sympathise more with the decision of a low-performing individual looking to avert failure than with someone who is already performing well and is seeking out a neuro-enhancer to achieve the top grade ($\beta=-0.598$; $p < 0.001$). High baseline performance was also associated with a stronger perception that the vignette protagonist was gaining an advantage over others ($\beta=0.286$; $p < 0.001$), however, respondents considered it less likely that most people would opt to use an enhancer if they were already performing well ($\beta=-0.155$; $p < 0.05$). The benefits of the intervention were seen to outweigh the risks less in the case of good performance than in case of possible failure ($\beta=-0.226$; $p < 0.01$), and respondents proved to be less likely to themselves use an enhancer to earn the best possible result at the exam, compared to a situation that threatens failure ($\beta=-0.382$; $p < 0.001$).

Similarly, in the employment context, respondents can sympathise more with the decision of a low-performing individual looking to avoid losing their job than with an already capable employee who is looking to secure a promotion ($\beta=-0.643$; $p < 0.001$). The vignette protagonist was perceived as gaining an advantage over others to a greater extent when the baseline performance was high ($\beta=0.436$; $p < 0.001$). However, respondents thought it was less likely that people would choose to use an enhancer if they were already performing well ($\beta=-0.219$; $p < 0.05$). Performance level had no impact on perceptions about the benefits outweighing risks. Compared to a scenario where losing one's job was a possibility, respondents were less likely to indicate they'd use an enhancer in order to get a promotion ($\beta=-0.313$; $p < 0.001$).

These findings indicate that on average, respondents consider a quasi-therapeutic intervention to be more acceptable than one aimed at maximising achievement.

Small gain vs substantial gain - The effect of neuro-enhancer efficacy

High efficacy neuroenhancers were positively associated with participant responses across all five measures in both the education and employment contexts. The results showed that high efficacy NE increased sympathy for the decision (EDU $\beta=0.234$; $p < 0.01$; EMP $\beta=0.282$; $p < 0.001$), the perception of the protagonist gaining an advantage over others (EDU $\beta=0.576$; $p < 0.001$; EMP $\beta=0.501$; $p < 0.001$), the perceived likelihood of most people doing the same (EDU $\beta=0.235$; $p < 0.01$; EMP $\beta=0.270$; $p < 0.01$), and the evaluation of the benefits outweighing risks (EDU $\beta=0.242$; $p < 0.01$; EMP $\beta=0.310$; $p < 0.01$). High efficacy NE also increased respondents' willingness to do the same as the vignette protagonist, that is, to use the neuroenhancer if they were in an analogous situation (EDU $\beta=0.346$; $p < 0.001$; EMP $\beta=0.434$; $p < 0.01$).

Unsurprisingly, respondents expressed a pragmatic preference for more potent enhancers compared to less powerful ones.

A pill vs a brain stimulation device - The effect of neuro-enhancer type

In the education context, whether the depicted NE method was a pill, or a brain stimulation device was irrelevant for perceptions of the degree to which the enhancer gives an advantage over others, and whether most people would decide similarly to the vignette protagonist. However, using the neuro-enhancer pill was associated with lower sympathy than a brain stimulation device ($\beta=-0.338$; $p < 0.001$). In both the education and employment contexts, respondents considered that a pill's benefits outweighed its risks less than in case of a brain stimulation device (EDU $\beta=-0.333$; $p < 0.001$; EMP $\beta=-0.291$; $p < 0.001$) and survey-takers expressed lower willingness to use the enhancer if it was a pill than if it was a device (EDU $\beta=-0.441$; $p < 0.001$; EMP $\beta=-0.238$; $p < 0.01$).

This is somewhat surprising given that brain stimulation is a comparatively novel and lesser-known intervention that the public might reasonably associate with higher levels of uncertainty and risk. Moreover, electrical brain stimulation might evoke associations with other, controversial forms of brain stimulation, such as electroconvulsive therapy, which enjoys an enduring negative attitude amongst the general public (Asztalos et al., 2020; Lauber et al., 2005; Wilhelmy et al., 2018). In a subsequent section I will investigate whether respondents had raised different concerns in relation to pills and brain stimulation, and whether ECT was a significant anchor for the perception of brain stimulation.

Based on this model, the (relatively) most accepted scenario of neuro-enhancer use is one in which a struggling individual opts for a high-efficacy brain stimulation device in order to avoid failure. Thus far, the experiment's findings are in line with insights from prior studies that had shown public preference for enhancement towards the norm, rather than above the norm (Cabrera et al., 2015), higher acceptance of enhancement to avert a loss rather than to gain an advantage (Fernandez et al., 2022), and a pragmatic preference for more efficacious interventions over ones that provide lower benefits (Sattler et al., 2013).

Importantly, while most of the experimental factors proved to be important elements in respondents' decision-making about various facets related to the acceptability and desirability of neuro-enhancement, nevertheless, the magnitude of the average effects is rather small. For example, the largest observed effect was the difference between sympathy scores for a high performing individual vs a failing individual, which amounted to a mean difference of ~0.6 points on an 11-point scale. In addition, little of the observed variation in the data can be accounted for by a regression model containing only the experimental manipulations (r^2 values ranged from 0.03% to 1.6%). The next section investigates the degree to which demographic characteristics shape attitudes towards enhancement.

Education Context	Can you sympathise with the decision?	Will the protagonist have an advantage over others?	Would most people do the same?	Do the benefits outweigh the risks?	Would you do the same?
R-squared	0.013	0.015	0.003	0.007	0.01
Constant term	5.914 (0.098)	4.886 (0.082)	5.399 (0.084)	4.581 (0.09)	4.022 (0.105)
Male protagonist compared to female	-0.1 (0.087)	-0.067 (0.073)	-0.004 (0.075)	-0.105 (0.08)	-0.085 (0.094)
High baseline performance compared to failing	-0.598*** (0.087)	0.286*** (0.073)	-0.155* (0.075)	-0.226** (0.08)	-0.382*** (0.094)
Pill compared to brain stimulation device	-0.338*** (0.087)	0.027 (0.073)	0.121 (0.075)	-0.333*** (0.08)	-0.441*** (0.094)
High efficacy compared to low efficacy NE	0.234** (0.087)	0.576*** (0.073)	0.235** (0.075)	0.242** (0.08)	0.346*** (0.094)

Table 4. Education context regression coefficients of experimental manipulations on 5 response variables. Standard errors in parentheses.
* $p < 0.05$;
** $p < 0.01$;
*** $p < 0.001$

Employment Context	Can you sympathise with the decision?	Will the protagonist have an advantage over others?	Would most people do the same?	Do the benefits outweigh the risks?	Would you do the same?
R-squared	0.012	0.016	0.004	0.006	0.008
Constant term	5.385 (0.097)	4.624 (0.080)	5.136 (0.084)	4.224 (0.088)	3.487 (0.102)
Male protagonist compared to female	0.084 (0.087)	0.087 (0.072)	-0.035 (0.076)	0.077 (0.079)	0.001 (0.091)
High baseline performance compared to failing	-0.643*** (0.087)	0.436*** (0.072)	-0.219*** (0.076)	-0.149 (0.079)	-0.313*** (0.091)
Pill compared to brain stimulation device	-0.101 (0.087)	-0.084 (0.072)	-0.062 (0.076)	-0.291*** (0.079)	-0.238** (0.091)
High efficacy compared to low efficacy NE	0.282*** (0.087)	0.501*** (0.072)	0.270*** (0.076)	0.310*** (0.079)	0.434*** (0.091)

Table 5. Employment context regression coefficients of experimental manipulations on 5 response variables. Standard errors in parentheses.
* $p < 0.05$;
** $p < 0.01$;
*** $p < 0.001$

The effect of demographic indicators

Adding demographic indicators to the regression model, as shown in **Tables X & Y,** has a marginal effect on the experimental manipulations and the pattern of significant vs. non-significant predictors remains the same.

Respondents' gender had no effect on expressed sympathy towards the vignette protagonist's decision, nor on perceptions of how most people would decide under similar conditions to those depicted in the story. However, female respondents were less likely to believe that an individual using an enhancer would gain an advantage over others (EDU β=-0.272; $p < 0.001$; EMP β=-0.212; $p < 0.01$), and they were also less likely to believe that the benefits of enhancers outweighed their risks (EDU β=-0.298; $p < 0.001$; EMP β=-0.352; $p < 0.001$). Furthermore, female respondents were less likely to indicate that they would decide to use a neuro-enhancer than males (EDU β=-0.602; $p < 0.001$; EMP β=-0.564; $p < 0.001$).

Regarding age groups, there is a rather consistent pattern in the education context, which suggests that compared to the youngest generation (18–24-year-olds) every successive cohort shows progressively lower acceptance of neuroenhancement. The difference between the views of the youngest generation and other age groups increases with every cohort. In other words, the older a respondent, the more different their view was compared to the youngest age bracket. The direction of the effect is negative for all response variables, meaning that compared to the youngest group, older respondents expressed less sympathy, lower agreement that NE provides an advantage over others, lower agreement that most people would decide similarly to the character in the vignette, lower assessment of the benefits outweighing risks, and lower likelihood to use the enhancer if the respondent was in the vignette protagonist's shoes.

This effect was statistically significant across almost all response variables, except for the difference between 18–24-year olds' and 25–34-year olds' perceptions of whether use of a neuro-enhancer provides an advantage to the protagonist, and the difference between 18–24-year olds' and 25-35-, and 35-44-year olds' views on whether most people would decide similarly to the protagonist. In these 3 measures, there was no statistically significant mean difference between the age groups.

A slightly different picture emerges for the employment context, here, the effect of age is less consistent. With respect to two response variables, sympathy with the protagonist and the perception that they gain an advantage over others via NE, only respondents above 45 differed significantly from 18-24-year olds and the direction of the difference was negative, meaning they gave lower scores. On the question whether most people would decide to use an enhancer, only the oldest age group differed significantly from the youngest (β=-0.358; $p < 0.001$). Finally, with regard to perceptions of benefits vs risks and the decision to use the neuroenhancer, there was no difference between 18-24-year olds' and 25-34-year olds' views, but for older age group the familiar pattern set in, with older cohorts giving progressively lower and lower scores.

In the education context, no response variables were impacted by having a university degree, while in the employment context respondents with a degree expressed more sympathy with the vignette protagonist (β=0.261; $p < 0.01$).

In summary, it holds across both contexts that females have somewhat more negative perceptions of neuroenhancement and a lower willingness to use, and we may observe a generational divide that is more pronounced with respect to the educational context than employment, and which suggests that with increasing age perceptions of neuroenhancement become more negative. It is important to note here as well that the amount of variation explained by these regression models is still very small, amounting to at most 3% in the education context and 2.5% in the employment context This suggests that even though experimental manipulations and certain demographic characteristics are relevant influencers of perceptions of neuroenhancement, respondents' views seem to be shaped by other factors.

Next, I'm going to investigate whether respondents from different countries expressed different views in the experiments.

Education Context	Can you sympathise with the decision?	Will the protagonist have an advantage over others?	Would most people do the same?	Do the benefits outweigh the risks?	Would you do the same?
R-squared	0.027	0.025	0.012	0.03	0.027
Constant term	6.596 (0.164)	5.412 (0.137)	5.792 ((0.142)	5.463 (0.15)	5.017 (0.176)
Male protagonist compared to female	-0.102 (0.087)	-0.064 (0.073)	-0.002 (0.075)	-0.103 (0.079)	-0.078 (0.093)
High baseline performance compared to failing	-0.587*** (0.087)	0.293*** (0.073)	-0.147* (0.075)	-0.217** (0.079)	-0.375*** (0.093)
Pill compared to brain stimulation device	-0.323*** (0.087)	0.036 (0.073)	0.131 (0.075)	-0.317*** (0.079)	-0.431*** (0.093)
High efficacy compared to low efficacy NE	0.232** (0.087)	0.576*** (0.073)	0.237** (0.075)	0.239** (0.079)	0.345*** (0.093)
Female respondent compared to male	-0.088 (0.087)	-0.272*** (0.073)	-0.124 (0.075)	-0.298*** (0.079)	-0.602*** (0.093)
Respondent age 25–34 compared to 18–24	-0.365* (0.168)	-0.181 (0.14)	-0.113 (0.145)	-0.388* (0.153)	-0.344[9] (0.18)
Respondent age 35–44 compared to 18–24	-0.641*** (0.165)	-0.31* (0.138)	-0.151 (0.142)	-0.657*** (0.151)	-0.693*** (0.177)
Respondent age 45–54 compared to 18–24	-0.69*** (0.165)	-0.375** (0.138)	-0.283* (0.142)	-0.847*** (0.15)	-0.705*** (0.176)
Respondent age 55+ compared to 18–24	-1.11*** (0.149)	-0.705*** (0.125)	-0.667*** (0.129)	-1.243*** (0.136)	-1.062*** (0.16)
Respondent has a university degree (reference category: no degree)	0.169 (0.1)	0.026 (0.084)	-0.042 (0.087)	0.132 (0.092)	-0.037 (0.107)

Table 6. Education context regression coefficients of experimental manipulations and demographic indicators on 5 response variables. Standard errors in parentheses.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

[9] Borderline significant, p=0.055

Employment Context	Can you sympathise with the decision?	Will the protagonist have an advantage over others?	Would most people do the same?	Do the benefits outweigh the risks?	Would you do the same?
R-squared	0.018	0.025	0.009	0.02	0.02
Constant term	5.727 (0.164)	5.084 (0.135)	5.343 (0.142)	4.829 (0.147)	4.14 (0.170)
Male protagonist compared to female	0.087 (0.087)	0.092 (0.072)	-0.40 (0.076)	0.084 (0.079)	0.016 (0.091)
High baseline performance compared to failing	-0.646*** (0.087)	0.430*** (0.072)	-0.229** (0.076)	-0.157* (0.079)	-0.316*** (0.091)
Pill compared to brain stimulation device	-0.113 (0.087)	-0.089 (0.072)	0.052 (0.076)	-0.307*** (0.079)	-0.244** (0.091)
High efficacy compared to low efficacy NE	0.283*** (0.087)	0.503*** (0.072)	0.278*** (0.076)	0.310*** (0.079)	0.433*** (0.091)
Female respondent compared to male	-0.165 (0.087)	-0.212** (0.072)	-0.139 (0.076)	-0.352*** (0.079)	-0.564*** (0.091)
Respondent age 25–34 compared to 18–24	-0.139 (0.168)	-0.78 (0.139)	0.042 (0.146)	-0.136 (0.152)	0.038 (0.175)
Respondent age 35–44 compared to 18–24	-0.237 (0.166)	-0.179 (0.137)	0.027 (0.144)	-0.337* (0.150)	-0.340* (0.173)
Respondent age 45–54 compared to 18–24	-0.426** (0.165)	-0.350** (0.136)	-0.053 (0.144)	-0.425** (0.149)	-0.462** (0.172)
Respondent age 55+ compared to 18–24	-0.494*** (0.150)	-0.591*** (0.124)	-0.358** (0.130)	-0.786*** (0.135)	-0.612*** (0.156)
Respondent has a university degree (reference category: no degree)	0.261** (0.101)	-0.118 (0.083)	-0.024 (0.088)	0.086 (0.091)	-0.03 (0.105)

Table 7. Employment context regression coefficients of experimental manipulations and demographic indicators on 5 response variables. Standard errors in parentheses.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Country comparison

As outlined in an earlier section, there are important cultural, political, and economic differences between the countries investigated here, as well as differences with regard to the salience of, and public discussion about neuro-enhancement. Consequently, it may be expected that respondents from different countries might express different attitudes towards enhancement. This section will seek to investigate whether such differences are indeed present, however, it is important to note that the survey did not draw on matched samples from the participating countries. As a result, the findings described below should be interpreted with some level of caution.

Country-level differences were investigated by fitting regression models for each country separately. The primary aim of this analysis was to understand whether there was a difference with regard to the effect of experimental manipulations based on country. Therefore, the models are sparse and only include the experimental manipulations, without demographic indicators. For the sake of readability, I will only highlight effects that were significant in the regression models at the $p < .05$ level of statistical significance and refer the reader to the overview in Appendix A2 for the precise values and regression coefficients.

Considering the employment context first, in Austria, the protagonist's gender was irrelevant across all five variables. However, pills proved to be a significant factor for three of the five outcome measures. Compared to a brain stimulation device, an enhancing pill was associated with lower levels of sympathy for the decision, lower perception that the benefits outweigh the risks, and lower likelihood that the respondent would do the same as the protagonist. Whether the protagonist in the story was performing well or failing on their job was only a significant factor for measures of sympathy, where good performance elicited a lower average rating from respondents. Finally, the efficacy of the neuroenhancer meaningfully influenced evaluations of perceived advantage gained by the protagonist through the enhancer, and whether the respondent sympathised with the decision. In both cases, higher efficacy interventions were associated with higher average ratings on the response variables.

The pattern is somewhat different for the education context. Surprisingly, the protagonist's gender was a significant factor for how most people would decide in such a situation, which suggests that in general, Austrian male university students are seen as more prone to using an enhancer for their studies, than females. Pills were associated with lower levels of sympathy, lower perception that the benefits outweigh the risks, and lower likelihood that the respondent would do the same. Good baseline performance elicited lower sympathy from respondents, a lower assessment that most people would decide as the protagonist, and lower likelihood that the respondent herself would decide to use an enhancer. With respect to the efficacy of the enhancer, a more potent method was associated with higher assessments that the protagonist gains an advantage over others, a higher perception that others would decide the same, and higher likelihood that the respondent would do the same.

Moving on to the employment context in Germany, gender was not a significant factor across any of the response variables. Pills are associated with lower perceptions of the benefits outweighing the risks, but this factor had no effect on any of the other outcome measures, suggesting that the anti-pharmaceutical sentiment amongst German respondents may be lower compared to their Austrian counterparts. Good baseline performance was a significant factor for three of the five response variables. It was associated with less sympathy, lower perception that most people would do the same, and higher assessments of benefits gained over others. Finally, high NE efficacy was significantly associated with all outcome measures, leading to higher sympathy, higher perception of gaining advantage over others, higher assessment that most people would opt to use it, higher ratings on the benefits outweighing risks, and it was the only factor affecting respondents' likelihood of using the enhancer themselves, where it correlated with higher ratings.

In the education context, gender remains an insignificant factor. Pills are associated with lower sympathy, lower perception of benefits, and lower likelihood on the respondent's part do use the enhancer. High baselines performance correlates with lower average values on sympathy, higher ratings on the protagonist gaining an advantage over others, but lower likelihood that the respondent would use the enhancer. Finally, and somewhat surprisingly, NE efficacy was only a significant factor for perceptions of benefits gained, where it was associated with higher average values. This suggest that for German respondents considering the educational use of enhancers, how an intervention is perceived is largely independent of its efficacy.

In Hungary, the experimental manipulations had very little effect, suggesting that respondents' decision-making is largely independent of the factors investigated here. In the employment context protagonist gender and pill vs brain stimulation were irrelevant factors. Good baseline performance correlated with lower sympathy, and a higher perception that the protagonist gains an advantage over others. High efficacy enhancers were associated with more sympathy for the decision, greater perception of benefits over others, and greater likelihood that the respondent would opt to use the enhancer in a similar situation. In the education context, only neuroenhancer efficacy was a relevant factor, where higher efficacy was associated with greater perception of benefits, and greater likelihood to decide to use the enhancer.

In the United Kingdom, experimental factors in the employment context were mostly not significant determinants of responses. Protagonist gender and pill vs brain stimulation were not relevant factors. Good baseline performance was associated with higher perceptions of advantage over others, while higher neuroenhancer efficacy correlated with higher perceptions that most people would do the same, higher perception of advantages gained, higher perception of benefits outweighing risks, and greater likelihood that the respondent would do the same.

In the education context, the pattern is markedly different. The protagonist's gender is significantly associated with all response variables. Males elicited less sympathy from respondents, lower likelihood that most people would do the same, lower perception of gaining an advantage over others, lower perception that benefits outweigh the risks, and lower likelihood that the respondent herself would use an enhancer.

Lastly, turning to the United States, in the employment context, gender and pill vs brain stimulation were insignificant factors. Good baseline performance was associated with lower sympathy, and lower likelihood that the respondent would decide to use the enhancer. High efficacy enhancers were associated with greater sympathy, greater perception of advantage over others, and higher likelihood that the respondent would use the enhancer.

In the education context, good baseline performance correlates with lower sympathy but is irrelevant for the other variables, while high efficacy is positively associated with all five response variables.

The most salient difference among countries appears to be that pills are viewed negatively in Austria and Germany, especially in the context of education, while this factor is entirely irrelevant for respondents' assessments in Hungary and the USA. In the UK, pills are also associated with more negative assessments in education but not in employment, while there appears to be a negative effect of male vs female protagonist across all outcome measures in the UK, and for perceptions of whether most people would decide to use the enhancer, in Austria. Otherwise, respondents from all countries exhibited some degree of pragmatic decision-making, whereby higher efficacy enhancers were more likely to be embraced than lower efficacy ones, and good baseline performance tended to be associated with lower acceptance. Although these pragmatic factors influence decisions in all countries, they were the only relevant considerations in Hungary and the USA.

Importantly, the amount of explained variation by these models is very low in all countries, suggesting that the effect of experimental factors on respondents' judgments is small and that other aspects are more decisive.

Reasoning about neuroenhancement

How did participants reason about their assessments of the protagonists' decisions in the education and employment contexts? As described in the Methods chapter, open-ended comments were coded inductively, whereby arguments and statements expressed in relation to the vignette were assigned codes that sought to capture the essence of each distinct point a respondent had made. Subsequently, codes were grouped into ten higher order categories, which are briefly described below in order of decreasing frequency. The proportion of each code by country and experimental condition is reproduced in Appendix A3 and A4.

The largest category was comprised of comments related to the **health effects** of neuroenhancers, with slightly over 30% of respondents making a statement about this. Respondents mentioned concerns about the immediate side-effects of the enhancers (10.6%), as well as their unknown longer-term consequences (12.4)%, general comments about the intervention being unhealthy, risky, dangerous (7.1%), or potentially leading to addiction (1.9%).

The second largest category was made up of comments that expressed some form of **acceptability assessment**, which was mentioned by over 26% of respondents. Within this category, a large number of comments were about pragmatic risk/benefit assessments, where some respondents believed that such a calculus tilted in favour of the enhancer (6.8%) and that it was worth a try (5%) while others held the opposite view (9%). This category also includes statements about specific qualifying conditions when neuroenhancement might be acceptable, for example, as a short-term solution or last resort but not as a regular practice (1.1%), or only under medical supervision (0.5%). Some respondents argued that these methods should only be used for medical purposes (1.1%) or that there was no need to use them at all (4.6%).

The third category includes codes capturing five different **moral arguments**. This type of comment was made by approximately 20% of survey-takers. Arguments included the perspective that one should rely on individual effort and one's natural abilities as opposed to enhancers (7%), the view that enhancement was a form of cheating or unfair advantage (2.4%), that it was wrong to risk health for performance (2.2%), that enhancement represented a form of meddling or tampering with the body/brain (3.6%), but also the perspective that one should embrace available means to get ahead and improve oneself (5%).

The fourth category includes several codes pertaining to the **situation** in which the protagonist resorts to the use of an enhancer. These comments were mentioned by over 14% of respondents. Statements in this category include the view that neuroenhancement represents a form of desperation and coping with stress (10%), the notion that it is driven by performance demands (0.7%), that it represents illegitimate pressure from the labour market (0.8%), as well as expressions of empathy and understanding for the protagonist and their circumstances (4.4%).

Over 9% of comments talked about **alternatives** to neuroenhancement. This category included three codes. Some participants suggested other methods, such as diet, sleep, or exercise as preferable interventions compared to pills and devices (3.6%). Some comments stated that one should rather move on and find something else to do instead of resorting to neuroenhancement (1.8%). Finally, a set of comments argued that neuroenhancement did not represent a real and meaningful solution to the problem faced by the protagonist (4.4%).

The category **gut reaction** includes statements of unqualified support (1.4%), or unqualified disapproval of neuroenhancement (2.7%), as well as emotionally laden statements that describe it as 'crazy', 'nonsensical', or 'horrible' (2.7%). These types of responses occurred in 7% of comments overall.

Sceptical comments were put forward by 6.2% of respondents, who expressed the idea that the neuroenhancer likely wouldn't work or that its effects were due to placebo.

Next, 5% of respondents described **uncertainty** with regard to neuroenhancement. This category included comments where the respondent said they could not make up their minds and couldn't decide (2.7%), as well as those who said they would need more information to make a decision (2.2%).

Approximately 3% of respondents made **anti-drug** comments, which either meant rejecting pills and pharmaceuticals in general (1.9%) or comparing electrical devices favourably to pharmaceuticals (1%).

In addition, 2% of respondents made diverse **other** comments that occurred in such small numbers that they didn't warrant the creation of a unique code, or they were uninterpretable, or nonsense responses.

Most respondents (72.7%) had provided only one argument in their comment, 20% provided two arguments, 4.7% listed three distinct points, 1% offered four arguments, and 0.1% gave five arguments.

Overall, it can be said that participants mobilised a variety of arguments and perspectives without any one type of argument being clearly dominant or representing a majority position. Views range from gut rejection of enhancement to acceptance as a justified pursuit. While health related concerns are quite widely shared, arguments from an ethic of authenticity and fairness are also present, as is the notion that it is good to embrace enhancement to achieve one's goals and get ahead. Importantly, the comments shed some light on how some respondents view the circumstances under which enhancement use takes place, and in these comments, there is an emphasis on societal pressures to perform and cope with demands.

In the following sections I will first consider the distribution of codes across countries, and then investigate whether different experimental conditions were associated with different types of arguments.

Interestingly, only a handful of participants likened the use of brain stimulation to the much more familiar – and controversial – electroconvulsive therapy, suggesting that for the overwhelming majority of respondents, electroshock did not serve as an anchor to interpret and understand the brain stimulation method depicted the vignettes.

Arguments across countries

In order to get a sense of whether respondents from different countries had thought differently about the practice of neuroenhancement overall, I performed χ^2 tests with the country variable as the independent variable and each binary coded variable as the response variable. Table 8. shows the claims and proportions where the distribution of responses differed significantly based on country of origin.

Starting with the education context, there was an association between respondents' country and the frequency of the argument that neuroenhancement represents a form of **coping with pressure**, $\chi^2(4,1705) = 17.259$, $p < 0.01$. Mentions of the **unknown long-term effects** of neuroenhancement, $\chi^2(4,1705) = 36.554$, $p < 0.001$ were also associated with countries, as well as the conditional distribution of **ambiguous** comments, $\chi^2(4,1705) = 34.585$, $p < 0.001$. The argument that the respondent would need to **wait for more evidence** on neuroenhancers before making a decision, $\chi^2(4,1705) = 14.232$, $p < 0.01$ and expressions of **scepticism** in relation to NE also varied based on country, $\chi^2(4,1705) = 14.556$, $p < 0.01$, as did the perception that NE was a form of **cheating**, $\chi^2(4,1705) = 15.003$, $p < 0.01$. Concerns about **addiction** also showed an association with respondents' country of origin, $\chi^2(4,1705) = 9.570$, $p < 0.05$.

In the employment setting, the proportion of the argument that there was **no need** to use NE was different across countries $\chi^2(4,1897) = 18.893$, $p < 0.001$. The argument claiming a **favourable risk/benefit ratio** of the enhancer was also associated with country of origin, $\chi^2(4,1898) = 13.438$, $p < 0.01$. The claim expressing that neuroenhancement is a form of **coping with pressure** was associated with respondents' country $\chi^2(4,1897) = 12.932$, $p < 0.05$. In addition, the proportion of the argument that one should seize neuroenhancement for improvement, and **to get ahead** was different across countries too, $\chi^2(4,1897) = 10.741$, $p < 0.05$. The claim that neuroenhancement was **worth a try** was strongly associated with country of origin, $\chi^2(4,1897) = 20.407$, $p < 0.001$, and respondents from different countries expressed **ambiguity** in relation to enhancement in an uneven manner, $\chi^2(4,1897) = 26.661$, $p < 0.001$. The claim that the neuroenhancement method in the vignette was **dangerous or risky** differed by the geography of the respondent, $\chi^2(4,1898) = 9.467$, $p=0.05$, as did concerns about **side effects**, $\chi^2(4,1897) = 16.707$, $p < 0.01$. Whether respondents preferred **other methods** instead of the depicted neuroenhancement varied as a function of countries, $\chi^2(4,1898) = 30.447$, $p < 0.001$. The distribution of comments about the **unknown long- term effects**, $\chi^2(4,1898) = 31.188$, $p < 0.001$, **scepticism** about neuroenhancement, $\chi^2(4,1898) = 10.026$, $p < 0.05$, and the view that instead of using enhancers, the protagonist should **look for a different job**, $\chi^2(4,1898) = 13.840$, $p < 0.01$ also showed association with country.

What might we conclude from the above? Firstly, there were some overlaps but also differences between the types of arguments that differed across countries in the two contexts. In other words, different arguments differed across contexts. There were more arguments where a difference was apparent in the employment context compared to the education setting. The paragraph below interpret the row percentages from Table 8., meaning, that for each code, I will comment on the proportion of respondents from each country. Importantly, these are not overall percentages, but relative to the given codes.

Concerns about coping with pressure and fear of loss seem to be most prevalent in Hungary, where 31.3% of respondents agreed with this statement, while Germany and the United States had the lowest percentages of respondents concerned with these issues, at 15.6% and 12.5% respectively. When it comes to the unknown long-term effects of neuroenhancement, Hungary once again led in the percentage of respondents with this concern, at 35.4%. At the low end only 7.6% of those respondents who cited unknown long-term effects came from Germany. The sentiment of wanting to wait for more evidence or information on neuroenhancement was most popular in the United Kingdom, where almost 43% of respondents who expressed this argument were from. Austria, at 4.8%, had the lowest percentage of respondents who felt they needed to wait for more evidence. The scepticism that neuroenhancement doesn't work was most commonly expressed by respondents from the United States, where 35% of respondents said this, while Hungary had the lowest percentage of respondents who expressed scepticism, at 8.5%. Addiction concerns were mostly expressed by respondents from Austria (27.5%) and Germany (25%) with the smallest proportion Finally, the concern that neuroenhancement creates an unfair advantage and is akin to cheating was most prevalent in the United Kingdom, with 45.8% who gave this argument coming from the British Isles. Hungary had the lowest percentage of respondents who felt this way, at just 8.3%.

Looking at the employment contexts, the first thing to observe is that a larger number of arguments differed meaningfully across the countries, suggesting that the phenomenon is perceived differently. One of the most striking differences is the variation in the percentage of respondents who expressed no need for neuroenhancement, ranging from only 12% in the United States to 32.5% in Germany. This suggests that the perceived demand or pressure for cognitive enhancement may vary across cultures, depending on the social and economic context. Another notable difference is the high proportion of respondents from Hungary who reported ambiguous or undecided attitudes (48.8%), indicating a lack of information or awareness about the topic. It was quite common for Hungarian comments to list possible arguments both in favour and against the practice explaining why the respondent partially agrees and partially disagrees, without coming to a final position. Similarly, the proportion of respondents who expressed a preference for other methods than neuroenhancement was also highest in Hungary. Moreover, the data shows that respondents from the United States were more likely to endorse statements that reflect a positive or curious attitude towards neuroenhancement, such as favourable risk/benefit profile, worth a try, or be the best you can be, compared to respondents from other countries. This may reflect more openness towards the practice or a more culture that values achievement and self-improvement. Also noteworthy is the difference between countries with respect to the statement that instead of pursuing enhancers, one should move on and find something else that is more suited to one's abilities, a statement for which over 60% of the respondents who expressed it came from Austria and Germany, while only 6% of those with this view came from the USA.

Education context	**Austria**	**Germany**	**Hungary**	**United Kingdom**	**United States**	**Total**
coping with pressure / fear of loss / high stakes / desperation	18%	15.6%	31.3%	22.7%	12.5%	100%
unknown long-term effects	16.7%	7.6%	35.4%	22.7%	17.7%	100%
ambiguous	5.3%	5.3%	49.1%	14%	26.3%	100%
addiction	27.5%	25%	15%	12.5%	20%	100%
wait for more evidence / more information	4.8%	7.1%	11.9%	42.9%	33.3%	100%
sceptical / doesn't work	17.9%	16.2%	8.5%	22.2%	35%	100%
cheating / doping / unfair advantage	18.8%	10.4%	8.3%	45.8%	16.7%	100%
Employment context	**Austria**	**Germany**	**Hungary**	**United Kingdom**	**United States**	**Total**
no need	23.1%	32.5%	17.9%	14.5%	12%	100%
favourable risk/benefit profile	8.3%	18.3%	13.8%	30.3%	29.4%	100%
coping with pressure / fear of loss / high stakes / desperation	17%	23%	24.8%	16.1%	19.1%	100%
be the best you can be / improvement is good / get ahead	10.5%	11.6%	28.4%	25.3%	24.2%	100%
worth a try	19.2%	17.3%	8.7%	17.3%	37.5%	100%
ambiguous / can't decide	4.9%	17.1%	48.8%	14.6%	14.6%	100%
concerns about side effects	15.3%	19.5%	23.3%	28%	14%	100%
other methods preferable	2%	8.6%	40%	22.9%	8.6%	100%
unknown long-term effects	11%	19.6%	33.7%	21.5%	14.1%	100%
sceptical / doesn't work	17.6%	21.6%	8.8%	20.6%	31.4%	100%
move on, change job, try something else	24.5%	36.7%	14.3%	18.4%	6.1%	100%

Table 8. Distribution of codes by country for codes where proportions differed significantly across countries.

Arguments and experimental factors

Next, I turn to analysing the distribution of comments based on experimental condition in each country separately, starting with the education context in Austria.

As expected, there was no association between the gender of the protagonist and the types of arguments people had made.

With respect to the type of enhancer, respondents were more likely to express **scepticism** about pills than brain stimulation ($p < 0.05$, df=1), and more likely to say these interventions should **only be for medical reasons** ($p < 0.05$, df=1).

With regard to the protagonist's baseline performance, respondents were more likely to argue that there was **no need** to undertake the enhancer when performance was high ($p < 0.01$, df=1), and they were more likely to argue that the neuroenhancement use represented a form of **coping with pressure** and desperation when the protagonist's performance was low compared to when they were already succeeding ($p < 0.001$, df=1). Moreover, arguments that **other methods**, such as better sleep regimes, a good diet and more exercise, or natural enhancers were preferable were expressed significantly more in response to a low performing individual than a succeeding person ($p < 0.05$, df=1). Respondents were also more likely to say that it is **wrong to risk health for performance**, when the protagonist in the vignette was high performing, compared to a struggling person ($p < 0.05$, df=1). Significantly more respondents expressed **empathy** and understanding for the decision of a low performing person to use an enhancer, compared to a high performing individual ($p < 0.01$, df=1).

Lastly, with regard to the neuroenhancer's efficacy, respondents were more likely to argue that the **risks** of the intervention compared unfavourably to its benefits, if the efficacy was low ($p < 0.01$, df=1).

Moving on to the employment context, which experimental conditions were associated with differences in argumentation? Here, respondents were more likely to argue that the neuroenhancement intervention was **not a real solution** to the problem described in the story, when the protagonist was a female compared to males ($p < 0.05$, df=1), but none of the other qualitative codes showed differing frequencies as a function of the protagonist's gender.

What was the picture like for pills vs brain stimulation? Respondents were more likely to argue that tDCS represented some kind of **'messing with the brain'** that should not be undertaken ($p < 0.05$, df=1) but none of the other arguments were associated with this factor.

With regard to baseline performance, significantly more respondents said that there was **no need** to undertake the enhancement if performance was already good, $\chi^2(1,312) = 29.181$, $p < 0.001$. Similar to the education context, here as well, respondents were more likely to view enhancement as an attempt to **cope with pressures** and stress if the protagonist's performance was low, $\chi^2(1,312) = 32.399$, $p < 0.001$. **Side effects** were more likely to be mentioned as a concern if the protagonist was performing well, $\chi^2(1,312) = 4.350$, $p < 0.05$. The argument that the enhancer was **not a real solution** to the problem faced by the protagonist was more common for a low performing individual than a high achieving one, $\chi^2(1,311) = 5.858$, $p < 0.05$. Respondents were also more likely to express the view that instead of pursuing an enhancer, one should simply **move on, look for an alternative** that is more suited to their personality, interests and abilities, $\chi^2(1.312) = 8.801$, $p < 0.01$, and failing performance was also associated with more frequent expressions of **empathy and understanding** for the decision, $\chi^2(1,312) =$

6.197, $p < 0.05$. On the contrary, the argument that **health is more** important was associated with good baseline performance, $\chi^2(1,312) = 4.000$, $p < 0.05$.

Turning to the efficacy of the intervention, low efficacy enhancers tended to be more associated with the argument that the **risk/benefit profile is unfavourable**, $\chi^2(1,312) = 4.008$, $p < 0.05$, and that instead of pursuing these, one should seek out **alternative methods**, such as sleep, exercise, etc., $\chi^2(1,312) = 5.145$, $p < 0.05$. In this context, low efficacy interventions were associated with the argument that enhancement represents a form of undesirable **messing**, or tampering with the brain, $\chi^2(1,312) = 4.168$, $p < 0.05$.

Next, I will consider the reasoning patterns of respondents in Germany, starting with the education context. None of the arguments were associated with the protagonist's gender, nor whether the method was a pill or a device. However, the argument that there is **no need** to use an enhancer was more common for high performing individuals than for struggling protagonists, $\chi^2(1,235) = 4.201$, $p < 0.05$.

With regard to NE efficacy, interventions providing small benefits were perceived to be **not worth the risks**, $\chi^2(1,235) = 5.997$, $p < 0.05$, while high efficacy ones were associated with more concerns about **unknown long-term effects**, $\chi^2(1,235) = 3.975$, $p < 0.05$.

In the German employment context, the pattern of arguments based on experimental factors was the following. Respondents were more likely to argue that the **long-term health** consequences of the intervention were unknown, if the protagonist was male compared to female, $\chi^2(1,408) = 5.341$, $p < 0.05$. Similar to the findings thus far, the argument that there is **no need** to use an enhancer was more associated with good performance than with failing performance, $\chi^2(1,408) = 50.013$, $p < 0.001$, while the view that neuroenhancement represented a form of **coping with pressure** was associated with low performance, $\chi^2(1,408) = 39.148$, $p < 0.001$. In addition, the pragmatic argument, that given the protagonist's circumstances, the enhancer was **worth a try**, was more common for low performing protagonists than high achievers, $\chi^2(1,408) = 6.350$, $p < 0.05$. **Concerns about side effects** showed an associated with high baseline performance, $\chi^2(1,408) = 6.368$, $p < 0.05$. The argument that neuroenhancement was a form of **illegitimate pressure from the labour market** was more likely to emerge in response to a low performing protagonist, $\chi^2(1,408) = 6.837$, $p < 0.01$, similar to the perspective that enhancement was **not a real solution**, $\chi^2(1,408) = 6.287$, $p < 0.05$, and that the one should rather **move one, change job**, than to resort to the user of neuroenhancers to keep their position, $\chi^2(1,408) = 15.777$, $p < 0.001$.

Low efficacy interventions were more associated with **unfavourable risk/benefit** ratio, $\chi^2(1,408) = 15.478$, $p < 0.001$, and these types of enhancers were more associated with concerns about **side effects** as well, $\chi^2(1,408) = 4.225$, $p < 0.05$. In this context, low efficacy interventions also attracted more **unqualified disagreement**, than high efficacy NEs, $\chi^2(1,408) = 6.904$, $p < 0.01$.

How did respondents in Hungary reason? In the education context, arguments did not differ as a function of the protagonist's gender. Significantly more respondents expressed the view that pills had an **unfavourable risk/benefit** profile, compared to brain stimulation, $\chi^2(1,436) = 7.461$, $p < 0.01$. This is a surprising finding, because this factor was not a significant determinant of the numerical ratings respondents gave on the quantitative response variables.

Low efficacy interventions were associated with the claim that the ratio of **risks vs benefits** is unfavourable, $\chi^2(1,344) = 8.694$, $p < 0.05$.

Turning to the Hungarian employment context, protagonist gender was not a significant factor.

Brain stimulation was more associated with the argument that it was **risky or dangerous**, $\chi^2(1,350) = 3.915$, $p < 0.05$, and with the claim that they were tantamount to **messing with the brain**, $\chi^2(1,350) = 4.192$, $p < 0.05$.

Regarding baseline performance, Hungarian respondents also held that there was **no need** to pursue enhancers if one is already performing well, $\chi^2(1,350) = 22.087$, $p < 0.001$. Conversely, use of an enhancer by a low performing protagonist was more associated with desperation and **coping with pressures**, $\chi^2(1,350) = 39.340$, $p < 0.001$, while the argument that one should seize opportunities to **get ahead** and improve themselves was more common for a protagonist who was already high achieving, $\chi^2(1,350) = 10.440$, $p < 0.001$.

Low efficacy neuroenhancer were more likely to be seen to have an **unfavourable risk/benefit** profile compared to high efficacy interventions, $\chi^2(1,350) = 5.214$, $p < 0.05$. Hungarian respondents were more likely to express **empathy and understanding** for a protagonist using a high efficacy intervention compared to a low one, $\chi^2(1,350) = 4.345$, $p < 0.05$.

In the United Kingdom, although quantitative indicators were all significantly influenced by the protagonist's gender factor, the only difference in argumentation as a function of this was seen in relation to concerns about **side effects**. These were more common for female protagonists than for males, $\chi^2(1,411) = 7.004$, $p < 0.01$.

Brain stimulation was more likely to be viewed as a form of **messing with the brain**, $\chi^2(1,410) = 7.206$, $p < 0.01$.

Good baseline performance was associated with the argument that there was **no need** to pursue enhancers, $\chi^2(1,410) = 10.440$, $p < 0.001$, but there was also an association with the argument that one should embrace improvements to **get head** and improve oneself, $\chi^2(1,410) = 4.107$, $p < 0.05$. Conversely, low performance was associated with the view that enhancement represents a form of **coping with pressures**, $\chi^2(1,410) = 4.034$, $p < 0.05$.

Low efficacy neuroenhancers were more likely to elicit the view that their **risk/benefit ratio** was unfavourable, $\chi^2(1,410) = 8.045$, $p < 0.01$, and that these were **not a real solution,** $\chi^2(1,410) = 5.164$, $p < 0.05$.

Turning to the employment context, vignettes with a male protagonist were more likely to be associates with the argument that neuroenhancement represents a form of **coping with pressure,** $\chi^2(1,412) = 9.456$, $p < 0.01$.

Pills were more likely to elicit the argument that **other methods**, like sleep and exercise are preferable to neuroenhancement, $\chi^2(1,412) = 7.073$, $p < 0.01$. In comparison, brain stimulation was more associated than pills with the claim that one should **rely on their own effort**, instead of pursuing enhancers, $\chi^2(1,413) = 6.182$, $p < 0.05$.

As in the other cases looked at so far, good performance was more associated with the argument that enhancement was **not needed**, $\chi^2(1,412) = 10.906$, $p < 0.001$, while failing performance showed an association with the argument that neuroenhancement was a form of **coping with pressure**, $\chi^2(1,412) = 20.518$, $p < 0.001$. Conversely, respondents tended to argue that one should use every means to **get ahead** if the protagonist had a high baseline performance, $\chi^2(1,412) = 15.287$, $p < 0.001$. In addition, failing performance was associated with the argument that enhancement is **not a real solution**, $\chi^2(1,413) = 5.077$, $p < 0.05$, while also correlating with expressions of **empathy and understanding**, $\chi^2(1,413) = 6.059$, $p < 0.05$.

High efficacy neuroenhancers also showed an association with the argument that one should embrace enhancers for improvement and to **get ahead**, $\chi^2(1,412) = 4.633$, $p < 0.05$, but the argument that it was **wrong to risk health for performance** was also associated with this factor, $\chi^2(1,412) = 4.718$, $p < 0.05$. Low efficacy enhancers were more likely to elicit the response that one should **rely on effort**, $\chi^2(1,413) = 4.938$, $p < 0.05$. Conversely, high efficacy enhancers elicited more **empathy and understanding**, $\chi^2(1,412) = 4.325$, $p < 0.05$.

Finally, what is the relationship between experimental manipulations and types of arguments put forward by respondents in the sample from the United States?

Starting with the education context, male protagonists was associated with the argument that neuroenhancement represented a **coping with pressure**, $\chi^2(1,423) = 4.948$, $p < 0.05$, with the claim the neuroenhancer was **worth a try**, $\chi^2(1,423) = 3.881$, $p < 0.05$, and male protagonists also elicited more expressions of **empathy and understanding**, $\chi^2(1,423) = 6.246$, $p < 0.05$.

Vignettes with a brain stimulation device were more likely to arouse perceptions of **risk and danger**, $\chi^2(1,423) = 9.339$, $p < 0.01$, and that it represented a form of **messing with the brain**, $\chi^2(1,423) = 5.470$, $p < 0.05$.

Failing performance was associated with the argument that neuroenhancement **represents coping with pressure**, $\chi^2(1,423) = 12.258$, $p < 0.001$.

High efficacy enhancers were more associated with the sentiment that it was **worth a try**, $\chi^2(1,423) = 3.991$, $p < 0.05$, while low efficacy enhancers were seen to have an **unfavourable risk/benefit** profile, $\chi^2(1,423) = 8.398$, $p < 0.01$.

Lastly, turning to the employment context in the USA, the protagonist's gender was not associated with differing arguments.

Brain stimulation was more likely to elicit the argument that it was **dangerous and risky**, $\chi^2(1,415) = 9.791$, $p < 0.01$.

Good performance was associated with the argument that neuroenhancement was **not needed**, $\chi^2(1,415) = 8.614$, $p < 0.01$, while low performance was associated with the argument that enhancement was a form of **coping with pressures**, $\chi^2(1,415) = 49.439$, $p < 0.001$. On the other hand, good performance went along with the argument that one should be the best they can be and embrace enhancers to **get ahead**, $\chi^2(1,415) = 10.369$, $p < 0.001$.

In the US sample high efficacy enhancers were associated with the argument that enhancement was a form of **coping with pressure**, $\chi^2(1,415) = 4.908$, $p < 0.05$, while low efficacy ones were associated with the view that the **risk/benefit profile** was unfavourable, $\chi^2(1,415) = 16.813$, $p < 0.001$, and these types of enhancers also tended to raise more **concerns about side effects**,

$\chi^2(1,415) = 7.486$, $p < 0.01$. In addition, low efficacy enhancers were associated with the argument that the idea of enhancement was **crazy and wrong**, $\chi^2(1,415) = 4.611$, $p < 0.05$.

Interim conclusions

Thus far, the analyses presented in this chapter have looked at the two contrastive vignette experiments and considered quantitative and qualitative responses provided by survey-takers. As interim conclusions, I would like to highlight a few points, before moving on to a different part of the survey. First, the four factors in the experimental study turned out to have statistically significant, but substantively marginal effects on respondents' decisions across all five response variables and in all the countries investigated. This was true across both the education and employment contexts. This suggests that there are other factors that weigh more heavily on respondents' views than neuroenhancer type, efficacy, the protagonist performance and intended aim, or their gender.

Second, there appear to be some country-level differences with regard to how the public views neuroenhancement. All countries exhibited a preference for higher efficacy interventions over lower ones and viewed enhancement in case of already good performance as less desirable. In addition, in Germany and Austria a form anti-pharmaceutical sentiment is apparent, which is not characteristic of Hungary or the US, but is somewhat present in the UK. In Hungary, the experimental manipulations turned out to be particularly weak, impacting almost none of the response variables.

In the context of education, addiction is a significant concern for Austrians and Germans, but less so for the UK and Hungary, while almost half of those who expressed concern over cheating in academia were from Britain. It is also striking that for Hungarian respondents, across both education and employment contexts the proportion of ambiguous responses is high. In the employment context, arguing that there was no need to use enhancers was most characteristic of Austrian and German respondents, while respondents from the US and the UK were more numerous amongst those who argued that the enhancers' benefits compared favourably to their risks. Brits, Americans and Hungarians were more likely to embrace the prospect of enhancement to achieve one's aims and get ahead, while Austrians and Germans were more likely to argue that one should move on from a job where enhancement seems necessary. With regard to qualitative perspectives, differences between countries appear to be more pronounced for the employment context than for education.

Using a neuroenhancer to improve upon already good performance elicits lower sympathy on quantitative measures, and is echoed by the finding from the qualitative data that some respondents in this setting said there was no need to use an enhancer when performance is good. Conversely, the qualitative data revealed that in case of a threatening failure respondents viewed enhancement as a coping mechanism to keep up with demands and pressures, which often elicited their empathy and understanding, however, this does not necessarily translate into agreement with the decision.

Thus, we may make preliminary distinctions between some markedly different ways of relating to neuroenhancement. Some people express gut rejection and consider the prospect entirely crazy, analogous to a 'yuck factor'. Another approach proceeds from risk/benefit analyses and considers whether the side effects and other known factors are worth taking on in exchange for some benefit, and this calculus is informed by whether the goal is to advance further in life, or to maintain one's status and avoid failure. Concerns about the side-effects of neuroenhancers are widespread and respondents often explained that side-effects like headaches or insomnia would likely negate any benefits gained by the enhancer, which was therefore undesirable. Moreover, respondents raised concerns about long-term health consequences and the unknowns related to enhancer use. Tolerance of risks is higher when the stakes are perceived to be higher. Others argue from a moral perspective, most notably from the background of an ethic of authenticity where reliance on natural abilities is cherished, from fairness, comparing neuroenhancer use to doping, or from naturalness where enhancement is seen as meddling or messing with the brain that should be avoided. A critical perspective also exists, which suggests that enhancement is a response to performance pressures, either to avoid failure and make ends meet, or to meet ever increasing demands. Some people meet neuroenhancement with scepticism, questioning whether such improvements are possible at all or whether they are just quackery or placebo, while some are uncertain and reluctant to articulate a clear position. The qualitative data There is also perspective, hitherto unexplored, which holds that neuroenhancement does not represent a real solution to the types of problem one encounters in the course of their lives, suggesting not only behavioural alternatives like sleep and exercise, but a reconsideration of where the problem lies that someone might seek to address with the help of a neuroenhancer.

Claims about Neuroenhancement

Following the two experiments the survey presented 14 claims which were derived from NERRI public engagement activities and sought to capture perspectives that the public had expressed. First, I will report descriptive analyses of the level of agreement with these claims and then turn to multivariate methods to explore, whether there are any latent variables underlying the responses. Subsequently, I will explore

Table 9. shows the values of the mean and standard deviation for each variable, along with a percentage indicating the proportion of respondents who expressed some level agreement with the statement. This percentage was calculated by recoding the original 11-point continuous variable into a categorical one with three levels, where scores between 0-4 were taken to indicate disagreement, the mid-point (5) of the scale was considered to indicate neutrality, while scores between 6-10 were interpreted as some level of agreement.

Claim	Mean (SD)	% Agree
Some people will use neuro-enhancers to cope with increasing demands in life	7.5 (2.1)	88.6
It is an expression of human nature to try to overcome the limitations of our body and mind	7.49 (2.2)	87
Neuro-enhancement should never be used on children	8.4 (2.7)	85
It is essential that public authorities oversee and control neuro-enhancement	7.7 (2.6)	82.3
People's achievements should come from their own effort and not from pills and devices	7.62 (2.6)	79.2
People need to be protected from pressures to use neuro-enhancers	7.3 (2.5)	77.9
Neuro-enhancement will increase competition between people	6.97 (2.6)	75.3
People should be content with their talents and abilities and not use artificial means to improve their performance	6.8 (2.8)	69.1
I can imagine neuro-enhancement opening up fascinating new opportunities	5.94 (2.7)	65.7
Neuro-enhancement will threaten social cohesion	6.24 (2.7)	61.5

Only people with a medical problem should have access to neuro-enhancement	6 (2.9)	60.1
If a neuro-enhancer is safe, it should be available as a consumer product	5.2 (3.1)	51.9
Neuro-enhancement should be available to all those who might want it	4.7 (3.3)	46.7
As life gets more pressured, neuro-enhancement may be the only way out	3.89 (2.9)	33.7

Table 9. Mean, standard deviation, and percentage in agreement with claims on neuroenhancement. Ordered from highest to lowest agreement.

From claims to value orientations

Next, the claims are investigated with multivariate methods. Using principal components analysis, two components with eigenvalues larger than 1 were extracted, which accounted for 44.5% of the variance in the data. The components were found to be uncorrelated, hence it was appropriate to use a Varimax rotation, treating the components as orthogonal. The rotated component loadings are shown in Table 10.

Rotated Component Matrix	Component	
Claim	Societal / Restrictive	Individual / Permissive
People should be content with their talents and abilities and not use artificial means to improve their performance	0.699	
People's achievements should come from their own effort and not from pills and devices	0.743	
It is essential that public authorities oversee and control neuro-enhancement	0.51	
Only people with a medical problem should have access to neuro-enhancement	0.604	
People need to be protected from pressures to use neuro-enhancers	0.606	
Neuro-enhancement should never be used on children	0.41	
Neuro-enhancement will threaten social cohesion	0.669	
If a neuro-enhancer is safe, it should be available as a consumer product	-0.508	0.534
Neuro-enhancement should be available to all those who might want it	-0.563	0.519
It is an expression of human nature to try to overcome the limitations of our body and mind		0.601
I can imagine neuro-enhancement opening up fascinating new opportunities		0.699
Some people will use neuro-enhancers to cope with increasing demands in life		0.614
As life gets more pressured, neuro-enhancement may be the only way out		0.513
Neuro-enhancement will increase competition between people		0.584

Table 10. Claims loading on societal restrictive and individual permissive components. Varimax with Kaiser normalization, Coefficients below 0.4 suppressed

A reliability analysis on the items belonging to the two components indicated that the 14 questions may be seen as two separate scales measuring distinct concepts, with 7 questions in each scale. Given that the 14 claims about NE were not designed to measure any specific latent constructs the interpretation of the two scales is not entirely straightforward. However, it seems justifiable to observe that scale 1 contains items that are prescriptive, restrictive, and formulate views on how NE *should* be dealt with. These items pertain more to the potential harmful societal consequences of NE and involve protective measures. On the other hand, scale 2 contains items that are more permissive and individualistic in nature. Hence, we label them 'Societal-Restrictive (SR for short) and 'Individual-Permissive (IP for short) respectively. For the 'Societal/Restrictive' scale Cronbach's alpha = 0.750; while for the 'Individual-Permissive scale Cronbach's alpha = 0.735.

The two contrastive vignette experiments preceded the randomised presentation of the 14 claims. Therefore, the question emerges whether the vignettes created a context effect in the responses to these 14 claims. To investigate this possibility regression models were fitted using the experimental manipulations as explanatory variables to predict scores on the two scales separately. A few of the sixteen experimental conditions indeed influenced the SP and IP scales.

None of the experimental conditions in the employment context had a statistically significant impact on the value of the SP scale. However, controlling for other variables, respondents who were randomly allocated to an education vignette with a high performing protagonist scored on average 0.117 points higher on SP than respondents who were allocated to a low-performing protagonist ($p < 0.05$). For the IP scale, none of the randomly allocated education conditions had an impact, however, those respondents who saw an employment vignette with a high efficacy neuroenhancer scored on average 0.164 points higher ($p < 0.001$) than respondents who saw a vignette with a low efficacy enhancer. While it is important to be aware of these influences and the two effects are statistically significant, the regression coefficients are marginal from a substantive point of view, amounting to approximately one-tenth of a point difference on an 11-point scale, and the explained variation is equally small ($r^2 = 0.003$, that is 0.3%). Thus, the size of the effects is negligible.

Binocular Values

There is a moderate negative correlation between the two scales (Pearson's $r = -0.367$, $p < 0.001$), showing, it might be thought, that the two scales capture opposing values. The idea of pairs of values in opposition is a basic feature of a contemporary theory of values, Schwartz places ten universal and core values in a circular structure depending on whether they are in opposition or complimentary. *"One oppositional pair is openness to change versus conservatism. On this dimension, self-direction and stimulation values oppose security, conformity and tradition values"* (Schwartz, 2003, p. 269). Hence the expectation is that subscribing to individual permissive values to be opposed to societal restrictive values. To test this idea the original continuous variables were recoded into 3-point categorical variables using a tertile split, dividing the 0-10 continuous range into 3 equal parts. Table 11. shows that some people express agreement with both values simultaneously. It is notable that the proportion of those scoring low on both scales is very low, suggesting that the majority of respondents can identify, to some extent, with the two value orientations. Moreover, 42.1% of respondents scored high on the SR scale while having moderate scores on IP, and 16.5% have high scores on both scales. In total, 64% of respondents have high SR scores, while 35% have high IP scores. This could be a sign of genuine ambivalence expressed as the parallel for societal values, while also accepting individual enhancement.

	Low Societal / Restrictive	Mid- Societal / Restrictive	High- Societal / Restrictive	Total
Low-Individual / Permissive	0.20%	0.70%	5.50%	6.40%
Mid- Individual / Permissive	0.30%	16.20%	42.10%	58.60%
High- Individual / Permissive	1.90%	16.70%	16.50%	35.00%
Total	2.30%	33.60%	64.10%	100.00%

Table 11. Cross tabulation of support for Societal-Restrictive and Individual-Permissive values.

A fruitful way of looking at this may be offered by Erik Parens' notion of a *binocular habit of thinking* with regard to the issue of technologically shaping ourselves. He draws on the metaphor of the way in which the human brain constructs our perception of depth and three dimensionality by integrating different streams of information coming from our two eyes. Drawing on this metaphor, Parens suggests that "*if we want to deeper understanding – and ultimately better action – we need to aspire to think with least two "lenses" at once*" (Parens, 2015, p. 33). While the academic debate about enhancement that I briefly reviewed in Chapter 1 is often highly polarized between proponents and opponents, Parens suggests that for a deeper and fuller appreciation of the complexity of the enhancement phenomenon we should learn to adopt different stances. It appears that for large segments of the public, seemingly contradictory views may be entertained simultaneously.

Considering value scales in the context of the experiments

Having established that the 14 claims which had been derived from extensive public consultation exercises are reasonably expressive of two distinct value orientations in relation to neuroenhancement, I will now investigate the relationship between these values and survey responses to the two experiments discussed earlier, once again using multiple linear regression.

The most striking difference between these and previous models lies in the amount of variation explained by the regressions, while the pattern of significant and non-significant experimental factors remained the same. Starting with the education context, the inclusion of the two scales increases the explanatory power of the model considerably. For sympathy, the model explains over 25% of the observed variation, which may still be considered low, but it represents a 20-fold increase over the base model with only the experimental factors. The largest increase in explanatory power was for the 'Would most people do the same?' question, where the R^2 value jumped 44-fold. For the question 'Do the benefits outweigh the risks?' the effect size increased by over 32-fold, followed by 'Would you do the same?' where the increase was 29-fold. Finally, for the question whether the protagonist gains an advantage over others the increase was almost 10-fold.

Controlling for other variables, the SR scale is associated negatively with expressed levels of sympathy, perceptions of benefits outweighing risks, and whether the participant would do the same as the vignette's protagonist. There was no effect of the SR scale on perceptions of whether most people would decide to use the enhancer, while both SR and IP scales were positively associated with perceptions of whether the protagonist will have an advantage over others by using the enhancer. On the contrary the IP scale shows a positive and highly significant association with all response variables. The magnitude of the regression coefficients is worth noting here, especially for sympathy and likelihood to use the enhancer. For each 1-unit increase on the (11-point) Individual-Permissive scale, the response variables increased by approximately 0.8 points as well.

Turning to the employment context, we find a similar highly similar effect. The amount of explained variation increases by similar multipliers as in the education context and the direction and magnitude of the effect of the SR and IP scales is the same. Higher scores on the SR scale were correlated with lower sympathy towards the protagonist, lower perception that they would gain an advantage over others, or that the benefits of the enhancer outweigh its risks, and lower likelihood that the respondent herself would decide to use an enhancer under similar circumstances. In contrast, higher scores on the IP scale correlated strongly with higher average values across all five response variables.

These findings are of central importance. What they suggest is that in addition to the small effect sizes observed in the base experiment, individuals' respective points of view from which they approach the phenomenon of neuroenhancement plays a very significant role in informing their decisions when they encounter the practice in specific contexts. This is very much in line with what we would expect on the basis of Social Representation Theory, which emphasises the importance of different positions, projects, milieus that serve as vantage points from which the object 'neuroenhancement' will take shape against. Moreover, these value-led baselines do not only pertain to perceptions of risk, but come to shape a more holistic view of the practice of neuroenhancement, as demonstrated by the observation that the effect of value orientations includes expressions of sympathy and perceptions of how others are likely to act. Irrespective of whether the depicted condition was one of enhancement toward the norm, or enhancement above the norm, the two value orientations push perceptions of the practice in opposing directions.

As a visual illustration of this point, in Figure 4 I have plotted the average values on the 'Would you do the same?' question as a function of an individual respondents' combined score on both scales, i.e. the tertile split introduced above.

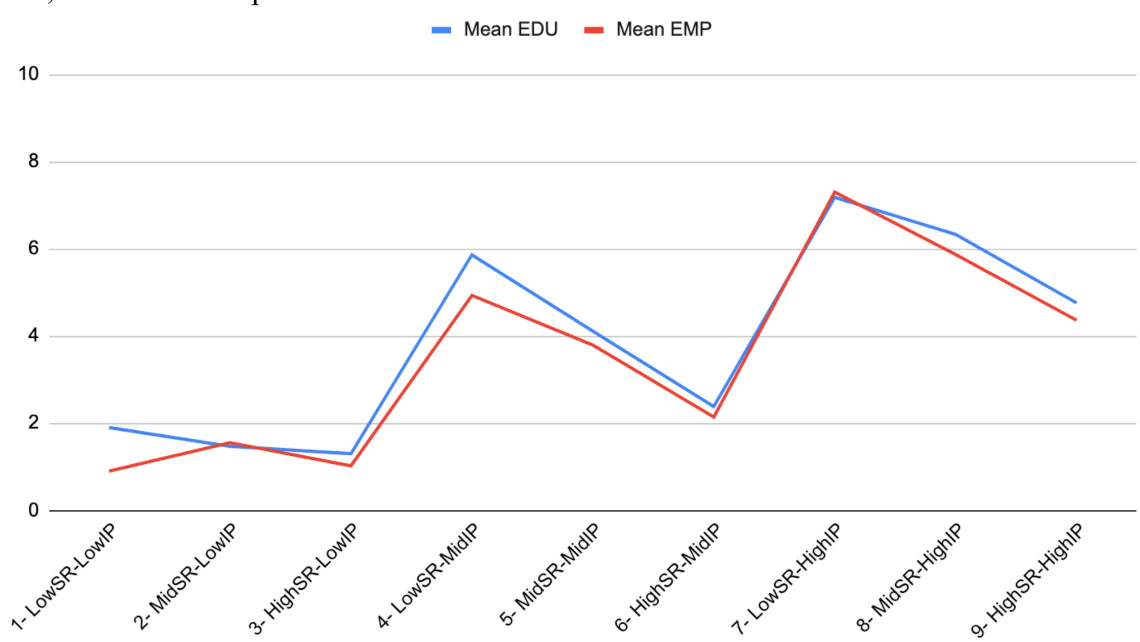

Figure 4. Line chart of average values on *'Would you do the same?'* plotted by SR/IP scale category based on tertile split.

Education Context	Can you sympathise with the decision?	Will the protagonist have an advantage over others?	Would most people do the same?	Do the benefits outweigh the risks?	Would you do the same?
R-squared (model with experimental factors only)	0.013	0.015	0.003	0.007	0.01
R-squared (model with factors and value scales)	0.266	0.137	0.134	0.225	0.29
Constant term	2.878 (0.269)	1.040 (0.244)	1.938 (0.250)	2.297 (0.253)	2.522 (.283)
Male protagonist compared to female	-0.016 (0.087)	-0.023 (0.068)	0.043 (0.07)	-0.034 (0.071)	0.010 (.079)
High baseline performance compared to failing	-0.559*** (0.087)	0.286*** (0.068)	-0.148* (0.07)	-0.190** (0.071)	-0.319*** (.079)
Pill compared to brain stimulation device	-0.346*** (0.087)	0.024 (0.068)	0.118 (0.07)	-0.340*** (0.071)	-0.451*** (.079)
High efficacy compared to low efficacy NE	0.231** (0.087)	0.562*** (0.068)	0.222** (0.07)	0.241** (0.071)	0.355*** (.079)
Societal-Restrictive Scale	-0.263*** (0.024)	0.061** (0.021)	-0.004 (0.022)	-0.251*** (0.022)	-0.467*** (0.025)
Individual-Permissive Scale	0.815*** (0.024)	0.569*** (0.021)	0.581*** (0.022)	0.676*** (0.022)	0.799*** (0.025)
Employment Context	**Can you sympathise with the decision?**	**Will the protagonist have an advantage over others?**	**Would most people do the same?**	**Do the benefits outweigh the risks?**	**Would you do the same?**
R-squared (model with experimental factors only)	0.012	0.016	0.004	0.006	0.008
R-squared (model with factors and value scales)	0.18	0.153	0.124	0.20	0.28
Constant term	3.185 (0.283)	0.697 (0.238)	2.256 (0.253)	2.381 (0.251)	2.332 (0.277)
Male protagonist compared to female	-0.053 (0.079)	0.061 (0.067)	-0.06 (0.071)	0.047 (0.071)	-0.036 (0.078)
High baseline performance compared to failing	-0.639*** (0.079)	0.417*** (0.067)	-0.228** (0.071)	-0.142* (0.071)	-0.293*** (0.078)
Pill compared to brain stimulation device	-0.094 (0.079)	-0.082 (0.067)	-0.066 (0.071)	-0.283*** (0.071)	-0.226** (0.078)
High efficacy compared to low efficacy NE	0.166* (0.079)	0.406*** (0.067)	0.179* (0.071)	0.197** (0.071)	0.292*** (0.078)
Societal-Restrictive Scale	-0.228*** (0.025)	0.062** (0.021)	-0.044* (0.022)	-0.255*** (0.022)	-0.459*** (0.024)
Individual-Permissive Scale	0.654*** (0.025)	0.595*** (0.021)	0.545*** (0.022)	0.626*** (0.022)	0.757*** (0.025)

Table 12. Multiple linear regression coefficients with experimental factors and SR / IP scales as predictors. Education and employment contexts. Standard errors in parentheses.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

In order to further investigate the segmentation of respondents based on their respective value orientations, I will now turn to the method of k-means cluster analysis.

Deriving points of view via cluster analysis

The cluster analysis has resulted in a segmentation into four distinct groups. Table 13. contains each cluster's mean and median responses on the 14 claims about neuroenhancement, as well as the proportion of individuals who agreed with each statement.

When describing the points of view below, I will refer to these overall percentages, which express agreement with particular statements and were calculated by aggregating the portion of people who responded above 0 on a scale ranging from -5 to +5. Looking at the median value for each statement allows us to get a sense of the strength of this agreement.
Two clusters represent rather robust ‘Pro’ and ‘Anti’ enhancement opinions. The contrast between the individuals' points of view in these two clusters is striking, although there are some statements on which they agree. An overwhelming majority (95%) of individuals in the ‘Anti’ cluster strongly believe that people should be content with their talents and abilities and not resort to artificial means to enhance themselves. This view is strongly rejected by those in the ‘Pro’ enhancement cluster, where just over 12% agree with the statement. Nevertheless, around 80% of those in the ‘Anti’ cluster and 96% in the ‘Pro’ cluster believe it is an expression of human nature to seek to overcome our limitations. While technological means to accomplish that appear to be acceptable for those in the ‘Pro’ cluster, the ‘Anti’ view rejects this route, as 98% of respondents believe that individual achievement should come from effort alone without reliance on technological aids, which is a sentiment rejected by around 70% of those in the ‘Pro’ cluster. Both groups overwhelmingly agree that some individuals will use enhancers to cope with increasing demands, but only 6% of respondents in the ‘Anti’ cluster hold that neuroenhancement may be a way out of increasing pressures and demands, while 68% of the ‘Pro’ camp agrees with that assessment. The ‘Anti’ cluster strongly endorses the view that people need to be protected from pressures to use enhancers (92%), but only 40% of respondents in the ‘Anti’ cluster share this opinion. The two groups mostly agree that public authorities need to oversee neuroenhancement, with 93% and 71% agreeing in the ‘Anti’ and ‘Pro’ clusters, respectively. The view of respondents in these two clusters diverges considerably on the matter of access to neuroenhancers. While the ‘Anti’ cluster believes the technology should be restricted to individuals with a medical condition (84%) and not made available to others who might want to use them (94%), not even if products are found to be safe (90%), the ‘Pro’ cluster strongly rejects such restrictions. Over 80% believe that NEs should not be restricted to cases of medical necessity, and 94% hold that they should be available as consumer products if proven safe. While both groups agree that neuroenhancement will likely increase competition between people, with 74% and 79% agreeing in the ‘Anti’ and ‘Pro’ groups, respectively, individuals in the two clusters strongly disagree on whether NE will threaten social cohesion. The ‘Anti’ cluster strongly believes this is the case (84%), while the ‘Pro’ cluster is sceptical of that outcome, as only 22% expressed agreement. Finally, there is a consensus among the two clusters that NE should never be used on children.

Besides these two rather straightforward points of view, an additional cluster may be best characterised as a Neutral position. In contrast, the final cluster appears to be comprised of those who are Ambivalent about the topic. Although neutrality and ambivalence may be viewed as closely related or interchangeable descriptions, here, I use neutral to refer to a position that mostly refrains from making strong judgments on any of the questions, which can be observed in that the cluster's mean and median responses to the 14 attitude statements are very close to 0, the neutral point of the scale, for half of the statements. The standard deviation also shows that the majority of the responses are spread quite narrowly around that neutral point. The only statement that enjoys high endorsement by this group concerns the acceptability of using neuroenhancement in children, which is quite strongly rejected (76%).

In contrast, respondents in the ambivalent cluster show stronger levels of agreement with both 'Anti' and 'Pro' statements. For example, respondents in this cluster simultaneously believe that neuroenhancement might open up fascinating new opportunities (83%) and that people should be content with their talents and abilities and refrain from using enhancers (82%). At the same time, the cluster's members lean somewhat towards making neuroenhancement available to consumers if the products are deemed safe (74%), and they strongly believe that striving to overcome our limitations is part of human nature (94%). Further, individuals in this cluster support public authorities' oversight over enhancement (93%), believe that people need to be protected from pressures (90%) and hold that NE will increase competition in society (93%) and threaten cohesion (80%). The label 'Ambivalent' seems to adequately capture this stance because it is characterised by simultaneous and somewhat contradictory attitudes towards the object in question.

The most unambiguously shared view is that neuroenhancement should never be used on children. Respondents in all clusters showed very strong agreement with this statement, which is a finding well in line with other research demonstrating firm rejection of the use of enhancers in minors (Ball & Wolbring, 2014; Sattler & Wörn, 2019).

Are different points of view more characteristic of certain genders? Looking at the conditional distribution of respondents' gender and their cluster membership shows that men are more likely than women to fall into the pro-enhancement cluster, and that women are more likely to fall into the anti-enhancement cluster. This difference is statistically highly significant ($\chi 2=46.762$, df=3, $p<0.001$). While a third of women (33%) fall into the 'Anti' cluster, less than one-fifth (16%) were allocated to the 'Pro' cluster. The proportion of men and women across the two other clusters was more balanced and almost identical to the two gender's overall distribution in the sample. In order to dig deeper, binary logistic regression models were fitted for each cluster separately with respondent gender as the independent variable. This analysis showed that for the ambivalent and neutral clusters there is no difference between the odds ratios of men and women. However, women were around 34% more likely to belong to the 'Anti' cluster than men (B=0.293; S.E.=0.06; Wald=23.810; df=1; $p<0.001$; Exp(B)=1.34; 95% CI (1.19, 1.5)), conversely, women were 34% less likely than men to be members of the 'Pro' cluster (B=-0.411; S.E.=0.7; Wald=34.094; df=1; $p<0.001$; Exp(B)=0.663 95% CI (0.578, 0.761)).

Similar analyses revealed differences with regard to the respondents age and their cluster membership as well. There was a statistically significant difference between the proportion of respondents in each cluster, depending on the respondent's age ($\chi 2=59.876$, df=12, $p<0.001$). The Ambivalent and Neutral clusters have approximately even representation in the sample, with approximately one quarter of respondents falling into these categories, while the 'Anti' group was found to be the most populous, with 30% of respondents falling into this category, and the 'Pro' cluster the smallest with only 19% of respondents. Binary logistic regressions showed a somewhat inconsistent effect of age group on cluster membership. Treating the oldest age group as the reference category, respondents aged between 25-34 were approximately 30% more likely to fall into the ambivalent cluster (B=0.288; S.E.=0.089; Wald=10.371; df=1; $p<0.001$; Exp(B)=1.33; 95% CI (1.11, 1.5)), while there was no difference for the other age groups. Respondents aged 34-45 were 29% more likely to be allocated to the neutral cluster

	AMBIVALENT			NEUTRAL			ANTI			PRO		
CLAIM	Mean (SD)	Median	% Agree	Mean (SD)	Median	% Agree	Mean (SD)	Median	% Agree	Mean (SD)	Median	% Agree
People should be content with their talents and abilities and not use artificial means to improve their performance	2.42 (2.195)	3	82.60%	1.33 (2.271)	1	66%	3.91	5	95.30%	-1.82	-2	12.70%
It is an expression of human nature to try to overcome the limitations of our body and mind	3.14 (1.756)	3	94.30%	1.48 (1.947)	1	78.10%	2.02	2	81.70%	3.62	4	96.50%
People's achievements should come from their own effort and not from pills and devices	3.46 (1.686)	4	94.90%	1.93 (2.325)	2	75.70%	4.43	5	98.30%	-0.51	-1	31.70%
I can imagine neuro-enhancement opening up fascinating new opportunities	2.05 (1.982)	2	83.80%	0.26 (2.056)	1	57%	-1.02	-1	37.30%	3.41	4	97.40%
Some people will use neuro-enhancers to cope with increasing demands in life	3.13 (1.804)	3	94.80%	1.33 (1.939)	1	77.80%	2.45	3	86.60%	3.23	3	97.20%
As life gets more pressured, neuro-enhancement may be the only way out	0.12 (2.783)	1	50.20%	-1.33 (2.182)	-1	23.20%	-3.37	-4	6.40%	1.08	2	68.10%
It is essential that public authorities oversee and control neuro-enhancement	3.56 (1.1884)	4	93.10%	1.19 (2.256)	1	65.80%	3.82	5	93.20%	1.8	2	71.20%
Only people with a medical problem should have access to neuro-enhancement	1.81 (2.494)	2	73.10%	0.51 (2.28)	1	52.90%	2.68	3	84.10%	-2.04	-2	13.20%
People need to be protected from pressures to use neuro-enhancers	3.11 (1.934)	3	90.40%	0.89 (2.251)	1	61.10%	3.63	5	92.40%	0.98	1	59.20%
If a neuro-enhancer is safe, it should be available as a consumer product	1.69 (2.373)	2	74.90%	-0.01 (2.158)	0	46.50%	-2.72	-3	10%	3.28	4	94.10%
Neuro-enhancement should never be used on children	4.14 (1.948)	5	93.80%	2.53 (2.969)	4	76.60%	4.29	5	93.40%	2.25 (3.148)	4	70.40%
Neuro-enhancement should be available to all those who might want it	1.2 (2.537)	1	66.50%	-0.2 (2.258)	0	43.30%	-3.63	-4	4.50%	3.04	3	90.90%
Neuro-enhancement will increase competition between people	3.23 (1.778)	3	93.80%	0.39 (2.174)	1	53.30%	2.05	3	74.50%	2.14	2	79.60%
Neuro-enhancement will threaten social cohesion	2.25 (2.186)	2	80.90%	0.09 (2.108)	0	43.20%	2.84	3	84%	-1.22	-1	22.50%

Table 13. Mean, standard deviation, median and % in agreement with 14 claims on NE cross tabulated with cluster membership

than respondents aged 55 and above (B=0.257; S.E.=0.09; Wald=8.112; df=1; p<0.01; Exp(B)=1.29; 95% CI (1.08, 1.54)), while the rest of the age groups showed no difference. A stronger effect of age emerged for the 'Pro' and 'Anti' clusters'. The oldest age group was most likely to be a member of the 'Anti' cluster, while younger age groups were between 41%-23% less likely to belong to this cluster (p<0.01 for all age groups), with the youngest age group, those between 18-24 years showed the largest difference in odds ratio compared to the oldest group. Table 16. shows the test statistics and 95% confidence intervals for each age group. Turning to the 'Pro' cluster, the pattern is reversed, whereby the younger age groups were between 24-40% more likely to be in this cluster, compared to the oldest age group (p<0.05 for all age groups). See Table X. for test statistics and 95% confidence interval ranges.

Gender	Ambivalent	Neutral	Anti	Pro	Total
Male	25.40%	25.30%	27.10%	22.30%	100%
Female	26.90%	23.90%	33.20%	16%	100%
Total	26.20%	24.50%	30.30%	19%	100%

Table 14. Condition distribution of gender and cluster membership (n=5329)

Age group	Ambivalent	Neutral	Anti	Pro	Total % of sample
18-24	11.10%	11.90%	9.70%	12.80%	11.20%
25-34	20.30%	17.20%	14.20%	17.90%	17.20%
35-44	17.70%	20.90%	16.90%	20%	18.70%
45-54	18%	18.40%	18.60%	19.50%	18.60%
55+	32.90%	31.60%	40.60%	29.70%	34.30%
Total % of sample	26.20%	24.50%	30.30%	19%	100%

Table 15. Conditional distribution of cluster allocation by age group. (N=5332)

Age group	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI lower	95% CI upper
18-24	-0.45	0.105	18.391	1	<0.001	0.638	0.519	0.783
25-34	-0.52	0.091	33.031	1	<0.001	0.594	0.498	0.71
35-44	-0.391	0.086	20.616	1	<0.001	0.676	0.571	0.801
45-54	-0.252	0.085	8.847	1	<0.01	0.777	0.659	0.918
Constant	-0.583	0.049	142.702	1	<0.001	0.558		

Table 16. Binary logistic regression of age group and allocation to the 'Anti' cluster. Reference category: age group 55 and above.

Cluster membership showed a statistically significant relationship with university level education as well ($\chi 2$=18.66, df=3, p<0.001). Binary logistic regressions showed that the odds of being a member of the 'Pro' or 'Anti' clusters were not associated with respondents' level of education. Those with a university degree were approximately 19% less likely to belong to the Ambivalent cluster than those without a completed higher education diploma (B=-0.206; S.E.=0.073; Wald=8.026; df=1; p<0.01; Exp(B)=0.814; 95% CI (0.706, 0.939)). Conversely, university graduates were approximately 24% more likely to belong to the Neutral cluster than those without a degree (B=0.221; S.E.=0.071; Wald=9.782; df=1; p<0.01; Exp(B)=1.247; 95% CI (1.086, 1.432)).

Looking at the distribution of cluster membership across the five countries included in the sample we can see that the proportions are different and this difference is statistically significant ($\chi2$=307.946, df=12, p<0.001). Austrian and German respondents strongly overlapped in their cluster allocations, with the 'Anti' group being the most populous (38-40%), and the 'Pro' cluster being the smallest for both countries (15-16%), while the Ambivalent and Neutral clusters had approximately one fifth and one fourth of respondents, respectively. For Hungary, the ambivalent cluster was the largest, which echoes the large number of ambiguous qualitative comments seen earlier. In Hungary, over a third of respondents were in this category, followed by the 'Anti' cluster with another 30% of respondents. The Pro cluster counted almost 20% of respondents and the neutral group was the smallest, with 14%. In the UK, cluster membership was quite evenly distributed, with the Ambivalent group having the most respondents (28.1%), the Neutral and Anti clusters almost exactly 25% of survey-takers each, with the Pro cluster counting almost 21%. Finally, in the USA, the Neutral cluster was the largest with almost one third of the sample, followed by the Ambivalent group with almost 28%, the Pro cluster with 23%, and the 'Anti' cluster counting only 16.7% of respondents.

Based on the patterns of cluster membership, the two most similar countries are Germany and Austria, while the two most dissimilar are Germany and the United States. Figure 5 shows these distributions as a clustered bar chart. Importantly, these country comparisons are to be interpreted with caution, because the surveys did not use matched samples. However, the overall *gestalt* of the findings tends to align with existing research on country differences in attitudes to technology. For example, the SIENNA survey found that 47% of the US public supported cognitive enhancement, while in Germany this figure was only 36% (Prudhomme, 2020). Moreover, representative surveys in Germany show that the public has mixed feelings about the impact of technology on their quality of life, with less than half of respondents expecting that it will improve living standards for future generations, while 60% believe technology contributes to increased pressures on individuals (TechnikRadar, 2018). In contrast, a 2019 study in the US found that 58% of Americans expect that technology will continue to make life better for their children, and 61% have highest expectations of innovations in the domain of medicine (Ipsos, 2019).

Country	Ambivalent	Neutral	Anti	Pro	Total
Austria	20.60%	24.80%	38.30%	16.30%	100%
Germany	18.80%	25.70%	40.40%	15.10%	100%
Hungary	35.90%	14.10%	30.20%	19.70%	100%
United Kingdom	28.10%	25.60%	25.40%	20.90%	100%
United States	27.70%	32.70%	16.70%	23%	100%
Total	26.20%	24.50%	30.30%	19%	100%

Table 17. Conditional distribution of cluster allocation by nationality (N=5332)

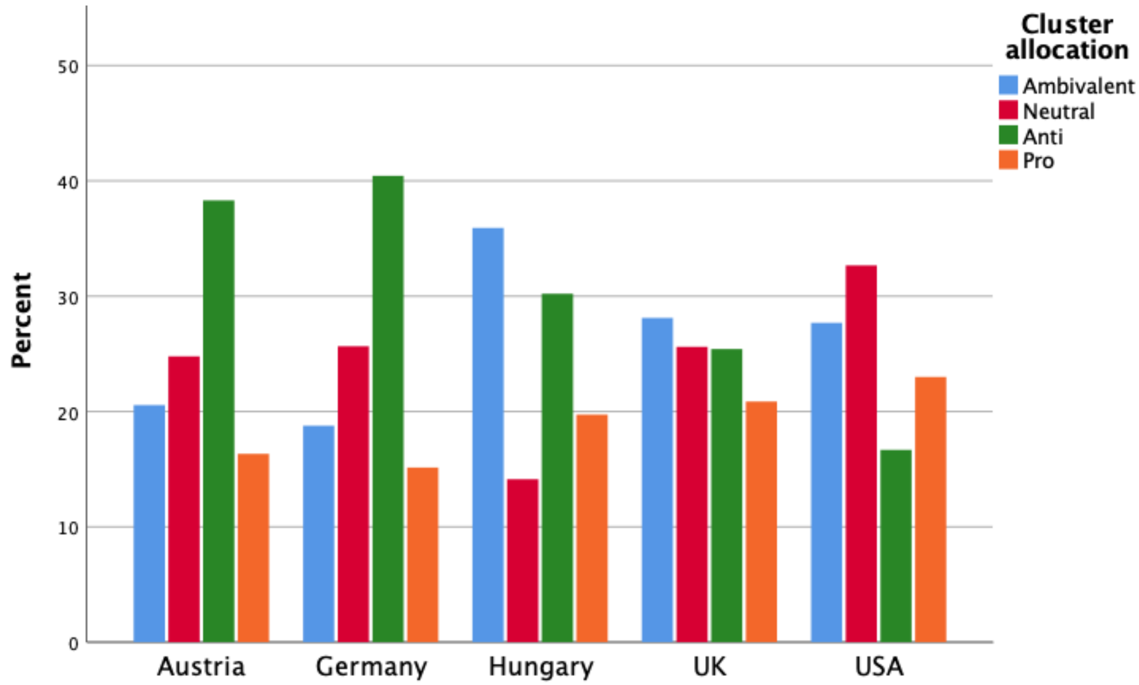

Figure 5. Clustered bar chart of the proportion of clusters in each country.

Next, I will investigate whether respondents in the four clusters had responded differently to the education and employment experiments.

	N	Mean	SD	S.E.	95% CI lower	95% CI upper
Employment						
Ambivalent	1397	3.91	3.311	0.089	3.73	4.08
Neutral	1308	3.26	2.763	0.076	3.11	3.41
Anti	1614	1.51	2.492	0.062	1.39	1.64
Pro	1013	6.05	3.292	0.103	6.25	6.25
Education						
Ambivalent	1397	4.23	3.341	0.089	4.06	4.41
Neutral	1308	3.51	2.898	0.08	3.35	3.67
Anti	1614	1.78	2.702	0.067	1.65	1.91
Pro	1013	6.49	3.19	0.1	6.29	6.69

Table 18. Mean and standard deviation of "Would you do the same?" experimental variable in education and employment contexts for each cluster.

For the employment context, one-way ANOVA showed that there was a statistically significant difference between all four clusters (F(3, 5328) = [508.138], p<0.001). Tukey's HSD Test for multiple comparisons found that the mean value of the dependent variable was significantly different between the Ambivalent and Neutral clusters (p <0.001, 95% C.I. = [0.36, 0.94]), between the Ambivalent and Anti clusters (p<0.001, 95% C.I. = [2.12, 2.67], between the Ambivalent and Pro clusters (p<0.001, 95% C.I. = [-2.46, -1.83], between the Neutral and Anti clusters (p<0.001, 95% C.I. = [1.46, 2.02], between the Neutral and Pro clusters (p<0.001, 95% C.I. = [-3.11, -2.48] and the difference was largest between the Anti and Pro clusters (p<0.001, 95% C.I. = [-4.84, -4.23]).

Similarly, for the education context, the one-way ANOVA revealed that there was a statistically significant difference across all four clusters (F(3, 5328) = [522.273], p<0.001). Post-hoc multiple comparison via Tukey's HSD further showed that there was a significant difference between the Ambivalent and Neutral clusters (p<0.001, 95 C.I. = [0.43, 1.03], the Ambivalent and Anti clusters (p<0.001, 95% C.I. = [2.17, 2.74], the Ambivalent and Pro clusters (p<0.001, 95% C.I. = [-2.58, -1.94], between the Neutral and Anti clusters (p<0.001, 95% C.I. = [1.44, 2.02], the Neutral and Pro clusters (p<0.001, 95% C.I. = [-3.31, -2.66], and finally, between the Anti and Pro clusters (p<0.001, 95% C.I. = [-5.03, -4.4].

What this suggests is that across all the experimental conditions, irrespective of which specific vignette respondents were exposed to, members of the four clusters gave significantly different responses on whether they themselves would decide to use the described enhancer, if they were in the vignette protagonist's shoes. This further indicates that the four clusters represent distinct outlooks that fundamentally shape respondent's relation to neuroenhancement. In addition, the mean values reveal that those in the Anti cluster uniformly reject enhancement, those in the Pro cluster are open to accepting the practice, while both the Ambivalent and Neutral clusters lean towards rejection, with the Ambivalent group being close to the mid-point of the scale.

The next section will explore the types of reasoning that characterise the perspectives of the clusters as derived from open-ended qualitative comments.

Arguments by cluster

The previous sections have established that the two value orientations, SR and IP are significant determinants of individuals' attitudes in relation to neuroenhancement, and that we can identify at least four different clusters on the basis of their overall views about NE. As a final step in a long series of analyses I will investigate whether there are distinct ways of reasoning about enhancement the distinguish the clusters, and where the overlaps may be. Appendix A5 and Appendix A6 contain the conditional distribution of every code for the four clusters.

In Tables 19 and 20 below, I have collated the arguments in each cluster in descending order of frequency.

The most common argument among the Ambivalent cluster was related to the unknown (long-term) effects of neuroenhancement, which was mentioned by 14.7% of them. This suggests that they are aware of the potential benefits of neuroenhancement, but also concerned about the possible harms that might not be evident in the short term. The second and third most common arguments were concerns about side effects (10.9%) and the unfavourable risk/benefit profile or low performance gain from neuroenhancers (10.1%). These arguments indicate that respondents are not convinced that the benefits of neuroenhancement outweigh the costs, either in terms of health or performance. They might perceive neuroenhancement as dangerous, risky, or not safe, as 7.5% of them argued, or with scepticism skeptical as an ineffective method, as 7.1% of them argued. These arguments reflect a rational or pragmatic approach, as well as a low expectation of neuroenhancement. Another argument among the Ambivalent cluster was coping with pressure, fear of loss, high stakes, or desperation, which was mentioned by 8.9% of them. This argument suggests that they understand the reasons why some people might resort to neuroenhancement, especially in competitive or stressful situations. These arguments reflects an empathic or situational approach, as well as a recognition of the social and psychological factors that influence the decision.

Conversely, some of the respondents also expressed favourable arguments for neuroenhancement, such as an attractive risk/benefit profile (8.1%), or recognition of the argument that improvement is good and one should embrace enhancement to get ahead (4.6%). These arguments indicate that they see some value or potential in neuroenhancement, either in terms of enhancing their abilities or achieving their goals, but the frequency of this perspective among the cluster was rather low.

Other arguments that were expressed by the ambiguous respondents include the moral argument that one should rely on effort and cherish authenticity (6.7%), but an approximately equal proportion couldn't really make up their minds about the practice. (6%). Some members of the cluster also argued that neuroenhancement was not a real solution (4.4%), that it was worth a try (4.2%), but also that there was no need for it (3.6%), and that other methods preferable such as sleep, diet, or exercise were preferable, (3%), and that more information was needed to make a judgment.

In summary, the data shows that the Ambivalent cluster has a complex and diverse set of arguments for and against neuroenhancement, which reflect different approaches, perspectives, and factors that influence their decision. Their ambivalence might stem from a lack of information, evidence, or experience, or from a balance or trade-off between benefits and risks, or from a conflict or dilemma between values and motivations. The Ambivalent cluster represents a heterogeneous and dynamic group of respondents.

In the Neutral cluster, the most common response, given by 10.6% of the respondents, was that they were uncertain about the unknown (long-term) effects of neuroenhancement. This indicates a level of caution or wariness about the potential consequences of altering one's brain function. The next most frequent responses, each given by around 9% of the respondents, were that they were skeptical about the efficacy of neuroenhancement or that they considered the risk/benefit profile to be unfavourable or low. These responses suggest a lack of confidence or interest in the expected outcomes of neuroenhancement. Approximately 6% considered neuroenhancement to be risky or dangerous. Other common responses, each given by around 8% of the respondents, were that they were concerned about the side effects of neuroenhancement or that they preferred to rely on their own effort and natural abilities. The data also reveals some positive or empathetic attitudes towards neuroenhancement, such as a favourable risk/benefit profile, or the recognition that the practice might represent a form of coping with pressure or high stakes, understanding the decision. Similarly, some argued that it was worth a try, or that embracing enhancement for the achievement of one's goals was good. These responses, however, were less frequent, each given by around 5% or less of the respondents. The data also shows some strong negative or moralistic reactions to neuroenhancement, such as dangerous, risky, not safe, messing with body/brain, unnatural, artificial, not a real solution, madness, wrong, or rejecting chemicals/drugs. These responses, however, were also relatively rare, each given by around 4% or less of the respondents. Finally, some responses indicated a lack of clarity or conviction, such as ambiguity or unqualified disagreement. Overall, the data shows that the Neutral cluster respondents had a range of diverse opinions on neuroenhancement.

In the Anti cluster, the most common theme was the uncertainty or fear of the potential unknown long-term effects of enhancers (19.7%) along with worries about the method's safety, or side effects (11.8% and 8.3%, respectively). Another prominent theme was the preference for relying on one's natural or authentic abilities in delivering cognitive performance, such as via effort, or lifestyle factors (12.8% and 4.1%, respectively). Neuroenhancement was rejected as unnatural, artificial, or messing with the body or brain (7.9%). Some respondents also expressed skepticism about the efficacy or benefits of neuroenhancement, questioning whether it would work at all, or whether its benefits would outweigh its risks (8.3% and 7.2%, respectively). Additionally, some respondents raised the ethical objections that neuroenhancement was cheating (5%), or simply stating that it was wrong and objectionable (6.6%). A smaller proportion of respondents also mentioned other reasons for their opposition, such as neuroenhancement not being a real solution (5%), but a small proportion saw the practice as a form of desperate coping with pressure or fear of failure (3.7%). Concerns about addiction and dependence also surfaced (3.5%). Finally, some respondents simply disagreed with neuroenhancement without giving a specific reason (4.8%), or stated that there was no need for it (3.3%).

Finally, among those who were classed 'Pro' neuroenhancement, the most common reason for supporting the use of enhancers was a favourable risk/benefit profile, which accounted for 20.4% of the coded open-ended responses. This suggests that these respondents perceived the potential benefits of neuroenhancement to outweigh the possible harms, or that they were willing to accept some risks for the sake of improved performance. The second most frequent reason was the perception that neuroenhancement was called for in a situation of stress when one needed to cope with pressure and the stakes were high, which was mentioned by 14% of the responses. This implies that some of the 'pro' respondents accept the motivation to use neuroenhancers to deal with challenging or stressful situations, or to avoid falling behind in a demanding environment. The third most common reason was the desire to be the best one can be, improve oneself, or get ahead, which reflected 11.6% of the responses. This shows that some of the respondents in this cluster valued neuroenhancement as a means of enhancing their abilities, skills, or opportunities, or as a form of self-actualization. Other reasons that were mentioned by smaller proportions of respondents included the pragmatic argument that the enhancer was worth a try (9.4%), however, concerns about unknown effects were also mentioned (6.7%), empathy or understanding for the decision (6.4%), unfavourable risk/benefit profile or low performance gain (6.1%), concerns about side effects (6.1%), and dangerous, risky, or not safe (3.6%). Some of the 'pro' respondents also expressed unqualified support (3.6%), skepticism or disbelief (3.3%), or the need for more information or evidence (3%). The data thus reveals a range of factors that influenced the 'pro' respondents' attitudes to neuroenhancement, with varying degrees of certainty, optimism, caution, and curiosity.

Ambivalent	%	Neutral	%	Anti	%	Pro	%
unknown (long-term) effects	14.7%	unknown (long-term) effects	10.6%	unknown (long-term) effects	19.7%	favourable risk/benefit profile	20.
concerns about side effects	10.9%	skeptical / doesn't work	9.6%	rely on effort / authenticity / natural or nothing	12.8%	coping with pressure / fear of loss / high stakes / desperation	1
unfavourable risk/benefit profile / low performance gain	10.1%	unfavourable risk/benefit profile / low performance gain	9.1%	dangerous / risky / not safe	11.8%	be the best you can be / improvement is good / get ahead	11.
coping with pressure / fear of loss / high stakes / desperation	8.9%	concerns about side effects	7.8%	unfavourable risk/benefit profile / low performance gain	8.3%	Worth a try	9.
favourable risk/benefit profile	8.1%	rely on effort / authenticity / natural or nothing	7.6%	concerns about side effects	8.3%	unknown (long-term) effects	6.
dangerous / risky / not safe	7.5%	favourable risk/benefit profile	6.3%	messing with body/brain / unnatural / artificial	7.9%	empathy / understanding for the decision	6.
skeptical / doesn't work	7.1%	dangerous / risky / not safe	6.3%	skeptical / doesn't work	7.2%	unfavourable risk/benefit profile / low performance gain	6.
rely on effort / authenticity / natural or nothing	6.7%	coping with pressure / fear of loss / high stakes / desperation	5.3%	Madness, wrong, objectionable	6.6%	concerns about side effects	6.
ambiguous / can't decide	6%	empathy / understanding for the decision	5%	not a real solution	5%	dangerous / risky / not safe	3.
empathy / understanding for the decision	5%	Worth a try	4.5%	cheating / doping / unfair advantage	5%	unqualified support	3.
be the best you can be / improvement is good / get ahead	4.6%	be the best you can be / improvement is good / get ahead	4.3%	Unqualified disagreement	4.8%	skeptical / doesn't work	3.
not a real solution	4.4%	other methods preferable (sleep, diet, exercise, etc.)	4%	other methods preferable (sleep, diet, exercise, etc.)	4.1%	other	3.
Worth a try	4.2%	messing with body/brain / unnatural / artificial	4%	coping with pressure / fear of loss / high stakes / desperation	3.7%	more information needed / wait for evidence	
no need	3.6%	not a real solution	3.8%	addiction or dependence	3.5%		
other methods preferable (sleep, diet, exercise, etc.)	3%	ambiguous / can't decide	3.5%	no need	3.3%		
more information needed / wait for evidence	3%	Unqualified disagreement	3.3%				
		more information needed / wait for evidence	3%				
		Madness, wrong, objectionable	3%				
		rejecting chemicals/drugs	3%				

Table 19. Codes above 3% frequency in each of the four clusters, sorted by descending frequency. Education context.

Ambivalent	%	Neutral	%	Anti	%	Pro	%
coping with pressure / fear of loss / high stakes / desperation	14.30%	concerns about side effects	11.70%	unknown (long-term) effects	17.50%	coping with pressure / fear of loss / high stakes / desperation	21.30%
concerns about side effects	13.50%	unknown (long-term) effects	9.00%	concerns about side effects	13.50%	favourable risk/benefit profile	14.80%
unknown (long-term) effects	11.30%	coping with pressure / fear of loss / high stakes / desperation	8.10%	unfavourable risk/benefit profile / low performance gain	11.50%	be the best you can be / improvement is good / get ahead	13.60%
unfavourable risk/benefit profile / low performance gain	9.80%	unfavourable risk/benefit profile / low performance gain	8.10%	rely on effort / authenticity / natural or nothing	9.40%	Worth a try	11.60%
no need	7.10%	skeptical / doesn't work	7.80%	dangerous / risky / not safe	8.70%	concerns about side effects	10.70%
dangerous / risky / not safe	6.40%	rely on effort / authenticity / natural or nothing	7.30%	no need	7.60%	empathy / understanding for the decision	8.50%
favourable risk/benefit profile	6.20%	dangerous / risky / not safe	7.10%	coping with pressure / fear of loss / high stakes / desperation	6.80%	unfavourable risk/benefit profile / low performance gain	6.80%
Worth a try	5.80%	not a real solution	7.10%	skeptical / doesn't work	6.60%	unknown (long-term) effects	4.60%
rely on effort / authenticity / natural or nothing	5.60%	Worth a try	6.10%	wrong to risk health for performance	5.30%	no need	4.40%
not a real solution	5.30%	no need	4.90%	not a real solution	5.10%		
empathy / understanding for the decision	5.30%	other methods preferable (sleep, diet, exercise, etc.)	4.20%	messing with body/brain / unnatural / artificial	5.10%		
be the best you can be / improvement is good / get ahead	4.70%	favourable risk/benefit profile	3.70%	other methods preferable (sleep, diet, exercise, etc.)	4.60%		
skeptical / doesn't work	4.70%	ambiguous / can't decide	3.70%	cheating / doping / unfair advantage	4.00%		
messing with body/brain / unnatural / artificial	3.20%	Unqualified disagreement	3.70%	move on, change job, try something else	3.60%		
other methods preferable (sleep, diet, exercise, etc.)	3.00%	wrong to risk health for performance	3.20%	Madness, wrong, objectionable	3.50%		
wrong to risk health for performance	3.00%			rejecting chemicals/drugs	3.00%		
				Illegitimate pressure from labour market	3.00%		

Table X. Codes above 3% frequency in each of the four clusters, sorted by descending frequency. Employment context.

Bridging investigations

Thus far, the thesis offered an overview of how neuroenhancement emerged as a topic of intense scrutiny, media reporting, and policy action (Part I), and it investigated the general public's perceptions in Austria, Germany, Hungary, the United Kingdom, and the United States.

A central argument, that was underpinned by a variety of analytic methods, has been that the public should not be viewed as a single monolithic entity that may be said to possess an attitude concerning a phenomenon as complex as neuroenhancement. Instead, I have sought to demonstrate that concealed underneath average values of acceptability are different perspectives on the issue and that these perspectives are animated by diverse concerns.

Whereas this chapter used a large-scale representative survey to segment the public and investigate these perspectives, in the following section, I will turn to a more narrowly defined context, which I am labelling the Proactionary Social Milieu. This part will look at qualitative interviews conducted with users of neuroenhancement technologies.

In order to explain what I mean by the Proactionary Milieu, it is helpful to first introduce a sister concept: precaution. The Precautionary Principle refers to a risk management philosophy, primarily applied in the domains of environmental and public health policy, that prioritises the prevention of harm even in the absence of conclusive scientific evidence. The Precautionary Principle can be traced to German thought of the early 19th century and especially to the notion of *Vorsorge*, which expresses a form of foresight, anticipatory care and concern, and is translated into English as precaution (Fuller, 2012; Hanson, 2018). It has found influential elaborations during the 1970s, for example, in the work of philosopher Hans Jonas who developed an 'imperative of responsibility' to deal with the unprecedented challenges and uncertainties of a highly technological society (Jonas, 1987). With regard to environmental issues, the principle is also enshrined into European law by the Lisbon Treaty (European Union, 2008). Although the principle is intended to ensure safety and protect individuals and society from harm, it has also been criticised for being unreasonably strict and hindering scientific progress (Holm & Harris, 1999).

In contrast, the Proactionary Principle was coined in 2004 by transhumanist philosopher Max More, and it was articulated as a response to the dominant conservative position that had taken hold of the US Bioethics Commission during the Bush administration, which had led to restrictive policies and the cutting of federal funding for stem cell research. Techno-progressive thinkers like More sought to outline an alternative approach to the Precautionary Principle. More's version states that: *"People's freedom to innovate technologically is highly valuable, even critical, to humanity. This implies several imperatives when restrictive measures are proposed: Assess risks and opportunities according to available science, not popular perception. Account for both the costs of the restrictions themselves, and those of opportunities foregone. Favor measures that are proportionate to the probability and magnitude of impacts, and that have a high expectation value. Protect people's freedom to experiment, innovate, and progress"* (More, 2004).

At its core, this approach represents a fundamentally different attitude towards risk. In Fuller's summary: "*whereas precautionaries regard significant risk-taking as ultimately corrosive to our freedom, the limits of which are already evidenced in the actual world, proactionaries regard risk-taking as necessary to discover the limits of what is possible, which by no means is exhausted by what has already happened"* (Fuller, 2012, p. 164). In other words, precaution is oriented towards *protecting* what we already have, know, and value, while proaction aims at *exploring* what we might possibly come to have, know, and value. The principle of proaction and its more elaborate articulation by Fuller and Lipinska as the Proactionary Imperative are among the core tenets of transhumanist thinking and position risk-taking as a fundamental and constitutive part of being human (Fuller & Lipinska, 2014). However, in this context, risk-taking pertains specifically to the kinds of undertakings that might contribute to the unfolding and realisation of human potential and the overcoming of our limitations. In that sense, risk-taking is animated by a larger, more ambitious vision. Risks are not only assessed with reference to the present and what we might lose but also, perhaps more importantly, against possible gains that may be realized in an enhanced future, weighing possible harms against benefits we might forego by not pursuing potentially risky paths.

A Proactionary Milieu is thus one characterised by a commitment to this broader goal of self-transcendence and enhancement, where individuals pursue activities that express this vision and are willing to take on risks to achieve it.

In describing the Proactionary Milieu, it is useful to draw on the notion of the *project,* which was a conceptual innovation introduced into Social Representation Theory by Bauer and Gaskell. They emphasised that *"subject-object relations are relative to a project, a "future-for-us," an ongoing movement, an anticipation "not-yet" which defines both the object as well as the people's experience"* (Bauer & Gaskell, 2008, p. 343). In a sense, 'the project' forms the interpretive context and background against which any given object – in this case, brain hacking and sensory augmentation – is articulated and acquires its meaning and significance. Therefore, there is a relationship of mutual constitution between the subject, object, and project.

Importantly, a project is temporal in nature and may extend in time towards the past as a sense of a group's collective memory and shared history, and towards the future as a horizon of expectation. For the Proactionary Milieu, this forward-looking orientation is especially significant, as it reflects the group's core aim of accelerating progress towards a desired future.

The subsequent two chapters detail studies that investigate the Proactionary Milieu to provide a rich account of the project(s) that animate this milieu. In each case, the point of entry is provided by specific neuroenhancement-related practices: brain hacking, and sensory augmentation.

Part III – Proactionary Milieus

Chapter 5.
Brain Hackers
An Exploratory Account of the Practice of Do-It-Yourself Brain Stimulation

The findings described in this chapter represent an exploratory study of the practice of brain hacking, understood as the use of Do-It-Yourself or commercially available brain stimulation devices outside academic or professional environments. This work represents my first foray into neuroenhancement user perspectives. Despite the very small interviewee sample size, this work played an important role in the conceptualisation of the Proactionary Milieu. Before describing the findings derived from the interviews, the first section will offer an introduction to the rise of brain hacking as a practice, followed by a summary of existing literature on DIY neurostimulation users.

The Emergence of Brain Hacking

Beginning in the late 2000s, the microelectronics manufacturing industry underwent advances that drastically reduced the production cost of microchips and other electronics components, such as sensors and actuators. This contributed to the establishment of companies like Arduino and the Raspberry Pi Foundation, which offered cheap, open-source hardware components that allowed hobbyists to build their own computers, robots, and embedded systems of all kinds (Tanenbaum et al., 2013). This has fuelled the growth and wider proliferation of maker, hacker, and DIY cultures during the late 2000s and early 2010s and saw the emergence of hackspaces and sites of making, building and socialising around technological projects (Ames et al., 2014; Taylor et al., 2016; Toombs, 2017). Inspired by the model of DIY electronics pioneered by Arduino and its kin, projects emerged that sought to democratise biology and neuroscience in a similar fashion[10].

Advances in manufacturing and miniaturization also made electroencephalography devices, used to read the electrical activity of the brain, viable as consumer products. This was a major development, as brain reading technology used to be available only for clinical and research settings at a very high cost. Companies such as NeuroSky and Emotiv put affordable brain sensing headsets on the market, which they contended would serve as the next interface for human-computer interaction and as tools for mental self-care and improvement. Concurrently, games and toys driven by brain-computer interfaces, such as Mattel's Mindflex, emerged alongside a burgeoning interest in the development of an 'app store' for brain technologies.[11] Although that particular vision has not (yet) been realised, reports demonstrate a steadily increasing interest in neurotechnology products, with one major online retailer recording significant growth every quarter since 2014 (Waltz, 2019) as new companies continue to establish themselves in the consumer neurotechnology space (Coates McCall et al., 2019; Wexler & Thibault, 2019). OpenBCI, an open-source brain-computer interface hardware project that offers modular biosensing equipment helped to further lower the barrier to entry for incorporating brain data and brain-controlled interfaces into product prototyping, educational activities, citizen science efforts, or personal projects. During the mid-2010s several brain hackathons were organised by companies, academic projects, and art/science centres across the US and Europe, where technology enthusiasts from diverse backgrounds took to building new products, tools, games, or artistic and creative applications that leveraged BCIs and neural signals (Guger et al., 2019; Valjamae et al., 2017). Neurotechnology was generally gaining momentum in this period with increased funding and hopes for delivering

[10] See or example: https://bento.bio/ a company seeking to democratize access to DNA analysis.
[11] See https://web.archive.org/web/20091119214028/http://store.neurosky.com/collections/applications

innovation where pharmaceuticals had failed (Baldwin et al., 2013). The ease of access to brain-computer interfaces afforded by these commercial and open-source products helped to position the brain as a novel site of tinkering and hacking, where the central nervous system appeared as a new technological platform that could be measured, tweaked, optimised, and interfaced with other technological systems.

The DIY brain stimulation movement arose in tandem with these developments, and saw individuals constructing basic electrical brain stimulation devices such as transcranial direct-current stimulation (tDCS) kits comparable to those found in academic research, for the purposes of self-treating medical conditions and experimenting with cognitive enhancement (Wexler, 2016b). However, brain stimulation methods do not merely 'read' brain activity, like most consumer/DIY neurotechnology products, but also 'write' information to the brain in the form of electrical stimulation that modulates brain activity. This makes it a much more risky and uncertain practice that generated a great deal of attention and concern from the neuroscience community and from neuroethicists (Fitz & Reiner, 2015; Wurzman et al., 2016). In light of this concern, it is surprising that only a very small number of studies have actually investigated the community of DIY or home users of electrical brain stimulation.

Jwa undertook a study to explore user demographics, motivations for using the technology, practices and experiences regarding stimulation effects, as well as user concerns (Jwa, 2015). Her research drew on multiple methodologies, including an online survey (n=121), content analysis of forum posts, and a small number (n=4) of interviews with the most influential "power users" from online tDCS communities. Some of these power users also ran YouTube channels where they shared their experiences with the broader community and at the time of Jwa's data collection, the subscriber base of these users amounted to around 800 to 2700 individuals. Survey responders were predominantly male (94%) and most of them were in their 20s and 30s but a substantial portion was in their 50s or over and most of the respondents were from the US and Canada (74%). The primary motivation for use was cognitive enhancement (59%) but 11% reported using brain stimulation to treat medical conditions, primarily depression, and some used it for both purposes (24%). Although 44% of users rated their use of tDCS as successful, one of the power users highlighted that the effects are usually "extremely subtle", and web content analysis revealed that many users of DIY devices have problems in assessing the effectiveness of their setups.

Wexler also reported of an exploratory study based on open-ended interviews with tDCS users and the observation of online discussion groups and websites (Wexler, 2016a). She found that users drew heavily from the scientific literature to create their electrode montages and other practical aspects of their stimulation practice, however, there were some grey areas in research concerning session duration and frequency of use, which online users tried to cover by sharing their own experiences with each other. Some users' practices diverge from scientific guidelines as they try to push the limits to self-treat in the most effective way possible and to obtain results faster. Concerning the effectiveness of tDCS, many users distance themselves from the scientific reports on the method's validity, depending instead on their own subjective feelings of effectiveness. This tendency occurs in both groups of users who treat themselves with tDCS for medical conditions and for cognitive enhancement. Some of those who use it for enhancement try to apply more quantifiable methods to measure the effects, for instance by using open-source cognitive tests. Although online users often discuss the placebo effect, they rarely do anything to control for it.

In another study by Wexler an online survey was circulated to consumers of commercial tDCS devices via the main device manufacturers' newsletters (Wexler, 2018). Although the response rate was rather low, this approach yielded a larger sample size than previous studies, with 339 valid responses. The survey found that almost three-quarters of respondents used tDCS for cognitive enhancement, while approximately one-quarter had used it for restoration, such as to restore diminished cognitive abilities. Almost half of the respondents reported using tDCS to self-treat a medical or psychological condition, with depression being the most commonly mentioned disease. More users found their use to be successful (42.5%) than not (27.6%), although a substantial portion were not sure (29.9%). In addition, compared to the enhancers, those who reported using tDCS to treat a condition were more likely to report their practice as being successful.

Wexler also found a tendency to use tDCS less and less over time and there was a portion of people (5.8%) who purchased a device but never used it. The most frequent reasons were concerns about the safety of the procedure and lack of guidance provided by the manufacturer. Over one-third of consumers used the device, but then quit it because of a lack of perceived efficacy, side-effects or concerns about the long-term effects. However, most of the users never tried to measure the results they obtained via stimulation (47.7%), while others relied on their self-observation and self-reflection (19.5%), and only a small group (12.3%) used tests to measure the efficacy of their tDCS use. Over 70% of respondents claimed tDCS to be a relatively safe technique, but more than half (54%) agreed that it should not be used on children. Wexler's research also revealed that those who purchased tDCS devices can be characterised as early adopters of new technologies and were generally highly educated, with liberal political leanings, with an above-average interest in science and technology.

Interviewees

This small study is based on three semi-structured interviews conducted with members of a brain hacker collective. The three interviewed individuals were well-educated, white males who, at the time of our conversation, either already held or were working towards doctoral degrees in subjects directly related to brain research, such as neuroimaging and computational neuroscience. They were collaborating on a DIY project to create an affordable and open-source piece of equipment that would allow for recording brain activity via EEG and concurrent administration of electrical brain stimulation.

While studies of DIY brain stimulation users described above were focused more narrowly on neurostimulation practices, perceptions of effects, and general demographics, my interest in conducting semi-structured interviews with brain hackers was to explore their motivations in greater detail and to build a deeper understanding of the context of their activity. As I shall explain below, interviewees' personal motivations for being involved in brain hacking differed significantly. In an effort to capture their narratives, each interviewee was assigned a pseudonym that sought to express their perspective. While these pseudonyms might risk oversimplification, the intention is to succinctly and non-judgmentally convey informants' overall attitudes as they emerged from the analysis.

The findings will be described in two steps. First, I will give an overview of each interviewee, emphasising the broader project against which each respondents' brain hacking activity takes shape. Then, I will discuss a small number of key themes and situate brain hacking with respect to the broader neuroenhancement discussion.

Ray, the Transhumanist

Interviewee 1 was a PhD student in his early twenties, who will be referred to as *Ray, the Transhumanist*. His involvement in brain enhancement research spans both professional and non-professional contexts, and it is motivated by his deeply held conviction that advances in artificial intelligence research will soon reach a point, where machines overcome human intelligence. His activities in DIY brain stimulation and brain hacking are informed by the normative conviction that humanity *must* pursue enhancement practices because it is the inevitable trajectory of scientific progress and that it is also a necessity emerging from the fact that human capacities will soon be far surpassed and outstripped by intelligent machines.

> ***Ray:*** *"Well, if you create an entity that's smarter than you, speaking very simplistically and hypothetically now, you create an entity that's smarter than you, but you do not have the ability to augment your intelligence and cognitive capacities, then you're left in a pretty strange position of not understanding why this entity is doing certain things. […] Even if you could have access to how it did its reasoning, you might not be able to comprehend it. Like even today, we are not able to comprehend how AI systems work exactly, even though we make them work. […] So, if you have something that's really smart and, you know, much smarter than you, and you don't know how it works, then that's not a position you want to be in, generally. […] So, the only real option I see to not really fall behind in these things is to try as much as possible to merge and become these things."*

Ray held that this prospect was receiving far too little attention at the moment, even though a great deal of research would need to go into disciplines like material science, bioinformatics, and other fields that can build the foundations for such human-machine merger. His commitment to pursuing brain research and, indeed, brain hacking are part of a much broader project that is animated by Ray's transhumanist conviction and set of beliefs about the future of humanity. According to this view, people merge with the technology they create as an unavoidable necessity. This view closely echoes the conviction of leading transhumanist thinkers, who have been making similar statements and projections about the future of humanity (Goertzel, 2013; Koene & Deca, 2013; Kurzweil, 2005). The notion of this inevitable merger achieved broader popularity around 2019 when famed inventor and technology investor Elon Musk proclaimed that his motivation for launching a brain-computer interface development company was to allow humans to merge with advanced AI in order to avoid being left behind the technology's progress (Lopatto, 2019). As Ray explained, brain science and artificial intelligence each contribute to the other field's development, yet it appears that from the perspective of humanity, there is a race and a sense of urgency to reach a sufficient level of understanding of brain function along with the capability to intervene into it to enable enhancement *before* the age of superintelligent machines dawns upon us.

There is a remarkable duality inherent to this view in that the progression of technology in a particular direction – towards human-machine merger – is perceived to be both an unavoidable and deterministic path, one that also carries huge risks for humanity, while at the same time it is also a greatly desirable goal that he himself is passionate to advance and contribute to.

Ray sees his current efforts, both within and outside academia, as small contributions to the advancement of knowledge that might lead to powerful brain enhancements and AI systems in the future. While this more distal aim is the primary driver, it is complemented by a much more proximal motivation, which is to create a financially successful commercial neuroenhancement product. The two goals are not unrelated, as the successful enterprise can help move forward the larger agenda. The product as he described it would be a simple-to-use brain stimulation headset to control mood and cognition targeted at people working in *"high-intensity jobs, like lawyers, doctors, etc."* Ray envisions that brain stimulation will become a widespread and accepted everyday practice over the following decades, even though there are many unfounded concerns around it at present. One such *"misconception"* has to do with the notion that brain stimulation is akin to electroshock therapy, which Ray dispels vehemently, explaining how the amount of electricity involved is orders of magnitude smaller than in electroshock, and that the comparison to ECT is fundamentally misplaced.

In addition to the desire to create a commercially successful enterprise, his practice is very much underpinned by the values of the open-source software development community, which cherishes knowledge sharing. In response to a question about why he is interested in making a brain reading/stimulation device widely available, Ray said this:

> ***Ray:*** *So that the tools are there...kind of like, I write software. Why do I write software libraries? Why do I share software online? It's because software is best written if you have lots of reusable components and there is this whole sharing thing, and if someone creates it, you don't have to reinvent the wheel. And it's nice to have the tool available, and then people can do even better research and so on. So that's one thing I'm quite interested in, right? Research. Also, the second thing is in a kind of non-academic, kind of non-professional way, me and some people, we collect data, do little experiments and are trying to just see, really do research, but outside of our paid jobs. Why do that? Well, why not? I mean, it's fun. Mostly.*

Both reasons suggest that engaging in brain hacking is driven by intrinsic motivations, the desire to contribute tools and knowledge to advance the field, and the personal pleasure and satisfaction derived from the activity itself. Looking towards the future, Ray imagined a world where brain stimulation enjoys broad societal uptake and is part of everyday life.

> ***Ray:*** *"One image I've been using...it would be nice, you wake up in the morning, you go to your coffee machine if you have one, and you make a coffee, and you drink it, and there's a certain enhancement there, and it's very easy to do, and it's very cheap and affordable. It would be nice if you could wake up, put this on* [the brain stimulation kit]*, turn it on, and hopefully, by that time, it's much more polished up and safer and actually cheaper than coffee even."*

Since the time of the interview in 2015, a product that essentially claims to achieve what Ray had outlined was launched under the brand name Feelzing, a disposable electric stimulation patch that purports to balance the activity of the sympathetic and parasympathetic nervous systems in order to deliver a purportedly jitter-free, clear, focused and energised state of mind[12] but the product failed to take off and as of 2022 the patches are no longer available to order.

In summary, Ray's activities within the brain hacker collective are best understood against the background of his overarching commitment to a more ambitious vision of advancing human-

[12] See https://www.feelzing.com

technology merger. Brain hacking is a small part of that, driven by the motivation to contribute both knowledge, tools, but also commercially successful products.

Nick, The Fringe Revolutionary

Interviewee 2 has a somewhat different set of motivations. Referred to by the pseudonym *Nik, The Fringe Revolutionary,* he is in his early forties and comes from a background in Pharmacology, and in an informal way, he is the leader and most active member of the group. He became interested in using brain stimulation methods to emulate the effects of nootropic drugs that are used to improve cognitive performance in various dementias. This has been his central research interest since his undergraduate studies. Nik's involvement in brain hacking is primarily the result of an unsuccessful academic career. Having completed a PhD in neuroscience in the early 2000s, Nik couldn't find any suitable grants to pursue his research interests and had to move his experiments, as he says, *"to the garage side of the world".* He has taken up various consulting roles for biotechnology companies and works in a variety of IT-related contexts as well while trying to achieve commercial success for the product he is working on with his fellow brain hackers. Consequently, a central theme of the interview concerned the critique of the current scientific establishment, which Nik viewed as a fundamentally flawed system. This assessment was justified to a significant extent by his own outsider role, which he viewed as evidence of the system's failure.

> ***Nik:*** *"I think the actual system is fundamentally flawed. Otherwise, I wouldn't do it in my bedroom. [..] Very few people, in a way, research is managed and organized […] you know, very few people can work on a specific topic from undergrad and then to postgrad and then into probably more than one postdoc and so forth. You know, you need a totally different system."*

The heart of Nik's critique is that research is not driven by the interests of scientists but by the preferences of funders and "accountants", who seem to have "misplaced priorities". This theme surfaced several times during the conversation, and Nik appeared quite embittered by the fact that he had to pursue his own research outside of the academic circles where he felt it would rightfully belong. The image of current brain research emerging from Nik's narrative depicts it as a highly constrained endeavour, where talent is wasted on an industrial scale as young researchers struggle to find any available positions, and even if they do, those are roles *"where effectively your hand skills are required"* to apply specific techniques that can be used to investigate a variety of substantive research topics. This system prohibits young researchers from following their individual academic interests or pursuing a question over an extended period of time, making genuine progress impossible because young researchers are forced to switch topics multiple times to find positions to support themselves financially. A somewhat similar critiques have been articulated by scholars, comparing the structure of academia to drug gangs "with an expanding mass of outsiders and a shrinking core of insiders" (Afonso, 2014). Nik's frustration with this situation was exacerbated by his belief that he has some potentially revolutionary ideas about how to target precise molecular mechanisms in the brain using stimulation methods. He admitted that this was a very bold claim and described that the approach would rest on a new theory about the physiological role of brain waves, which is a hitherto unsolved issue in neuroscience. Nik envisions that the modular tool he and his fellows are developing will allow for the verification of his hypotheses, which often draw on *"scientifically controversial"* principles. It was not entirely clear from the interview whether Nik's lack of success in pursuing an academic career was due to the incompatibility of his theories with mainstream science, or whether it was his motivation to pursue research oriented at enhancement.

Beyond structural problems in the organisation of science, there are also several unexplored avenues in present-day research, which Nik described in great technical detail. On his account, electrical brain stimulation is only one element within a more extensive array of methods and tools that could be beneficial both in terms of providing insight into brain function, treating various disorders, and achieving enhancement effects. These methods include various forms of electrical, laser, sound, and magnetic brain stimulation techniques, all of which form part of Nik's own brain hacker repertoire and self-experimentation practice.

Nik also viewed his and his fellow brain hackers' activities as providing a valuable service to science by exploring topics and avenues that fall outside the remit of conventional laboratory research and then using every available channel to talk about their findings to raise awareness and potentially arouse mainstream interest to channel investment towards these topics. Futurist-themed events and meetups are primary avenues for such dissemination. In his view, there are enormous 'white spots', underexplored topics and stimulation methods that mainstream research is not pursuing, but DIY researchers like himself are. In addition, he interpreted the group's activities oriented at the development of an open-source tool for simultaneous brain data recording and stimulation as a crucial step in democratising access to experimentation and research because current devices capable of that functionality were prohibitively expensive and available to research institutions only.

With regard to experimentation itself, Nik was very open about the difficulty involved in overcoming the limitations of pursuing this type of activity under non-ideal conditions, such as the home or a hackspace. He described the challenges of working with volunteers, where proper blinding and controls were not easily feasible. However, these difficulties were perceived to be roadblocks and challenges to overcome, as opposed to insurmountable obstacles.

Doubting Thomas

The final interviewee, *Doubting Thomas,* had a background in Engineering and was pursuing a PhD in neuroimaging at the time of our conversation, but he described his primary role in the group as performing various signal extraction and optimization-related tasks, as his primary interest was in the physics of signal manipulation. My interview with Thomas was shorter than the other two, lasting approximately 30 minutes, during which Thomas occasionally joked that his perspectives may be *boring*, because he manifested a largely sceptical attitude towards the current state of knowledge about tDCS and brain hacking practices in general, explaining his own involvement as one driven mainly by a curiosity about things related to the brain and the engineering challenges involved in building some of the electronics. He became aware of tDCS via a person running demonstrations in his local undergraduate university hackspace, where he tried a variety of devices, and his interest was piqued by tDCS.

> ***Thomas:** "I sort of read up about it and concluded, well, if there is a long-term risk, it's by far less than driving, you know, sort of background level of risk. So, I tried it, and well, there is a tingling, at least from the current. So OK, in some sense, it's working, as in there is actually current going through me. Whether it makes a difference, you perceive stuff differently... I'm still dubious."*

Despite personal involvement in the project, Thomas described the commercial availability of brain stimulation devices and the current hype around the topic as a somewhat unfortunate development.

> ***Thomas:*** *"I think it's slightly bad that it's happening before there's proper research because it seems a sure-fire way of creating a pseudoscience or to get something labelled as pseudoscience."*

While he was also active in the group's work around the open-source brain stimulation and measurement device, he referred to the collective as "they" as opposed to "we", like the other informants did, expressing that he perceived himself to be a bit of an outsider. Describing the activities of the group, he said:

> ***Thomas:*** *"So they are mostly interested in, ha-ha ... running a load of Nik's crazy stimulation paradigms on people, trying to see if there's an effect. And again, I think it's just fun. It's not actually science or anything, so he's not blinding them or himself, but it's interesting, they do a load of other stuff, too, like reading things with an EEG, controlling stuff based on it, and they are interested in even trying to make it a lot easier to do this stuff, like building kits that would let people stimulate one another, whatever. I still think it's sort of too early, sort of in a way. I'm like, OK, fine, do it because it doesn't look hugely dangerous, but until you've proven that it's useful, it seems a bit dumb."*
>
> ***Interviewer:*** *"So you have doubts about the utility of the whole thing?"*
>
> ***Thomas:*** *"Yeah, hugely! And I think, as I say, until comparatively recently, there were no good studies, recently, there have been some better ones and they've been really mixed in their findings."*

However, despite this scepticism, Thomas planned to stay involved with the group's activities because he felt excited and motivated by the engineering challenge related to the creation of a simultaneous brain reading and stimulation device that would only cost a fraction of the currently available choices. He also echoed Ray's perspective about the value of offering such an affordable device to the community, and he saw this a meaningful step towards ensuring that better and higher quality studies and data might get produced, which would help advance the field from its current state.

Science and brain hacking

As discussed in the introduction, existing research has shown that DIY neurostimulation users tend to be highly educated and scientifically literate. The present sample confirmed this trend, but it also offers some further insights into perceptions about the relationship between brain hacking and science.

All three respondents may be characterised as scientists, and it was clear that science was an important aspect of their self-identity. They broadly agreed that there were obvious and significant differences between proper scientific conduct, and brain hacking, with science being adequately controlled, rigorous and methodical, while brain hacking was less controlled, exploratory and, mostly, *fun*. In the context of this DIY practice, the brain emerges as a malleable site of experimentation and playful interaction. In fact, interviewees often used the expression 'playing around' to refer to the practice of brain hacking. However, this fun activity acquired different meanings in the context of each informant's relationship to research. While this evaluation was a neutral assertion of fact in the case of Ray, and a somewhat ironic remark in the case of Thomas, who were both currently actively embedded in academia, for Nik, who was an outsider, brain hacking offered the only, and admittedly sub-optimal way, of pursuing research at all.

The importance of proper *tools* to conduct research, their current lack of availability, and, most notably, their prohibitively high costs were recurrent themes in all interviews. Subjects shared the belief that it was desirable to have a modular and customizable device readily available for the wider public, and they were united in the pragmatic effort of making that happen. They all saw this as a valuable contribution that would unlock further research, increase the quality of data, and contribute to dispelling inaccurate myths related to brain stimulation.

Brain stimulation practices

Interviewees discussed at length their actual use of tDCS and shared their experiences about its effects, risks, and the efficacy of the method. All three interviewees described having used tDCS with the intention to modulate mood and increase cognitive capacities, but their views on efficacy were very different. Their description of the effects included three different types of outcomes. Tom reported never having experienced any benefit at all or attributed whatever he did perceive to placebo, emphasising the need for proper study-blinding and underlining the unreliability of self-experiments. Ray described moderately positive outcomes comparable to caffeine or beer, depending on the stimulation protocol, depicting tDCS as a superior method to chemical substances due to the lack of any intoxicating or other physiological side-effects, such as jitteriness. On this account tDCS served a compensatory role in the sense that it brought sub-optimal levels of attention or mood back to *"what's normal for me"*. Nik reported of extraordinary results and the one-time but since irreproducible unlocking of a vigilant and creative state of mind. All interviewees emphasised that tDCS was extremely safe, at least acutely, although long-term risks were still somewhat uncertain, and they each evoked their own technical and scientific expertise as the source of their confidence in the method.

Smart drugs vs brain stimulation

The use of smart drugs was discussed in all interviews, and it became apparent that subjects used this term differently than the media or the academic discussion about pharmacological cognition enhancement. Interviewees considered the Racetam class of drugs (Gouliaev & Senning, 1994), also referred to as nootropics, to be the *real* smart drugs, and they all had personal experience with them.

Importantly, unlike the substances at the centre of the discussion and debate about pharmacological cognitive enhancement, Racetams are not stimulants, and their effects unfold over an extended period of use, purportedly elevating baseline levels of focus and attention without any unwanted side-effects.

Tom expressed deep scepticism about nootropics too, despite having undertaken a month-long self-experiment with the drug, while Ray and Nik reported having experienced definite benefits from the substance. However, all subjects rejected the use of psychostimulants like modafinil, Adderall or Ritalin, which are at the heart of the conventional discourse about pharmacological cognitive enhancement. This rejection was justified with recourse to several arguments, including their illegality, their harmful physiological side-effects, and perhaps most importantly their lack of 'real' cognition enhancing potential.

> ***Nik:*** *"They're not true nootropics, they keep you awake, but they do not really enhance your cognition in terms of processing speed, memories that can be stored, memory capacity and so forth."*

Psychostimulants were viewed as an emergency solution in situations where one might need to temporarily push *performance*, but their effects might not turn out the way users intend. Consequently, interviewees made a distinction between genuine enhancement methods that improved upon an individual's baseline set of abilities in some cognitive domain, and other interventions that merely pushed one's ordinary capability to perform, such as conventional psychostimulants. Although all participants rejected psychostimulants, Thomas was perhaps most opposed to their use, saying that *"the thing I value most is my mind"* and psychostimulants were seen as something that might have undesired long-term consequences, although he acknowledged the substance's long-standing medical use as a reason for considering their risk profile acceptable. In the end, Thomas emphasised the illegality of psychostimulants as the main deterring factor.

Ethics and enhancement

Ethical issues were not a priority to any of the interviewees and there was broad agreement that concerns around tDCS were greatly blown out of proportion. Nik and Ray suggested that ethical issues and moral worries are usually articulated by those who are least knowledgeable about the technological matters, which greatly derails conversations towards irrelevant matters. Those who are knowledgeable tend to communicate in risk/benefit ratios instead of vague moralising language. Brain stimulation was perceived as something that is safer and perhaps equally or less effective than other, commonly accepted enhancement methods. Caffeine served as a frequent comparator, but the overall practice of education was also evoked as a justification that people are broadly in favour of enhancing themselves but have inconsistent and often ill-informed views about the differential risks of methods. Here again, respondents' scientific and technical background served as the basis of their confidence in assessing the methods.

Thomas also spoke of the risk of coercion where people might need to use enhancers to do well in exams and similar situations, but he dismissed that scenario as a philosophical worry that had very little bearing on reality as he believed that this type of enhancement would not become widespread. At least, not until the benefits that could be gained by them was sufficiently robust. Here, he drew an analogy with deep brain stimulation used for the treatment of Parkinson's disease, where the method has achieved profound effects, essentially eliminating tremors. Until enhancement methods delivered effects of such magnitude, ethical worries appeared to be remote.

Nik expressed criticism at the moralising tone of those describing tDCS as a dangerous new practice, and he referred to the extended history of similar electro-therapies that go back decades, if not centuries. Instead, he embraced a strictly consequentialist approach whereby ethical discussions should proceed based on scientifically verified risk/benefit ratios. Reflecting on the potential social disparities that enhancement by brain stimulation might give rise to, he said this:

> ***Nik:* "***I would actually say that in particular if we talk about tDCS, but also with other methods, they are very, very accessible, and probably more accessible than drugs. So it's not going to be something for the privileged few, not at all. In fact, I would expect that the privileged few would probably not use it because they don't have this need to push that far unless they really want to. But that's a matter of personal choice, and it doesn't really depend on the level of wealth or social status, but in my experience, you know, the really rich,*

instead of doing it themselves, just tend to hire more consultants. It's the consultants who are going to use it. "

In Nik's view, enhancement will not be a prerogative of the wealthy but rather another method through which already exhausted and over-extended individuals who work in high-pressure, high-stakes, or simply unforgiving work environments will attempt to stay afloat and maintain their competitiveness. The method was not seen as perpetuating inequalities but as a means to cope with demands, which echoes some of the perspectives identified in the previous chapter on public attitudes. Interestingly, even though Nik did not consider such a scenario desirable, he also did not seem particularly concerned about the fact that his efforts might contribute to bringing about such a situation.

Chapter 6.
"I want to be a cyborg"
A Study of Voluntary Cyborgisation

We are all cyborgs

The science fiction image of the biotechnologically enhanced human has permeated popular culture throughout the latter half of the 20th and into the 21st century. The notion of the cyborg – or cybernetic organism – traces its origins to the 1960s US programme of space research. The term was coined by cyberneticists Nathan Kline and Manfred Clynes in the article *Cyborgs and Space*, and the concept was meant to describe the technological supplementation of the human body for the purposes of space exploration (Clynes & Kline, 1960). The first cyborg was a laboratory rat, which Clynes and Kline had fitted with an osmotic pump that could release chemicals into the animal based on physiological signals. The motivating idea was to ensure that biological systems could survive and function in the inhospitable environment of outer space. To achieve this, it seemed easier to adapt the organic body with technological feedback loops to suit the conditions in outer space, rather than the other way around. Despite visions of fundamentally transforming the human body through cybernetic extensions, Clynes and Kline believed that such interventions would actually *"leave man free to explore, to create, to think, and to feel"* (Clynes & Kline, 1960, p. 27). The reconfiguration of the body as a composite of spare parts that can be medically (re)assembled is rooted in the staggering rate of medical progress achieved during the 1950s and '60s. Advances in this period were revolutionary and even prompted the reconceptualization of death into *brain death*, as breakthroughs in artificial ventilation and transplantation medicine made it possible to move vital organs across bodies and it appeared like medical science was on the verge of making the body endlessly repairable (Serlin, 2004).

In her highly influential essay, *A Manifesto for Cyborgs*, Donna Haraway creatively appropriated the term in the 1980s and developed a greatly expanded interpretation of the concept (Haraway, 1991). While Clynes and Kline understood the breaching of boundaries between organic and artificial systems at a merely technological level, Haraway took the concept of the cyborg and theorised it not merely as an artefact of technoscience but as something that expressed the human condition. In her famous formulation: *"By the late twentieth century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism; in short, we are all cyborgs."* (Haraway, 1991, p. 150)

At the heart of Haraway's notion of the cyborg is the idea that the dichotomies, which Western thought had come to rely upon, such as the organic/artificial or the human/animal distinctions were being progressively surpassed by technoscience itself. According to Haraway, these distinctions were increasingly blurred, fleeting and indefinable. The idea of the "human" as a category of beings that could be neatly separated from the web of other entities was an illusion. Paraphrasing Latour in a 2006 interview, Haraway expressed this idea by saying, *"we have never been human"*, at least not in the sense of the autonomous and ontologically closed entity that Western thought had presupposed (Gane, 2006). In the same interview, Haraway also reflected on the history of the cyborg and recognized it as a product of militant capitalism, the space race and wartime frenzy in which the paradigm of Mutually Assured Destruction carried the day. For her, the cyborg was a historically situated figure that had a specific purpose, namely, to think about the possibility of critique and the future of feminism in the emerging regime of informatics, the rearranging landscape of technoscience and the transformation of capitalism under the Reagan Star Wars era. However, by that time the term had taken on a life of its own.

In popular culture cyborgs had become staples of science fiction literature and films, where they most commonly denoted characters, whose bodies have been transformed, augmented, or altered through the incorporation of technologies. More often than not, in such mergers of flesh and technology cyborgs are depicted as monstrous beings whose existence was degraded due to their partly technological nature (Oetler, 1995). Literary scholars interpret the figure of the cyborg as the representation of a wide variety of cultural anxieties related to hybridity, the dissolution under late Capitalism of familiar societal structures and certainties in life, and the threat of technology to naturalness and a life of authenticity (Bacon, 2013; Short, 2005).

However, scholars in cognitive science and the philosophy of mind, most notably Andy Clark have used the term in a much more positive meaning, arguing that humans were *natural-born cyborgs* in the sense that our cognitive architecture owes its uniqueness precisely to our capability to seamlessly incorporate technological artefacts into its functioning. Our minds naturally extend into our surroundings and into our tools, which we use to scaffold our cognition, be that with the help of pen and paper, a pocket calculator, or networks of supercomputers. For Clark, our cyborgian existence does not even require for the skin to be breached, as we are *naked* cyborgs, human-technology symbionts, “thinking and reasoning systems whose minds and selves are spread across biological brain and nonbiological circuitry” (Clark, 2003, p. 3). As we continue to rely on technology in more and more aspects of our lives, the line between our minds and the tools we use will only become more blurred.

Finally, another meaning of the cyborg, that is somewhat related to Clark’s notion of the natural-born cyborg, is articulated by scholars in medical sociology who have been researching the experiences of the growing number of people among us whose lives are intimately intertwined with a piece of implanted technology, such as a deep brain stimulator, insulin pump, or internal cardiac defibrillator. Scholars like Gill Haddow argue that far from the dehumanisation depicted in genres of science fiction, we might instead need to look at ‘being cyborg’ as the new de facto ontological status of humanity brought about by our increasing hybridisation with various forms of biomedical technologies that serve to support and enable our continued survival. In this context, Haddow speaks of *everyday cyborgs* who are at the forefront of living this hybrid reality. She writes:

> *[a]n ever increasing reliance on such biomedical solutions that are expensive and fast is creating a 21st century identity crisis in modern Western societies. The identity crisis is due to the numerous and diverse creation of human hybrids. This hybridity is driven by the need for human beings to do everything in their power to avoid their demise. Over time, and as individuals age, their bodies will increasingly become a collage of organs and devices used to repair the structure and function of their viscera. Individuals will be less than 100 per cent human as they increasingly become augmented by different types and kinds of materials. The ‘born body’ of a human being, will become the exception rather than the rule and the ‘techno-organic hybrid body’ the new norm.* (Haddow, 2021, p. 22)

The common feature in all interpretations of the cyborg is the idea of the merging or hybridization of the human body with technology. Whether the cyborg is understood as a metaphor for the human condition, as the embodiment of cultural anxieties, as a natural extension of our cognitive architecture, or as the result of our increasing reliance on biomedical technologies, the central trope is the same: the human condition is inextricably linked with technology.

Cyborg Nest Ltd., and its Founders

It is against this complex conceptual history and tapestry of meanings that a small British company founded in September 2015 decided to call itself Cyborg Nest.[13] It was launched by Liviu Babitz, Neil Harbisson, and Moon Ribas. Babitz is a former executive of the human rights charity Videre, which supplies oppressed and marginalised communities with filming equipment to document and fight abuses of power. Babitz had worked undercover for many years and when he left the organisation, he was looking for the next thing to devote his energies to. He traces the origin of Cyborg Nest to a serendipitous London lunch with his friends that was attended by Harbisson and Ribas, after which Babitz could not rid himself of the notion that every product, service, and activity that we as humans know is somehow linked to the types of senses we possess. *"We heard that bird singing, and it was amazing, so we created music. Everything that we created, we created because of our senses"* (TEDx Talks, 2016). According to company lore, this realization led to the idea that we might greatly enrich the human experience if we furnished ourselves with more senses with the help of technology. The other two co-founders of the company were already cyborg celebrities exploring this very notion through their own lives and practice, but through new products, they wanted to bring this experience to the wider world.

Harbisson and Ribas both have electronics implanted in their bodies. What sets them apart from the millions of others who can say the same is that they pursued elective cyborgisation and fitted themselves with implants that serve no apparent medical or therapeutic purpose.[14] Neil Harbisson is a colourblind artist who perceives the world in shades of grey due to a congenital visual disorder known as achromatopsia. Since the early 2000s, he has been using a device co-developed with Adam Montandon, called the eyeborg (Wade, 2005). It initially consisted of a camera, a microcomputer and a pair of headphones and it converted electromagnetic light waves into sound frequencies, thereby making colours audible. Due to gradual improvements, the device was developed into an antenna that was surgically attached to Harbisson's skull in such a way that he now perceives colour information through auditory vibrations perceived via bone conduction. The antenna's capability has been further extended so he is able to 'hear' ultraviolet and infrared frequencies and can receive colour information sent directly to his implant via the Internet. Harbisson is an artist who produces visual and auditory works based on his unique experience of colours represented through sounds. The implantation procedure of the antenna was carried out by an anonymous surgeon in Spain because Harbisson had difficulty convincing hospital bioethics committees to permit the operation (Harbisson, 2019). Describing his antenna, Harbisson often proclaims that instead of using technology, he has *become* technology, deliberately foregrounding his hybrid status. In his public talks Harbisson frequently shows his passport photo that features his implanted antenna sticking out of his head, which is evoked as proof of his government acknowledged cyborg status. He emphatically describes the moment when he started to dream with colour-sounds, as the point when he felt he had become a cyborg, for that signalled to him that the software in his chip implant and his brain had united. In his dreams, it was not the software that was generating colour sounds, but rather, his brain (TED, 2012).

---

[13] The company was first established as Cyborg Labs Ltd. but within two months changed its name to Cyborg Nest.

[14] Although Neil Harbisson probably represents an edge-case in this respect.

Moon Ribas is a dancer and performance artist who - until recently - had an implant in her arm that produced tactile vibrations proportional to the intensity of plate tectonic movements and earthquakes happening around the globe in real time (Ribas, 2020). Ribas refers to her implant as a seismic sense that allows her to connect to the planet in a deeper way and experience it as a dynamic, living entity (TEDx Talks, 2015). Both Harbisson and Ribas are very active in promoting the creation and use of technology to extend human perception and in 2010 they launched the Cyborg Foundation to advance this aim, followed by co-founding Cyborg Nest with Babitz. The duo has acquired considerable fame and they evangelize the notion of merging technologies with the human body in university lectures, conferences, documentaries, and mainstream media (Talks at Google, 2016).

Although Harbisson and Ribas, the most well-known figures among the founders had played a role in launching Cyborg Nest and played a major role in attracting attention, there aren't many public mentions of their affiliation with the company and they both stepped down from directorship roles in April 2017, shortly after the company released its first product. The original company got renamed, and then dissolved in 2019, with a new Cyborg Nest Ltd. launched in 2018 with Liviu Babitz, Scott Cohen, a music industry professional, and Olivier de Simone, a technology entrepreneur as co-founders.

The North Sense

Image 1. The North Sense device. Copyright Cyborg Nest Ltd.

Cyborg Nest's first product was a small device called the North Sense, which users had to attach to their body via a system of pierced transdermal anchors (see Image 1). The device gives off a gentle vibration whenever the user faces magnetic north. Conceptually, the North Sense builds on the idea of sensory substitution, which is a thoroughly researched topic in psychology and neuroscience and denotes the phenomenon of translating between sensory modalities (Bach-y-Rita et al., 1969). In this case, the device signals the wearer's orientation in space with respect to cardinal directions, in the form of a small tactile stimulation. A similar product was developed by a German university spinoff under the name feelSpace navBelt[15],

[15] See https://feelspace.de/en/

which is intended to be an assistive device for visually impaired persons. It is a belt-shaped soft wearable with tactile vibrators around its circumference. The device can be paired with a smartphone to give directional cues to its wearer or to act as a compass, continually signalling the direction of north. The device builds on academic research related to the topic of sensory substitution and the integration of directional cues into one's experience (Kärcher et al., 2012; König et al., 2016). A DIY version of a north-orientation device exists as well under the label North Paw[16], released by the Sensebridge hacker community in Canada.

The primary difference between these projects and the North Sense is twofold. First, the North Sense required a much more invasive form of attachment to the body due to the pierced anchoring system. This was initially promoted as an important feature of the experience to foreground the "permanence" of the integration of the body with a piece of technology. Second, Cyborg Nest promoted itself as a human enhancement company that was in the business of creating artificial senses for people to expand their experience of the world. In its promotion campaigns it has heavily drawn on the language of human enhancement and cyborgs and its co-founders were frequent speakers at related future-oriented, techno-progressive events. Thus, it is one of the first companies to actively embrace the vision of technological human enhancement, playing a leading role in its advocacy. Although its two cyborg celebrity co-founders, Harbisson and Ribas had stepped down from directorship roles, in its early days, the company relied on their prominence to attract attention. Consequently, the North Sense garnered a great deal of media coverage when it was first released in early 2017. Articles in mainstream outlets from the BBC to the Guardian and the Smithsonian Magazine ran stories or interviews with co-founder and CEO Liviu Babitz, who became one of the first users of the North Sense, along with Scott Cohen, prior to the device's release to the public (Albeck-Ripka, 2017; Emslie, 2017; Eudes, 2017; Thaddeus-Johns, 2017).

The North Sense also attracted some criticism from those in the body modification community, who expressed scepticism about the feasibility of the anchoring system, which they argued had a very high likelihood of leading to rejections (Robertson, 2017).

Within the categorisation of neuroenhancement technologies, the North Sense falls into the class of sensory enhancement devices, which have hitherto received comparatively little attention from researchers (Jebari, 2015). However, it is important to highlight that the North Sense sits entirely outside the framework of familiar medical enhancement technologies, as it is neither a medical technology applied 'off-label', outside its normal indication, nor is it any other form of investigational device. Rather, it is a novel commercial product released unto the market with the promise of delivering a new sensory experience.

How did users find out about the North Sense?

The majority of respondents reported that they first learned of the North Sense through online channels. These channels included articles, social media posts, and advertisements on platforms such as Facebook, Instagram, and YouTube. Respondents encountered this information in the form of algorithmically served content, or because they were already following individuals such as Neil Harbisson, or because they were actively seeking out information related to human enhancement. For a few respondents, their interest was initially in sensory magnet implants and they were looking to find more information about that topic when they stumbled upon the North Sense and decided to pursue it instead.

---

[16] See https://sensebridge.net/projects/northpaw/

Several respondents indicated that they were familiar with earlier endeavors such as Sensebridge's North Paw, which aimed to achieve objectives comparable to those of the North Sense. However, these respondents expressed reservations about the North Paw's form factor. Specifically, they objected to the device's design as an ankle bracelet, which they found unattractive and cumbersome and the North Paw too closely resembled an ankle monitor used for individuals under house arrest.

For two respondents, their interest in the North Sense was connected to their careers as science/technology writers and they decided to embark upon this experience as part of that professional role to convey the specific North Sense experience to readers or to incorporate it as background research for other writing engagements they were involved in. These two respondents represent outliers in the dataset to the extent that – as I shall explain below – their interest in the topic was more casual and bound up primarily with their professional roles. However, for most other respondents, their interest in topics related to enhancement far predated their encounter with the North Sense and many of them spoke with great enthusiasm about the device as a product that *finally* allowed them to experiment with sensory enhancement. As one participant said:

> *I've been following Neil Harbisson's online presence for about two years now. That's how I came across the Cyborg Foundation. Actually, I think since the Cyborg Nest was founded, I've been following them because I'm really into cybernetic augmentations. Of course, I was really, really psyched when I got to know that they are making this project and it can actually be a product that you can buy and amplify your senses and get a new sense! – PT2@T1*

As the above quote illustrates, most respondents expressed enthusiasm in their narratives, which reflected their thrill of being involved in this project of innovation that they viewed as a leading-edge development. Participating in something that was in the process of emerging and that had the possibility of indicating a fascinating future aroused satisfaction among several respondents.

The founders of the North Sense opened pre-orders for the device almost a year before its delivery, intending to assess the level of demand for their product. They did not anticipate the high volume of interest that ensued, which implied that many customers placed orders when the device was still in an early stage of development. Thus, rather than merely purchasing a product, these customers were effectively supporting and funding the project, akin to a crowdfunding campaign. Some respondents acknowledged this, and even regarded their payment as a donation that they might not recover, but still valued the opportunity to contribute to the effort. They viewed the North Sense's launch as a preliminary step in a possible long-term process of improvement and refinement of sensory augmentation, and they felt it was important to facilitate its initiation. Even if the device proved to be unsuccessful, many respondents believed it had the merit of exposing the concept of sensory enhancement to a wider audience. Therefore, for several respondents, the purchase decision involved an awareness that they were part of an experiment with uncertain outcomes.

Motivations – Why did users decide to purchase the device?

Respondents had a variety of expectations that ranged from an improved navigational sense, which a small number of them hoped to gain, to more abstract ideas about acquiring a different kind of appreciation of the world and the surrounding environment, while others mostly expressed uncertainty about what to expect.

> *I don't really know. I hope at the highest level that it gives me a new sense of reality and a new respect for just different things in life. Like just always going out my mind a little bit more. […] And basically just starting to open my mind more. Help me understand reality a bit more, and what's the bigger picture. — PT15@T1*

This approach was quite broadly espoused by respondents who tended to view the North Sense not in terms of tangible and practical benefits, or as something valuable in a utilitarian sense of the word. Rather, they were curious and open to whatever the effect might be and how the new stream of information and input provided by the North Sense would affect them.

> *I am very, very interested in what it will do after, let's say 100 days of wearing it, to my, to my subconscious. So ... What will happen when I stop thinking about it? Will it in fact add, information to my memory? Will it change the way I think about places? Will it change my movement patterns? I don't know. That's something that I'm very curious about. I see it as a, as a very, early attempt to extend the human sensory system. And I'd love to see more of that coming and explore other senses as well, but let's start with this one. — PT11@T1*

> *Well, because I wanted to, I just liked the idea of how your brain is very mouldable and so that things like this, and I was very curious how things would be after I had been wearing it for a while. And I like having a new viewpoint on the world. — PT08@T1*

This curiosity and openness towards the uncertainties of the experience was characteristic of most respondents. However, it also became apparent that as interested and passionate as they were about the North Sense, this enthusiasm was often not occasioned by the specific properties of the device but by a general interest in enhancement. One interviewee even expressed that if a different kind of enhancement device had been released to the market, they would probably have purchased that. Thus, the North Sense tapped into an existing hunger and desire for some practical way of fulfilling a more general and undirected interest that the respondents in this sample had towards the notion of enhancing themselves technologically and that existing enhancers like pharmaceuticals or neurostimulation could not satisfy. This was reflected in respondents' accounts of their motivations to pursue the North Sense, which was almost universally driven by a desire to 'know more' and to 'be better'. In this pursuit of becoming better, use of the North Sense was not different to any other activity one would undertake. As PT11 and PT12 put it:

> *Because, I can be better. […] ? Why would I start eating healthy? Why would I start lifting weights or whatever? Well, it's because I could be better. Why wouldn't you want to be more healthy? […] You could be considering all sorts of cool ways of doing all sorts of cool things, you should start considering them. Once I start considering them, well, heck, yeah, I got to become more interesting […] There's so much stuff out there and I want to see stuff and feel stuff. I like the idea of more of extending my ability to interact in the world and perceive the world and be a person. — PT12@T1*

> *I do think that constant experimentation with new, possibilities is what gives me, insight, what inspires me, What potentially triggers new ideas even, about,*

> *solutions that I might need for my personal life or for my professional life. […] I think there is a potential to tap into by mixing artificial new information flows with my, like default body systems. — PT11@T1*

This notion of *wanting to be more* is a foundational tenet of transhumanist thought and several respondents explicitly endorsed transhumanism as their personal philosophy. A number of respondents also expressed a clear affirmation of the importance of pursuing human enhancement at a large scale, which was perceived to be the next stage of human evolution, where humans would take control of the species' continued development. This trope has been present in transhumanist thought since the movement's name was coined by Julian Huxley (Huxley, 1957).

Several respondents were of the conviction that the aim and purpose of pursuing enhancement was to overcome the limitations of the human body, which they viewed as something that was deficient and ultimately lacking. This type of reasoning is characteristic of certain transhumanist thinkers who argue for enhancement from the starting point that our current mode of being is flawed and limited (Bostrom, 2008; Persson & Savulescu, 2012). As Max More put it in a hypothetical letter addressed to Mother Nature: *"You gave us limited memory, poor impulse control, and tribalistic, xenophobic urges. And you forgot to give us the operating manual for ourselves! What you have made us is glorious, yet deeply flawed" (More, 2013, p. 449)*. A number of respondents expressed similar sentiments referring specifically to the limitations of our sensory capacities that are only able to perceive a tiny slither of the vast quantities of information that would be possible to perceive if we had adequate receptors to do so. This limitation was seen by respondents as a significant barrier and upper bound on what was possible for humans to know at all. Many respondents espoused the proactionary ideals of risk taking, self-experimentation and self-improvement on the path to achieving ever increasing levels of technological augmentation and merger to surpass these limitations.

> *I think that's the natural path for human beings. I think that's the way to, that human being should go. It should upgrade itself. We are at the time that our evolution is at our hand. We have the technology to evolve ourselves in a direction that we want, not in a direction that the environment imposes on us. Not something that nature wants, something that we want. And I think that's the best way to, that's the right way to advance the civilisation. — PT10@T1*

> *I would be excited about doing anything to my body to make it better, even if it wasn't broken already. PT23@T1*

Embarking on the North Sense journey was viewed by several respondents as part of their contribution to advancing this broader ideal and vision. Especially those respondents who could not directly participate in the creation of enhancement technologies directly viewed it almost as an obligation that they act as advocates and ambassadors of the idea, even if they recognised that the North Sense itself was a rudimentary and early manifestation of the larger ambition. Nevertheless, using it was a way of expressing commitment to that larger pursuit.

> *I'm a very pro-future, pro-technology oriented person. So, this is right in line with that. And having an opportunity to be on the cutting edge of the forefront of it is exciting. And honestly, I think that as time goes by, this thing, not North Sense specifically, but the idea of augmenting or replacing parts of our body*

> *with enhancements is only going to become more common. There's a level of social acceptance that needs to go along with that. So, if I can help lay the groundwork for social acceptance of elective augmentation, then great. I'm not a scientist and I'm not really an engineer in this sense, so that's not a way that I can contribute, but this is, by being outspoken about it, by letting people know, "Hey, this is a technology that's not just in science fiction stories. It's becoming part of our day-to- day world. We're just like everybody else." Yeah. Anything that I can do to help in that regard I think is worthwhile. — PT18@T1*

However, it is worth highlighting a relative minority opinion that was also present in the sample, which was critical of transhumanism for representing an exacerbation of existing power imbalances and inequalities that favour those who are already privileged. For PT20 – a heavily body modified French respondent – becoming cyborg, performing body modifications, and attaching the North Sense were seen as subversive, anarchist acts that showcase an alternative way of being in society. He did not view the body as something deficient that would need to be overcome, rather, he felt that life under contemporary capitalism dulled humans, and his body modification practice was a way for him to make himself more human and invigorate, enliven his senses.

Concerns – What worries did users have about the device?

When asked about whether they had had any concerns about the device prior to purchasing it, most respondents reported not to have been vexed by any serious worries. A few respondents pointed to the device's steep price of a few hundred dollars and said they feared that experience might turn out to be nothing and the effort and money would then have been wasted. However, no concerns about safety, undesired effects were expressed. One participant mentioned questions related to data availability and open sourcing of the design.

The lack of any concerns raises the question as to why respondents decided to trust the company in the first place. This might be explained by the theory of salient value similarity, which posits that individuals' risk perception hinges on the perceived congruence of values between oneself and the institutions and actors involved in a specific technology (Siegrist et al., 2000). Regarding the North Sense, respondents who adhered to a transhumanist perspective and orientation identified Cyborg Nest as an organisation that shared that vision and endeavour, a perception that was arguably reinforced by the involvement of cyborg celebrities Harbisson and Ribas with the company at the outset. This perception of value congruence probably reduced any apprehensions they might have had about the device. Nonetheless, a few respondents explicitly indicated that they had deliberated on the possible advantages and disadvantages of the device and determined that the risks were trivial and any potential health-related harms easily controllable, so the potential benefits surpassed the potential risks by far. In this assessment, risks were mainly associated with the possible negative outcomes of the subdermal piercings.

A different set of concerns was articulated by female respondents who tended to raise the issue of the device's visibility. Given that the North Sense is most commonly placed at the centre of the chest, it is located in an area of the body that is more often exposed and visible for females than for males. Many participants wished to retain agency over the disclosure of their 'cyborgness' to the broader public. They voiced apprehensions that such visibility could provoke undesired interactions and might even result in forms of prejudice, intimidation, or erroneous assumptions by others that they were subject to surveillance by a body-mounted device. One participant articulated the concern that her career goal of becoming an academic professor would preclude any visible body modifications, as the field imposed very rigid and formal norms on its members' appearance.

Respondents' fear about exposing themselves as cyborgs casts familiar worries about enhancement leading to discrimination against the un-enhanced in an interesting new light. Based on the experiences and concerns of interviewees in this sample, at present it is more likely that early adopters would face discrimination and potential threats. In this respect, several respondents cited the case of Google Glass that was vehemently rejected by the public and its wearers often denounced and harassed. The most famous precedent of a 'cyborg hate crime' is the case of MIT professor Steve Mann, who was allegedly assaulted in a Paris McDonalds because of his highly visible augmented reality headgear that was not tolerated by restaurant managers (Popper, 2012).

How have others responded to the North Sense?

Respondents generally reported no serious negative experiences related to the ways in which others had responded to their decision to pursue the North Sense. Close friends and family tended to be supportive of their choice, which several interviewees attributed to acceptance towards their 'weirdness' and 'being different' than most people. One respondent (PT25) mentioned that their family disapproves of their entire body modification practice, and they view it as something that is morally flawed, saying that he had come to terms with the stigma attached to such activities. This form of self-identification as being 'unlike the majority' was almost universally shared and was summed up by PT23, who said:

> *Well, I mean, to be honest, they already know I'm pretty weird. So it's not a huge shocker for them. I already just, like, I do a lot of out of the ordinary things, and I move around a lot, I sleep at weird times, I'm into weird things, I discuss things in a weird way. — PT23@T1*

Several respondents said that the North Sense provided an occasion to have truly fascinating conversations with people about human enhancement and their convictions about its importance. The North Sense served almost as a prop and conversation starter, which interviewees often used as a springboard to advocate for the values of human enhancement. A few respondents mentioned that some people, especially members of the older generations, felt almost offended by the North Sense as they viewed the intervention as an unnatural insult to the body.

> *I think they have this, almost holy idea, like I said they have an almost holy, body that shouldn't be, that shouldn't be altered, that shouldn't be, opened, to insert something. I mean it's pretty much the same story when I talk about the chip that I wear. — PT11@T1*

However, the most frequent comment and response interviewees encountered from others was a deep and profound sense of perplexity about why anyone would attach a compass to their chest with piercings when they could easily access that same functionality on their phone or in another tool. This reaction was met by my respondents with an equally deep sense of confusion about why anyone would fail to recognise the inherent value of that pursuit. Interviewees described that in such conversations they frequently had to explain why they believed that the North Sense was something other than, or more than, a mere tool, like a compass. Even though every smartphone has the capability to display the user's orientation in relation to cardinal directions, respondents argued that there was a fundamental difference between using a tool for such a purpose. In these explanations, respondents' comments largely followed the line of reasoning that Cyborg Nest provided in their product promotion, distinguishing a tool from a sense with reference to the fact that senses cannot be turned off, they are always on, streaming information whether we want them to or not. The most succinct formulation of this distinction between a tool and sense was offered by PT07 who said that the distinguishing feature of a sense was that it *"volunteers a new piece of information passively, when it would not have occurred to you to seek out that information"*. This interpretation was shared by several respondents and there was broad agreement that those who raised the question about the 'why?' were fundamentally misunderstanding the purpose of the North Sense. For users, the point of having this device was not primarily to acquire a tool that they could use in goal-oriented ways, even though some respondents reported happily that the North Sense had occasionally helped them navigate better. I should acknowledge that better navigation was among the desired outcomes for a small number of respondents. However, the deeper purpose of having the device was to experience an expanded frame or enriched perception of the world. One respondent characterised the experience by saying that the North Sense was actually a device which carried *"philosophical weight"*, the primary value of which lay in the kinds of thoughts and questions it triggered in a person's mind. As such, the North Sense experience was not viewed and evaluated against some benchmark of utility. Rather, it is conceived of as an opportunity to experience the world more completely. In this regard, the experience is similar to the ways in which recipients of magnetic implants described their experience of being able to perceive electromagnetic fields.

Their first-person accounts often emphasize the qualitative aspects of sensory enhancement over their usefulness.[17] One of the first recipients of the magnetic implant described the experience as follows:

> *"The implant has changed my perception of the world around me in a small but significant way. Information is constantly flowing around us, and we remain blissfully unaware of most of it. Having a tiny bit of that data stream pulled into your conscious awareness is a shocking experience. Functionally I have changed very little, but I am now more aware of what it is I don't feel. There is an untold amount of information flowing around us that we don't experience; my implant makes me think about this more."* (Larratt, 2004)

Effects – What is the North Sense experience like?

There are a variety of effects that users had reported, some more widely shared than others. Several respondents described that the device led to the formation of new types of memories that were enriched with an understanding of their location and orientation in space and that these memories were somehow more vivid than others. The quotes below illustrate how respondents experienced this effect, which some of them had anticipated in advance, while for others it was a surprising development.

> *At first, it affected my life in the way that I wasn't expecting it, so it changed my memories, because I remembered every moment that I feel that buzzing. So it could be me walking down the street and passing the same streets, and the same buildings, and the same shops that I pass every day, and because I felt this buzzing, my mind had new impulses I remembered these moments. I remember sitting in the office and explaining something to my work colleagues, and I don't*

[17] See http://feelingwaves.blogspot.com/

remember what we were talking about. I remember the situation, because I felt the buzzing. — PT17@T1

We got to a mine... An old chalk mine, and we got undergrounds and just walked around and I still can... I still know how the mine shafts were aligned. […] I recall the moment when I was walking along one mine shaft and I could feel that North Sense was vibrating, so this one main mine shaft was perfectly aligned with north, and now sometimes when I turn north somewhere, it just brings up these memories. — PT04@T1

Besides this experience, which one respondent described as a *"memory highlighter"*, another frequent outcome of using the device was a slightly changed perception of space, or rather, the emergence of a new type of mental map, where locations at which the wearer had experienced the North Sense's buzz got connected to each other as nodes on a network inside a mental map. Users gradually developed an understanding of the relations between the places they had visited and felt the buzz.

for example, going from home to my studio and then going from my studio, I don't know, to friend's house. These different dots in the map that are important for you, they have a relation. So you generate these relation between where's my house, where's my office or my studio, where's my, I don't know, my girlfriend's house and how these three different dots in the map are related. And you have a relationship with those. So when you're going to move from one place to another, you think in a very subtle way, because it's not like a conscious process. You think about this relationship between these different dots in the map — PT09@T1

every time I go to a new place, using it kind of gives me a better sense in relation to everywhere else, which is what I was expecting. But now it's starting to happen without me thinking about it. And I'm sure that will happen even more as time goes on. — PT05@T1

One respondent spoke about how this experience took on a deeply emotional quality as she started to have more experience with the device.

after I got used to this idea of thinking explicitly where I am and where everything is and all this, after this first phase of amusement cooled down, then it started the more emotional thing, I guess. […] So it would buzz and then I would say, "Oh, here to my left is the East right?" And my friend is maybe in North Carolina, and I feel like now by knowing where he is in respect of where I'm biking now, I remember him. Or my family is in Barcelona and I'm in LA, so I know where Barcelona is from here. And I started feeling like it's connecting me more to people. It would make me think of people who are in different places, and indirectly I would just think, "Oh, I have to call this person or text this person when I get home." — PT22@T2

A somewhat similar, emotionally rich experience was described by another participant, who also spoke about the ways in which the North Sense's gentle buzz anchored him and mentally connected him to other places of significance in his life.

> *It literally just pops into my mind. It's like, "Ah." I guess it just brings up a picture. I visualize where I am in relation to the world outside rather than just walking up these stairs. It introduces a sort of visual picture connecting me to the physical world beyond the walls that I'm looking at. It's interesting. When the idea pops into my head, when I get the buzz and I say, "Oh yeah, I'm facing north now," then in a way it's a bit of a cascade of images that I associate with North, and I very often, I have family that live in Scotland, so I make the journey north several times a year, so I sort of stop, thinking of that journey, that place in Scotland, and then possibly just beyond, I might think of the Arctic. […] In a way, it stretches out my imaginary field of view northwards of where I am. It's definitely rooted into places that I am right now, but just extends that view in my head. PT06@T1*

In a similar vein to these experiences, a few respondents hinted at another effect, which some North Sense users described eloquently by saying that the experience was somewhat like a *'tap on the shoulder'* that serves to anchor and bring them back to the present moment, as if cutting through the noise of whatever it was that they were doing at that given moment.

> *not in an intrusive way, just gives me a little gentle reminder, a tap on the shoulder saying, "Hey, look at what's in front of you." Sometimes it's just, "Hey remember where you are in the world." Sometimes it's, "Hey look, there's other things in the world that are constantly giving off energy and sending information and signals." It's definitely changed the way that I perceive things because now everything has this extra layer of texture. PT12@T1*

Several respondents described how the North Sense has added this new layer to their perception of the world and they were enthusiastic about the way in which the device had opened up a new facet of reality for them to consider.

Finally, several respondents mentioned that had grown quite used to the sensation of the North Sense's buzz and that on those occasions when they had not attached the device, they felt a strange absence.

> *There are times when I haven't worn it. For example if it's been recharging or I've been somewhere without my laptop to recharge it or something. That's been quite strange, because I've really noticed it when it hasn't been there, the absence. I've really noticed the absence, and that's something I didn't expect. – a PT06@T1*

> *I started to miss it when it wasn't there. It was surprising how quickly it became part of what my brain is expecting to see, not see, but experience. – PT13@T1*

In summary, the effects of the North Sense can be described as rather subtle and indirect nevertheless most respondents encountered and interpreted them as being quite profound. The strength of the experience was not related to the intensity of the device's direct physiological impact, as would be the case with a pharmacological agent or a brain stimulation device, which exert an effect on the body that the individual is a passive recipient of. Instead, the North Sense experience was more reflective and unfolded over a more extended period of time. As such, besides a form of sensory enhancement, it might be better characterised as an epistemic enhancer (Danaher, 2013), for it allowed users access to an aspect of everyday reality that is ordinarily concealed.

Experimentation and the Freedom to Choose

Some respondents hadn't really considered the broader ethical and societal implications of enhancement technologies and struggled somewhat to articulate a position, especially as they saw the North Sense to be entirely unproblematic from an ethical perspective. Those who articulated a position expressed Proactionary values, and specifically stressed the importance of personal choice and the freedom to individually weigh risks and benefits, and to experiment, as long as it caused no harm to others.

> *I know that there's an intrinsic risk to anytime you're putting something in your body, but it's a thing that I'm choosing to do. It's entirely elective. I have no ethical concerns about human augmentation as a whole, so that was never really an issue for me. PT18@T1*

> *I don't see why there should be any issues with getting something like this. I mean, I don't see why getting human modification would be ethically wrong. I can see how it, the only part of the ethics, where it would bother me would be for people that aren't willing or wanting it. But don't know, I haven't really thought about it too much more than that. PT08@T1*

> *One of the core of my philosophies is that we should have a choice, options. Yes, I think there's there should be some boundaries. I think a lot of these boundaries need be dissolved incrementally. I don't think we can just start having designer babies and all that just yet. But ultimately, I'm not one for boundaries. I think it needs to be measured. And I think it needs to be calm, kind of laid out in a smart timeline, but I don't foresee any serious boundaries in terms of human augmentation. – PT19@T1*

One interviewee even went so far as to suggest that we should set up entire cities or city districts as sandbox environments, where those individuals, companies or organisations that want to experiment with technological, social, or regulatory innovations that may be risky or uncertain could locate to try their experiments and document the results carefully. The lessons of those experiments could then be applied, *"up-streamed"*, to society at large. In explaining this, he drew on the analogy of software development, where iteration and experimentation were fast and easy, and he wanted to adapt that model to all domains of innovation. He particularly emphasised that we should renew our commitment to pursuing riskier endeavours.

> *[e]volution in software is like at a very rapid pace compared to every other vertical basically. And the reason is because it's very lightweight to try new things. People aren't afraid to fail. You know, if your app doesn't work, you just try again. Like there's no problem there. And it reminded me of times when people were trying things with higher risk profiles, like the Wright brothers and that kind of thing. And it's interesting that while I'm learning all of that, my exposure at work, at [major software company] has been an opposing thing because we work in, for instance autonomous driving and there are huge safety ramifications, obviously, for category five driving. And so you know, people there are very afraid to fail, you know? But then it's apparent in the innovation rate, as I would call it, and so my goal is to kind of make the largest sandbox*

environment possible. – PT23@T1

In this vision, higher-risk undertakings are confined to spaces set up for that sort of experimentation and pursued by individuals who are willing to embrace those risks in pursuit of larger gains

Vision meets reality

The account of respondents' experiences with the North Sense would be profoundly incomplete without a discussion of the hurdles and difficulties encountered along the way. Follow-up interviews revealed a range of complications and problems.

The first set of difficulties was related to the North Sense as a piece of technology that users had to learn to use. A significant part of this was learning how to calibrate the device in order for it to accurately detect North. This process was unintuitive for several respondents, and they had to reach out to Cyborg Nest to solicit support, which in the case of all interviewees was provided by the CEO, Liviu Babitz himself. In addition, the device was designed to be as minimalistic as possible without any buttons, lights and with no screen. From the perspective of Cyborg Nest, these were valuable features intended to make the device as invisible as possible and to distance it from the slew of other attention seeking gadgets that were on the market. The North Sense was meant to be invisible as a piece of technology. One that is simple there streaming its information to the body in an unobtrusive and transparent manner. However, on this aspiration the device had completely failed. The only way to interact with the device was via a simple smartphone app for setup. However, this meant that users had no understanding of such basic properties as the device's current battery level, which led to a great deal of frustration and instead of making the device recede into the background, it became a source of uncertainty. Perhaps more importantly, most users encountered problems related to the device's accuracy. On the one hand, the North Sense was extremely sensitive to the wearer's body angle and was only accurate in detecting North in a relatively narrow range. This meant that users had to be mindful of their body posture and adapt themselves to the requirements of the device. This adaptation requirement occurs in other forms as well. Given the North Sense's location at the centre of one's chest, the device and the anchors interfere with daily activities and get in the way during such quotidian activities as dressing or hugging. Several respondents reported of the North Sense snagging and getting caught on things, which have caused pain and injury to some wearers. There was thus a strange dialectic to the experience of several interviewees, whereby the technology that was meant to exert a liberatory effect and stretch the body's horizons, ended up imposing its own restrictions and limitations, choreographing the body to adhere to the demands and requirements of the technology by constraining movement, dictating posture, and rewriting habits.

In addition, the North Sense was also found to be somewhat inaccurate, or at least, users had to learn to distinguish its 'true' signals from mistaken and incorrect ones. A learning process that involved a high degree of effort from participants as they struggled to decipher why the device was signalling north at a location where it was incorrect, or why it was failing to do so where it should have. For some respondents it was clear that devices and machinery that exhibit strong electromagnetic radiation, such as transformers or other large pieces of equipment can trigger the North Sense's buzz, but this was not straightforward to all interviewees. Even though respondents were determined to embed the North Sense into their lives and to think of it as a genuine sense, as was marketed by the manufacturer, these difficulties prevented most respondents from actually perceiving the device as such. The narrative offered by Cyborg Nest in response to such perceived inaccuracies was to compare the North Sense to other natural senses, and the way in which they need to be maintained and "learned". They would point to the ways in which other senses are sometimes deceived, such as in the case of optical illusions. While this narrative was convincing to some users for at least some of the time, who managed to find their way around the device's quirks, one respondent found this explanation to be deeply unsatisfying:

> *I get kind of the pitch that he was trying to explain, that it's not a mechanical precision instrument. It's not a tool. It's supposed to be a natural, a sensory thing. But I don't bite into an apple and randomly taste chicken. It's to the point where it becomes so inconsistent that I can't, I know I'm not supposed to trust in it, but I can't rely on it to tell me the truth. If I was seeing hallucinations, I might start doubting my vision and this is kind of the same thing. — PT16*

Four interviewees had already discontinued use of the North Sense at the time of the first interview, and repeat interviews revealed that another 7 respondents, over half of those who volunteered their time twice also had to stop using the device. The most common reason was that their piercings never healed correctly or that they had been rejected by the body over the period when the North Sense was attached, so people suffered local infections, which is a frequent occurrence with such piercings, experiencing pain and discomfort. In fact, most respondents did not have a long period of active use of the device because they ran into problems after a few weeks or a few months at best. Of those respondents who had experience actually wearing the North Sense at any of the interview time points, only a single respondent reported not having faced any issues whatsoever. Several respondents pivoted to using the device more like a wearable, attaching it to their body with the help of sports tape or other bands, which avoided the issues related skin irritation and pain. Some interviewees considered this to be a slight diminishment of their cyborg experience, which they saw as being related to an intimate physiological coupling between the body and a piece of technology, while for others the decisive factor in cyborgism was the perceptual and cognitive effect, which they could benefit from equally, or even better with the help of the taped method. However, without the delivering on the bold claim of permanently attaching a piece of technology to oneself, in a manner similar to how the role models, Neil Harbisson and Moon Ribas had done, a mere wearable North Sense experience carried much less of the original vision.

Facing the prospect of having to discontinue their use of the device left most respondents sad but not disillusioned or disgruntled. They also expressed the view that if the North Sense experience was available in an improved form factor, preferably as a *fully implantable* device, they would not hesitate to install it. For these interviewees, the vision that the North Sense had put forward was highly motivating and exciting, but as an early prototype it was severely lacking in technological execution and demonstrated in an unambiguous way how difficult it was to interface and interact with the human body. As PT16 summarised: *"it made me really appreciate how streamlined the human body is and how it's really not meant to have stuff sticking out of it."*

Nevertheless, reflecting on the hardships and the difficulties, respondents were left unwavering in their and proactionary conviction and commitment.

> *I mean, it's an experience, if you're trying to push the edges of being a human, and experimenting with your own body, you got to take the risks. — PT02@T2.*

Chapter 7 - Conclusion

The thesis presented a study of the phenomenon of neuroenhancement, which involves the use of advanced technologies to deliberately improve upon, augment, and extend human capacities. It drew on a combination of quantitative and qualitative methods to examine the attitudes and practices of the general public in five countries (Austria, Germany, Hungary, the United Kingdom, and the United States) and of users of neuroenhancement technologies from across the world. In the first chapter, I said I would set out to make two distinct contributions to the literature. In this concluding section, I will attempt to briefly synthesise the degree to which this proved to be successful and discuss some of the limitations of my approach and possible future research directions.

Are there points of view on neuroenhancement?

My first claim was to deploy a mixed methods strategy to overcome some important limitations of existing large-scale survey-based and experimental work on neuroenhancement, namely, that they both treat the public as a mostly undifferentiated monolith. Instead, my undertaking was to draw on the notion of points of view, inspired by Social Representation Theory, and seek to combine quantitative and qualitative methods to identify particular ways of viewing and relating to the subject of neuroenhancement.

I believe this undertaking may be considered at least a partial success. In Chapter 4, I have described two contrastive vignette experiments - one in employment and one in education - which investigated five different aspects of neuroenhancement, sympathy with the protagonist, perception of advantage gained over others, perception of how most people would decide in a similar situation, views on risks and benefits, and whether the respondent herself would choose to use the enhancer. The experiment included four experimental factors, protagonist gender, protagonist performance (whether they were failing or succeeding in their role), neuroenhancer efficacy (high vs low) and neuroenhancer type (pill vs tDCS). The selection of NE-technology was informed by prevailing conversations at the time of data collection, as non-invasive electrical brain stimulation was attracting significant attention.

Some experimental factors proved to exert a significant effect on respondents' views, notably, good baseline performance of the protagonist was associated with lower acceptance, while higher efficacy enhancers with greater acceptance. There are country-level differences as well, for example regarding negative attitudes towards pills vs brain stimulation. However, perhaps the most important finding is that across all vignettes, including where a situation of enhancement towards the norm was compared against enhancement above the norm, the effect of the experimental manipulations was marginal. In addition, younger respondents tended to be more supportive of enhancement than older generations.

Considering the ways in which respondents had argued about the experiment, I found a number of different types of reasons and concerns that largely echoed those that had been distilled from an extensive series of public engagement activities within the NERRI project. Importantly, while the primacy of medicine and therapy was very prominent at public events and is a core feature of the neuroethics debate, respondents hardly evoked the perspective that the technologies depicted in the vignettes should be reserved for medical use. Nevertheless, health-related worries were highly prevalent, not just about immediate undesirable effects, but also the unknown long-term consequences of enhancers. Pragmatic risk/benefit assessments and both positive and negative gut reactions were also expressed. In addition, respondents presented moral arguments evoking the primacy of authenticity in one's achievements, the issue of cheating, or 'messing' with the brain, but also, a small minority advanced the argument that it was acceptable to pursue enhancers to achieve one's goals and aspirations. Respondents' arguments also revealed that they consider situational pressures to be important elements when weighing neuroenhancement, and the argument was often voiced that neuroenhancement, especially when seeking to avoid some loss, could be seen as a desperate attempt to cope with increasingly harsh and unforgiving employment circumstances. Here, country differences were manifest as well, for the view that one should resist such demands and instead move on and find alternatives was more associated with Austria and Germany but less so with other countries. Moreover, there is scepticism and uncertainty about both the practical efficacy of neuroenhancers, whether they work as claimed and intended, but also with regard to the acceptability of the practice itself, as arguments from the public revealed ambivalence and hesitation.

In a subsequent step, I used a set of fourteen claims derived from public engagement activities and using multivariate analysis found that without having explicitly designed the questions in such a way, the items can be seen to gauge two different value sets. One oriented towards the nature of human achievement as untampered by technology, the protection of people from pressures and societal harms, and the other towards openness and permissive individual values. I found that individuals who scored high on the Societal-Restrictive scale were less likely to accept enhancement, while those who scored high on the Individual-Permissive scale were more likely to be open to the practice, when measured in the context of the employment and education experiments. Importantly, both extremes were rare, and most respondents could at least partially agree with both value sets. Crucially, the effect of these values on expressed attitudes was far greater than the effect of experimental manipulations, which suggests that individuals approach the issue of enhancement from distinct points of view that are informed by their respective value orientations. This finding is significant and strongly aligns with the original aspiration of my undertaking, which was to suggest that we can advance the societal discussion on enhancement by understanding the plurality of views that individuals hold with regard to the phenomenon.

In a subsequent step, I sought to further differentiate and segment opinion groups using cluster analysis methods and qualitative open-ended data. This analysis suggested that there are four opinion groups, ambivalent, neutral, anti, and pro.

Country differences were again present, with Austria and Germany appearing most negative and ambivalent towards enhancement with high proportions of anti-enhancement respondents, while the UK and USA having a higher proportion of Pro-enhancement respondents. Hungary had a high proportion of ambivalent respondents, which mirrors the fact that the state of public discussion and policy engagement with enhancement has been the lowest among the five investigated countries. Low awareness translated into high degrees of ambivalence and uncertainty, which was expressed across all arms of the study. The experimental manipulations had the lowest impact on Hungarian respondents, their arguments had the highest proportion of ambiguous responses, and the proportion of the ambivalent cluster was also high in Hungary.

However, digging deeper into the types of arguments made by individuals in the different clusters revealed two further points. First, the large number of disparate arguments advanced by those in the neutral and ambivalent clusters confirmed that the labelling of their overall stance was on the right track, but also suggested that even more nuanced and finer grained clustering approaches may have been able to detect further, definite subgroups. These groups did not have any particular orientation in their arguments and participants had made comments that spanned the entire spectrum. In contrast, the anti and pro arguments had a clear orientation. Members of the anti cluster mobilised negative arguments that foregrounded the morally corrupt nature of enhancement, its unfavourable risk/benefit profile, the fact that it was not a real solution to life's problems, or that it was unnatural or tantamount to cheating. Similarly in the pro cluster, I found a variety of supportive and accepting arguments, including ones based on risk/benefit ratios, but also the moral argument that enhancement of one's abilities was a valid pursuit, as well as the argument that sometimes resorting to enhancers is the only way to avoid failures and keep oneself afloat. Thus, while those open to enhancement may be inadvertently supporting and legitimating prevailing societal structures that put growing pressures on individuals and they consider technical means of adaptation acceptable, others reject that people should change themselves to fit workplace or university expectations. In this sense, the embracing of a technological novelty might go hand in hand with maintaining the societal status quo, while rejecting the technological novelty could mean not accepting prevailing societal structures. Here again, even finer grained future investigations could identify further, non-overlapping, concise points of view.

The study may be considered a partial success, for it identified a small number of broad stances towards enhancement, and it used experimental methods to demonstrate the importance of respondents' pre-existing value orientations in shaping views on enhancement.

Nevertheless, the study also had several limitations.

First, the NERRI survey would have benefited from further randomization to eliminate the context effect of the experimental vignettes on broader attitude statements. Even though the context effect was marginal, negating it entirely via the study design would have been a superior choice.

Second, the experimental manipulations may not have been particularly effective because they might have failed to tap into respondents' moral imagination. In other words, the experimental factors that were chosen (gender, base performance, efficacy, enhancer type) may not have been sufficiently different from each other in a morally relevant sense to elicit stronger reactions. Although this is a possibility, the purpose of the study was to investigate attitudes towards realistic varieties of enhancement, as opposed to sharpening the distinction through hypothetical scenarios, or to measure the difference between morally unambiguous therapeutic vignettes and morally contested enhancement scenarios. As such, including more extreme enhancements or stark, unrealistic contrasts may have produced findings that don't translate to the real world. Moreover, the purpose of the study was to demonstrate that however large or small an average difference may be between experimental conditions, we may still identify different ways of relating to the subject.

While to some extent this commitment to plausible enhancement scenarios may be seen as a virtue, both experiments addressed highly pragmatic circumstances where cognitive performance was of key importance. In order to gain a fuller understanding of the public's views, further components may have been included, which could have addressed the application of neuroenhancement to other domains, such as morality, affect, or sensory capacities. In particular, the inclusion of a non-productivity-oriented vignette may have shed more nuanced light on how participants view the practice.

In addition, future research should strive to understand techno-moral change (Swierstra, 2013), that is the evolution of norms and values as a result of technological advances. This would call for the incorporation of the dimension of temporality into studies of the kind I presented here. The value orientations identified in this study could be further developed into a validated scale, which might be administered at regular intervals in combination with contrastive vignette experiments. This would allow us to track whether and how broad value commitments shift and whether and how they influence the perception of particular types of neuroenhancer use.

The Proactionary Milieu

The final part of the thesis turned towards neuroenhancement users with the aim of advancing our understanding of the perspectives, experiences and motivations of this group. My aim was to find real-world examples of where the aspiration for enhancement beyond the productivity-oriented discourse of neuroethics was being enacted and pursued. As reviewed in Chapter 1, the literature on neuroenhancement users is sparse and has focused largely on consumers of smart drugs. My interview projects with brain hackers and sensory augmentation users contributes to this body of literature and has revealed some new insights.

Neuroscientist and tDCS researcher Nick Davis suggested that DIY users might be viewed as *adventurers*, who derive pleasure from the activity of exploring their brain function and stretching their horizons with scientific tools, even if this exploration involves a certain amount of risk. Davis also evoked the longstanding tradition of self-experimentation in science as a valuable source of novel insights (Davis, 2016). Risk-taking, innovation and self-experimentation are cherished proactionary values.

The picture emerging from my interviews suggests that there may be more heterogeneous reasons driving involvement in the pursuit of brain hacking, which are connected to individuals' broader ambitions, commitments, and projects. My findings cannot be interpreted to generalise to the overall practice of brain hacking or emerging subcultures around it. Nevertheless, for each of my three respondents, brain hacking acquired meaning against the background of a different project. I use the term *project* specifically with the meaning intended for it within Social Representation Theory, where this notion is understood as a mediator between the subject (individuals) and the object of representation (in this case brain hacking). The project embeds the subject and the object in a temporal dimension and acts as the carrier of meaning (Bauer & Gaskell, 1999). For Nik, brain hacking is about contributing to research and attempting to prove theories about brain function that are not embraced by mainstream neuroscientists, which means that he has no choice but to pursue this activity outside of established frameworks and infrastructures. For Thomas, brain hacking is a rather marginal activity that is tangentially related to his academic pursuits, and despite being fundamentally sceptical, he is first and foremost motivated by the engineering challenge without any deep identification with transhumanist ideas or visions of human enhancement. Finally, for Ray, brain hacking forms part of a larger commitment to a longer-term vision of human-AI merger of which brain hacking is but one small, albeit important, part.

Recalling More's Proactionary Principle, and its emphasis on science-based risk assessment and the protection of individual experimentation, we may describe the group as embracing a Proactionary stance. However, none of the interviewees actually believed tDCS to be risky at all and have actively contested the representation of tDCS as such. They felt confident in making this assessment based on their understanding of how the devices worked and how they interacted with the brain. They considered public worries about the method to be misplaced. Therefore, they did not perceive themselves to be taking on any substantial risk that might be worth it for some substantial benefits to be gained. They recognised the risks to be negligible and the current benefits equally small. Nevertheless, their practice of brain hacking was situated in broader contexts and frameworks of significance that provided it with meaning beyond the immediate effects of the intervention itself.

To some extent, time has proven them correct on the question of risks. At-home use of tDCS is now approved for the treatment of depression in Europe and the latest reviews suggest that the method is indeed safe if established protocols are adhered to (Antal et al., 2022).

Comparing this practice with the much better researched phenomenon of pharmacological cognition enhancement using psychostimulants, there are some striking differences. On the basis of much existing literature neuroenhancement with drugs appears to be driven by competitive motivations and the desire to boost performance in a narrow sense that is geared towards higher achievement, most notably in academia (DeSantis & Hane, 2010; Franke et al., 2012; Steward & Pickersgill, 2019; Vargo & Petróczi, 2016). In contrast, such competitive motivations were entirely absent in this sample. In fact, drug use aimed at boosting performance was largely shunned by respondents, not least because of the higher risks of psychostimulants.

Although interviewees expressed the view that their neurostimulation product might lead to the exacerbation of competitive pressures, gaining competitive advantage did not feature as a motivation of their own practice at all. Rather, they embraced a curious and somewhat instrumental approach to their own mental and affective states, seeking to acquire greater deliberate control over them, not unlike the way in which most individuals use familiar substances like coffee or alcohol. For the interviewees, the possible repertoire of interventions to modulate their mental states was broader.

In addition, while pharmacological enhancement is mostly a passive undertaking, requiring the mere ingestion of a substance on the part of the subject, which then exerts its physiological effects on the body, brain hacking, at least in the way practiced by the informants of this study, requires more knowledge, skill and active involvement in the setup and performance of the enhancement itself. This aspect seems to contribute to the attraction of the undertaking, as it positions the practice in the vicinity of science and research, which all participants were passionate about.

Wexler argued that the practice of DIY/home brain stimulation *"sits at the nexus of maker and DIY cultures, citizen science movements, and self-experimentation and self-tracking initiatives. Like "biohackers," home users source inexpensive versions of restricted laboratory tools for use at home; like "life hackers," they are primarily interested in self-improvement"* (Wexler, 2017, p. 4). As such, the practice is an expression of a broader cultural shift whereby neuroscience and the malleability of the brain acquire greater public prominence (Rose & Abi-Rached, 2013), individual mental capacities are increasingly understood as resources that are to be carefully optimised, and an ever growing arsenal of commercial products appear that cater to the needs of 'quantified selves' (Sharon, 2017). While I partly agree with this interpretation, I believe that the interviewees in this study have presented perspectives that stretch the boundaries of the life hacking and quantified-self movements, which have achieved very broad cultural prominence and are becoming widely adopted due to the proliferation of cheap wearable biometric tracking devices and smart watches, which are now ubiquitous.

Building on an in-depth ethnographic exploration of technological human enhancement advocacy as a new social movement, MacFarlane distinguished between 4 types of constituents in this space: 1) specialists, such as academics and industrialists, who work in fields of techno-scientific knowledge production, 2) technical hobbyists, who possess high levels of technical/scientific knowledge and pursue fringe/experimental forms of innovation, 3) consumers, who can mobilise their disposable income to support human enhancement-related products and projects, and 4) fantasists, who tend to not be engaged in techno-scientific knowledge production but who propagate optimistic visions about its future prospects (MacFarlane, 2020, p. 88)

The findings presented in this thesis suggest that two of the three informants (Ray and Nik) can be adequately described using MacFarlane's typology, because they are both highly active in promoting and disseminating ideas about the importance of human enhancement, especially with regard to the brain, while being actively involved in its development not merely as users and consumers of existing products but as the creators of new relevant technologies. However, they pursue this activity against the background of very different levels of institutional embedding. Hence, the pursuit of brain hacking – at least for two of the three interviewees in the sample – was wrapped up in a broader agenda of pursuing human enhancement advocacy related activities, which took the form of organising events, giving talks, participating at hackathons, and other community-centred activities. For the final interviewee, brain hacking is mostly an extension of his engineering skills to a new domain where the primary motivation is curiosity and a certain sense of 'coolness' that accompanies the hacker image (Torgersen & Schmidt, 2013).

In contrast, the interviewees in the North Sense project were a more diverse mixture from MacFarlane's typology. Some of them possessed high levels of technical and scientific skills, including a neuroscience PhD and an engineer, while others were of the consumer or fantasist type, who participate in the project of technological enhancement through deploying their time and income.

This study has drawn on repeat interviews to investigate the experiences of the users of a commercially available sensory augmentation product, the North Sense. In that it also offered a qualitative exploration of the proactionary approach to enhancement technologies, which was found to be characterised by a strong belief in the universal importance of pursuing enhancement to elevate humanity from its currently constrained and limited status. This deficiency was primarily articulated in relation to our epistemic capacity, which respondents saw in relation to the breadth of experiences that we are capable of having by virtue of the default human sensory system. Even though the North Sense experience itself offered only a tiny and imperfect glimpse at the prospect of technological sensory enhancement, interviewees were eager to embrace this prospect.

Their motivations for purchasing the North Sense were primarily rooted in their longstanding interest in technology and human augmentation. Many of them had already been following the activities of the North Sense's founders and were excited to find a product that finally allowed them to experiment with sensory enhancement. For several respondents, the purchase decision included an awareness that they were part of an experiment with uncertain outcomes and this uncertainty was part of the allure of the experience.

While brain hackers had a highly scientific and calculated approach to the risks of brain stimulation - although they viewed those risks to be negligible - North Sense users were more experimental in their approach. Some interviewees already had magnetic or RFID implants and were thus already 'cyborg', for most subjects in my sample, the intervention to install the North Sense anchors represented a greater degree of novelty and a plunge into the unknown, as they accepted the discomfort and risks of undergoing a form of body modification in pursuit of their enhancement goals. Several respondents spoke about the importance of adopting such an open and risk-friendly approach for the sake of the higher order pursuit of enhancement.

In fact, this higher order project of enhancement is what had primacy over the accidental manifestation of that vision in the form of the North Sense device. The North Sense happened to be available and it happened to speak the language of cyborg enhancement, where other products - such as the feelSpace belt - were positioned as an accessibility technology, which thus carried far less appeal than a purportedly cyborg technology that was promoted by cyborg celebrities Neil Harbisson and Moon Ribas.

Studying the group of North Sense users allowed me to investigate the meaning of an enhancement pursuit that was not extrinsically determined and motivated. As Cohen suggested, perhaps the most crucial argument against enhancement is that it may cause negative externalities for others (Cohen, 2013). However, this leaves open the possibility of pursuing enhancements to one's self that are not competitive or other-facing, but rather, perceived as intrinsically valuable. What interviews with North Sense users has revealed is that for the group of committed proactionaries, practical transhumanists, who embrace the ideals of risk-taking, self-experimentation, and self-transcendence, active participation in and enactment of the aspiration of technological enhancement is constitutive of their identity and their technology use can be seen as definitional for their sense of self. From this perspective, the North Sense device itself was nothing but an incidental, immediately available form of enacting the broader vision. What had primacy, was the vision itself. Therefore, although the particular device was incidental it was nevertheless expressive of how members of this social group see themselves. Some of them went so far as to view themselves as a 'new type of human', as they finally acquired the capability to integrate with technology for non-medical, elective reasons, purely as an act of choice.

While respondents placed great emphasis on individual choice, which is a familiar proactionary trope expressed most notably in the form of morphological freedom, the interviews also revealed a meaning of enhancement that is seldom addressed in neuroethics discussions. Instead of the seemingly individualistic pursuit of performance enhancement, what we find in descriptions of North Sense user experiences are mentions of connections to places and people, a deeper appreciation of aspects of reality that were hitherto unknown, and the desire to share in this experience and exchange about it with others. While the body is to some extent perceived as an inherently limited and 'flawed' vehicle, respondents also spoke of the way in which through integration of a technology with their bodies they gained a novel type of grounding in the world. Thus, in line with the polyvalence of authenticity, suggested by Parens (Parens, 2015), for North Sense users, the incorporation of technology acts as an enhancement of their humanness, while simultaneously pointing towards its overcoming.

Perhaps the most important aspect of the study was the discovery that despite high expectations, great enthusiasm, and firm commitment, for most respondents the experience ended in a form of failure, as they had to abandon the North Sense for its inability to attach properly to the body. Thus, the body, that simultaneous source and constraint of all human experience emerged as the barrier to voluntary cyborgisation.

What happened afterwards is most revealing.

The failure of the intended outcome led to a reconsideration of some former beliefs, which, in my interviews, prompted discussions about what it actually meant to be a cyborg. Was it really necessary to have technological augmentations performed on the body or was it more about the cognitive effects of the technology that may unfold their enhancing effects irrespective of the type and degree of integration with the human body? Most participants were left somewhat unsure of their position with regard to cyborgism, and while the experience was at least a bit 'sour' for several respondents, they did not view it in terms of definitive success or failure. They viewed it as an experiment and an opportunity to learn, whereby the next version, the next iteration, North Sense 2.0 or some other technology that will manifest in the future will be better and improved. Despite all the hurdles and difficulties, which included painful wounds, bleeding infections, daily frustrations with a dysfunctional device and a poor user experience, they remained unwavering in their commitment to the broader pursuit of human enhancement and the growing merger of the body with technology. As such, they found a way to focus on the valuable aspects of the experience, while diminishing or reconsidering those that were negatively affected by the experience (Festinger, 1957).

The North Sense experience also foregrounds the importance of the body's materiality, which is often erased or neglected in transhumanist visions (Hayles, 1999). What the narratives of North Sense users revealed is an example of the clash between the utopian vision of enhancing the scope of human experience, and the painful and bloody reality of trying to interface a piece of rudimentary technology with the biological body. This aspect also highlights the gap between the promoted ideal of seamless integration between the body and technology, a sort of 'plug-and-play' compatibility, where the brain's ability to extract patterns of information from any stream of data is simply taken for granted, and the immense complexities of interfacing with biology in the real world.

In contrast to everyday cyborgs described in Haddow's (2021) accounts of internal cardiac defibrillator patients who undergo a profound transformation of their subjectivity as they struggle to incorporate the experience of being inseparably tied to a machine for their continued survival, the North Sense experience of elective cyborgisation might be better characterised as a form of privileged luxury. Those who can afford to experiment might derive epistemic satisfaction from such an experience, as they gain a subjective sense of perceiving the world in a richer and more complex way.

Transhumanism is often characterised as a hyper-rationalistic pursuit, as a rapture of the geeks, one that is hostile to the body, views the intellect as the essential human characteristic that should be liberated from the confines of its biological form. There may be some truth to that, if we consider prominent visions of mind-uploading popular in the writings of Kurzweil (Kurzweil, 2005) and other thought leaders. However, the aspiration exhibited here was at least in part driven by a striving towards a richer and deeper human experience.

Bibliography

Abelson, R. P. (1976). Script processing in attitude formation and decision making. In J. S. Carrol & J. W. Payne (Eds.), *Cognition and social behavior,*. Lawrence Erlbaum.

Ada Lovelace Institute. (2021). *The Citizens' Biometrics Council*. Ada Lovelace Institute.

Adams, A., Albin, S., Amunts, K., Asakawa, T., Bernard, A., Bjaalie, J. G., Chakli, K., Deshler, J. O., De Koninck, Y., Ebell, C. J., Egan, G., Hale, M. E., Häusser, M., Jeong, S.-J., Illes, J., Lanyon, L., Li, P., Li, Y., Magistretti, P., … Zheng, J. (2020). International Brain Initiative: An Innovative Framework for Coordinated Global Brain Research Efforts. *Neuron*, *105*(2), 212–216. https://doi.org/10.1016/j.neuron.2020.01.002

Adee, S. (2017, January 14). Zapping the brain really does seem to improve depression. *New Scientist*. https://www.newscientist.com/article/2117398-zapping-the-brain-really-does-seem-to-improve-depression/#:~:text=Health%209%20January%202017%20By%20Sally%20Adee%20Transcranial,may%20be%20a%20useful%20tool%20for%20treating%20depression.

Afonso, A. (2014). How Academia Resembles a Drug Gang. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2407748

Agar, N. (2005). *Liberal eugenics: In defence of human enhancement*. Blackwell Pub.

Albeck-Ripka, L. (2017). *This Man Is a Cyborg and He Could Make You One Too*. Vice. https://www.vice.com/en/article/gvdd97/liviu-babitz-biohacking-cyborg-technology-v24n1

American Psychiatric Association. (2008). *The practice of electroconvulsive therapy: Recommendations for treatment, training, and privileging (A task force report of the American Psychiatric Association)*. American Psychiatric Pub.

Ames, M. G., Bardzell, J., Bardzell, S., Lindtner, S., Mellis, D. A., & Rosner, D. K. (2014). Making cultures: Empowerment, participation, and democracy - or not? *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, 1087–1092. https://doi.org/10.1145/2559206.2579405

Ansari, D., De Smedt, B., & Grabner, R. H. (2012). Neuroeducation – A Critical Overview of An Emerging Field. *Neuroethics*, *5*(2), 105–117. https://doi.org/10.1007/s12152-011-9119-3

Antal, A., Luber, B., Brem, A.-K., Bikson, M., Brunoni, A. R., Cohen Kadosh, R., Dubljević, V., Fecteau, S., Ferreri, F., Flöel, A., Hallett, M., Hamilton, R. H., Herrmann, C. S., Lavidor, M., Loo, C., Lustenberger, C., Machado, S., Miniussi, C., Moliadze, V., … Paulus, W. (2022). Non-invasive brain stimulation and neuroenhancement. *Clinical Neurophysiology Practice*, *7*, 146–165. https://doi.org/10.1016/j.cnp.2022.05.002

Arendt, H. (1958). *The human condition* (2nd ed). University of Chicago Press.

Asztalos, M., Könye, P., & Gazdag, G. (2020). Laikusok elektrokonvulzív terápiával kapcsolatos attitûdje Magyarországon. *Ideggyógyászati Szemle*, *73*(9–10), 311–316. https://doi.org/10.18071/ISZ.73.0311

Babcock, Q., & Byrne, T. (2000). Student Perceptions of Methylphenidate Abuse at a Public Liberal Arts College. *Journal of American College Health*, *49*(3), 143–145. https://doi.org/10.1080/07448480009596296

Bach-y-Rita, P. (2002). Sensory substitution and qualia. *Vision and Mind*, 497–514.

Bach-y-Rita, P., Collins, C. C., Saunders, F. A., White, B., & Scadden, L. (1969). Vision substitution by tactile image projection. *Nature*, *221*(5184), 963–964.

Bacon, S. (2013). "We Can Rebuild Him!": The essentialisation of the human/cyborg interface in the twenty-first century, or whatever happened to The Six Million Dollar Man? *AI & SOCIETY*, *28*(3), 267–276. https://doi.org/10.1007/s00146-012-0387-1

Baldwin, T., Cole, J., & Fitzgerald, M. (2013). Novel neurotechnologies. *London: Nuffield Council on Bioethics*.

Ball, N., & Wolbring, G. (2014). Cognitive enhancement: Perceptions among parents of children with disabilities. *Neuroethics*, *7*(3), 345–364.

Banjo, O. C., Nadler, R., & Reiner, P. B. (2010). Physician Attitudes towards Pharmacological Cognitive Enhancement: Safety Concerns Are Paramount. *PLoS ONE*, *5*(12), e14322. https://doi.org/10.1371/journal.pone.0014322

Bard, I., Gaskell, G., Allansdottir, A., da Cunha, R. V., Eduard, P., Hampel, J., Hildt, E., Hofmaier, C., Kronberger, N., Laursen, S., Meijknecht, A., Nordal, S., Quintanilha, A., Revuelta, G., Saladié, N., Sándor, J., Santos, J. B., Seyringer, S., Singh, I., … Zwart, H. (2018). Bottom Up Ethics—Neuroenhancement in Education and Employment. *Neuroethics*, *11*(3), 309–322. https://doi.org/10.1007/s12152-018-9366-7

Bauer, M. W., & Gaskell, G. (1999). Towards a Paradigm for Research on Social Representations. *Journal for the Theory of Social Behaviour*, *29*(2), 163–186. https://doi.org/10.1111/1468-5914.00096

Bauer, M. W., & Gaskell, G. (2008). Social Representations Theory: A Progressive Research Programme for Social Psychology. *Journal for the Theory of Social Behaviour*, *38*(4), 335–353. https://doi.org/10.1111/j.1468-5914.2008.00374.x

Beddington, J., Cooper, C. L., Field, J., Goswami, U., Huppert, F. A., Jenkins, R., Jones, H. S., Kirkwood, T. B. L., Sahakian, B. J., & Thomas, S. M. (2008). The mental wealth of nations. *Nature*, *455*(7216), 1057–1060. https://doi.org/10.1038/4551057a

Bergström, L. S., & Lynöe, N. (2008). Enhancing concentration, mood and memory in healthy individuals: An empirical study of attitudes among general practitioners and the general population. *Scandinavian Journal of Public Health*, *36*(5), 532–537. https://doi.org/10.1177/1403494807087558

Besson, L. (Director). (2014). *Lucy*. EuropaCorp Distribution.

Bikson, M., Bestmann, S., & Edwards, D. (2013). Transcranial devices are not playthings. *Nature*, *501*(7466), 167–167.

Billiard, M., & Broughton, R. (2018). Modafinil: Its discovery, the early European and North American experience in the treatment of narcolepsy and idiopathic hypersomnia, and its subsequent use in other medical conditions. *Sleep Medicine*, *49*, 69–72. https://doi.org/10.1016/j.sleep.2018.05.027

Bjønness, J. (2019). Gendered aspects of Danish students' non-medical use of prescription pharmaceuticals for enhancement purposes in the 'performance society'. *Drugs: Education, Prevention and Policy*, *26*(4), 309–318. https://doi.org/10.1080/09687637.2019.1590530

Björneborn, L. (2020). Adjacent possible. In A. Gare (Ed.), *The Palgrave encyclopedia of the possible* (pp. 1–12).

Bohan, E. (2018). *A History of Transhumanism. Thesis for: Doctor of Philosophy (PhD).* Macquarie University. https://www.researchgate.net/publication/332289738_A_History_of_Transhumanism

Bohan, E. (2022). *Future superhuman: Our transhuman lives in a make-or-break century*. NewSouth Publishing.

Bostrom, N. (2005a). A history of transhumanist thought. *Journal of Evolution and Technology*, *14*(1).

Bostrom, N. (2005b). In defense of posthuman dignity. *Bioethics*, *19*(3), 202–214. https://doi.org/10.1111/j.1467-8519.2005.00437.x

Bostrom, N. (2008). Why I want to be a posthuman when I grow up. In *Medical enhancement and posthumanity* (pp. 107–136). Springer.

Bostrom, N., & Savulescu, J. (2008). Human Enhancement Ethics: The State of the Debate. In J. Savulescu & N. Bostrom (Eds.), *Human Enhancement* (pp. 1–22).

Bowen, G. A. (2008). Naturalistic inquiry and the saturation concept: A research note. *Qualitative Research*, *8*(1), 137–152. https://doi.org/10.1177/1468794107085301

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage Publications.

British Medical Association. (2007). *Boosting your brainpower: Ethical aspects of cognitive enhancements*. British Medical Association.

Brooker, C. (Director). (2011). *Black Mirror*. Endemol Shine UK.

Brumboiu, I., Porrovecchio, A., Peze, T., Hurdiel, R., Cazacu, I., Mogosan, C., Ladner, J., & Tavolacci, M.-P. (2021). Neuroenhancement in French and Romanian University Students, Motivations and Associated Factors. *International Journal of Environmental Research and Public Health*, *18*(8), 3880.

Bryman, A. (2004). *Social research methods*. Oxford University Press.

Buchanan, A. E., Brock, D. W., Daniels, N., & Wikler, D. (2001). *From chance to choice: Genetics and justice*. Cambridge University Press.

Burger, N. (Director). (2011). *Limitless*. Relativity Media.

Burstin, K., Doughtie, E. B., & Raphaeli, A. (1980). Contrastive Vignette Technique: An indirect Methodology Designed to Address Reactive Social Attitude Measurement1. *Journal of Applied Social Psychology*, *10*(2), 147–165. https://doi.org/10.1111/j.1559-1816.1980.tb00699.x

Buyx, A. M. (2008). Be careful what you wish for? Theoretical and ethical aspects of wish-fulfilling medicine. *Medicine, Health Care and Philosophy*, *11*(2), 133–143. https://doi.org/10.1007/s11019-007-9111-1

Cabrera, L. Y. (2015). *Rethinking human enhancement: Social enhancement and emergent technologies*. Palgrave Macmillan, in the US is a division of St Martin's Press, LLC.

Cabrera, L. Y., Fitz, N. S., & Reiner, P. B. (2015). Empirical Support for the Moral Salience of the Therapy-Enhancement Distinction in the Debate Over Cognitive, Affective and Social Enhancement. *Neuroethics*, *8*(3), 243–256. https://doi.org/10.1007/s12152-014-9223-2

Champagne, J., Gardner, B., & Dommett, E. J. (2019). Modelling predictors of UK undergraduates' attitudes towards smart drugs. *Trends in Neuroscience and Education*, *14*, 33–39. https://doi.org/10.1016/j.tine.2019.02.001

Clark, A. (2003). *Natural-born cyborgs: Minds, technologies, and the future of human intelligence*. Oxford University Press.

Clinton, B. (2000). *President clinton: Announcing the completion of the first survey of the entire human genome*. The White House at Work Archives. https://clintonwhitehouse3.archives.gov/WH/Work/062600.html

Clynes, M. E., & Kline, N. S. (1960). Cyborgs and space. *Astronautics*, *14*(9), 26–27.

Coates McCall, I., Lau, C., Minielly, N., & Illes, J. (2019). Owning Ethical Innovation: Claims about Commercial Wearable Brain Technologies. *Neuron*, *102*(4), 728–731. https://doi.org/10.1016/j.neuron.2019.03.026

Coenen, C., Schuijff, M., Smits, M., Klaassen, P., Hennen, L., Rader, M., & Wolbring, G. (2009). *Human enhancement: A report for the European Parliament science technology options assessment*.

Cohen, I. G. (2013). What (if anything) is wrong with human enhancement; what (is anything) is right with it. *Tulsa L. Rev.*, *49*, 645.

Conrad, E. C., Humphries, S., & Chatterjee, A. (2019). Attitudes Toward Cognitive Enhancement: The Role of Metaphor and Context. *AJOB Neuroscience*, *10*(1), 35–47. https://doi.org/10.1080/21507740.2019.1595771

Conrad, P. (2007). *The medicalization of society: On the transformation of human conditions into treatable disorders*. Johns Hopkins University Press Baltimore.

Coveney, C., Williams, S. J., & Gabe, J. (2019). Enhancement imaginaries: Exploring public understandings of pharmaceutical cognitive enhancing drugs. *Drugs: Education, Prevention and Policy*, *26*(4), 319–328. https://doi.org/10.1080/09687637.2019.1593318

Cyranoski, D. (2018). Beijing launches pioneering brain-science centre. *Nature*, *556*(7700), 157–158. https://doi.org/10.1038/d41586-018-04122-3

DAK Forschung. (2015). *DAK-Gesundheitreport 2015*. DAK-Gesundheit. https://www.dak.de/dak/download/vollstaendiger-bundesweiter-gesundheitsreport-2015-2109030.pdf

Danaher, J. (2013). On the need for epistemic enhancement: Democratic legitimacy and the enhancement project. *Law, Innovation and Technology*, *5*(1), 85–112.

Davies, R. T. (Director). (2019). *Years and Years*. StudioCanal.

Davis, N. J. (2016). The regulation of consumer tDCS: Engaging a community of creative self-experimenters. *Journal of Law and the Biosciences*, *3*(2), 304–308. https://doi.org/10.1093/jlb/lsw013

de Oliveira Cata Preta, B., Miranda, V. I. A., & Bertoldi, A. D. (2020). Psychostimulant Use for Neuroenhancement (Smart Drugs) among College Students in Brazil. *Substance Use & Misuse*, *55*(4), 613–621. https://doi.org/10.1080/10826084.2019.1691597

Delgado, J. M. R. (1969). *Physical control of the mind: Toward a psychocivilized society* (Vol. 41). World Bank Publications.

DeSantis, A. D., & Hane, A. C. (2010). "Adderall is definitely not a drug": Justifications for the illegal use of ADHD stimulants. *Substance Use & Misuse*, *45*(1–2), 31–46.

Dijkstra, A. M., & Schuijff, M. (2016). Public opinions about human enhancement can enhance the expert-only debate: A review study. *Public Understanding of Science*, *25*(5), 588–602.

Diller, L. H. (1996). The Run on Ritalin: Attention Deficit Disorder and Stimulant Treatment in the 1990s. *The Hastings Center Report*, *26*(2), 12. https://doi.org/10.2307/3528571

Dinh, C. T., Humphries, S., & Chatterjee, A. (2020). Public Opinion on Cognitive Enhancement Varies across Different Situations. *AJOB Neuroscience*, *11*(4), 224–237. https://doi.org/10.1080/21507740.2020.1811797

Doerksen, M. (2018). *How to make sense: Sensory modification in grinder subculture*.

Douglas, T. (2008). Moral Enhancement. *Journal of Applied Philosophy*, *25*(3), 228–245. https://doi.org/10.1111/j.1468-5930.2008.00412.x

Dubljević, V., Sattler, S., & Racine, É. (2014). Cognitive Enhancement and Academic Misconduct: A Study Exploring Their Frequency and Relationship. *Ethics & Behavior*, *24*(5), 408–420. https://doi.org/10.1080/10508422.2013.869747

Dumit, J. (2004). *Picturing personhood: Brain scans and biomedical identity*. Princeton Univ. Press.

Durant, J., Bauer, M. W., & Gaskell, G. (Eds.). (1998). *Biotechnology in the Public Sphere: A European Sourcebook*. Science Museum.

Eagleman, D. (Director). (2015). *Can we create new senses for humans [video file].* TED. https://www.ted.com/talks/david_eagleman_can_we_create_new_senses_for_humans.

Elliott, P. (2014). Electricity and the brain: An historical evaluation. In R. C. Kadosh (Ed.), *The stimulated brain* (pp. 3–33). Elsevier.

Emanuel, P., Walper, S., DiEuliis, D., Klein, N., Petro, J. B., & Giordano, J. (2019). *Cyborg soldier 2050: Human/machine fusion and the implications for the future of the DOD.* U.S. Army Combat Capabilities Development Command Chemical Biological Center. https://apps.dtic.mil/sti/citations/AD1083010

Emslie, K. (2017). *This Artificial Sixth Sense Helps Humans Orient Themselves in the World*. Smithsonian Magazine. https://www.smithsonianmag.com/innovation/artificial-sixth-sense-helps-humans-orient-themselves-world-180961822/

Esfandiary, F. M. (1981). Upwing Priorities. *Future Life, Issue 21.* https://archive.org/details/Up-wingPriorities1981

Eudes, Y. (2017). *En Angleterre, l'implant « North sense » créé par Liviu Babitz indique le nord*. Le Monde. https://www.lemonde.fr/festival/article/2017/07/24/liviu-babitz-et-son-implant-qui-indique-le-nord_5164327_4415198.html

European Commission. (2011). *Mobilisation and Mutual Learning (MML) Action Plans on Societal Challenges call for proposals—Science in society, work programme 2012*. Publications Office of the European Union.

European Union. (2008). *Consolidated Versions of the Treaty on European Union and the Treaty on the Functioning of the European Union (2008/C 115/01)*. Office for Official publications of the European Communities.

Farah, M. J., Illes, J., Cook-Deegan, R., Gardner, H., Kandel, E., King, P., Parens, E., Sahakian, B., & Wolpe, P. R. (2004). Neurocognitive enhancement: What can we do and what should we do? *Nature Reviews Neuroscience*, *5*(5), 421–425.

FDA. (2019). *General wellness: Policy for low risk devices—Guidance for industry and Food and Drug Administration staff*. US Food and Drug Administration. https://www.fda.gov/media/90652/download

Felsen, G., & Reiner, P. B. (2017). Quantitative Anticipatory Ethical Analysis Should Inform Neurotechnology Development. *AJOB Neuroscience*, *8*(2), 75–77. https://doi.org/10.1080/21507740.2017.1320329

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80–92. https://doi.org/10.1177/160940690600500107

Fernandez, K., Hamilton, R., Cabrera, L., & Medaglia, J. D. (2022). Context-Dependent Risk & Benefit Sensitivity Mediate Judgments About Cognitive Enhancement. *AJOB Neuroscience*, *13*(1), 73–77. https://doi.org/10.1080/21507740.2021.2001077

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford University Press.

Finger, G., Silva, E. R. da, & Falavigna, A. (2013). Use of methylphenidate among medical students: A systematic review. *Revista Da Associação Médica Brasileira*, *59*(3), 285–289. https://doi.org/10.1016/j.ramb.2012.10.007

Fitz, N. S., Nadler, R., Manogaran, P., Chong, E. W., & Reiner, P. B. (2014). Public attitudes toward cognitive enhancement. *Neuroethics*, *7*(2), 173–188.

Fitz, N. S., & Reiner, P. B. (2014). The Perils of Using Electrical Stimulation to Change Human Brains. In R. C. Kadosh (Ed.), *The Stimulated Brain* (pp. 61–83). Elsevier. https://doi.org/10.1016/B978-0-12-404704-4.00003-X

Fitz, N. S., & Reiner, P. B. (2015). The challenge of crafting policy for do-it-yourself brain stimulation. *Journal of Medical Ethics*, *41*(5), 410–412. https://doi.org/10.1136/medethics-2013-101458

Forgy, E. W. (1965). Cluster analysis of multivariate data: Efficiency vs. Interpretability of classifications. *Biometrics*, *21*, 768–769.

Forlini, C. (2020). Empirical data is failing to break the ethics stalemate in the cognitive enhancement debate. *AJOB Neuroscience*, *11*(4), 240–242.

Forlini, C., & Hall, W. (2016). The is and ought of the Ethics of Neuroenhancement: Mind the Gap. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01998

Forlini, C., & Racine, E. (2009). Autonomy and Coercion in Academic "Cognitive Enhancement" Using Methylphenidate: Perspectives of Key Stakeholders. *Neuroethics*, *2*(3), 163–177. https://doi.org/10.1007/s12152-009-9043-y

Franke, A. G., Bagusat, C., Dietz, P., Hoffmann, I., Simon, P., Ulrich, R., & Lieb, K. (2013). Use of illicit and prescription drugs for cognitive or mood enhancement among surgeons. *BMC Medicine*, *11*(1), 102. https://doi.org/10.1186/1741-7015-11-102

Franke, A. G., Lieb, K., & Hildt, E. (2012). What users think about the differences between caffeine and illicit/prescription stimulants for cognitive enhancement. *PloS One*, *7*(6), e40047.

Fuchs, M. (Ed.). (2002). *Enhancement: Die ethische Diskussion über biomedizinische Verbesserungen des Menschen* (Stand: September 2002). Dt. Referenzzentrum für Ethik in den Biowissenschaften.

Fukuyama, F. (2002). *Our posthuman future: Consequences of the biotechnology revolution* (1st ed). Farrar, Straus and Giroux.

Fuller, S. (2009). Reviewed Work: The Handbook of Science and Technology Studies by Edward J. Hackett, Olga Amsterdamska, Michael Lynch, Judy Wajcman. *Isis*, *100*(1), 207–209. https://doi.org/10.1086/599701

Fuller, S. (2011). *Humanity 2.0: What it means to be human past, present and future*. Springer.

Fuller, S. (2012). Precautionary and Proactionary as the New Right and the New Left of the Twenty-First Century Ideological Spectrum. *International Journal of Politics, Culture, and Society*, *25*(4), 157–174. https://doi.org/10.1007/s10767-012-9127-2

Fuller, S., & Lipinska, V. (2014). *The proactionary imperative: A foundation for transhumanism*. Springer.

Funk, C., Kennedy, B., & Podrebarac Sciupac, E. (2016). *U.S. Public Wary of Biomedical Technologies to 'Enhance' Human Abilities*. Pew Research. https://www.pewresearch.org/science/2016/07/26/u-s-public-wary-of-biomedical-technologies-to-enhance-human-abilities/

Gane, N. (2006). When we have never been human, what is to be done? Interview with Donna Haraway. *Theory, Culture & Society*, *23*(7–8), 135–158.

Gary, P. R. (2007). Adjusting for Nonresponse in Surveys. In J. C. Smart (Ed.), *Higher Education: Handbook of Theory and Research* (Vol. 22, pp. 411–449). Springer Netherlands. https://doi.org/10.1007/978-1-4020-5666-6_8

Gaskell, G., Bard, I., Allansdottir, A., da Cunha, R. V., Eduard, P., Hampel, J., Hildt, E., Hofmaier, C., Kronberger, N., Laursen, S., Meijknecht, A., Nordal, S., Quintanilha, A., Revuelta, G., Saladié, N., Sándor, J., Santos, J. B., Seyringer, S., Singh, I., … Zwart, H. (2017). Public views on gene editing and its uses. *Nature Biotechnology*, *35*(11), 1021–1023. https://doi.org/10.1038/nbt.3958

Gaskell, G., Stares, S., & Pottage, A. (2012). How Europe's ethical divide looms over biotech law and patents. *Nature Biotechnology*, *30*(5), 392–394.

Goertzel, B. (2013). Artificial general intelligence and the future of humanity. In M. More & V.-M. Natasha (Eds.), *The transhumanist reader: Classical and contemporary essays on the science, technology, and philosophy of the human future* (pp. 128–137). Wiley Online Library.

Goldstein, M. (1990). The Decade of the Brain: An era of promise for neurosurgery and a call to action. *Journal of Neurosurgery*, *73*(1), 1–2. https://doi.org/10.3171/jns.1990.73.1.0001

Gouliaev, A. H., & Senning, A. (1994). Piracetam and other structurally related nootropics. *Brain Research Reviews*, *19*(2), 180–222.

Government Office for Science. (2005). *Drugs Futures 2025*. Government Office for Science. https://www.gov.uk/government/publications/drugs-futures-2025

Graf, W. D., Nagel, S. K., Epstein, L. G., Miller, G., Nass, R., & Larriviere, D. (2013). Pediatric neuroenhancement: Ethical, legal, social, and neurodevelopmental implications. *Neurology*, *80*(13), 1251–1260. https://doi.org/10.1212/WNL.0b013e318289703b

Greely, H., Sahakian, B., Harris, J., Kessler, R. C., Gazzaniga, M., Campbell, P., & Farah, M. J. (2008). Towards responsible use of cognitive-enhancing drugs by the healthy. *Nature*, *456*(7223), 702–705. https://doi.org/10.1038/456702a

Grunwald, A., & Hartlieb, J. von (Eds.). (2012). *Ist Technik die Zukunft der menschlichen Natur? 36 Essays* (1. Auflage). Wehrhahn Verlag.

Guarniero, G. (1974). Experience of tactile vision. *Perception*, *3*(1), 101–104.

Guger, C., Allison, B. Z., Walchshofer, M., & Breinbauer, S. (2019). The BR4IN.IO Hackathons. In A. Nijholt (Ed.), *Brain Art* (pp. 447–473). Springer International Publishing. https://doi.org/10.1007/978-3-030-14323-7_17

Gutmann, A., & Thompson, D. F. (2000). *Democracy and disagreement: Why moral conflict cannot be avoided in politics, and what should be done about it* (3. printing). Belknap Press of Harvard Univ. Press.

Habermas, J. (1999). *The Structural transformation of the public sphere: An inquiry into a category of bourgeois society* (10. print). MIT Press.

Habermas, J. (2003). *The future of human nature*. Polity.

Haddow, G. (2021). *Embodiment and everyday cyborgs: Technologies that alter subjectivity*. Manchester University press.

Hakoköngäs, E., & Sakki, I. (2016). The naturalized nation: Anchoring, objectification and naturalized social representations of history. *Journal of Social and Political Psychology*, *4*(2), 646–669. https://doi.org/10.5964/jspp.v4i2.664

Hämäläinen, N. (2016). *Descriptive ethics: What does moral philosophy know about morality?* Springer.

Hameed, J., Harrison, I., Gasson, M. N., & Warwick, K. (2010). *A novel human-machine interface using subdermal magnetic implants*. 1–5.

Hamzelou, J. (2015). *Megabucks pouring into global brain science projects*. New Scientist. https://www.newscientist.com/article/dn27318-megabucks-pouring-into-global-brain-science-projects/

Hansen, J. (2010). *Biotechnology and Public Engagement in Europe*. Palgrave Macmillan UK. https://doi.org/10.1057/9780230277502

Hanson, J. (2018). Precautionary Principle: Current Understandings in Law and Society. In D. A. Dellasala & M. I. Goldstein (Eds.), *Encyclopedia of the Anthropocene* (pp. 361–366). Elsevier. https://doi.org/10.1016/B978-0-12-809665-9.10451-3

Hansson, S. O. (2015). Ethical implications of sensory prostheses. In J. Clausen & N. Levy (Eds.), *Handbook of Neuroethics*. Springer Netherlands.

Haraway, D. J. (1991). A Cyborg Manifesto:Science, Technology, and Socialist-Feminism in the late Twentieth Century. In D. J. Haraway, (Ed.), *Simians, cyborgs, and women: The reinvention of nature* (pp. 149–182). Routledge.

Harbisson, N. (2019). Hearing colors: My life experience as a cyborg. In *CREATIVITY, IMAGINATION AND INNOVATION: Perspectives and Inspirational Stories* (pp. 117–125). World Scientific.

Harris, J. (2007). *Enhancing evolution: The ethical case for making better people* (5. print., and 1. paperback print., with a new preface). Princeton University Press.

Harrison, I. (2015). *Sensory enhancement, a pilot perceptual study of subdermal magnetic implants. (Doctoral dissertation)*. University of Reading.

Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. University of Chicago Press.

Hermes, S., Clemons, E., Wittenzellner, D., Hein, A., Böhm, M., & Krcmar, H. (2020). *Consumer Attitudes towards Firms that Monetize Personal Information: A Cluster Analysis and Regulatory Implications*. 24th Pacific Asia Conference on Information Systems. https://www.researchgate.net/profile/Sebastian-Hermes/publication/341452670_Consumer_Attitudes_towards_Firms_that_Monetize_Personal_Information_A_Cluster_Analysis_and_Regulatory_Implications/links/5ec2356192851c11a8704454/Consumer-Attitudes-towards-Firms-that-Monetize-Personal-Information-A-Cluster-Analysis-and-Regulatory-Implications.pdf

Hermes, S., Sutanrikulu, A., Schreieck, M., & Krcmar, H. (2021). Who Quits Privacy-Invasive Online Platform Operators? A Segmentation Study with Implications for the Privacy Paradox. *Hawaii International Conference on System Sciences*, 1–10. https://doi.org/10.24251/hicss.2021.564

Herpich, F., Melnick, M. D., Agosta, S., Huxlin, K. R., Tadin, D., & Battelli, L. (2019). Boosting learning efficacy with noninvasive brain stimulation in intact and brain-damaged humans. *Journal of Neuroscience*, *39*(28), 5551–5561.

Holden, C. (2002). From PUS to PEST. *Science*, *298*(5591), 49–49. https://doi.org/10.1126/science.298.5591.49b

Holland, J., Thomson, R., & Henderson, S. (2006). *Qualitative longitudinal research: A discussion paper.* London, South Bank University: Families and Social Capital ESRC Research Group.

Holm, S., & Harris, J. (1999). Precautionary principle stifles discovery. *Nature*, *400*(6743), 398–398. https://doi.org/10.1038/22626

Holstein, J. A., & Gubrium, J. F. (1995). *The active interview*. SAGE Publications.

Horgan, J. (2005). The forgotten era of brain chips. *Scientific American*, *293*(4), 66–73.

Horn, G. (2008). *Brain science, addiction and drugs*. Academy of Medical Sciences.

Hsieh, H.-F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Hughes, J. (2004). *Citizen Cyborg: Why democratic societies must respond to the redesigned human of the future*. Westview Press.

Huxley, J. (1957). *New bottles for new wine*.

Ilieva, I., Boland, J., & Farah, M. J. (2013). Objective and subjective cognitive enhancing effects of mixed amphetamine salts in healthy people. *Neuropharmacology*, *64*, 496–505.

Ilieva, I. P., Hook, C. J., & Farah, M. J. (2015). Prescription stimulants' effects on healthy inhibitory control, working memory, and episodic memory: A meta-analysis. *Journal of Cognitive Neuroscience*, *27*(6), 1069–1089.

Illes, J., & Raffin, T. A. (2002). Neuroethics: An emerging new discipline in the study of brain and cognition. *Brain and Cognition*, *50*(3), 341–344. https://doi.org/10.1016/S0278-2626(02)00522-5

Ipsos. (2019). *GET Creative/USA TODAY NETWORK, Charles Koch Institute – Technology Survey*. Ipsos. https://www.ipsos.com/sites/default/files/ct/news/documents/2019-03/technology_press_release.pdf#:~:text=Washington%2C%20DC%2C%20March%201%2C%202019%20%E2%80%94%20A%20recent,family%20and%20friends%20compared%20to%20their%20own%20experiences.

Irwin, A., & Wynne, B. (Eds.). (1996). *Misunderstanding science? The public reconstruction of science and technology* (1. paperback ed). Cambridge University Press.

Jebari, K. (2015). Sensory Enhancement. In J. Clausen & N. Levy (Eds.), *Handbook of Neuroethics* (pp. 827–838). Springer Netherlands. https://doi.org/10.1007/978-94-007-4707-4_106

Jonas, H. (1987). *Das Prinzip Verantwortung: Versuch einer Ethik für die technologische Zivilisation* (7. Aufl). Insel-Verl.

Jones, R. A. L. (2014). Reflecting on public engagement and science policy. *Public Understanding of Science*, *23*(1), 27–31. https://doi.org/10.1177/0963662513482614

Jovchelovitch, S. (2008). The rehabilitation of common sense: Social representations, science and cognitive polyphasia. *Journal for the Theory of Social Behaviour*, *38*(4), 431–448.

Jowett, B. (1892). *The dialogues of Plato: Translated into English, with analyses and introductions.* Oxford University Press.

Juengst, E. (1998). What does Enhancement Mean? In E. Parens (Ed.), *Enhancing Human Traits. Ethical and Social Implications* (pp. 29–47). Georgetown University Press.

Jwa, A. (2015). Early adopters of the magical thinking cap: A study on do-it-yourself (DIY) transcranial direct current stimulation (tDCS) user community. *Journal of Law and the Biosciences*, *2*(2), 292–335.

Kadosh, R. (2013). Using transcranial electrical stimulation to enhance cognitive functions in the typical and atypical brain. *Translational Neuroscience*, *4*(1), 20–33.

Karch, S. B. (1999). Cocaine: History, use, abuse. *Journal of the Royal Society of Medicine*, *92*(8), 393–397.

Kärcher, S. M., Fenzlaff, S., Hartmann, D., Nagel, S. K., & König, P. (2012). Sensory augmentation for the blind. *Frontiers in Human Neuroscience*, *6*, 37.

Karsch, F. (2015). *Medizin zwischen Markt und Moral: Zur Kommerzialisierung ärztlicher Handlungsfelder*. transcript Verlag. https://doi.org/10.1515/transcript.9783839428900

Kaspersky Labs. (2020). *The Future of Human Augmentation 2020*. https://media.kasperskydaily.com/wp-content/uploads/sites/86/2020/09/17130024/Kaspersky-The-Future-of-Human-Augmentation-Report.pdf

Kass, L. (2003). *Beyond therapy: Biotechnology and the pursuit of happiness*. Executive Office of the President.

Kass, L. R. (2004). *Life, liberty and the defense of dignity: The challenge for bioethics* (1. paperback ed). Encounter Books.

Kastenhofer, K., & Torgersen, H. (2015). Spekulative Verantwortung. In A. Bogner, M. Decker, & M. Sotoudeh (Eds.), *Responsible Innovation* (pp. 349–358). Nomos. https://doi.org/10.5771/9783845272825-349

Kettner, M. (2006). „Wunscherfüllende Medizin “–Assistenz zum besseren Leben. *GGW*, *2*(6), 7–16.

Klerman, G. L. (1972). Psychotropic Hedonism vs. Pharmacological Calvinism. *The Hastings Center Report*, *2*(4), 1. https://doi.org/10.2307/3561398

Koene, R., & Deca, D. (2013). Whole brain emulation seeks to implement a mind and its general intelligence through system identification. *Journal of Artificial General Intelligence*, *4*(3), 1.

Koestler, F. A. (2004). *The unseen minority: A social history of blindness in the United States*. American Foundation for the Blind.

Komesaroff, L., Komesaroff, P. A., & Hyde, M. (2015). Ethical Issues in Cochlear Implantation. In J. Clausen & N. Levy (Eds.), *Handbook of Neuroethics* (pp. 815–826). Springer Netherlands. https://doi.org/10.1007/978-94-007-4707-4_125

König, S. U., Schumann, F., Keyser, J., Goeke, C., Krause, C., Wache, S., Lytochkin, A., Ebert, M., Brunsch, V., & Wahn, B. (2016). Learning new sensorimotor contingencies: Effects of long-term use of sensory augmentation on the brain and conscious perception. *PloS One*, *11*(12), e0166647.

Krämer, K., & Nolting, H.-D. (2009). *DAK Gesundheitsreport 2009. Schwerpunktthema Doping am Arbeitsplatz.* DAK.

Kramer, P. D. (1993). *Listening to Prozac*. Penguin Books.

Kronberger, N. (2015). Of worlds and objects: Scientific knowledge and its publics. In G. Sammut, E. Andreouli, G. Gaskell, & J. Valsiner (Eds.), *The Cambridge handbook of social representations*. Cambridge University Press.

Kurzweil, R. (1990). *The age of intelligent machines* (3. print). MIT Press.

Kurzweil, R. (2005). *The singularity is near: When humans transcend biology*. Penguin.

Lamont, M., & Swidler, A. (2014). Methodological Pluralism and the Possibilities and Limits of Interviewing. *Qualitative Sociology*, *37*(2), 153–171. https://doi.org/10.1007/s11133-014-9274-z

Lang, F. (Director). (1927). *Metropolis*.

Larratt, S. (2004). *Larratt, S. (2004). The gift of magnetic vision. Modblog*. Modblog. https://news.bme.com/2004/02/06/the-gift-of-magnetic-vision-the-publishers-ring/

Larriviere, D., Williams, M. A., Rizzo, M., Bonnie, R. J., & On behalf of the AAN Ethics, Law and Humanities Committee. (2009). Responding to requests from adult patients for neuroenhancements: Guidance of the Ethics, Law and Humanities Committee. *Neurology*, *73*(17), 1406–1412. https://doi.org/10.1212/WNL.0b013e3181beecfe

Lauber, C., Nordt, C., Falcato, L., & Rössler, W. (2005). Can a seizure help? The public's attitude toward electroconvulsive therapy. *Psychiatry Research*, *134*(2), 205–209. https://doi.org/10.1016/j.psychres.2004.07.010

Lishner, D. A., Batson, C. D., & Huss, E. (2011). Tenderness and Sympathy: Distinct Empathic Emotions Elicited by Different Forms of Need. *Personality and Social Psychology Bulletin*, *37*(5), 614–625. https://doi.org/10.1177/0146167211403157

Looi, C. Y., & Kadosh, R. C. (2015). The use of transcranial direct current stimulation for cognitive enhancement. In *Cognitive Enhancement* (pp. 307–341). Elsevier.

Lopatto, E. (2019). *Elon Musk unveils Neuralink's plans for brain-reading 'threads' and a robot to insert them*. The Verge. https://www.theverge.com/2019/7/16/20697123/elon-musk-neuralink-brain-reading-thread-robot

Löwith, K. (2011). *Meaning in history: The theological implications of the philosophy of history*. University of Chicago Press.

MacFarlane, J. M. (2020). *Transhumanism as a New Social Movement: The Techno-Centred Imagination*. Springer.

Maher, B. (2008). Poll results: Look who's doping. *Nature*, *452*(7188), 674–675. https://doi.org/10.1038/452674a

Maier, L. J., Haug, S., & Schaub, M. P. (2016). Prevalence of and motives for pharmacological neuroenhancement in Switzerland—Results from a national internet panel. *Addiction*, *111*(2), 280–295.

Marraccini, M. E., Weyandt, L. L., Rossi, J. S., & Gudmundsdottir, B. G. (2016). Neurocognitive enhancement or impairment? A systematic meta-analysis of prescription stimulant effects on processing speed, decision-making, planning, and cognitive perseveration. *Experimental and Clinical Psychopharmacology*, *24*(4), 269.

Marris, C. (2001). Public views on GMOs: Deconstructing the myths. *EMBO Reports*, *2*(7), 545–548. https://doi.org/10.1093/embo-reports/kve142

Martin, J. (2006). *The meaning of the 21st century: A vital blueprint for ensuring our future*. Riverhead Books.

Maslen, H., Douglas, T., Cohen Kadosh, R., Levy, N., & Savulescu, J. (2014). The regulation of cognitive enhancement devices: Extending the medical model. *Journal of Law and the Biosciences*, *1*(1), 68–93.

Maslen, H., Douglas, T., Kadosh, R. C., Levy, N., & Savulescu, J. (2015). Do-it-yourself brain stimulation: A regulatory model. *Journal of Medical Ethics*, *41*(5), 413–414.

Maslen, H., Santoni de Sio, F., & Faber, N. (2015). With Cognitive Enhancement Comes Great Responsibility? In B.-J. Koops, I. Oosterlaken, H. Romijn, T. Swierstra, & J. van den Hoven (Eds.), *Responsible Innovation 2* (pp. 121–138). Springer International Publishing. https://doi.org/10.1007/978-3-319-17308-5_7

More, M. (2004). *The Proactionary Principle*. Extropy Institute. https://www.extropy.org/proactionaryprinciple.htm

More, M. (2013). A letter to Mother Nature. *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future*, 449–450.

Moscovici, S. (2008). *Psychoanalysis: Its image and its public*. Polity.

Moynihan, R., CG, P., Heath, I., & Henry, D. (2002). Selling sickness: The pharmaceutical industry and disease mongeringCommentary: Medicalisation of risk factors. *Bmj*, *324*(7342), 886–891.

Murphy, E. R., Illes, J., & Reiner, P. B. (2008). Neuroethics of neuromarketing. *Journal of Consumer Behaviour*, *7*(4–5), 293–302. https://doi.org/10.1002/cb.252

Myers, J. (1992). Nonmainstream body modification: Genital piercing, branding, burning, and cutting. *Journal of Contemporary Ethnography*, *21*(3), 267–306.

Nadler, R., & Reiner, P. B. (2011). Prototypes or Pragmatics? The Open Question of Public Attitudes Toward Enhancement. *AJOB Neuroscience*, *2*(2), 49–50. https://doi.org/10.1080/21507740.2011.559926

Nagel, S. K., Carl, C., Kringe, T., Märtin, R., & König, P. (2005). Beyond sensory substitution—Learning the sixth sense. *Journal of Neural Engineering*, *2*(4), R13.

Nichols, A. L., & Maner, J. K. (2008). The Good-Subject Effect: Investigating Participant Demand Characteristics. *The Journal of General Psychology*, *135*(2), 151–166. https://doi.org/10.3200/GENP.135.2.151-166

Nitsche, M. A., Cohen, L. G., Wassermann, E. M., Priori, A., Lang, N., Antal, A., Paulus, W., Hummel, F., Boggio, P. S., & Fregni, F. (2008). Transcranial direct current stimulation: State of the art 2008. *Brain Stimulation*, *1*(3), 206–223.

Nordmann, A. (2004). *Converging Technologies – Shaping the Future of European Societies*. European Commission.

Nordmann, A. (2007). If and then: A critique of speculative nanoethics. *Nanoethics*, *1*(1), 31–46.

Norton, Q. (2006). *A sixth sense for a wired world*. Wired. https://www.wired.com/2006/06/a-sixth-sense-for-a-wired-world/

Novich, S. (2015). *Sound-to-touch sensory substitution and beyond. (Doctoral dissertation).* Rice University.

O'Connor, C., & Joffe, H. (2015). How the Public Engages With Brain Optimization: The Media-mind Relationship. *Science, Technology, & Human Values*, *40*(5), 712–743. https://doi.org/10.1177/0162243915576374

Oetler, M. (1995). From Captain America to Wolverine: Cyborgs in Comic Books, Alternative Images of Cybernetic Heroes and Villians. In C. Hables-Gray (Ed.), *The Cyborg Handbook* (pp. 219–223). Routledge New York.

Ohler, N. (2015). *Der totale Rausch: Drogen im Dritten Reich* (2. Auflage). Kiepenheuer & Witsch.

Onwuegbuzie, A. J. (2003). Effect Sizes in Qualitative Research: A Prolegomenon. *Quality and Quantity*, *37*(4), 393–409. https://doi.org/10.1023/A:1027379223537

Österreichische Suchtpräventionsstrategie Strategie für kohärente Präventions- und Suchtpolitik. (2015). Bundesministerium für Gesundheit (BMG).

Ovanesoff, A. (2019). *Waking up to a new reality: Building a responsible future for immersive technologies.* Accenture. https://www.accenture.com/_acnmedia/accenture/redesign-assets/dotcom/documents/global/1/accenture-g20-yea-report.pdf

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible Research and Innovation: From Science in Society to Science for Society, with Society. *Science and Public Policy*, *39*, 751–760.

Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., & Guston, D. (2013). A framework for responsible innovation. *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, *31*, 27–50.

Pancaldi, G., & Bertucci, P. (2001). Electric bodies: Episodes in the history of medical electricity. *Bologna Studies in History of Science*, *9*.

Parens, E. (Ed.). (1998a). *Enhancing human traits: Ethical and social implications*. Georgetown University Press.

Parens, E. (1998b). Special supplement: Is better always good? The enhancement project. *The Hastings Center Report*, *28*(1), S1–S17.

Parens, E. (2015). *Shaping our selves: On technology, flourishing, and a habit of thinking*. Oxford University Press.

Parent, A. (2004). Giovanni Aldini: From animal electricity to human brain stimulation. *Canadian Journal of Neurological Sciences*, *31*(4), 576–584.

Partridge, B. J., Bell, S. K., Lucke, J. C., Yeates, S., & Hall, W. D. (2011). Smart Drugs "As Common As Coffee": Media Hype about Neuroenhancement. *PLoS ONE*, *6*(11), e28416. https://doi.org/10.1371/journal.pone.0028416

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods.* (3rd ed.). SAGE.

Persson, I., & Savulescu, J. (2012). *Unfit for the future: The need for moral enhancement*. OUP Oxford.

Pfister, W. (Director). (2014). *Transcendence*. Warner Bros. Pictures.

Pollan, M. (2021). *This is your mind on plants*. Penguin Press.

Popper, B. (2012). *New evidence emerges in alleged assault on cyborg at Paris McDonald's.* The Verge. https://www.theverge.com/2012/7/19/3169889/steve-mann-cyborg-assault-mcdonalds-eyetap-paris

Prudhomme, M. (2020). *SIENNA D3.5: Public views of human enhancement technologies in 11 EU and non-EU countries*. https://doi.org/10.5281/ZENODO.4068194

Quednow, B. B. (2010). Ethics of neuroenhancement: A phantom debate. *BioSocieties*, *5*(1), 153–156. https://doi.org/10.1057/biosoc.2009.13

Racine, E., & Forlini, C. (2010). Cognitive Enhancement, Lifestyle Choice or Misuse of Prescription Drugs?: Ethics Blind Spots in Current Debates. *Neuroethics*, *3*(1), 1–4. https://doi.org/10.1007/s12152-008-9023-7

Ragan, C. I., Bard, I., & Singh, I. (2013). What should we do about student use of cognitive enhancers? An analysis of current evidence. *Neuropharmacology*, *64*, 588–595.

Rainey, S., & Erden, Y. J. (2020). Correcting the brain? The convergence of neuroscience, neurotechnology, psychiatry, and artificial intelligence. *Science and Engineering Ethics*, *26*(5), 2439–2454.

Rainie, L., Funk, C., Anderson, M., & Tyson, A. (2022). *Public cautious about enhancing cognitive function using computer chip implants in the brain*. Pew Research. https://www.pewresearch.org/internet/2022/03/17/public-cautious-about-enhancing-cognitive-function-using-computer-chip-implants-in-the-brain/

Rasmussen, N. (2008). On speed. In *On Speed*. New York University Press.

Rawls, J. (1971). *A Theory of Justice*. Harvard University Press.

Reiner, P. B. (2019). Experimental Neuroethics. In S. K. Nagel (Ed.), *Shaping Children* (pp. 75–83). Springer International Publishing. https://doi.org/10.1007/978-3-030-10677-5_6

Reinhart, R. M., & Nguyen, J. A. (2019). Working memory revived in older adults by synchronizing rhythmic brain circuits. *Nature Neuroscience*, *22*(5), 820–827.

Renier, L., & De Volder, A. G. (2013). *Sensory substitution devices: Creating "artificial synesthesias"*.

Repantis, D., Bovy, L., Ohla, K., Kühn, S., & Dresler, M. (2021). Cognitive enhancement effects of stimulants: A randomized controlled trial testing methylphenidate, modafinil, and caffeine. *Psychopharmacology*, *238*(2), 441–451. https://doi.org/10.1007/s00213-020-05691-w

Repantis, D., Schlattmann, P., Laisney, O., & Heuser, I. (2010). Modafinil and methylphenidate for neuroenhancement in healthy individuals: A systematic review. *Pharmacological Research*, *62*(3), 187–206.

Research Councils UK. (2010). *Concordat for engaging the public with research: A set of principles drawn up by the funders of research in the UK*. Research Councils UK. http://www.rcuk.ac.uk/per/Pages/Concordat.aspx

Ribas, M. (2020). Waiting for Earthquakes. In C. Hables-Gray, H. J. Figueroa-Sarriera, & S. Mentor (Eds.), *Modified* (pp. 193–196). Routledge.

Roberts, C. A., Jones, A., Sumnall, H., Gage, S. H., & Montgomery, C. (2020). How effective are pharmaceuticals for cognitive enhancement in healthy adults? A series of meta-analyses of cognitive performance during acute administration of modafinil, methylphenidate and D-amphetamine. *European Neuropsychopharmacology*, *38*, 40–62. https://doi.org/10.1016/j.euroneuro.2020.07.002

Robertson, A. (2017). *I hacked my body for a future that never came.* The Verge. https://www.theverge.com/2017/7/21/15999544/biohacking-finger-magnet-human-augmentationloss

Roco, M. C., & Bainbridge, W. S. (Eds.). (2002). *Converging technologies for improving human performance: Nanotechnology, biotechnology, information technology and cognitive science*. Kluwer Academic Publishers.

Rose, N. S. (2007). *Politics of life itself: Biomedicine, power, and subjectivity in the twenty-first century*. Princeton University Press.

Rose, N. S., & Abi-Rached, J. M. (2013). *Neuro: The new brain sciences and the management of the mind*. Princeton University Press.

Rose, S. (2002). ‘Smart Drugs’: Do they work? Are they ethical? Will they be legal? *Nature Reviews Neuroscience*, *3*(12), 975–979. https://doi.org/10.1038/nrn984

Rowbottom, M., & Susskind, C. (1984). *Electricity and medicine: History of their interaction*. San Francisco Press.

Royal Society. (2019). *IHuman: Blurring lines between mind and machine*. The Royal Society.

Sabin, J. E., & Daniels, N. (1994). Determining" medical necessity" in mental health practice. *The Hastings Center Report*, *24*(6), 5–13.

Sahakian, B., & Morein-Zamir, S. (2007). Professor's little helper. *Nature*, *450*(7173), 1157–1159. https://doi.org/10.1038/4501157a

Saldaña, J. (2021). *The coding manual for qualitative researchers* (4E [Fourth editiion]). SAGE Publishing Inc.

Sammut, G. (2010). *The Point of View: Towards a Social Psychology of Relativity [Doctoral dissertation]*. London School of Economics.

Sandel, M. (2007). *The Case Against Perfection*. Harvard University Press.

Santarnecchi, E., Feurra, M., Galli, G., Rossi, A., & Rossi, S. (2013). Overclock your brain for gaming? Ethical, social and health care risks. *Brain Stimulation: Basic, Translational, and Clinical Research in Neuromodulation*, *6*(5), 713–714.

Sattler, S., Forlini, C., Racine, É., & Sauer, C. (2013). Impact of Contextual Factors and Substance Characteristics on Perspectives toward Cognitive Enhancement. *PLoS ONE*, *8*(8), e71452. https://doi.org/10.1371/journal.pone.0071452

Sattler, S., & Wörn, J. (2019). Public perceptions of prescription drug use for cognitive enhancement in healthy children and adolescents. In *Shaping children* (pp. 85–103). Springer.

Scarf, M. (1970, November 15). Brain Researcher Jose Delgado Asks-'What Kind of Humans Would We Like to Construct?'. *The New York Times*.

Scheske, C., & Schnall, S. (2012). The Ethics of "Smart Drugs": Moral Judgments About Healthy People's Use of Cognitive-Enhancing Drugs. *Basic and Applied Social Psychology*, *34*(6), 508–515. https://doi.org/10.1080/01973533.2012.711692

Schleim, S., & Quednow, B. B. (2017). Debunking the ethical neuroenhancement debate. *Rethinking Cognitive Enhancement*, 164–176.

Schöne-Seifert, B., Talbot, D., Opolka, U., & Ach, J. S. (Eds.). (2009). *Neuro-Enhancement: Ethik vor neuen Herausforderungen: [Tagung, die im Herbst 2005 zum Thema 'Neuro-Enhancement - Verbesserung des Menschen und seines Gehirns: ethische, soziale und rechtliche Aspekte' am Hanse-Wissenschaftskolleg in Delmenhorst stattfand]*. mentis.

Schwartz, S. H. (2003). A proposal for measuring value orientations across nations. *Questionnaire Package of the European Social Survey*, *259*(290), 261.

Schwarz, N., & Sudman, S. (1992). *Context Effects in Social and Psychological Research*. Springer New York.

Serlin, D. (2004). *Replaceable you: Engineering the body in postwar America*. University of Chicago Press.

Sharon, T. (2017). Self-tracking for health and the quantified self: Re-articulating autonomy, solidarity, and authenticity in an age of personalized healthcare. *Philosophy & Technology*, *30*(1), 93–121.

Sharon, T., & Zandbergen, D. (2017). From data fetishism to quantifying selves: Self-tracking practices and the other values of data. *New Media & Society*, *19*(11), 1695–1709.

Short, S. (2005). *Cyborg cinema and contemporary subjectivity*. Springer.

Shorter, E. (1997). *A history of psychiatry: From the era of the asylum to the age of Prozac*. Wiley.

Shorter, E., & Healy, D. (2007). *Shock therapy: A history of electroconvulsive treatment in mental illness*. Rutgers University Press.

Siegrist, M., Cvetkovich, G., & Roth, C. (2000). Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis*, *20*(3), 353–362.

Silvers, A. (1998). A fatal attraction to normalizing: Treating disabilities as deviations from "species-typical" functioning. In E. Parens (Ed.), *Enhancing Human Traits*. Georgetown University Press.

Singh, I. (2002). Bad Boys, Good Mothers, and the Miracle of Ritalin. *Science in Context*, *15*(4), 577–603. https://doi.org/10.1017/S0269889702000650

Singh, I., Bard, I., & Jackson, J. (2014). Robust Resilience and Substantial Interest: A Survey of Pharmacological Cognitive Enhancement among University Students in the UK and Ireland. *PLoS ONE*, *9*(10), e105969. https://doi.org/10.1371/journal.pone.0105969

Singh, I., & Kelleher, K. J. (2010). Neuroenhancement in Young People: Proposal for Research, Policy, and Clinical Management. *AJOB Neuroscience*, *1*(1), 3–16. https://doi.org/10.1080/21507740903508591

Smallman, M. (2018). Science to the rescue or contingent progress? Comparing 10 years of public, expert and policy discourses on new and emerging science and technology in the United Kingdom. *Public Understanding of Science*, *27*(6), 655–673. https://doi.org/10.1177/0963662517706452

Smith, M. E., & Farah, M. J. (2011). Are prescription stimulants "smart pills"? The epidemiology and cognitive neuroscience of prescription stimulant use by normal healthy individuals. *Psychological Bulletin*, *137*(5), 717.

Sparrow, R. (2005). Defending deaf culture: The case of cochlear implants. *Journal of Political Philosophy*, *13*(2), 135–152.

Specker, J., Schermer, M. H., & Reiner, P. B. (2017). Public attitudes towards moral enhancement. Evidence that means matter morally. *Neuroethics*, *10*(3), 405–417.

Spence, C. (2014). The skin as a medium for sensory substitution. *Multisensory Research*, *27*(5–6), 293–312.

Spence, C. (2018). Sensory substitution: Unfulfilled promises and fundamental limitations. In F. Macpherson (Ed.), *Sensory substitution and augmentation*. Oxford University Press.

Steel, D., Bolduc, N., Jenei, K., & Burgess, M. (2020). Rethinking Representation and Diversity in Deliberative Minipublics. *Journal of Deliberative Democracy*, *16*(1). https://doi.org/10.16997/jdd.398

Steinley, D. (2006). K-means clustering: A half-century synthesis. *British Journal of Mathematical and Statistical Psychology*, *59*(1), 1–34.

Steward, A., & Pickersgill, M. (2019). Developing expertise, customising sleep, enhancing study practices: Exploring the legitimisation of modafinil use within the accounts of UK undergraduate students. *Drugs: Education, Prevention and Policy*, *26*(4), 347–355. https://doi.org/10.1080/09687637.2018.1555231

Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? *Public Understanding of Science*, *23*(1), 4–15.

Stilgoe, J., Macnaghten, P., & Owen, R. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568–1580.

Stock, G. (2003). *Redesigning humans: Choosing our genes, changing our future* (1st Mariner Books ed). Houghton Mifflin.

Stupple-Harris, L. (2015). *Public attitudes to human enhancement*. ScienceWise. https://webarchive.nationalarchives.gov.uk/ukgwa/20170110110308/http://www.scien cewise-erc.org.uk/cms/assets/Uploads/Public-attitudes-to-human-enhancement-Sciencewise-Social-Intelligence-Report-2015.pdf

Sturgis, P. (2014). On the limits of public engagement for the governance of emerging technologies. *Public Understanding of Science*, *23*(1), 38–42.

Sugarman, J., & Sulmasy, D. P. (2001). *Methods in medical ethics*. Georgetown University Press.

Swan, M. (2012). Health 2050: The realization of personalized medicine through crowdsourcing, the quantified self, and the participatory biocitizen. *Journal of Personalized Medicine*, *2*(3), 93–118.

Sweeny, C. (Director). (2015). *Limitless*. CBS Television Distribution.

Swierstra, T. (2013). *Nanotechnology and Technomoral Change*. *15*(1), 200–219.

Syakur, M., Khotimah, B., Rochman, E., & Satoto, B. D. (2018). *Integration k-means clustering method and elbow method for identification of the best customer profile cluster*. *336*, 012017.

TAB. (2020). *BRIEF NR. 51*. Büro für Technikfolgenabschätzung beim deutschen Bundesrat.

Talks at Google (Director). (2016, November 21). *What's it Like to be a Cyborg? | Neil Harbisson + More | Talks at Google [Video].* YouTube. https://www.youtube.com/watch?v=rRU62Csr_jI

Tanenbaum, T. J., Williams, A. M., Desjardins, A., & Tanenbaum, K. (2013). *Democratizing technology: Pleasure, utility and expressiveness in DIY and maker practice*. 2603–2612.

Taylor, N., Hurley, U., & Connolly, P. (2016). Making Community: The Wider Role of Makerspaces in Public Life. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 1415–1425. https://doi.org/10.1145/2858036.2858073

TechnikRadar. (2018). *Was die Deutschen über Technik denken*. acatech München und Körber-Stiftung, Hamburg. https://www.acatech.de/publikation/technikradar-2018-was-die-deutschen-ueber-technik-denken/download-pdf?lang=de

TED (Director). (2012, July 20). *Neil Harbisson: I listen to color [Video]*. YouTube. https://www.youtube.com/watch?v=ygRNoieAnzI

TEDx Talks (Director). (2015, January 27). *Searching for my sense | Moon Ribas | TEDxMünchen [Video]*. YouTube. https://www.youtube.com/watch?v=qU6UPUlbmLw

TEDx Talks (Director). (2016, November 16). *They thought I hacked my body. I really hacked my mind. | Liviu Babitz | TEDxAntwerp [Video]*. YouTube. https://www.youtube.com/watch?v=DDEhVJxYgEQ

ter Meulen, R. (2012). Human Enhancement: A Policy Perspective for the European Union. In T. A. Boer & R. Fischer (Eds.), *Human enhancement: Scientific, ethical and theological aspects from a European perspective*. Church and Society Commission of CEC.

Thaddeus-Johns, J. (2017). *Meet the first humans to sense where north is*. The Guardian. https://www.theguardian.com/technology/2017/jan/06/first-humans-sense-where-north-is-cyborg-gadget

Thévoz, M. (1984). *The painted body*. Skira/Rizzoli.

Thompson, C. (2013). *Good science: The ethical choreography of stem cell research*. MIT Press.

Thomson, H. (2019, October 31). Europe's first home brain-zap device for depression launched in UK. *New Scientist*.

Thurstone, L. L. (1967). The Measurement of Social Attitudes. In M. Fishbein (Ed.), *Readings in attitude theory and measurement* (pp. 14–25). John Wiley & Sons, Ltd.

Toombs, A. L. (2017). Hackerspace Tropes, Identities, and Community Values. *Proceedings of the 2017 Conference on Designing Interactive Systems*, 1079–1091. https://doi.org/10.1145/3064663.3064760

Torgersen, H., & Schmidt, M. (2013). Frames and comparators: How might a debate on synthetic biology evolve? *Futures*, *48*, 44–54.

Tversky, A., & Kahneman, D. (1979). An analysis of decision under risk. *Econometrica*, *47*(2), 263–292.

UK House of Lords. (2000). *House of Lords Select Committee on Science and Technology, Science and Society*. House of Lords. https://publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm

Vagwala, M. K., Bicquelet, A., Didziokaite, G., Coomber, R., Corrigan, O., & Singh, I. (2017). Towards a Moral Ecology of Pharmacological Cognitive Enhancement in British Universities. *Neuroethics*, *10*(3), 389–403. https://doi.org/10.1007/s12152-017-9336-5

Valjamae, A., Evers, L., Allison, B. Z., Ongering, J., Riccio, A., Igardi, I., & Lamas, D. (2017). The BrainHack Project: Exploring Art - BCI Hackathons. *Proceedings of the 2017 ACM Workshop on An Application-Oriented Approach to BCI out of the Laboratory*, 21–24. https://doi.org/10.1145/3038439.3038447

Vargo, E. J., & Petróczi, A. (2016). "It Was Me on a Good Day": Exploring the Smart Drug Use Phenomenon in England. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.00779

Veit, W., Earp, B. D., Faber, N., Bostrom, N., Caouette, J., Mannino, A., Caviola, L., Sandberg, A., & Savulescu, J. (2020). Recognizing the Diversity of Cognitive Enhancements. *AJOB Neuroscience*, *11*(4), 250–253. https://doi.org/10.1080/21507740.2020.1830878

Viertbauer, K., & Kögerler, R. (Eds.). (2019). *Neuroenhancement: Die philosophische Debatte* (Erste Auflage). Suhrkamp.

Vincent, K. A. (2013). The advantages of repeat interviews in a study with pregnant schoolgirls and schoolgirl mothers: Piecing together the jigsaw. *International Journal of Research & Method in Education*, *36*(4), 341–354. https://doi.org/10.1080/1743727X.2012.705276

von Schomberg, R. (2013). A Vision of Responsible Research and Innovation. In R. Owen, J. Bessant, & M. Heintz (Eds.), *Responsible Innovation* (pp. 51–74). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118551424.ch3

Wade, G. (2005). *Seeing things in a different light*. BBC. https://www.bbc.co.uk/devon/news_features/2005/eyeborg.shtml

Wagner, G. (2017). *Selbstoptimierung: Praxis und Kritik von Neuroenhancement*. Campus Verlag.

Walsh, V. Q. (2013). Ethics and Social Risks in Brain Stimulation. *Brain Stimulation*, *6*(5), 715–717. https://doi.org/10.1016/j.brs.2013.08.001

Waltz, E. (2019). The brain hackers. *Nature Biotechnology*, *37*(9), 983–987. https://doi.org/10.1038/s41587-019-0238-4

Warwick, K. (2016). Transhumanism: Some practical possibilities. *FifF Kommunikation*, *2016*(2), 24–27.

Webster, J., Tompkins, W., & Crabb, T. (1987). *Sensory substitution for space gloves and for space robots*. Jet Propulsion Lab., California Inst. of Tech., Proceedings of the Workshop on Space Telerobotics, Volume 2.

Wexler, A. (2016a). The practices of do-it-yourself brain stimulation: Implications for ethical considerations and regulatory proposals. *Journal of Medical Ethics*, *42*(4), 211–215. https://doi.org/10.1136/medethics-2015-102704

Wexler, A. (2016b, July 24). Zapping Their Brains at Home. *The New York Times*. https://www.nytimes.com/2016/07/24/opinion/sunday/zapping-their-brains-at-home.html

Wexler, A. (2017). The social context of "do-it-yourself" brain stimulation: Neurohackers, biohackers, and lifehackers. *Frontiers in Human Neuroscience*, *11*, 224.

Wexler, A. (2018). Who Uses Direct-to-Consumer Brain Stimulation Products, and Why? A Study of Home Users of tDCS Devices. *Journal of Cognitive Enhancement*, *2*(1), 114–134. https://doi.org/10.1007/s41465-017-0062-z

Wexler, A., & Reiner, P. B. (2019). Oversight of direct-to-consumer neurotechnologies. *Science*, *363*(6424), 234–235. https://doi.org/10.1126/science.aav0223

Wexler, A., & Thibault, R. (2019). Mind-Reading or Misleading? Assessing Direct-to-Consumer Electroencephalography (EEG) Devices Marketed for Wellness and Their Ethical and Regulatory Implications. *Journal of Cognitive Enhancement*, *3*(1), 131–137. https://doi.org/10.1007/s41465-018-0091-2

Wiesing, U. (2009). The History of Medical Enhancement: From Restitutio ad Integrum to Transformatio ad Optimum? In B. Gordijn & R. Chadwick (Eds.), *Medical Enhancement and Posthumanity* (Vol. 2, pp. 9–24). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8852-0_2

Wilhelmy, S., Rolfes, V., Grözinger, M., Chikere, Y., Schöttle, S., & Groß, D. (2018). Knowledge and attitudes on electroconvulsive therapy in Germany: A web based survey. *Psychiatry Research*, *262*, 407–412. https://doi.org/10.1016/j.psychres.2017.09.015

Williams, S. J., Martin, P., & Gabe, J. (2011). The pharmaceuticalisation of society? A framework for analysis. *Sociology of Health & Illness*, *33*(5), 710–725.

Wilsdon, J., & Willis, R. (2004). *See-through science: Why public engagement needs to move upstream*. Demos.

Wolbring, G. (2013). Hearing beyond the normal enabled by therapeutic devices: The role of the recipient and the hearing profession. *Neuroethics*, *6*(3), 607–616.

Wolpe, P. R. (2002). Treatment, enhancement, and the ethics of neurotherapeutics. *Brain and Cognition*, *50*(3), 387–395.

Wolstenholme, G. (1963). *Man and His Future*. Ciba Foundation.

Wong, W. L., Su, X., Li, X., Cheung, C. M. G., Klein, R., Cheng, C.-Y., & Wong, T. Y. (2014). Global prevalence of age-related macular degeneration and disease burden projection for 2020 and 2040: A systematic review and meta-analysis. *The Lancet Global Health*, *2*(2), e106–e116.

World Health Organization. (2019). *Deafness and hearing loss.* https://www.who.int/newsroom/factsheets/detail/deafness-and-hearing-loss

Wurzman, R., Hamilton, R. H., Pascual-Leone, A., & Fox, M. D. (2016). An open letter concerning do-it-yourself users of transcranial direct current stimulation: DIY-tDCS. *Annals of Neurology*, *80*(1), 1–4. https://doi.org/10.1002/ana.24689

Yesley, M. S. (2008). What's ELSI got to do with it? Bioethics and the Human Genome Project. *New Genetics and Society*, *27*(1), 1–6. https://doi.org/10.1080/14636770701843527

Zohny, H. (2015). The Myth of Cognitive Enhancement Drugs. *Neuroethics*, *8*(3), 257–269. https://doi.org/10.1007/s12152-015-9232-9

Zwart, H., Brenninkmeijer, J., Eduard, P., Krabbenborg, L., Laursen, S., Revuelta, G., & Toonders, W. (2017). Reflection as a Deliberative and Distributed Practice: Assessing Neuro-Enhancement Technologies via Mutual Learning Exercises (MLEs). *NanoEthics*, *11*(2), 127–138. https://doi.org/10.1007/s11569-017-0287-4

Zwart, H., Landeweerd, L., & van Rooij, A. (2014). Adapt or perish? Assessing the recent shift in the European research funding arena from ‘ELSA’ to ‘RRI’. *Life Sciences, Society and Policy*, *10*(1), 11. https://doi.org/10.1186/s40504-014-0011-x

Appendix A

Appendix A1. Coding frame with example comments.

Category	Code	Example comments
Health	concerns about side effects	- I may not be able to deal with insomnia - the side effect are not great - I disagree because insomnia isn't a pleasant side effect
Health	unknown (long-term) effects	- "I feel there may be too many unknown risks to the brain." - "I would not trust that this device would not have harmful effects the future." - "You don't really know the long term effects"
Health	dangerous / risky / not safe	- Wow, seems like a scary procedure. - it could be very dangerous. - its too dangerous to take pills
Health	addiction or dependence	- Pills scare me, addiction ???? - I understand why it could benefit him but he could get addicted and who knows what could happen next - silly, little advantage and could be addictive
Acceptability Assessment	unfavourable risk-benefit profile / low performance gain	- I don't believe the benefits outweigh the negatives. - Don't agree because the risk in my opinion is not worth it. - Just doesn't seem to make much of a difference for justn10% improvement.
Acceptability Assessment	favourable risk-benefit profile	- Yes I agree. Fifty percent increase is amazing. If the side effects low and the possible headache is tolerable this pill could help m people. - It has no known side affects, & might help keep her job. - I agree because there appear to be no serious side effects.
Acceptability Assessment	worth a try	- its worth a try - If it helps with few side effects then I believe it may be worth tryi - Try it and see what happens
Acceptability Assessment	no need	- I disagree because she already met her boss expectations - Does not seem like a pressing enough need

		- She is doing well enough without the pill and there isn't enough an advantage to make it worth it.
Acceptability Assessment	only for medicine	- Never take any "medication" unless you really have to and then on the advice of a qualified doctor. - Don't like the idea of taking pills for advantage rather than for medical problems - drugs are only for ilness
Acceptability Assessment	only for short-term / as a last resort	- As a short term measure this would be fine, I wouldn't do it long tho - the side effects are bearable compared with the chance of impr learning to complete the tasks as it is likely to be a short term n - Her future employment is at stake if she fails her degree so on balance as a short term measure this pill is an acceptable optio
Acceptability Assessment	needs professional/medical oversight	- You should not use any type of device / medication without talk a doctor - Theres no way something like that should be attempted without medical advice - It seems like the may be dangerous to put electrodes on yourse without medical supervision...
Moral	rely on effort / authenticity	- If one can't do it without pills or machines it's not natural and it w last. - Do it on your own or not at all - I like doing things under my own merit.
Moral	be the best you can be / improvement is good / get ahead	- Anything you can do to get a edge or better yourself - Because u need to take risks to get rewarded - I agree with her decision, because in the long run she will get h promotion.
Moral	wrong to risk health for performance	- i wouldnt want to risk my health for a job - i dont know if i would be willing to become and insomniac for a j - I wouldn't risk my mental health for a job.
Moral	messing with body/brain / unnatural / artificial	- I think it is unatural and hazardous to her health. - i would not want to mess with my brain in that way - It is not natural
Moral	cheating / doping / unfair advantage	- I feel it would be dishonest. Likening the situation to an athlete taking steroids. - Because it is wrong, not fair to the other employees

		- it is unfair for her to se it as it is like using performance enhanci drgs
Situation	coping with pressure / fear of loss / high stakes / desperation	- It's his livelihood, he wouldn't be able to support himself or his family, in the same position I'd do anything for my family. - Need to hold onto a job to help pay your bills and get ahead int world - I agree with her because if she didn't try anything she would los job
Situation	empathy / understanding for the decision	- She is desperate to keep her job and wants to do whatever she do reasonably to keep it. I understand that. - I agree with jacks choice cuz I've been in his shoes before - I can sympathize with his willingness to find any advantage to h him perform better
Situation	Illegitimate pressure from labour market	- you should not have to use electrical currents to help you get a - I don't think your job should should have those type of expectat - Demanding such performance is a sin
Situation	Competition and performance pressures	- Sometimes you need to do what you need to to stay ahead and productive. There is always someone trying to out do you. - Today's world is tough & never slows.
Alternatives	not a real solution	- pill will eventually not work, then what - i disagree because better concentration has little to do with gett promotion - Paul should learn where he has made mistakes at work and ai improve his own performance and ask for further training/suppo from his employer. No amount of electronic brain stimulation ca achieve this for him.
Alternatives	other methods preferable	- There are non medication alternatives to this situation - I disagree. He should simply use proper nutrition and study har - I would find a better way, like eating healthier
Alternatives	move on, change job, try something else	- using a drug to help you keep a job is in no way healthy. If he c keep up pace at his current job, find another job, there are a lot them out there. - She needs to face reality - should she be looking for another (m suitable) job - I can see why she would want to try but I think the risks aren't w I would just look for another job instead.

Sceptical	skeptical / doesn't work / placebo	- the machine is just an expensive placebo and will not help in the long run - This pill sounds like a quack remedy - I think the device is a scam and won't help him at all.
Uncertain	ambiguous / can't decide	- not sure - i am nuetral - i have no idea
Uncertain	more information needed / wait for evidence	- I dont believe that we know enough about the brain to experime with it in this manner - I will not take any kind of pills that I really do not know anything about - I would need more information before I would take a pill with su claims, so I do not agree completely, but I understand her conc about her grades
Gut argument	Unqualified disagreement	- not something i would do - Just wouldn't - Not good
Gut argument	unqualified support	- Agree - Best for him - It was a good choice.
Gut argument	Madness, crazy, stupid	- IT IS WRONG THING TOO DO - This is horrible! - he is a fool
Anti-drug	rejecting chemicals/drugs	- i don't like taking pills - dont take a drug for any reason - Pills, or drugs are not good for anyone.
Anti-drug	Devices rather than chemicals	- electrical current should cause no lasting side effects unlike a p - I feel that as there is nothing actually entering the body, such as pill, it is worth a try - I don't mind electrical stimuli but am anti chemical / drug stimula
Other	Other	- i can't - It's not excellent - The 1st candidate seems more like the logical choice to hire.

Appendix A2 - Country level regression analyses across education and employment contexts

AUSTRIA – EMPLOYMENT CONTEXT

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.535	0.224		15.804	0.00E+00
	Employment protagonist male	0.055	0.201	0.008	0.275	7.83E-01
	Employment Pill NE	**-0.754**	**0.201**	**-0.114**	**-3.743**	**0.00E+00**
	Employment Good performance	-0.258	0.201	-0.039	-1.28	2.01E-01
	Employment High NE efficacy	0.027	0.201	0.004	0.134	8.94E-01
Dependent Variable: Would you make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.121a	0.015	0.011	3.285		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.175	0.213		24.245	0.00E+00
	Employment protagonist male	-0.01	0.192	-0.002	-0.051	9.60E-01
	Employment Pill NE	**-0.601**	**0.192**	**-0.095**	**-3.131**	**2.00E-03**
	Employment Good performance	**-0.784**	**0.192**	**-0.123**	**-4.079**	**0.00E+00**
	Employment High NE efficacy	**0.431**	**0.192**	**0.068**	**2.241**	**2.50E-02**
Dependent Variable: Can you sympathise with the decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.170a	0.029	0.025	3.135		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.455	0.179		24.935	0.00E+00
	Employment protagonist male	0.175	0.161	0.033	1.091	2.76E-01
	Employment Pill NE	-0.043	0.161	-0.008	-0.269	7.88E-01

	Employment Good performance	0.308	0.161	0.059	1.916	5.60E-02
	Employment High NE efficacy	**0.433**	**0.161**	**0.082**	**2.692**	**7.00E-03**
Dependent Variable: Will X have an advantage over others? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.106a	0.011	0.008	2.624		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.134	0.181		28.289	0.00E+00
	Employment protagonist male	-0.139	0.163	-0.026	-0.852	3.95E-01
	Employment Pill NE	0.112	0.163	0.021	0.684	4.94E-01
	Employment Good performance	-0.119	0.163	-0.022	-0.728	4.67E-01
	Employment High NE efficacy	0.028	0.163	0.005	0.17	8.65E-01
Dependent Variable: Would most people make the same decision? (Emp)						
Model Summary						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.040a	0.002	-0.002	2.665		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.952	0.183		21.63	0.00E+00
	Employment protagonist male	0.001	0.165	0	0.004	9.97E-01
	Employment Pill NE	**-0.725**	**0.164**	**-0.134**	**-4.41**	**0.00E+00**
	Employment Good performance	-0.125	0.164	-0.023	- 0.761	4.47E-01
	Employment High NE efficacy	-0.031	0.164	-0.006	- 0.186	8.53E-01
a Dependent Variable: Do the benefits outweigh the risks? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.136a	0.019	0.015	2.684		
a Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

AUSTRIA – EDUCATION CONTEXT

Coefficients					
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	5.76	0.213		27.071
	Education protagonist male	0.21	0.191	0.033	1.101
	Education Pill NE	**-0.565**	**0.191**	**-0.09**	**-2.958**
	Education Good performance	**-0.707**	**0.191**	**-0.112**	**-3.701**
	Education High NE efficacy	0.257	0.191	0.041	1.346
Dependent Variable: Can you sympathise with the decision? (Edu)					
Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.152a	0.023	0.019	3.116	
Predictors: (Constant), Education High NE efficacy, Education Pill NE, Education protagonist male, Education Good performance					
Coefficients					

Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	5.474	0.179		30.546
	Education protagonist male	**0.449**	**0.161**	**0.085**	**2.791**
	Education Pill NE	-0.149	0.161	-0.028	-0.925
	Education Good performance	**-0.447**	**0.161**	**-0.084**	**-2.777**
	Education High NE efficacy	**0.493**	**0.161**	**0.093**	**3.068**
Dependent Variable: Would most people make the same decision? (Edu)					
Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.153a	0.023	0.02	2.624	
Predictors: (Constant), Education High NE efficacy, Education Pill NE, Education protagonist male, Education Good performance					
Coefficients					
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	3.746	0.233		16.046
	Education protagonist male	0.234	0.21	0.034	1.115

	Education Pill NE	**-0.685**	**0.21**	**-0.099**	**-3.267**
	Education Good performance	**-0.428**	**0.21**	**-0.062**	**-2.043**
	Education High NE efficacy	**0.572**	**0.21**	**0.083**	**2.732**
Dependent Variable: Would you make the same decision? (Edu)					
Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.146a	0.021	0.018	3.419	
Predictors: (Constant), Education High NE efficacy, Education Pill NE, Education protagonist male, Education Good performance					
Coefficients					
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	4.98	0.184		27.116
	Education protagonist male	-0.029	0.165	-0.005	-0.178
	Education Pill NE	-0.178	0.165	-0.033	-1.082
	Education Good performance	0.138	0.165	0.025	0.837
	Education High NE efficacy	**0.647**	**0.165**	**0.12**	**3.923**

Dependent Variable: Will X have an advantage over others? (Edu)					
Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.127a	0.016	0.012	2.69	
Predictors: (Constant), Education High NE efficacy, Education Pill NE, Education protagonist male, Education Good performance					
Coefficients					
Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	
1	(Constant)	3.908	0.187		20.893
	Education protagonist male	0.199	0.168	0.036	1.183
	Education Pill NE	**-0.564**	**0.168**	**-0.102**	**-3.36**
	Education Good performance	-0.194	0.168	-0.035	-1.156
	Education High NE efficacy	0.256	0.168	0.047	1.528
Dependent Variable: Do the benefits outweigh the risks? (Edu)					
Model Summary					

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	
1	.122a	0.015	0.011	2.739	
Predictors: (Constant), Education High NE efficacy, Education Pill NE, Education protagonist male, Education Good performance					

GERMANY – EMPLOYMENT CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.091	0.219		23.262	0.00E+00
	Employment protagonist male	-0.007	0.196	-0.001	-0.038	9.70E-01
	Employment Pill NE	-0.209	0.196	-0.032	-1.062	2.89E-01
	Employment Good performance	**-1.185**	**0.196**	**-0.181**	**-6.032**	**0.00E+00**
	Employment High NE efficacy	**0.526**	**0.196**	**0.08**	**2.679**	**7.00E-03**
Dependent Variable: Can you sympathise with the decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.199a	0.04	0.036	3.223		
Predictors: (Constant), Employment High NE efficacy, Employment Pill NE, Employment Good performance, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		

1	(Constant)	4.292	0.184		23.36	0.00E+00
	Employment protagonist male	-0.033	0.165	-0.006	-0.201	8.41E-01
	Employment Pill NE	-0.01	0.165	-0.002	-0.06	9.52E-01
	Employment Good performance	**0.414**	**0.165**	**0.076**	**2.513**	**1.20E-02**
	Employment High NE efficacy	**0.724**	**0.165**	**0.133**	**4.393**	**0.00E+00**
Dependent Variable: Will X have an advantage over others? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.153a	0.024	0.02	2.705		
Predictors: (Constant), Employment High NE efficacy, Employment Pill NE, Employment Good performance, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.074	0.219		14.016	0.00E+00
	Employment protagonist male	-0.109	0.197	-0.017	-0.554	5.79E-01
	Employment Pill NE	-0.274	0.197	-0.042	-1.39	1.65E-01
	Employment Good performance	-0.074	0.197	-0.012	-0.378	7.05E-01

	Employment High NE efficacy	**0.519**	**0.197**	**0.08**	**2.637**	**8.00E-03**
Dependent Variable: Would you make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.093a	0.009	0.005	3.229		
Predictors: (Constant), Employment High NE efficacy, Employment Pill NE, Employment Good performance, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5	0.19		26.288	0.00E+00
	Employment protagonist male	0.04	0.171	0.007	0.235	8.15E-01
	Employment Pill NE	-0.193	0.171	-0.034	-1.128	2.60E-01
	Employment Good performance	**-0.527**	**0.171**	**-0.093**	**-3.09**	**2.00E-03**
	Employment High NE efficacy	**0.553**	**0.171**	**0.098**	**3.241**	**1.00E-03**
Dependent Variable: Would most people make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		

1	.139a	0.019	0.016	2.801		
Predictors: (Constant), Employment High NE efficacy, Employment Pill NE, Employment Good performance, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.438	0.182		18.867	0.00E+00
	Employment protagonist male	0.285	0.164	0.053	1.74	8.20E-02
	Employment Pill NE	**-0.378**	**0.164**	**-0.07**	**-2.309**	**2.10E-02**
	Employment Good performance	0.042	0.164	0.008	0.26	7.95E-01
	Employment High NE efficacy	**0.471**	**0.164**	**0.087**	**2.878**	**4.00E-03**
Dependent Variable: Do the benefits outweigh the risks? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.124a	0.015	0.012	2.683		
Predictors: (Constant), Employment High NE efficacy, Employment Pill NE, Employment Good performance, Employment protagonist male						

GERMANY EDUCATION CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.944	0.227		26.196	0.00E+00
	Education protagonist male	-0.139	0.201	-0.021	-0.693	4.89E-01
	Education Pill NE	**-0.624**	**0.201**	**-0.094**	**-3.107**	**2.00E-03**
	Education Good performance	**-0.676**	**0.201**	**-0.102**	**-3.367**	**1.00E-03**
	Education High NE efficacy	0.107	0.201	0.016	0.531	5.95E-01
Dependent Variable: Can you sympathise with the decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.141a	0.02	0.016	3.293		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education protagonist male, Education Pill NE						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		

1	(Constant)	4.805	0.187		25.671	0.00E+00
	Education protagonist male	0.051	0.166	0.009	0.305	7.60E-01
	Education Pill NE	0.137	0.166	0.025	0.826	4.09E-01
	Education Good performance	**0.433**	**0.166**	**0.079**	**2.615**	**9.00E-03**
	Education High NE efficacy	**0.495**	**0.166**	**0.091**	**2.991**	**3.00E-03**
Dependent Variable: Will X have an advantage over others? (Edu)						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.463	0.233		19.179	0.00E+00
	Education protagonist male	-0.136	0.206	-0.02	-0.662	5.08E-01
	Education Pill NE	**-0.912**	**0.206**	**-0.134**	**-4.43**	**0.00E+00**
	Education Good performance	**-0.443**	**0.206**	**-0.065**	**-2.152**	**3.20E-02**
	Education High NE efficacy	0.11	0.206	0.016	0.533	5.94E-01
Dependent Variable: Would you make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		

1	.151a	0.023	0.019	3.378		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education protagonist male, Education Pill NE						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.638	0.187		30.144	0.00E+00
	Education protagonist male	0.075	0.166	0.014	0.455	6.50E-01
	Education Pill NE	0.009	0.166	0.002	0.054	9.57E-01
	Education Good performance	-0.111	0.165	-0.021	-0.672	5.02E-01
	Education High NE efficacy	-0.08	0.165	-0.015	-0.484	6.28E-01
Dependent Variable: Would most people make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.029a	0.001	-0.003	2.715		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education protagonist male, Education Pill NE						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.41	0.188		23.472	0.00E+00
	Education protagonist male	0.013	0.166	0.002	0.079	9.37E-01
	Education Pill NE	**-0.713**	**0.166**	**-0.13**	**-4.291**	**0.00E+00**
	Education Good performance	-0.314	0.166	-0.057	-1.89	5.90E-02
	Education High NE efficacy	0.116	0.166	0.021	0.698	4.85E-01
Dependent Variable: Do the benefits outweigh the risks? (Edu)						

HUNGARY EMPLOYMENT CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.877	0.223		21.845	0.00E+00
	Employment protagonist male	0	0.2	0	0.001	9.99E-01
	Employment Pill NE	0.179	0.2	0.027	0.895	3.71E-01
	Employment Good performance	**-0.527**	**0.2**	**-0.08**	**-2.635**	**9.00E-03**

	Employment High NE efficacy	**0.335**	**0.2**	**0.051**	**1.673**	**9.50E-02**
Dependent Variable: Can you sympathise with the decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.099a	0.01	0.006	3.268		
Predictors: (Constant), Employment High NE efficacy, Employment protagonist male, Employment Pill NE, Employment Good performance						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.047	0.184		27.504	0.00E+00
	Employment protagonist male	0.023	0.164	0.004	0.139	8.89E-01
	Employment Pill NE	-0.089	0.164	-0.016	-0.541	5.89E-01
	Employment Good performance	**0.543**	**0.164**	**0.101**	**3.303**	**1.00E-03**
	Employment High NE efficacy	**0.33**	**0.164**	**0.061**	**2.01**	**4.50E-02**
Dependent Variable: Will X have an advantage over others? (Emp)						
Model Summary						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.120a	0.014	0.011	2.686		
Predictors: (Constant), Employment High NE efficacy, Employment protagonist male, Employment Pill NE, Employment Good performance						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.22	0.226		14.242	0.00E+00
	Employment protagonist male	-0.036	0.202	-0.005	-0.177	8.60E-01
	Employment Pill NE	0.085	0.202	0.013	0.421	6.74E-01
	Employment Good performance	-0.328	0.202	-0.049	-1.621	1.05E-01
	Employment High NE efficacy	**0.468**	**0.202**	**0.071**	**2.312**	**2.10E-02**
Dependent Variable: Would you make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.087a	0.008	0.004	3.309		
Predictors: (Constant), Employment High NE efficacy, Employment protagonist male, Employment Pill NE, Employment Good performance						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.27	0.193		27.261	0.00E+00
	Employment protagonist male	-0.008	0.173	-0.001	-0.045	9.64E-01
	Employment Pill NE	-0.004	0.173	-0.001	-0.026	9.80E-01
	Employment Good performance	0.024	0.173	0.004	0.141	8.88E-01
	Employment High NE efficacy	0.104	0.173	0.018	0.6	5.49E-01
Dependent Variable: Would most people make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.019a	0	-0.003	2.829		
Predictors: (Constant), Employment High NE efficacy, Employment protagonist male, Employment Pill NE, Employment Good performance						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.098	0.204		24.987	0.00E+00
	Employment protagonist male	0.051	0.183	0.009	0.281	7.78E-01

	Employment Pill NE	-0.051	0.183	-0.009	-0.279	7.81E-01
	Employment Good performance	-0.213	0.183	-0.036	-1.168	2.43E-01
	Employment High NE efficacy	0.125	0.183	0.021	0.682	4.95E-01
Dependent Variable: Do the benefits outweigh the risks? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.043a	0.002	-0.002	2.987		
Predictors: (Constant), Employment High NE efficacy, Employment protagonist male, Employment Pill NE, Employment Good performance						

HUNGARY EDUCATIO CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.223	0.232		22.468	0.00E+00
	Education protagonist male	-0.145	0.207	-0.021	-0.699	4.85E-01
	Education Pill NE	-0.172	0.207	-0.025	-0.832	4.06E-01
	Education Good performance	-0.35	0.207	-0.052	-1.691	9.10E-02
	Education High NE efficacy	0.123	0.207	0.018	0.595	5.52E-01

Dependent Variable: Can you sympathise with the decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.064a	0.004	0	3.382		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.031	0.187		26.926	0.00E+00
	Education protagonist male	-0.084	0.166	-0.015	-0.507	6.13E-01
	Education Pill NE	0.16	0.166	0.029	0.962	3.36E-01
	Education Good performance	0.345	0.166	0.063	2.076	3.80E-02
	Education High NE efficacy	**0.607**	**0.166**	**0.111**	**3.652**	**0.00E+00**
Dependent Variable: Will X have an advantage over others? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.132a	0.017	0.014	2.719		

a Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.663	0.239		15.338	0.00E+00
	Education protagonist male	-0.103	0.213	-0.015	-0.484	6.28E-01
	Education Pill NE	-0.134	0.213	-0.019	-0.629	5.29E-01
	Education Good performance	-0.256	0.213	-0.037	-1.204	2.29E-01
	Education High NE efficacy	**0.386**	**0.213**	**0.056**	**1.817**	**7.00E-02**
Dependent Variable: Would you make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.071a	0.005	0.001	3.474		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	5.148	0.194		26.496	0.00E+00
	Education protagonist male	0.05	0.173	0.009	0.289	7.72E-01
	Education Pill NE	0.277	0.173	0.049	1.604	1.09E-01
	Education Good performance	0.07	0.173	0.012	0.405	6.86E-01
	Education High NE efficacy	0.297	0.173	0.053	1.719	8.60E-02
Dependent Variable: Would most people make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.073a	0.005	0.002	2.827		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.054	0.208		24.346	0.00E+00
	Education protagonist male	-0.294	0.185	-0.049	-1.592	1.12E-01
	Education Pill NE	0.307	0.185	0.051	1.66	9.70E-02
	Education Good performance	-0.012	0.185	-0.002	-0.064	9.49E-01

	Education High NE efficacy	0.31	0.185	0.051	1.68	9.30E-02
Dependent Variable: Do the benefits outweigh the risks? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.088a	0.008	0.004	3.02		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						

UNITED KINGDOM EMPLOYMENT CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.67	0.2		28.399	0.00E+00
	Employment protagonist male	0.2	0.179	0.034	1.118	2.64E-01
	Employment Pill NE	0.292	0.179	0.05	1.632	1.03E-01
	Employment Good performance	0.135	0.179	0.023	0.752	4.52E-01
	Employment High NE efficacy	-0.335	0.179	-0.057	-1.871	6.20E-02
Dependent Variable: Can you sympathise with the decision? (Emp)						
Model Summary						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.086a	0.007	0.004	2.94		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.421	0.167		26.435	0.00E+00
	Employment protagonist male	0.155	0.15	0.031	1.034	3.01E-01
	Employment Pill NE	-0.096	0.15	-0.019	-0.642	5.21E-01
	Employment Good performance	**0.638**	**0.15**	**0.128**	**4.255**	**0.00E+00**
	Employment High NE efficacy	**0.656**	**0.15**	**0.131**	**4.375**	**0.00E+00**
Dependent Variable: Will X have an advantage over others? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.187a	0.035	0.031	2.463		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.385	0.223		15.207	0.00E+00
	Employment protagonist male	-0.18	0.2	-0.027	-0.901	3.68E-01
	Employment Pill NE	0.077	0.2	0.012	0.386	7.00E-01
	Employment Good performance	-0.376	0.2	-0.057	-1.881	6.00E-02
	Employment High NE efficacy	**0.713**	**0.2**	**0.108**	**3.572**	**0.00E+00**
Dependent Variable: Would you make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.125a	0.016	0.012	3.278		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		

1	(Constant)	4.854	0.183		26.494	0.00E+00
	Employment protagonist male	0.005	0.164	0.001	0.029	9.77E-01
	Employment Pill NE	0.153	0.164	0.028	0.933	3.51E-01
	Employment Good performance	-0.182	0.164	-0.034	-1.109	2.68E-01
	Employment High NE efficacy	**0.43**	**0.164**	**0.08**	**2.615**	**9.00E-03**
Dependent Variable: Would most people make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.091a	0.008	0.005	2.698		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.943	0.187		21.092	0.00E+00
	Employment protagonist male	-0.167	0.168	-0.03	-0.998	3.18E-01
	Employment Pill NE	0.02	0.168	0.004	0.121	9.03E-01
	Employment Good performance	-0.192	0.168	-0.035	-1.147	2.52E-01

	Employment High NE efficacy	**0.654**	**0.168**	**0.118**	**3.902**	**0.00E+00**
Dependent Variable: Do the benefits outweigh the risks? (Emp)						

UNITED KINGDOM EDUCATIO CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.716	0.202		33.206	0.00E+00
	Education protagonist male	**-0.485**	**0.182**	**-0.081**	**-2.672**	**8.00E-03**
	Education Pill NE	**-0.375**	**0.182**	**-0.062**	**-2.065**	**3.90E-02**
	Education Good performance	**-0.71**	**0.182**	**-0.118**	**-3.908**	**0.00E+00**
	Education High NE efficacy	0.106	0.182	0.018	0.584	5.60E-01
Dependent Variable: Can you sympathise with the decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.135a	0.018	0.016	2.989		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.06	0.17		29.772	0.00E+00
	Education protagonist male	**-0.385**	**0.153**	**-0.077**	**-2.523**	**1.20E-02**
	Education Pill NE	-0.003	0.153	-0.001	-0.017	9.86E-01
	Education Good performance	0.231	0.153	0.046	1.511	1.31E-01
	Education High NE efficacy	**0.378**	**0.153**	**0.075**	**2.48**	**1.30E-02**
Dependent Variable: Will X have an advantage over others? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.116a	0.014	0.01	2.505		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		

1	(Constant)	4.402	0.23		19.135	0.00E+00
	Education protagonist male	**-0.449**	**0.207**	**-0.066**	**-2.174**	**3.00E-02**
	Education Pill NE	**-0.556**	**0.207**	**-0.081**	**-2.69**	**7.00E-03**
	Education Good performance	**-0.599**	**0.207**	**-0.088**	**-2.899**	**4.00E-03**
	Education High NE efficacy	0.1	0.207	0.015	0.482	6.30E-01
Dependent Variable: Would you make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.138a	0.019	0.015	3.39		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.432	0.182		29.802	0.00E+00
	Education protagonist male	**-0.447**	**0.164**	**-0.083**	**-2.731**	**6.00E-03**
	Education Pill NE	0.086	0.164	0.016	0.526	5.99E-01
	Education Good performance	-0.053	0.164	-0.01	-0.324	7.46E-01

	Education High NE efficacy	0.022	0.164	0.004	0.134	8.94E-01
Dependent Variable: Would most people make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.085a	0.007	0.004	2.686		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.011	0.198		25.323	0.00E+00
	Education protagonist male	**-0.553**	**0.178**	**-0.094**	**-3.114**	**2.00E-03**
	Education Pill NE	**-0.608**	**0.178**	**-0.103**	**-3.424**	**1.00E-03**
	Education Good performance	**-0.498**	**0.178**	**-0.084**	**-2.805**	**5.00E-03**
	Education High NE efficacy	0.145	0.178	0.025	0.816	4.14E-01
Dependent Variable: Do the benefits outweigh the risks? (Edu)						
Model Summary						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.165a	0.027	0.024	2.916		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						

UNITED STATES EMPLOYMENT CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.113	0.208		29.423	0.00E+00
	Employment protagonist male	0.253	0.187	0.041	1.348	1.78E-01
	Employment Pill NE	-0.175	0.187	-0.029	-0.933	3.51E-01
	Employment Good performance	**-0.831**	**0.187**	**-0.136**	**-4.438**	**0.00E+00**
	Employment High NE efficacy	**0.457**	**0.187**	**0.075**	**2.44**	**1.50E-02**
Dependent Variable: Can you sympathise with the decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.163a	0.027	0.023	3.024		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.92	0.181		27.156	0.00E+00
	Employment protagonist male	0.108	0.163	0.02	0.66	5.09E-01
	Employment Pill NE	-0.19	0.163	-0.036	-1.166	2.44E-01
	Employment Good performance	0.272	0.163	0.051	1.665	9.60E-02
	Employment High NE efficacy	**0.36**	**0.163**	**0.068**	**2.202**	**2.80E-02**
Dependent Variable: Will X have an advantage over others? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.095a	0.009	0.005	2.637		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		

1	(Constant)	4.216	0.235		17.943	0.00E+00
	Employment protagonist male	0.294	0.212	0.043	1.386	1.66E-01
	Employment Pill NE	-0.309	0.212	-0.045	-1.458	1.45E-01
	Employment Good performance	**-0.507**	**0.212**	**-0.074**	**-2.393**	**1.70E-02**
	Employment High NE efficacy	**0.438**	**0.212**	**0.064**	**2.068**	**3.90E-02**
Dependent Variable: Would you make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.115a	0.013	0.01	3.42		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.427	0.193		28.086	0.00E+00
	Employment protagonist male	-0.083	0.174	-0.015	-0.476	6.34E-01
	Employment Pill NE	0.256	0.174	0.045	1.468	1.42E-01
	Employment Good performance	-0.282	0.174	-0.05	-1.62	1.06E-01

	Employment High NE efficacy	0.231	0.174	0.041	1.327	1.85E-01
Dependent Variable: Would most people make the same decision? (Emp)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.081a	0.007	0.003	2.813		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.699	0.205		22.972	0.00E+00
	Employment protagonist male	0.205	0.184	0.034	1.114	2.66E-01
	Employment Pill NE	-0.314	0.184	-0.053	-1.701	8.90E-02
	Employment Good performance	-0.245	0.184	-0.041	-1.328	1.84E-01
	Employment High NE efficacy	0.33	0.184	0.055	1.789	7.40E-02
Dependent Variable: Do the benefits outweigh the risks? (Emp)						
Model Summary						

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.093a	0.009	0.005	2.978		
Predictors: (Constant), Employment High NE efficacy, Employment Good performance, Employment Pill NE, Employment protagonist male						

UNITED STATES EDUCATION CONTEXT

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.93	0.207		28.659	0.00E+00
	Education protagonist male	0.071	0.186	0.012	0.384	7.01E-01
	Education Pill NE	0.034	0.186	0.006	0.185	8.53E-01
	Education Good performance	**-0.551**	**0.186**	**-0.091**	**-2.959**	**3.00E-03**
	Education High NE efficacy	**0.587**	**0.186**	**0.097**	**3.154**	**2.00E-03**
Dependent Variable: Can you sympathise with the decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.133a	0.018	0.014	3.005		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.53	0.183		24.797	0.00E+00
	Education protagonist male	0.129	0.164	0.024	0.783	4.34E-01
	Education Pill NE	0.01	0.164	0.002	0.059	9.53E-01
	Education Good performance	0.29	0.164	0.054	1.768	7.70E-02
	Education High NE efficacy	**0.766**	**0.164**	**0.143**	**4.66**	**0.00E+00**
Dependent Variable: Will X have an advantage over others? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.155a	0.024	0.02	2.654		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.841	0.234		16.416	0.00E+00

	Education protagonist male	0.031	0.21	0.005	0.147	8.84E-01
	Education Pill NE	0.074	0.21	0.011	0.351	7.26E-01
	Education Good performance	-0.175	0.21	-0.026	-0.832	4.06E-01
	Education High NE efficacy	**0.569**	**0.21**	**0.084**	**2.702**	**7.00E-03**
Dependent Variable: Would you make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.088a	0.008	0.004	3.399		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.304	0.193		27.439	0.00E+00
	Education protagonist male	-0.148	0.174	-0.026	-0.85	3.95E-01
	Education Pill NE	0.367	0.174	0.065	2.11	3.50E-02
	Education Good performance	-0.237	0.174	-0.042	-1.364	1.73E-01
	Education High NE efficacy	**0.459**	**0.174**	**0.081**	**2.641**	**8.00E-03**

Dependent Variable: Would most people make the same decision? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.115a	0.013	0.009	2.808		
Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						
Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.5	0.203		22.159	0.00E+00
	Education protagonist male	0.129	0.183	0.022	0.706	4.80E-01
	Education Pill NE	-0.078	0.183	-0.013	-0.426	6.70E-01
	Education Good performance	-0.086	0.183	-0.015	-0.473	6.36E-01
	Education High NE efficacy	**0.389**	**0.183**	**0.066**	**2.129**	**3.30E-02**
Dependent Variable: Do the benefits outweigh the risks? (Edu)						
Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate		
1	.072a	0.005	0.001	2.95		

Predictors: (Constant), Education High NE efficacy, Education Good performance, Education Pill NE, Education protagonist male						

Appendix A3. Conditional distribution of codes by country in the Education context.
The table shows row percentages.

Category	Code (Education context)	AT	DE	HU	UK	USA	T
Health	unknown (long-term) effects	13.7%	10.6%	23.4%	11.7%	9%	
Health	concerns about side effects	7.90%	5.53%	10.69%	9.76%	7.57%	
Health	dangerous / risky / not safe	9.97%	8.51%	8.96%	7.32%	4.96%	
Health	addiction or dependence	3.78%	4.26%	1.73%	1.22%	1.89%	
Acceptability Assessment	favourable risk/benefit profile	6.19%	8.09%	5.20%	10.49%	9.22%	
Acceptability Assessment	unfavourable risk/benefit profile / low performance gain	5.8%	8.1%	10.4%	9.3%	8.5%	
Acceptability Assessment	Worth a try	4.81%	2.98%	3.47%	4.88%	5.20%	
Acceptability Assessment	no need	3.09%	3.40%	2.89%	3.66%	1.65%	
Acceptability Assessment	only for short-term / as a last resort	2.41%	2.13%	2.31%	0.98%	0.24%	
Acceptability Assessment	only for medicine	2.06%	0.43%	0.87%	1.71%	0.47%	
Acceptability Assessment	needs professional/medical oversight	1.37%	0.43%	0.58%	0.73%	0.95%	
Moral	rely on effort / authenticity / natural or nothing	5.84%	8.94%	10.40%	7.07%	7.09%	
Moral	be the best you can be / improvement is good / get ahead	2.75%	5.96%	6.07%	4.15%	5.91%	
Moral	messing with body/brain / unnatural / artificial	3.78%	2.55%	3.18%	4.88%	5.20%	
Moral	Madness, wrong, objectionable	4.47%	3.40%	2.89%	2.44%	3.78%	
Moral	cheating / doping / unfair advantage	3.09%	2.13%	1.16%	5.37%	1.89%	
Moral	wrong to risk health for performance	2.41%	0.43%	2.02%	0.00%	0.71%	
Situation	empathy / understanding for the decision	5.84%	1.70%	5.49%	4.63%	4.73%	
Situation	coping with pressure / fear of loss / high stakes / desperation	7.90%	8.51%	11.85%	7.07%	3.78%	

Alternatives	not a real solution	2.41%	4.26%	6.07%	2.68%	3.31%
Alternatives	other methods preferable (sleep, diet, exercise, etc.)	4.81%	2.98%	4.62%	1.95%	2.84%
Alternatives	move on, change job, try something else	1.03%	2.13%	0.87%	0.49%	0.47%
Sceptical	sceptical / doesn't work / placebo	7.6%	8.1%	3.2%	6.3%	9.7%
Uncertain	ambiguous / can't decide	1.03%	1.28%	8.09%	1.95%	3.55%
Uncertain	more information needed / wait for evidence	0.69%	1.28%	1.45%	4.39%	3.31%
Gut argument	Unqualified disagreement	3.09%	5.11%	2.02%	2.20%	4.26%
Gut argument	unqualified support	1.4%	2.1%	0.9%	1.7%	4%
Gut argument	Madness, crazy, stupid	4.47%	3.40%	2.89%	2.44%	3.78%
Anti-drug	rejecting chemicals/drugs	3.44%	3.83%	0.58%	2.44%	0.47%
Anti-drug	Devices rather than chemicals	3.09%	1.28%	0.58%	0.73%	0.47%
Other	other	3.09%	2.13%	2.02%	1.95%	3.07%
	Sample (n)	291	235	346	410	423

Appendix A4. Conditional distribution of codes by country in the Employment context.
The table shows row percentages.

Category	Code (Employment context)	AT	DE	HU	UK	US	T
Health	concerns about side effects	11.86%	11.27%	15.76%	15.98%	7.95%	1
Health	unknown (long-term) effects	9.3%	9.3%	20.6%	11.1%	7.2%	
Health	dangerous / risky / not safe	9.62%	6.37%	3.72%	6.78%	6.51%	
Health	addiction or dependence	1.60%	2.21%	0.57%	0.97%	1.93%	
Acceptability Assessment	unfavourable risk-benefit profile / low performance gain	7.4%	7.8%	12%	9.9%	9.4%	
Acceptability Assessment	favourable risk-benefit profile	2.88%	4.90%	4.01%	7.99%	7.71%	
Acceptability Assessment	worth a try	6.41%	4.41%	2.58%	4.36%	9.40%	
Acceptability Assessment	no need	8.65%	9.31%	6.02%	4.12%	3.37%	
Acceptability Assessment	only for medicine	1.28%	0.98%	0.29%	1.21%	1.93%	
Acceptability Assessment	only for short-term / as a last resort	0.96%	1.47%	0.57%	0.48%	0.24%	
Acceptability Assessment	needs professional/medical oversight	0.32%	0.00%	0.00%	0.24%	0.24%	
Moral	rely on effort / authenticity	5.13%	4.66%	6.59%	9.20%	5.54%	
Moral	be the best you can be / improvement is good / get ahead	3.21%	2.70%	7.45%	5.81%	5.54%	
Moral	wrong to risk health for performance	5.45%	3.92%	3.72%	2.66%	0.96%	
Moral	messing with body/brain / unnatural / artificial	3.21%	2.21%	4.58%	2.66%	3.37%	
Moral	cheating / doping / unfair advantage	1.92%	1.23%	1.15%	2.91%	2.41%	
Situation	coping with pressure / fear of loss / high stakes / desperation	12.18%	12.99%	16.33%	8.96%	10.60%	1
Situation	empathy / understanding for the decision	1.92%	5.64%	3.72%	3.87%	4.82%	
Situation	Illegitimate pressure from labour market	3.53%	1.96%	1.15%	0.73%	0.72%	
Situation	Competition and performance pressures	1.60%	1.72%	0.86%	0.24%	0.24%	

Alternatives	not a real solution	5.13%	5.15%	5.44%	5.57%	3.86%
Alternatives	other methods preferable	4.81%	1.47%	8.02%	3.87%	1.45%
Alternatives	move on, change job, try something else	3.85%	4.41%	2.01%	2.18%	0.72%
Sceptical	skeptical / doesn't work / placebo	5.77%	5.39%	2.58%	5.3%	8%
Uncertain	ambiguous / can't decide	0.64%	1.72%	5.73%	1.45%	1.45%
Uncertain	more information needed / wait for evidence	1.60%	2.45%	0.86%	1.94%	2.41%
Gut argument	Madness, wrong, objectionable	2.56%	1.72%	2.87%	1.45%	2.65%
Gut argument	Unqualified disagreement	2.88%	3.19%	1.15%	1.21%	2.89%
Gut argument	unqualified support	0.64%	0.49%	0.29%	0.00%	2.41%
Anti-drug	rejecting chemicals/drugs	2.24%	2.45%	0.86%	2.18%	1.20%
Anti-drug	Devices rather than chemicals	0.64%	1.23%	0.00%	0.97%	0.96%
Other	other	1.92%	1.72%	1.72%	0.97%	2.17%
	Sample (n)	312	408	349	413	415

Appendix A5. Proportion of arguments in each cluster, sorted in descending order of overall frequency. Education context.

Codes - Education context	Ambivalent	Neutral	Anti	Pro	Total
unknown (long-term) effects	14.70%	10.60%	19.70%	6.70%	13.60%
unfavourable risk/benefit profile / low performance gain	10.10%	9.10%	8.30%	6.10%	8.60%
concerns about side effects	10.90%	7.80%	8.30%	6.10%	8.50%
favourable risk/benefit profile	8.10%	6.30%	1.00%	20.40%	8.00%
rely on effort / authenticity / natural or nothing	6.70%	7.60%	12.80%	2.40%	7.80%
dangerous / risky / not safe	7.50%	6.30%	11.80%	3.60%	7.70%
coping with pressure / fear of loss / high stakes / desperation	8.90%	5.30%	3.70%	14.00%	7.60%
skeptical / doesn't work	7.10%	9.60%	7.20%	3.30%	7.00%
be the best you can be / improvement is good / get ahead	4.60%	4.30%	1.40%	11.60%	5.00%
empathy / understanding for the decision	5.00%	5.00%	2.70%	6.40%	4.60%
Worth a try	4.20%	4.50%	1.00%	9.40%	4.40%
messing with body/brain / unnatural / artificial	2.20%	4.00%	7.90%	1.50%	4.10%
not a real solution, just a short-term fix	4.40%	3.80%	5.00%	0.60%	3.70%
ambiguous / can't decide	6.00%	3.50%	0.80%	2.70%	3.30%
other methods preferable (sleep, diet, exercise, etc.)	3.00%	4.00%	4.10%	1.80%	3.30%
Madness, wrong, objectionable	2.00%	3.00%	6.60%	0.90%	3.30%
Unqualified disagreement	2.60%	3.30%	4.80%	1.80%	3.20%
no need	3.60%	2.30%	3.30%	1.80%	2.90%
cheating / doping / unfair advantage	2.40%	2.50%	5.00%	0.60%	2.80%
other	2.80%	2.50%	1.40%	3.30%	2.50%

more information needed / wait for evidence	3.00%	3.00%	1.00%	3.00%	2.50%
addiction or dependence	2.60%	1.80%	3.50%	0.90%	2.30%
unqualified support	2.60%	2.30%	0.40%	3.60%	2.10%
rejecting chemicals/drugs	1.20%	3.00%	2.30%	1.20%	1.90%
only for short-term / as a last resort	1.80%	1.50%	1.40%	0.90%	1.50%
wrong to risk health for performance	1.00%	0.30%	2.30%	0.30%	1.10%
only for medicine	0.40%	1.30%	2.50%	0	1.10%
move on, change job, try something else	0.40%	0.30%	2.10%	0.60%	0.90%
Health is more important	1.20%	0.50%	1.20%	0.30%	0.90%
needs professional/medical oversight	1.20%	0.50%	1.00%	0.30%	0.80%
Competition and performance pressures	0.40%	0	0.60%	1.50%	0.60%
placebo	0.20%	0.50%	0.60%	0.30%	0.40%
Illegitimate pressure from labour market	0	0	0.20%	0	0.10%

Appendix A6. Proportion of arguments in each cluster, sorted in descending order of overall frequency. Employment context.

Codes - Employment	Ambivalent	Neutral	Anti	Pro	Total
concerns about side effects	13.50%	11.70%	13.50%	10.70%	12.50%
coping with pressure / fear of loss / high stakes / desperation	14.30%	8.10%	6.80%	21.30%	12.10%
unknown (long-term) effects	11.30%	9.00%	17.50%	4.60%	11.30%
unfavourable risk/benefit profile / low performance gain	9.80%	8.10%	11.50%	6.80%	9.30%
dangerous / risky / not safe	6.40%	7.10%	8.70%	2.90%	6.50%
rely on effort / authenticity / natural or nothing	5.60%	7.30%	9.40%	1.50%	6.30%
no need	7.10%	4.90%	7.60%	4.40%	6.20%
favourable risk/benefit profile	6.20%	3.70%	0.50%	14.80%	5.70%
Worth a try	5.80%	6.10%	0.70%	11.60%	5.50%
skeptical / doesn't work	4.70%	7.80%	6.60%	2.40%	5.50%
be the best you can be / improvement is good / get ahead	4.70%	2.70%	0.80%	13.60%	5.00%
not a real solution, just a short-term fix	5.30%	7.10%	5.10%	2.40%	5.00%
empathy / understanding for the decision	5.30%	2.20%	1.50%	8.50%	4.10%
other methods preferable (sleep, diet, exercise, etc.)	3.00%	4.20%	4.60%	2.90%	3.70%
messing with body/brain / unnatural / artificial	3.20%	2.40%	5.10%	1.00%	3.20%
wrong to risk health for performance	3.00%	3.20%	5.30%	0.50%	3.20%
move on, change job, try something else	2.60%	2.00%	3.60%	1.70%	2.60%
Unqualified disagreement	2.10%	3.70%	2.60%	0.50%	2.30%
ambiguous / can't decide	2.80%	3.70%	1.00%	1.70%	2.20%
Madness, wrong, objectionable	2.40%	2.20%	3.50%	0.20%	2.20%

cheating / doping / unfair advantage	1.10%	1.00%	4.00%	1.00%	2.00%
more information needed / wait for evidence	1.70%	2.20%	1.60%	2.20%	1.90%
rejecting chemicals/drugs	0.90%	2.00%	3.00%	1.00%	1.80%
other	1.50%	1.70%	1.30%	2.40%	1.70%
Illegitimate pressure from labour market	0.60%	1.20%	3.00%	0.70%	1.50%
addiction or dependence	1.30%	1.70%	2.10%	0.50%	1.50%
only for medicine	0.20%	1.00%	2.60%	0.20%	1.20%
Competition and performance pressures	0.60%	0.50%	0.80%	1.70%	0.90%
Devices rather than chemicals	0.40%	1.50%	0	1.70%	0.80%
unqualified support	1.30%	1.00%	0	1.20%	0.80%
Health is more important	0.60%	0.50%	1.60%	0.20%	0.80%
only for short-term / as a last resort	0.40%	0.20%	0.70%	1.70%	0.70%
placebo	0	0	0	0.70%	0.20%
needs professional/medical oversight	0.20%	0.20%	0	0.20%	0.20%

Appendix B

Appendix B1. Brain Hackers – Interview Topic Guide

1. **Ease-in**

Can you tell me a bit about yourself? (What do you do? What did you study?)

2. **Interest in DIY tDCS**

How did you first hear about brain stimulation? What caught your attention? Where do you get your information about tDCS?
There's a lot of uncertainty around tDCS, what convinced you that it was a good idea to experiment with it?

3. **tDCS practices**

Can you tell me something about how you use tDCS?
What device(s) do you use? Purchased online or built by you? (If built, where did you acquire the know-how?)
Do you use is as part of your daily life/activities?
How long have you been using it? How often do you use it? What sorts of things do you use it for?
Could you walk me through an occasion when you used tDCS?
What effects have you noticed? (Any unexpected effects? Any unpleasant effects? How long do they last?)
How do you know if it's improving your abilities?
Do you run experiments as well? If yes, ask about: design, task, data capture, and comparison.
What are your plans with tDCS for the future? How do you intend to use it going ahead?
Do you think tDCS will become widely adopted? Why/not?

4. **Contrast with drugs & other cognition enhancement methods**

Have you thought about trying other ways to enhance mental performance? Stimulants? Recreational drugs?
In your experience, how is tDCS different from coffee/energy drinks/stimulants?
Some people say that it's ethically problematic to use such technologies to enhance cognition. Do you agree?

5. **Self-quantification and health consciousness**

Would you consider yourself a health-conscious person?
Do you watch your diet, exercise, sleep regime, etc.?
Do you use any self-tracking tools, wearable technologies? (Which? How?)

6. **Cool down & Exit.**

Is there anything else you would like to add? Something important we haven't touched upon?

Thank you very much! I'll be in touch with the results of the interview study.

Appendix B2. Brain Hackers Interviews

Nik

IB
Okay, so to ease into this conversation, I just thought you could tell me a little bit about your background, and what do you do? Like a very brief introduction to who you are?

Nik
Right. Well, I've been involved in cognition enhancement for quite a while. And that actually started back in my student days when I participated in nootropics design and development. So that was the drug side of the Force. And since then, I was quite curious about how far we can go. And then, obviously, I had a few U-turns in my life. My PhD was not really on enhancement, it was on mechanisms of brain death, actually. So quite the opposite. But it's obviously useful to know both sides of the medal. And also he gives additional assurance when it comes to possibilities of any side effects. Unexpected, harmful aspects of the issue and the quite a lot of questions coming down the pipe. And what I actually find quite a lot of concerns are probably not where they should be.

IB
So your PhD was in neuroscience?

NIK
Yes, it was.

IB
And was, did you do your PhD back in {country of origin}?

NIK
No, that was in Bristol.

IB
That was in Bristol? Were you involved in any of the EU projects around the enhancement because Bristol was really active in it?

NIK
Probably no, not at the time. But then again, if you think about it, Bristol was sort of the stronghold and probably the basement of glutamate pharmacology and at the end of the day, glutamate being the most important excitatory neurotransmitter in the CNS is the usual target for enhancement anyway. And if you look at classical nootropic drugs like ampakines, they all act on AMPA receptors, which are a subtype of ionotropic glutamate receptors. So, in terms of mechanisms, whether you will get higher doses or lower doses, so whether you look at pathological effects or physiological effects. It's a question of those and the question of condition nothing else.

IB
And so from the drugs, research on drugs, how did you move to brain stimulation? Or was your research not really concerning drugs with brain death or neuron-

NIK
Actually, I did that on astrocytes, it was done on astrocytes, no one really looked at them before and they are far more than critical for many such conditions which involve gliosis and transformation of astrocytes, and they are potentially just as vulnerable as neurons are. But that also says that potentially

they could be a very good target for enhancement just as well. I mean, they do have AMPA receptors. They do have kainite receptors, they do have a variety of metabotropic glutamate receptors, we just talk about glutamate, but much more.

IB
So what was your trajectory after the PhD?

NIK
Well after the PhD, frankly speaking, A, I could not find any suitable grant. B, I had nice and cheerful home office on my passport.

IB
Really?

NIK
Yes, of course. Well, that's the usual situation. you've submitted your thesis, you're done. Now go away and do whatever you want. So for quite a long time, we were hacking around when facing a kind of nowhere to go situation. <inaudible> opened up an information security company which we're still running, so we're still hiking around. Do that today. We'll do it later on. We'll do it tomorrow. It works quite well. But apart from that, well, you can't really quit what you've started and what you were doing for years. So it moved to the garage side of the world, but at the same time now, I'm also a consultant for a biotech company, which actually manufactures equipment for more general physical enhancement.

IB
What's more general physical enhancement?

NIK
Oh, in this case, it's hypoxic hyperoxic exposure. So biofeedback-controlled regulation of oxygen in the brain, which is quite useful in clinical terms, not just enhancement terms, but both complement each other rather well. And it's one of the things that are closely linked to preventive medicine. So I am preventive, and prevention and rehabilitation. And again, there are indicators that training your brain to withstand both hypoxia and oxidative stress is quite useful, not only in prevention of stroke, and potentially treatment of addictions and depression, but can generally have overall enhancing effects. So that may even complement what I'm doing on the enhancement side. On the biophysical front, so to say.

IB
I kind of thought that your main interest was in brain stimulation and tDCS and TMS-related things, but it seems it's actually much broader.

NIK
Well, you can't stick to one topic, well, maybe you can, but then you have to have quite a hefty share of luck, I would say. You know, very few people in a, in the way research is managed and organised. Those days, you know, very few people can work on a specific topic since undergrad than into post grad into probably more than one postdoc and so forth. You know, you need a totally different system, perhaps the one which was here, back in '67, just I'm not precisely sure since I wasn't around then.

IB
So your PhD you guys did the PhD around when?

NIK

2004.

IB
2004? And did you actually try to remain in academia?

NIK
Well, I did I worked for different grants and so on, but I couldn't find anything suitable. And when something suitable actually did appear, that was much later. You know, I had a different life and different obligations as well.

IB
And nowadays, are you thinking about gravitating back towards academia or more, you have a stronger interest in like commercial?

NIK
Well, nowadays, it's more private industry rather than academia. I mean, I guess it's probably too late to come back 10 years later and say okay, here I am. But, when it comes to I would I would say industrial side rather than commercial side because until, until it actually hits profit. Difficult to say, but he has some quite heavy consulting for a biotech company. For the time we are currently launching our own project which hopefully will become big, and we are considering putting our own device to Kickstarter. So or using alternative means of funding. There is a very strong team and hopefully we will succeed so whether you call it commercial or not.

IB
Well, not academic. And that device is the brain is that for brain stimulation?

NIK
Not only.

IB
Can you tell me how you moved towards brain stimulation? Why did you become interested in it?

NIK
Well, I wanted, I wanted to not just electrical, I wanted to emulate effects of nootropic drugs. And stimulation in itself is very interesting since, by its very nature, it can resolve problems which are very difficult to resolve with pharmacology. You know, in particular, problems related to delivery and targeting a specific area, you know, we're still very far away from designing drugs, which would target, let's say, left prefrontal cortex. In terms of stimulation, all you need is to position your electrode or coils, or source of light within the optical permeability window, or whatever else source of ultrasound, whatever useful stimulation over the required area. And some methods have very high resolution. So that's one problem, which is instantly solved. Another problem is obviously, periphery of effects, which the majority of drugs would inevitably have, by their very nature and dependence on the periphery again, you know, dependence on biotransformation, dependence on liver function, kidney function, and so forth.

IB
And when you say emulate the effects of nootropic drugs, what kinds of drugs do you have in mind? Like, what did you try to, to actually work on?

NIK
Well, ages ago, I had my own drug, which was, effectively a way to deliver advice and training. And by that time, I didn't go anywhere, because I see everything has collapsed, and they had to leave. I've only made it and then started testing it on mice. And then there were no mice anymore, and so forth.

IB
That was the P that was part of the PhD project, or before?

NIK
I still was an undergrad. It was a different, different culture, you know, you could, you could start doing quite serious research, if you can, even as an undergrad, even before that, interestingly enough.

IB
And that was, that was not in the UK?

NIK
No, that wasn't here, that was a different system. In fact, I would have preferred that system, which as I've said, may be a bit more old fashioned. But it actually gave you an opportunity to work on a specific topic, perhaps, until you die.

IB
What do you mean "old fashioned?"

NIK
Well, as far as I'm aware, you know, it was not always like that, it was not always that you may graduate, and then you have to find and take any postdoc, you know, where effectively a hand skills and so on are required. And then you might have to switch to another postdoc, just to keep you going. And the main interest, the main research interest, the main topic, of let's say, a PhD in your first postdoc and your second postdoc can be in an entirely different areas suggest that they use very similar techniques that you can apply. So you've learned how to run, I don't know, northern blots, and then you carry on doing the same for different experimental setup. And so it's primarily the actual, literally hand skill, which is more important than knowledge and research interest in a specific area. You know, this is not something that I would say is, especially in, it's probably tactically very effective, but strategically, I think it's a grand loss.

IB
So then, how come you left that system and came from the UK to do a PhD?

NIK
Well, it collapsed. Okay. And that's now there is a civil war going on there. If I go back, I may enjoy participating in the Civil War. So by collapse, they actually collapsed.

IB
Okay, so came to the UK, emulating the effects of nootropic drugs. Did you have any successes with the electrical stimulation based simulation or emulation or contributor?

NIK
Oh, yes, I'd say so. Of course, it's not that easy to verify, as compared to proper phonemic research. Of course, it's not possible to run a proper double blind trial in such and such conditions. But you know, when we talk about discovery of novel effects, especially those which are quite significant, and so forth, I would say that it's still quite useful. Someone has to start somewhere, maybe not as much to produce high quality data, which you then publish in Nature or New Scientist or somewhere else of an equal reputation, but to inspire people to look into those things, to raise attention from both academia and industry and say, Look, this is likely to work. And it will be big if it does. So please do not ignore this topic.

IB

So can you explain to me how the environment or the context in which this kind of experimentation or research takes place? How? Is it the hackspace environment or where?

NIK
It could be the hackspace, it could be at home. It doesn't really matter, you know, providing you have calm and little interference. It's not that difficult. I mean, of course, the obvious question would be how do you objectify? Because any subjective feelings could easily be a placebo, a placebo-like effect. <inaudible> of course, use different psychological batteries of tests, like those available at Quantified Mind and so on. Hopefully, for free, more and more, as in the example I've given, but again, psychological testing is not that simple and straightforward. And you have to avoid many pitfalls and underwater stones related to things like variability in individual capabilities and capacity depending on the state, for particular person that a particular time of day, or even time of a month or a year and exclude the effects of training and so forth. Far more interesting way of objectification is EEG, and the EEG is not that difficult to do. I mean, yes, it is difficult, but it's not impossible to do in a whole lab, and I've got a 19 channel machine. I've got lots of individual sensors, then you can also look at. This method is not really well known here. But you can also look at various low potential some degradation with very small, very small potentials and various levels. And to cut it short and not go into technicalities, you have very decent correlations between their change and metabolic rate under the electrode versus another electrode. So that's effectively a poor man's bond.

IB
<Inaudible and crosstalk>

NIK
Yes. So it would not replace fMRI. Yeah, but I mean, you know, the cost of proper fMRI equipment is, and in this case, equipment cost us a few 100 pounds of propolis. And yet, it gives quite a nice estimate for a specific area, okay, not not a very high resolution area, let's say, you can measure left temporal lobe versus right temporal lobe and then you apply your stimulus on one side, and then you can actually see whether there is a difference in local metabolism between let's say, T three and T four and then 20, Eg terms. So that's an interesting way of objectification that gives very straightforward results. And then I don't have this yet, but hopefully, in the near future, I will obtain fNIRS equipment as well, which is also used to estimate the local metabolic rate, so.

IB
Can you explain how that works just-

NIK
Well, fNIRS just uses infrared light, and it estimates the difference between oxidated and not oxidated haemoglobin because the absorption spectra for infrared light of a given wavelength is different. So we can measure the difference with small potential was method is a bit different from that, because it relies on the fact that those potentials are quite dependent on the pH of the venous blood, and which, in order changes quite strongly subject to level of metabolism in particular oxidation in the area. So those two methods complement each other very well. But the interesting thing is while you have to go into a quite greater length. And that's what we did at Hackspace to enable concurrent electrostimulation or sufficiently strong field magnetic stimulation, together with the measurement of any electrical potentials, whether traditional EEG or slow, for obvious reasons of interference, electrode separation, and so forth. But you can combine any electrical or sufficiently strong field magnetic stimulation with fNIRS very easily, because that would not interfere with your infrared light going in and out. This subject have In contrast, you can combine any electrical measurement with light stimulation. And I don't mean that traditional for tech stimulation, I mean, transcranial light, in particular transcranial laser stimulation, which even though it produces an electric field, when the laser ray goes through the tissue at sufficient strength, it's still too weak to interfere with, let's say, EEG measurements. So you can, again, play with, like mice named you suitable stimulation methods

with a suitable measurement method, with obvious disadvantages for the both, but it's not something that cannot be resolved.

IB
Yeah. I'm just a little bit concerned about the sound, but I think it's probably okay. I had a question. Yeah. So when you say you run an experiment, and it's difficult to objectify, do you do you run an experiment alone on yourself, let's say here, and then you compare with others who did the same thing by themselves, or?

NIK
well, I tend to run it on volunteers, and if I want to run it on myself, I'll ask someone else to run it on myself. And while they can't double blind it, for obvious reasons, they can still blind it. I mean, especially with some methods of stimulation that do not induce any local sensations. And when you turn that on and off, while staying behind the test subject, of course, she cannot feel any change. And sometimes, one of the main problems here is, every neurophysiologist is aware of this problem, and it even goes into the area of philosophy, so to say that, quite often, you can see very strong changes on the EEG as an example. But they're not really reflected in the behaviour. In contrast, you may see very strong subjectively reported changes, which did not seem to be really reflected in the great change in the EEG. So that's one of the problems, but generally speaking, if there is an effect, you will see it. Especially if especially as I've said, if a patient is not, well not a patient, their subject is not really aware of when it's on, when it's off, when it's over.

IB
So during the kind of shamming.

NIK
Yeah, there's always there's always a possibility to sham. I mean, even if you look at end user devices, like Focus, which is the first neurostimulation device available commercially for anyone, they do have shamming option. But where it's actually necessary because it's electrostimulation and you can feel the current quite well. But let's say if you use infrared laser transcranially, you know you don't see it. You don't you don't you don't feel it because we're talking cold laser here. Same applies to magnetic fields unless we are talking about something that the level of one Tesla where you can induce muscle twitching, and so forth. But I would never recommend anyone using you know, high power TMS in hackish garage conditions. You can induce seizures, you can induce migraine, you can induce many other things. However, there's quite a lot of data accumulating, that shows that there are definite effects in millitesla range and even microtesla range. And I can tell you that I've seen effects in a nanotesla range, even though like many will throw eggs and tomatoes at me now. But I've seen that many times. It just depends on the correct stimulation protocol, and this is an entirely different conversation topic.

IB
Okay, so we can go there a bit later, maybe?

NIK
Maybe, yeah.

IB
So can you tell me something about how you see the relationship between mainstream research in neurosimulation? And the kinds of projects that you are pursuing and the people in your circles are pursuing?

NIK

Well, there are two two ways to connect. One way, as I've said, you discover an interesting effect and shout about it.

IB
And in what forum do you shout about it?

NIK
Well, there are still ways of I mean, you can do can definitely publish it given enough data, you still can publish as an independent research. You can present at conferences, you can present at different talks, meetings, it could be word of mouth, because, you know, obviously, inevitably, some people you will connect with would be neuroscientists who are quite interested and so forth. It could be an unrelated talk, like I did, with the futurists, there is a huge interest in the topic. So there are ways to shout about it. I mean, Columbus did not even discover America, as you know, you know, he, he only reached the Caribbeans. And he probably saw Cuba, but he could shout well enough to get any gold out of the guy that you know, yet we still consider him to be the discoverer of a new continent. So that's one way. Another way, is, what we are aspiring to do is based on what we see, based on what we can do to produce a tool. So this is sort of Levin-Cook rather than Columbus approach. In this case, we just say, Okay, here's the microscope. You know, now, it's your turn to discover germs mutate. That's what we want to do. And there is a clear lack of instruments in the field. Surprisingly enough, surprisingly enough.

IB
A lack of instruments.

NIK
Yes, there is. I mean, the only device I'm aware of that allows simultaneous electrostimulation and measurement is StarStim. And I'm only talking about electrostimulation and nothing else. And I'm only talking about EEG and nothing else. And yet it has its own disadvantages despite the price. It's not very accessible. So one of the side effects actually a nice research tool that allows concurrent stimulation and measurement and is modular, which means different ways of stimulation can be applied subject to what stimulation unit you plug in. And at the same time, different measurement ways perhaps can be applied as well at least you might have a choice between traditional EEG. small potential for recording and perhaps fNIRS. So that would be quite handy. And at the same time, low price, so a side effect of it could be that people can actually select which particular models they need for their specific area of interest. And also enable such research in low fund tacticians, low, low funds conditions, third world academia, you name with charities. Because not everyone can afford, you know having a 64, Channel encephalographer, or not to mention any of a variety of other high end equipment yet still quite a lot of things couldn't be done without them. And I mean talking about stimulation itself, when there's obviously quite a lot done on tDCS, which is the simplest, when you don't actually need a very, you know, you can do it with a nine volt battery in two electrodes as the majority of people are aware of. Or you can do any electricity relation with your bench frequency generator, even though many people would say oh, it's unsafe because it's plugged into mains. But so is a large selection of various physiotherapy equipment. But, you know, what about ultrasound stimulation, what about <inaudible> and light stimulation? What about different methods combined? I mean, I can show. This is the prototype, which is not ready yet, produced by a friend in Kiev for me. So when you hold it close to the head, but not touching you have weak pulsed magnetic field stimulation when you touch you have your electrostimulation. And I'm saying that it's not ready yet, because it's got the placement for lasers, but doesn't have lasers there yet. They will be there. But the point is not even this. The point is, it's USB pluggable and truly software controlled. And it doesn't even matter what kind of software signal generator I use, I can plug it into a Windows box Linux box, I can plug it into Mac, doesn't matter. So even this is actually more advanced than what many of the top research labs currently have. I mean, let's say I want to try stimulation with noise.

IB

So like random noise?

NIK
Yeah, like random noise stimulation, I mean, the majority of units out there, they only support white noise, if they support it at all, you know. StarStim only supports tRNS with white noise. You plug it in, you use any software noise generator, and I've got one on my laptop, which supports pink noise, grey noise, blue noise, brown noise, black noise. So pick your colour. Did anyone ever do stimulation with let's say black noise? No. Not at all. So there's, there's... Or maybe if they did then never published, but that's just a good example, you know, showing how many unexplored things are there. And let's say you use this kind of stimulation method on a volunteer and you have, let's say three volunteers and you have EEG changes which appear to be very specific. And maybe they are also accompanied by some subjective state change report, you know, getting relaxed and sleepy getting agitated, and so forth. Now, that would be an effect, which definitely is, you know, worth shouting about, enabled by a new tool. So that's how these things can converge. And at the end of the day, again, to be maybe too, maybe too pathetic, but when we talk about such unexplored things, and I'm just giving you a very, very, very limited, very small example of something that no one has ever done. I can give you ten more examples, maybe more, of such huge white spots on the map, which are very easy to explore, but no one does it. And that probably comes down again to funding system to management system and so on in science and funding. The scientists cannot really do what they want. And they have to do what the accountants want.

IB
Why do you think is that? Because there seems to be a lot of interest now in various stimulation methods as people are recognising that pharmaceuticals are a bit more complicated than they assume that they are too expensive. So there seems to be a shift to non pharmacological.

NIK
It's a slow shift caused by acceptance of tDCS in the West. But there are many things which are not accepted yet, which are used outside very widely. I mean, if you look at various cold laser devices, when the bulk of them was manufactured in China, the only place you can find them was Alibaba. I mean, we're mainly talking about peripheral use now, but there's mounting volumes of data on central use of sufficiently strong light within the optical permeability window of tissues. And its beneficial effects. I mean, central beneficial effects.

IB
Of mounting data, you mean peer reviewed data or data from other sources?

NIK
It's, it comes from different sources. It could be randomised, it could be just a pilot study. But again, a pilot study is not something that should be ignored. And as I've said, maybe saying that is too pathetic. But again, we're talking about huge white spots. Penicillin was not discovered via proper double blind trial, it was actually discovered by chance, you know, by Fleming spotting it on some dishes, there is a problem with bacterial growth. So instead of dismissing it as an artefact and bad practice, you know, he investigated into it. Now, if you investigate into such things without actually initial mindset of dismissing it as an artefact, then yes, you can, you can have your false positive, but in this case, it's not that bad. I mean, negative results are also quite important here, because then then you will know that this particular signal, this particular stimulation protocol just doesn't work. Fine. And it's kind of like knowing that the drug is not active, but at the same time, it's not toxic. Yeah.

IB
So there's a lot of uncertainty around tDCS, and brain stimulation and a lot of, I wouldn't say an ethical controversy, but almost. What do you think about that? And that what convinced you that it was a safe and okay pursuit?

NIK
Well, the problem I can see with so-called ethical or even moral arguments, is, in my sort of experience of encountering different people, you know, people who really do know how these things work, and they talk about risk benefit ratio, you know, as you would with pharmaceuticals, and so on. Now, people will know a little, quite often talk about the moral side, too much, you know, "oh, it's a new method, so it should be dangerous." Well, tDCS, in particular, is not really a new method. For my birthday, I was given this electro stimulation device on the table there, which I'm not sure which year is it, but it looks like it comes from about the First World War time. tDCS has been known since early 19th century, and they used to call them galvanization. At that time, and they even had proper central effects observed in the few cases. But of course, it was just a physician trying it on let's say paralysed patient and seeing benefits. So that would not pass more than criteria, but there is no reason not to believe that they were not successful in the empiric way. Then in 60s, USSR, it was incredibly popular. It was called micropolarisation at the time and it was actively used, and it's still used. And I mean, now we'll have Roi's book that came, The Stimulated Brain, Roi Cohen's book, which came in August last year. But somewhere on my shelf, I have a book on clinical use of tDCS from a professor in Saint Petersburg. <inaudible> that is dated 2007. You know, that's established, I'm not talking about a book primarily written by a researcher for researchers, as in the case of Roy, but it's written by a clinician for clinicians. But practical methodology says you put the electrodes here, here, and here, you use this as well. And then you use this specific condition, you use such and such parameters and have so many stimulation sessions and so forth. So it's a handbook for your physiotherapist and let's say rehabilitation clinic. So it's, it's not really something that is particularly new or even I would say particularly advanced.

IB
What I had in mind with the ethical thing was actually more the bringing it to the public in the sense that it's still an investigational device, mostly-

NIK
Well, if it's safe, and it works, why not to bring it to the public? You know, the real ethical issues, they stem from risk benefit ratio. You know, I don't, I mean, the false ethical issues, they just stem from rather, retrograde worldview. That has nothing to do with science at all. Or they are also interested in ethical issues which ar esocial, which is an entirely different matter. But I would actually say that. In particular, if we talk about tDCS, but also with other methods, they are very, very accessible and probably more accessible than drugs. So it's not going to be something for the privileged few, not at all. In fact, I would expect that the privileged few would probably not use it, because they don't have this need to push that far unless they really want to. But that's a matter of personal choice. And it doesn't really depend on the level of wealth or social status, but in my experience, you know, the, the really rich, instead of doing it themselves, just tend to hire more consultants. It's the consultants are going to use it. I did write it in the argument and the topic on futurist list that, you know, it's not really an issue as Al Capone was saying, when he was challenged in his arithmetic skills, I can always hire accountants. So I did write on that list, that it's the accountants who are really concerned that they would not fulfil Al Capone's requests, so its them that are going to use it and not the boss. So the bulk of people who would use it, I would expect they will be people who are working hard and who need to push beyond normal limits. And I mean, I, I ran my project with my team. And, you know, we really wanted to succeed at the same time, I have two jobs in unrelated areas, one in biotech and one information security. Well, while in biotech with the hypoxia machine, and another one is an InfoSec. So that's a typical example. And I would expect that lots of people who would, you know, jump on the bandwagon they will be people from high tech industries, in particular IT, lots of programmers, lots of system administrators would find it useful. Perhaps stockbrokers, perhaps traders, perhaps people who need to move fast and people who need to sleep maybe three, four or five hours a day and not more.

IB

Could you say something about the effects when you've researched a new experience, like the positive beneficial effects?

NIK

Depends on the method depends on where you apply it. Sometimes effects were quite unexpected, which actually makes it more valuable because I mean, I may I have I make a bad guinea pig because I more or less know how it would work which sort of you know, it's very, it's very easy to get a placebo effect. It's far more interesting when you get a totally unexpected effect out of nowhere, and then you discover that's probably how it worked post factum. I mean, I have this effect at Hackspace when I was actually teaching a friend how to take EEG and you know what it all means. and I just thought you use <inaudible>. And then when she set everything up surprisingly very nicely, very carefully, and I asked her, well, let's do something, just select a place near an electrode where it's easy to hold and easy to use and fire this laser into my brain, which was 890 nanometers infrared impulse laser with 10 watts at the peak at 10 hertz, just Alpha entrainment, no, no, no, no, no, no specific, low level mechanism targeted. And so she did just for three minutes. And the sport was really small as well, one square millimetre. Then on the way back, I was on the tube and I was listening to music, not nothing particularly special, just some power metal. And suddenly, it really started to sound like if it was played by Bach. You know, when I came home, I, I could not take headphones out, and I just had to listen to the album to the very end. It was just so enjoyable. And at the same time, for some reason. I started to remember many old jokes. And even though some of them probably were granddad jokes, they were very funny. So that was sort of concurrent with enjoying the music. When it's all has gone, I actually checked the stimulation area. And apparently, in the description of Brodmann area 39, one of the functions ascribed to that was appreciation of music and sense of humour. I don't remember all, you know, all Brodmann areas, functions, I mean, I didn't remember that one. So you can always, you know, pick, pick your number going up to 51. And check in the reference more specific functions ask right. Of course, you remember the major ones like, Broca and Wernicke and so forth. But not great detail, which with all of the differences between right and left for every single area. So that came as a surprise, and that could be interesting, the sensory enhancement. But for me, the main lesson from it was with a particular small spot, and possibly, incidentally, stumbled, right <inaudible>, you know, you can perhaps, selectively stimulate a single Brodmann area. Because I've also checked whether there were any potential effects from neighbouring areas and there didn't seem to be any. But of course, it's just a single anecdotal case, but maybe if someone hears about it, they might be interested to carry on and check it. You know, I mean, I had some very interesting enhancement effects, even from a very big magnetic fields, I had interesting enhancement effects when I used to reverse with quite controversial procedures, protocols using them in the opposite direction, so.

IB

What was the effect?

NIK

Well, one of the most successful ones I ever had, is, when I literally had to force myself to sleep for about a week. I just lost any need to sleep. And I didn't feel tired or down or anything else. And I was incredibly productive at the same time. So I slept probably about two hours per day. The rest of the time, I could literally swallow, more than 100 pages per hour. And in fact the bulk of my ideas and I I've repeated it again. And I repeated it again. But third time, it didn't really work that well, second time, it worked fine. So there must be some tolerance built in now, but quite a lot of ideas. The best ideas I have they came from that period. So they were the result of...

IB

So there may be a way to unlock a kind of minimum sleep productivity?

NIK

Well, yes, yes, of course. Of course, it's not like in limit resolution, and, of course, we know that all the theories about you know, how only 10% of our brain been active and so on are utter rubbish.

Nevertheless, there are ways to enhance what we can do which can be applicable both in clinical conditions and in a typical case, would be probably not organic dementia is where the bulk of research is centred. Right now, and where if organic dementia they, sorry, probably can't restore it without other needs, grafting, and so forth, but improvement of let's say retardation or different developmental disorders. but also it could be applied to healthy humans. I personally don't see any ethical reasons why it shouldn't.

IB
And so, how do you foresee the future of this kind of non invasive brain stimulation going ahead?

NIK
Well, first of all BCIs will get widely acceptable.

IB
Acceptable in the sense of?

NIK
In the sense of everyone will use a BCI at certain point, whatever it would be just to play a game. Then, the next step, obviously, as with games are initially just an entertainment but then you know, you start getting learning enhancement games and so forth, they actually become more and more useful than techniques similar to neurofeedback. will get more widespread, I mean, they're already spreading for relaxation, focus and meditations and so on. It's already getting popular. So that's your basic non clinical neurofeedback. And then, finally, in conjunction with a stimulation will be used as well. You know, what if you are not very susceptible for neurofeedback? about 30% of people in clinical neurofeedback are just not responding to it. What if it's going too slowly? What if you want to enhance it and push further? I mean, it's not going to come just on its own. You know, it's going to be complemented with such things. And even Focus was marketed as the device for gamers. So I don't really see why over time it would not be acceptable. Quite a lot of people trust and judge it more than they will trust the drug.

IB
Yes, I was going to ask how you see the relationship between cognition enhancing drugs, pharmaceuticals and, and brains, for example, brain stimulation.

NIK
Well, one day Big Pharma will have to accept it and play the game. They will have to support that kind of research. And they will have to look into interactions between physical stimulation and drugs. And eventually they will end up producing their own stimulation devices. It's just inevitable.

IB
Because pharmaceuticals are limited as tools, or?

NIK
No, because they are complementary, because they complement physical methods and vice versa very well. In fact, this is something they want to try. Maybe tomorrow. Maybe tomorrow Hackspace Yes, because you can deliver cognition enhancement drugs via electrophoresis. Which, which is quite interesting.

IB
Can you explain?

NIK

Well, if you're used to DCs, let's say you have your water soluble drug, which you then place, you use saline solution anyway, which you then place under the electrode of interest as a part of the solution or the conductive solution. That way you can have a concurrent effect of a drug, and tDCS. And at the same time, okay, it would not be a precise delivery. But it's still more precise, if it's taken orally, for instance, I mean, if you put, if you put your electrode of water in drug solution, and saline over let's say, a bulging of left temporal artery, there is a greater chance you will get more drug absorbed in the left temporal area, and there is generally around this artery spread. So at least you can be hemisphere specific, if not lobe specific, and that's again, something that no one has ever tried before.

IB
But how would the drug actually cross?

NIK
Electrophoresis helps to cross the skin, then it goes with a local bloodflow and then it depends on where you put it. But I mean, even even, even as yes, if you can actually have some selectivity by choosing your right carotid area over the left. So even then, you can have left versus right, so the theory too, so yes, you can have made drugs, very spatially selective in that way, but you can enhance the spatial selectivity, at least in a very crude level. And there is also laserphoresis and ultrasound phoresis of drugs and so forth. I mean, physiotherapists should be familiar with this. But if you think about, for instance, there was quite an old paper saying that <inaudible>, again, a potential nootropic and an agonist of NMDA receptors, and tDCS actually go well together and potentiate, its activity 20 times.

IB
What was the drug you mentioned?

NIK
<inaudible>. Well, it's experimental. but no one stops you from using any of the ampakines in the solution. together with tDCS, and then you can have more targeted delivery, and at the same time, you can have synergistic effect. So there's lots of opportunities, which, again, no one has ever done it. But I would probably say that, if I apply for a grant to do it, I will be sent off.

IB
Why do you say that? Because just oddly enough, I was at the brain forum two weeks ago, and there were all these big companies like Medtronic and all these companies, they were saying very similar things like Medtronic is now all into targeted drug delivery, creating devices that basically circumvent the blood brain barrier and just go directly to the brain.

NIK
I'll give you an example is just a very basic example. Now, if I apply for a grant from a street, you know, as an independent researcher, who is going to take, who is going to take me? No one. At the same time. That kind of things with some adjustments I didn't tell you about. But you know, I don't want to go too deep into technical details are very easy to check. You know, at least they're very easy to try.

IB
And could you say something about what your long term goal or vision is with pursuing this kind of research?

NIK
Well, at the moment, as I've said, we want to create a universal modular tool, which would also be networked, you know, allowing full remote control and so forth. If that succeeds, that already would be a great step forward. And then as a vendor, then work with academia using the tool and so forth.

Well, then, to be honest, I think some of the things I've seen, and so on, they go much deeper. When we have a suitable tool than I can, perhaps have a higher possibility to pursue those things. Because I think that the problem with current neurostimulation scene is that everyone is obsessed with the device and the method but not the protocol. When you look at the level of mechanisms, it's still very, very crude. So I think I know the solution to this problem. And strangely enough, exactly because my background is not in it. I mean, even my BSC was pharmacology toxicology. So I'm actually a, I'm a pharmacologist. So I think they know how selectivity of physical stimulation methods could be brought to the level comparable with modern drugs.

IB
That's quite a claim.

NIK
Yes, that's quite a claim. And that's eventually what I want to do. And, as I've said, I've seen enough to justify this claim, at least for myself, I don't have the capability or capacity to justify for others now. But times are changing. And if I'm not run over by a lorry. Perhaps I still have time.

IB
So, in essence, the current project is to create a community to give a tool to the community. Yes. And to raise funds, I guess to be able-

NIK
Oh, yes. And then be able to use it to go deeper and deeper and deeper.

IB
When you say deeper and deeper, what does that mean?

NIK
Well, deeper and deeper, deeper, I mean, targeting specific molecular mechanisms. And that, again, has large overall implications. Because if let's say, a sufficiently weak electromagnetic signal can target a specific mechanism, then the most obvious question that comes up to the surface is does that happen in physiological conditions? Because I, after looking at these things, I believe, unlike many people who would still say that brainwaves, for instance, are just an epiphenomenon. And they are as related to physiological function of our brain as sound made by car engines, you know, related to car actually moving, you know, and it could be useful for diagnostics to find problems with the engine, but otherwise, it does not contribute to its effectiveness at all. In fact, quite the opposite because it's useful energy loss. So I believe that brainwaves are a mechanism of feedback feed forward. So if sufficiently big stimuli can target specific, let's say, ligand-receptor interactions, then why, physiologically, brainwaves can't do that, given a very specific frequency amplitude window, of course. So finally, that would be an explanation of the physiological role of brainwaves, which is again, there's a huge claim, but someone's got to make it. You know, I doubt I'm the first one to make it, and why I think I may know the mechanism by which it can actually act as a feedback or feed forward loop. So it's...

IB
Okay, that's, that's, that's huge. That's a huge project. I mean, wow, huge. It's not taking place. I just find it so strange that academic institutions are not.

NIK
Well, I think the problem is, you know, when when you are not restricted by, you know, need to search for grants, you know, fulfil the requirements, which come with it and you stick to what you're paid to research and does have some rather interesting effects on where you can actually go.

IB
So can you say something about the community that is that exists around this kind of thing, like how many people are involved?

NIK
Well it's get getting, it's getting larger and larger, of course, it won't be as largest. I don't know, an open source community in general. There are people who are interested people who are interested in terms of development. There are people who are even just interested to be volunteers and try new things. I mean, there's always there are people who just want to observe, you know, that people are more interested in ethical considerations as well. But I would say you know, if you haven't tried it, either on the test site or tester side, you know, it's, you know, I find it a little bit A strange. I mean, if you're into football at least go for the games ideally be a player or a coach. So I would say we are talking about at least dozens in London, at least. But there's a beginning. Yes. I mean, if you think about people who take, nootropic drugs that's much larger, but, like big because they're there for longer. I mean, they're known for longer. Yeah, I mean, tDCS. As I've said this, when Piracetam was Piracetam was there since 1964. And there was encephabol before Piracetam, a few years before that, which I would not have <inaudible> from nootropic. if I mean, tDCS is there for more than 200 years, can be quite formal. Just a question of being known, just the question of being acceptable. But then, as I've said, first BCIs will be accepted, become quite normal to wear something on your head that communicates to an electronic device. And then the next step is the device communicating to you.

IB
And do you think there's an-

NIK
Effectively, you know, first reading from the brain and then right into the brain. And then again, talking about physiological role of, again brainwaves as the best example, but there are other interesting things, you know, there are acoustic communications in the brain, and there are light communications in the brain, apparently, you know, there's quite a lot of interesting hypothesis around it and the role of optical neuronal communications coming out. So brainwaves are just the most obvious example, again, that would really help to investigate their role, for example, by the means of replay.

IB
Means of replay?

NIK
Replay, yes. Well, you save brainwave data from a certain area associated with a certain state, and then you try to induce that state back by playing it back. Yes. So you can, you kind of have a library of your own brainwaves associated with XYZ and try to play back and see whether there will be an effect or not.

IB
And how will you, what will be the method of, because basic neurofeedback probably wouldn't cut it?

NIK
Well, you save it as, I mean, the simplest way you save it as a wav file, and then you play it back.

IB
Oh, it's just like that?

NIK

Just like that I mean, I've got quite a selection of such files connected to different states. I didn't do the replay properly. And, and the way you play it back, I mean, it could be anything. It could be via an electrode, it could be about magnetic field. It could be <inaudible> light. Transcranial light that would be ultrasound modulated light. I mean, that's, that's possible. I mean, I can easily replay <inaudible> and just the file will play with my mp3 player. It just that instead of sound card you have. instead of instead of a sound card. You may even have a sound card as an output way it's not limiting the majority of cases it will be limiting because the majority of sound cards would cut at 20 hertz. So yes, when you play it back by a suitable physical method. And that, again, is not something that is very scary for many trying to play back their own brainwaves. Or for the most adventurous people, perhaps you know, their their, their partner's brainwaves, whatever. whether it works or not, that would be an important step in investigating their physiological function.

IB
So it sounds like you think the brain as a platform will kind of open up in the coming years through all kinds of different technological interventions. Yes, it will be more and more accepted. People will wear stuff in public?

NIK
Well, yes, yes, of course. It will be unless we fall down to Middle Ages. They will be.

IB
And it also sounds like you, so you follow the state of the art in academic research and you try to find the stuff that no one is pursuing, but that might be deduced from the things that others are-

NIK
Well, it's just interesting when you look at various published papers, and you see what else could be done that no one has ever done. And, again, it would be quite difficult to justify a grant by simply saying, "Oh, I'm interested in it, so I want to try it out." We're not going to do when it takes 100 quid worth of equipment, you just try it out. You know, and I'm not talking about, again, people start saying about really dangerous methodologies and so on. electroparesis of ampakines is a good example. Piracetam was one of the least toxic drugs, one cannot really imagine it's less toxic than sold.

IB
So what do you think about-

NIK
tDCS is also quite a safe method. Frankly, speaking, I don't see. I couldn't be mistaken. Well, could be mistaken. But I don't know when, more or less how tDCS works. And knowing very well how Piracetam works, you know, as to the point where it binds to serine in position seven <inaudible>, certain sub units of AMPA receptors and so forth. I mean, I can't see how the combination can actually for instance, induce excitotoxicity. I just can't, I could be mistaken. Yes, my thesis wasn't excitotoxicity. But I wouldn't mind trying it. And that's just one example. weak magnetic fields. If we go well below the levels, sufficient to just induce enough current to force neurons firing. I don't see what safety problems would be there. Yet, I do see mechanisms by which it might work. You know, they could be controversial. Yes, there is a TBT problem. But at the end of the day, Boltzmann constant multiplied the temperature. So yes, but the more controversial was essentially the more interesting to try.

IB
Controversial scientifically?

NIK

Controversial scientifically, not controversial and ethical. Many people would say that, you know, if, if it can't really influence, a classical chemical reaction doesn't doesn't have anything to show it doesn't have enough energy to do so then it doesn't work. You know, the bulk of TLVs in the West are still based on purely thermal effects. Which I don't think is right.

IB
And do you think there's an overlap between the people who who are involved in this kind of DIY brain stimulation research? And those who take let's say other nootropics? Ritalin, Adderall, Modafinil.

NIK
I would not call modafinil a nootropic.

IB
Okay.

NIK
And Ritalin as well, I just do not.

IB
Okay.

NIK
But there is obviously an overlap. And then I take nootropics, but then I was always taking them.

IB
Nootropics, but not stimulants.

NIK
Nootropics, but not stimulants, even though I would, I would take Ladasten if I needed it. But that's an exception. Ladasten is not a, Bromantane is not a very usual stimulant, I would call it an ergotropic.

IB
An ergotropic?

NIK
Yes, ergotropic, something that increases your stamina. You know, I will take it if I need to go to the office and let's say handle an audit at nine o'clock in the morning, while my plane just landed at 3am. And the difference in time zones is 10 hours. Right?

IB
That's what people take Modafinil for.

NIK
Yes, exactly, but-

IB
So you think modafinil and psychostimulants are more or let's say harmful or more problematic?

NIK
They're not true nootropics, they keep you awake, but they do not really enhance your cognition in terms of processing speed. Memories that can be stored, memory capacity and so forth. So there they

are. They are emergency medications, when you have to push over your limits. Just for instance, stay awake. You know, it's not, it's useful, but I would not, you know, overdo it generally, you know, even having a nice sleep is actually a nootropic in itself, where the stimulant is really not.

IB
So, will you close, like, we're kind of wrapping up, I recognise the time. So would you, this is kind of off the would you say say that you're like a health conscious person otherwise, so do you watch your diet and your exercise and sleep and you pay attention to like these very conventional-

NIK
I do when I can, but I don't think our lifestyle can allow that, you know, in particular in mine, and so. It's just, you know, people who can afford to be very health conscious, are actually quite lucky. I mean, if you can go to a gym in the middle of a day, I wonder where the hell do they work? Probably Bank of England off what I've heard. But in the majority of cases, it's actually a good, you know, different enhancement methods. And I'm not only talking about cognition enhancement right now, you know, they may not be ideal. But for many people, they are the only reasonable way to go on with their life quite often. And, again, coming back to the ethical argument, that might not be the very top that will be people who really have to push hard.

IB
So then the whole, maybe just calling it enhancement is misleading, in many ways because it kind of creates this image that you're surpassing the limitations. And I think it often creates false expectations, when it's when it's often about very mundane things, like you just said, when people are stressed and overworked and exhausted, and they need something to-

NIK
Yes, you can actually view it as a part of preventive medicine. Because we don't fully realise their potential health effects, but just stress reduction from being able to handle an incredibly heavy task. You know, what do we know? What kind of health benefits does it have in the future? You know, it probably does. And it's not that linear, I mean, but many, many drugs considered to be nootropic, perhaps not here, you know, you would be surprised that some of them are actually GABA agonists. You'd not expect that.

IB
When you say maybe not here, are there like huge differences geographically?

NIK
Enormous differences, enormous differences. All over the ex USSR, Far East, South America, they're widely accepted.

IB
What kind of substances?

NIK
Well, pretty much anything that we call a nootropic I mean ampakines for sure. Some other substances of interest, I would say as now some actually GABA <inaudible> Encephabol is not really a true nootropic, it just increases glucose transferred across blood brain barrier, but its usefulness as an adjustment. Same with vinpocetine, which only increases local blood flow to the brain. There are some more interesting things like Semax and Selank in Russia. And there's also Cerebrolysin, which is an NGF <inaudible> extract from porcine brain. Semax is effectively a part of the ACTG which preserves its nootropic properties with all other parts responsible for the hormonal activity, which gave ACTG its name, are chopped off. So it's a peptide you have to use nasally because it will disintegrate in the stomach. So there are lots of interesting things which are just sold over the counter.

You know, as soon as you leave the EU or the US, well you don't even have to leave, leave the EU. I mean quite a lot of those things. You can still buy in let's say Budapest or Prague, Krakow.

IB
Okay, I sense you have nine minutes to go on the call, just have one question, do you think that there's something very important in relation to this topic of DIY, particularly brain stimulation research that we completely failed to talk about, that we didn't touch on? Something that you think it would be important to say or add?

NIK
I'm not precisely sure because now I start thinking about more specific technical matters. And, you know, like people being concerned about safety programmes, not where they clearly are or where they could be. But I think my main mantra, and this is what I'm interested in the most is what I've already said that it's all about stimulation protocols, and selecting specific targets on the molecular level, than a fancy device or even the fancy physical methods, I mean, in many, many physical methods of stimulation, they actually converge at some point.

IB
Physical methods of stimulation being?

NIK
Well, I mean electromagnetic for different types of acoustic, and so forth. I mean, they they actually do converge to a point. I mean, even shaking the dipoles with ultrasound will produce local weak electrical field, supposedly, with a frequency close to that of the shaking sound right? Lasers, as I said, when going through tissue, especially if a certain volt level was reached they produce a secondary electrical field and so forth. So electrical stimulation can enhance the photon emission and optical spectrum.There could be a <inaudible> electric effects. So they do, they do sort of converge at some point. And what's important is what they target. Now, of course, important difference between differences between various methods which, which I enjoy. But at the end of the day, it's what you pick up as a target, what mechanism was involved. And the key thing is actually to know mechanisms actually make and same same same with drugs. Exactly the same. Which receptors does it act or doesn't act on? What are the effectors? Which signalling pathways activated same here in just that there is this huge rift between let's say, the molecular biology side of the neuroscience world and the electrophysiology side, so to say, of the neuroscience world and when it's finally breached, you know, we will see miracles.

IB
Why, because of differences in training, or?

NIK
Lots of different differences in training in perception. I mean, for many molecular biologists when they think about electrophysiology, when it's mentioned, they would say, do you mean patch clamp? for many electrophysiologists the minimal unit is the neuron. You know, when you obviously look at things like EEG, you have millions of neurons firing in concert, so they're not really that much interested at what's going on at the molecular level, and for many years, there were discussions of creating electropharmacology, you know, and having carefully compiled EEG profiles for every drug. that obviously, you know, raises up a question of whether replaying such profile physically would emulate effect of a drug. But it never really came through because of this risk that never came to life. Just this difference in the level at which different researchers look at things and so on. and this difference <inaudible> will will will have something of grand significance and gravity. gravity may be beyond imagination, but-

IB

Really? When you think about the potential, it's-

NIK
The potential, the potential there is really huge. I'd say so.

IB
And you know, talking about complementing the brain with like additional, let's say neuromorphic implants are just tweaking an existing biological system in such a way that the effects can be hugely profound.

NIK
Well, yes, that's also getting there, but we're sort of didn't touch the topic of implants and potentially nanobots.

IB
Yeah, I did want to get there. That's exactly what I meant. And you're saying that-

NIK
I think Ray would know more about about it than I do. You know, he is quite into it. I mean, then.

IB
But that's exactly what you're saying that there can be huge effects?

NIK
Hell yes.

IB
Just using non invasive methods, basically, yes,

NIK
Yes. And they are getting better. But as I've said, the key thing is the right protocol <inaudible>. And of course, it's nice to have a very low, let's say spatial resolution. Ultrasound can go down probably less than two square millimetres, and so on. And as I've said, if you can activate the single Brodmann area, and I believe I can, again, is a huge breakthrough. And if you can activate an area at a given depth, that's also a huge breakthrough. And that's difficult, but I also think they do know how to do that. But you can do it either by enhancing the actual technology. As you know, there is a TMS method using eight different coils position to concentrate the field within a specific deep brain area. But you can also do it while applying different stimulation protocols based on totally different principles from what is used now. So that's where we my main interest lies, and that's where I think there will be big advances inevitably. Because at the moment is quite crude at the level of on of enhancing the probability of neuronal firing reduce the probability of neuronal firing in the best case, it's entrainment of a certain brainwave. But we don't really know about the physiological function of brainwaves not, you know, not enough, not enough to a point that lots of people would still, as I've said, said, it's an epiphenomenon. And they're just not. They're just noise.

IB
But so the different principle is that actually, brainwaves are cau- They're causal, as opposed to being phenomena. Yes, that'd be the gist of the different principles.

NIK
Yes, I guess. So. I guess so.

IB
So if you can induce certain brain waves in very targeted areas, you can have-

NIK
You can we can regulate an interaction of a certain transmitter, whether it's with a certain receptor and vice versa.

IB
Focusing on complete loop?

NIK
On a complete loop, complete loop. Well, I guess that depends on what you call brainwaves. I mean, there's there's obviously, very slow oscillations, which are very interesting. They're also very high frequency oscillations, which were largely ignored. But if you look at tRNS, it's far more effective, for instance, when you use noise, above 100 hertz and not below. So it's this. Again, as I've said, other ways of communications between neurons which are still to be explored. You know, if you if you put glutamate on one end of the neuron, you have admission on the optical spectrum from the other end. Is that an accident? I don't think so. And again, Using light, concentrated light is very interesting for you can have a combination of effects due to that light wavelength. And then you can have further chemical effects. And then you can have additional effects due to the way you modulate that light.

Thomas

IB
So then how did you first hear about or become interested in tDCS neurostimulation?

THOMAS
I think that I first read about it in an article like two years ago. And at that point I didn't know anything about it. Wasn't really even in the field. I was more sort of doing an engineering degree. Ah yeah, it's quite interesting but not really, for me.

IB
Ah so your first degree was engineering, electrical engineering, or-

THOMAS
Yeah, it's actually a general course. I ended up specialising in sort of signal processing and stuff, what they call Information Engineering when they want to be fancy.

IB
Okay, and from there, you move to a PhD in neuroscience.

THOMAS
Sort of, neuroimaging. I wouldn't claim to look at the neuroscience stuff too often. I'm aware of it, and I work on it, but it's not the focus for me.

Ah I see. So then, how did you, like gradually enter the whole neurostimulation thing?

THOMAS
Yeah, so I looked at that, it was interesting. But obviously, that was just an interesting article that I read in New Scientist or Wired or whatever. And then about a year later, we had a visitor, {…} Hackspace, who was actually very similar guy to Nik, who's on is in very interested in this stuff. It's very, it's cruel to say credulous but very willing to believe it. I think perhaps optimistically. Just be like going around, you can try these things. Look, I've got a replica I made of Persinger's God helmet, this kind of thing. And obviously I was very sceptical. I tried the God helmet thing, because I think it's very, very clear that it can't be unsafe, given you expose yourself to similar field levels on the phone.

IB
Can you explain the God helmet?

THOMAS
So that was an incredibly dubious result that a researcher, Persinger, and his colleagues released where they had very, very low level magnetic fields fluctuating around the head in a weird pattern, a pattern that they never explicitly specified. And they said it caused a feeling of religious awe quite reliably.

IB
Did you actually try the God helmet?

THOMAS
Well, I did try that replica thing. That certainly didn't do anything for me. But indeed, a Swedish team tried to replicate the results and never managed. So it sounds like a bunk, I think. But it was interesting. I mean, the idea that oh, okay, a small field might actually make a difference. As it turns

out, I don't think it does, probably, but the idea was sort of planted and then the guy's like, Well, okay, this stuff is very, you know, finicky. Something that really does make a difference is tDCS.

IB
So that was the same occasion when you tried tDCS as well?

THOMAS
Yeah. So you had some set of flats. So that I was far more reluctant about because it sounded kind of not hugely unsafe. I mean, it's similar to putting like a AA battery across your head.

IB
I think that sounds good.

THOMAS
Well, it's not good, but it's not dangerous. You do dumber stuff than that if you ever do electrical things but yeah, maybe let me read about that. So sort of wandering off for half an hour he was using his God helmet on all these other people. Sort of read up on that and concluded well, if there is a long term risk, it's by far less than driving. It's a sort of background level of risk so I tried it. And well, there is a tingling at least from the current. So you know, okay, in some sense it's working in that there's actually current going through. Whether it makes a difference or you perceive stuff I'm still dubious I think maybe it did. I forget I think he, I can't even remember now which sort of locations he's having set up.

IB
I was gonna ask what was the-

THOMAS
I mean the intended effect was a sort of social like increasing sort of social reaction based kind of like if actually having a drink was I think how he described it. I should remember which brain centres that was, but my neuroanatomy has never been great anyway.

IB
And what kind of device was that? Was it a self made one was it a commercial one?

THOMAS
That was part self made part commercial. I think the actual sort of electrodes and stuff obviously, you buy. The controller was self made.

IB
And so you ended up in the {…} hackspace by chance?

THOMAS
I actually helped to start it. In its newest incarnation anyway, I think it's been around in other names for years but I started going again. But anyway, so I tried it. And I was like, well, this could be making a difference though it could also be placebo.

IB
How would you how would you tell? Like, have you tried running-

THOMAS

You'd have maybe a blind test; I don't have that much of an interest in it. It's interesting. You should really run some blind tests. He agreed, then he left. I don't think he did anything with it again for like, a year and a half. Whatever.

IB
And so, how did you, how did the topic pop up again?

THOMAS
Yeah. So I saw people posted on the {…} Hackspace mailing list, because by this point, I'd moved to {…}. And they were saying, oh, yeah, okay. People are interested in this stuff. Frankly, for me, I thought this sounds pretty crazy. To be honest, they don't sound like the most scientifically minded, but I thought I'd have a look anyway. And then in person, I think I'd gotten the wrong impression, in a way. I mean, people like Ray, who's actually doing PhD in neuroscience stuff, even Nik I believe holds a PhD. I think he's way too credulous about this, but he at least has good reasons for thinking it.

IB
Okay, so you kind of joined that brain hacker group in {…}. What kinda stuff do you guys do?

THOMAS
Yeah. So they are mostly interested in Nik running a load of his crazy stimulation paradigms on people trying to see whether there's an effect. And again, I think it's just like, it's not actually science or anything, because he's not blinding them or himself. So. But it's interesting, they do a lot of other stuff, too, like reading things with an EEG and controlling stuff based on it. And they're interested in even trying to make it a lot easier to do this stuff, like building kits that would let people stimulate one another, whatever. I still think it's too early in a way. But okay, fine, do it because it doesn't look hugely dangerous. Until you prove that it's useful. It seems a bit dumb.

IB
So you have doubts about the utility of the whole methods?

THOMAS
Yeah, hugely. I think, as I say, until comparatively recently, there were no good studies. Recently, there have been some better ones. And they've been really mixed in their findings.

IB
So you kind of follow the academic literature on tDCS?

THOMAS
A little bit, not hugely.

IB
When you say they are trying to do this, do you really not consider yourself part of the group trying to do that, or you're like in between?

THOMAS
I'd say in between. I mean, for one thing, I don't go there that often, say once every two weeks, which they often are, like two or three nights a week, sometimes, I mean at peak times, sometimes it varies.

IB
And have you used, do you own a tDCS kit yourself?

THOMAS

I do not.

IB
So you never use them as part of?

THOMAS
No, I'm gonna be very boring.

IB
No, actually it's very interesting. So can you say something about what your "experiment" space looks like?

THOMAS
I wouldn't call it an experiment. I mean, okay, it's sort of an experiment. Basically, just "hey you there, you want to try this thing?" They try the thing. They say whether they feel any sort of effects, often they've been told what the effect should be. So they know what to say, anyway. It's not a proper experiment.

IB
And the "Hey, you?" would literally to someone who is there at Hackspace like, "Hey!"

THOMAS
Not really, I'd say it tends to be initiated more by the people. Yeah, there will be people hanging around and looking at Nik doing it to himself and asking if I can have a go usually. Maybe Nik will say, if anyone wants to go, would you like a go?

IB
But what do you think about that? Do you think that's like an okay, procedure or do you think that's a problematic procedure?

THOMAS
Well, problematic from the point of view of experiment design, yeah. But it isn't really an experiment, problematic, safety wise, morally, not at all. It's just so well, not that dangerous compared to what we do every day.

IB
So what would you compare it to in terms of risk that you think it poses?

THOMAS
I mean, there's always this sort of philosophical question, isn't there like is smoking one cigarette comparable to taking off however many minutes of your life? Obviously not, there are uncertainty factors with lots of things. While admitting that there is no long term research on health impacts, the simple fact is that the currents involved are so small, effects seem so small, that even if someone was doing it regularly, I couldn't see there being any real risk.

IB
And so have you, you've used tDCS a couple of times? Yeah. What kinds of effects have you actually noticed, or how would you describe the experience? Or what was the intended outcome of-

THOMAS
So tDCS specifically, there's always that sort of tingling electrode on your scalp, that's probably the most noticeable and objective thing is actually sticking because of the electricity, and that's cool.

Actually, there's this attentuation paradigm, and I'm not going to be able to remember which part of the cortex it goes on. But the idea is to make you more sociable. It's meant to be comparable to beer, it's meant to sort of trigger dopamine release, I believe if I understood properly. I don't remember. It's interesting.

IB
Did it make you feel more sociable?

THOMAS
Yeah, it did. But you're gonna feel more sociable when you've got a huge helmet and a load of wires on it, either you'll feel very embarrassed, or you will feel very sociable. So I did, I don't find that convincing at all, what I think might have been true.

IB
And in terms of research, or experiments, it's cognition enhancing effects, which a lot of people seem to be very interested in. Did you guys try any?

THOMAS
Yeah, there's been a few of those. So I've tried that once. The idea is that you put it around somewhere near the motor cortex actually, which is weird, because it wasn't the way you'd expect it to be. But supposedly people stimulated there to ground I think, just the gear or whatever. The impact on numerical tasks, I tried it and did pretty much exactly the same within error bounds, maybe even slightly worse. So I was like, pretty sceptical. That said, some other people there tried it so there's about five of us maybe that tried it, and a couple of them did better. Out of five, two do better. It's not a proper study at all.

IB
Do you think that the guys doing this kind of DIY tDCS experimentation, they would like to what do you think is the motivation behind this? Is it a fun, kind of thing to play around with? Or are there other motivations?

THOMAS
I think it's varied, I think, as they say, Nik is a real true believer and honestly believes that all of these things make a huge difference in a really useful way. Like he thinks he controls his mood through using them. Indeed he does control his mood through using them, but I think a lot of it's placebo, and what he expects to happen. Other people for different reasons, though, like Ray is there because he's actually interested in researching this stuff. And I think he's very interested in trying to take research out of his lab. I don't know entirely what it is. Other people are there. I think a lot of it's more yeah, this seems cool. I think it's very seldom that people think yes, I want to do this specifically for x or y or z benefit.

IB
Because it's just too early or too unknown?

THOMAS
Yeah. I mean, some people are very keen as in they say, "Oh, wow, if it can do that, that'd be great." And then they try it and say "Eh, maybe it does." I think it's quite rare for people to be as enthusiastic as Nik is.

IB
And so what would you say? How big is the community In {…} or in the UK around this?

THOMAS
I shouldn't really guess. You'd be better off asking somebody who's more into it. I think people who reliably show up to those meetings, there's only a few, say, three or four or five something. They will always be a crowd of other people who are interested. I think there are lots of people are slightly interested. Not many people actually do it.

IB
Yeah, that's interesting. And so coming from like an academic, you're kind of at the intersection of an academic, the academic world around this and the DIY world. So do you think the commercial availability of tDCS is that a good thing, or is that a not so good thing?

THOMAS
Well, I think the good news is that it's not a very important thing, at least yet. Either way, there won't be a huge difference. It isn't going to hurt a load of people, it probably isn't going to help a load of people either. I think it's slightly bad that it's happening before there's proper research just because it seems a surefire way to either create pseudoscience or get something labelled as pseudoscience.

IB
So the thing that the method is, would you say that the method is promising but just too early?

THOMAS
Yeah, like promising with doubts and it's too early.

IB
Promising with doubts. Okay, that's cool. And do you think there's an overlap between the brain stim community with tDCS and smart drugs?

THOMAS
Yeah hugely, I think hugely. I've never been, especially into that stuff myself. Speaking anonymously, so I can say I tried sort of traditional drugs a few times out of interest, recreational. And obviously, the effect is so much greater than most so-called smart drugs.

IB
What do you mean by smart drugs?

THOMAS
So the only extent that I've tried stuff in that end is piracetam, which is meant to help you focus. I was interested, again, looked up the risks found it was low risk. I was like well, let's see. Negligible effects, I found.

IB
Have you taken it over a longer period?

THOMAS
I did take it over a little while, about a month. It was a self experiment. Sounds kind of crazy when I put it like that.

IB
No, not really. I think there's a lot of interest in the racetams and nootropics. And particularly, the guys you mentioned, Nik and Ray, and maybe Nik in particular. Very-

THOMAS

Yeah, yeah he is.

IB
So what about the other so-called smart drugs like modafanil, ritalin, adderall?

THOMAS
Yeah, I dunno. Those clearly have a stronger effect, but I'm reluctant to try it. Because that's quite intimidating.

IB
Because the strong effect?

THOMAS
Probably more the legality. I mean, obviously, sort of, for me, the thing I value most is like my mind anyway, I suspect that's true of a lot of people. If you'd lose it, you'd want it back. Yeah. So it's partly that, partly the worry that you could cause some sort of permanent change. But I think mostly the legality one because a lot of these have enough of a history now, if people see, okay, it's pretty safe.

IB
A lot of people say that it's kind of an ethically problematic thing that people use various cognition enhancing technologies like tDCS or smart drugs. Do you see an ethical issue with these?

THOMAS
It's interesting. I mean, I, again, for the sort of the more extreme smart drugs, I think the ethical issues are perhaps more related to the current state of our law, perhaps the risks about interactions with other drugs or other sort of medical risks, but maybe not. I think there is clearly sort of a philosophical worry about, you know, what happens if people need to buy X product to actually do well at exams or to do well in a job, whatever, but that remains a very theoretical thing. I can't see the world getting like that very fast. Maybe a lack of imagination on my part.

IB
So you're sceptical about, like the societal acceptance of-

THOMAS
Yeah. And also, even if they were accepted, I don't think it makes that much of a difference. And it's anecdotal. But people I know who've used Ritalin, kind of, it has made a big difference to their behaviour, but in the end, they've not done a lot better or worse on things that they usually would.

IB
So there's a big effect on behaviour, which doesn't translate into the performance boost that they're looking for.

THOMAS
I'd guess that, but again, I think it's way too early to say. But yeah, I mean, anecdotally, I've seen friends who would be sort of very demotivated to revise for exams, so they'd take that to revise for exams, but end up manically cleaning the flat or whatever.

IB
So it gives them the motivation for the wrong thing.

THOMAS
Yeah, it can.

IB
So just slightly coming back to the to tDCS thing, do you plan to continue to remain in this DIY hackspace?

THOMAS
Yeah. Yeah, no, I'm interested. I mean, in some ways, it's not at least they want to make their own sort of product. weapons. and I'm with them on that, mainly out of interest. They want me to do some electrical stuff for it, and I'm gonna do it. Because it's an interesting challenge. And I don't see any problem with it.

IB
It's mostly the, the engineering challenge that-

THOMAS
Well, that's why I'm staying with them. Yeah. I mean, I like the idea of the stimulation stuff. I also quite like the idea you could make a kit that would make experiments easier to run. I think part of why there aren't loads of good experiments is that it costs a lot to set up.

IB
Why do you think by the cost a lot because there's this discrepancy-

THOMAS
That is changing a fair bit. Like one of the judges in the axon pointed out sort of something similar to what we did is being done now for about 500 US dollars, before it was like 5000. We're hoping to make one at say 50. But I think that's less of a stepping away, because obviously 500, a lab could pay for pretty easily. 5000 is a bit more aaah. If we're a funded lab, we could. Well-funded I should say.

IB
Switching topics slightly, would you say that you're like a health conscious person, like you're-

THOMAS
Moderately.

IB
So you watch your sleep and your diet and exercise? Do you pay attention to these sorts of things, or-

THOMAS
I pay attention somewhat, as I say, moderately. I think a lot of the quantified self stuff is again, worrying so much about details that it's a bit absurd. I think, basically, you know, if you eat reasonably fresh food, not too heavy a meat based diet, do a bit of exercise and don't drink a lot, you're doing pretty much the best you can do.

IB
So you're not into self tracking?

THOMAS
Well, no, I do dally with it. I track my sleep. Not in any sort of level of detail more than just time, but I track the time very carefully. I tried to use sort of sleep cycle stuff to wake up at a good time. Again, I don't know if it's actually proven, but it seems to make a difference subjectively.

IB

And do you think there's an overlap between the people who are into smart drugs broadly and the quantified self people?

THOMAS
Yes. Although I think perhaps just by chance, most of the people that I've met, are more theoretically into the quantified self thing than actually doing it.

IB
Because it's just too time consuming or?

THOMAS
I think so. Yeah, time consuming, effort. Also, I mean, it's very good to sort of measure whatever you do to yourself. But if say you want to have a load of drinks one night? It's not especially, yeah.

IB
And just thinking about the broader or more long term uptake of cognition enhancement, and you kind of mentioned that you're sceptical about this. Can you say more about why do you think it's not going to be received-

THOMAS
Well, I think it will, I just think it will be quite a different world by the time it has. I don't think existing stuff appears to make a large enough difference, that it's really a worry, or even people really take it up. I mean, even something that was well designed and didn't look like a clumsy helmet with a load of wires. Why would you bother wearing it; there's a barely perceptible difference? I think more generally, there will probably come a point when there are a load of enhancement things that make a big difference. But by then, we could have drastically changed as a society anyway, it's not even worth me speculating.

IB
So you think it's a very long term prospect? A long way off?

THOMAS
Sort of, I think this thing where few people in a few city centres are very interested in tiny differences will grow a fair bit. But I don't think it will ever be a huge sort of society changing thing. I think what would be society changing is more longer term stuff that actually makes a very big difference. But I only think that, I don't know.

IB
What do you mean by more longer term stuff, so like piracetam that actually works?

THOMAS
Essentially that, yeah, drugs that worked better in that way, and were safer, and had sort of an atmosphere of more legal acceptance around them. Or things like that, sort of technologies in the offering. I mean things. I think it's interesting to contrast a lot of this stuff to things that have been done medically. For instance, there are sort of deep brain stimulation treatments for Parkinson's and epilepsy. And there, the differences are really dramatic. Someone goes from, in the case of Parkinson's, having a huge Parkinsonian tremor, to not having one. I think when you have effect sizes of that kind of magnitude, it would be a huge thing that would change the world in some way.

IB
And do you think that that's, that's clearly a treatment or something that is very well defined and very, evidently a disorder. Do you think that the same kind of effect can be obtained in the optimisation of the normal?

THOMAS
By definition, yes, I mean, tool use. It's the most basic example a person can't lift something that weighs 1000 kilos, unless they're incredibly strong, whereas a machine that they get to use can so yeah, I think, obviously, people tend to draw a line, they tend to be like, Oh, well, using machine it's very different to enhancing yourself. I think obviously, the line's quite blurred at some point.

IB
But can you, can you like? Do you think that technologies that are more invasive like tDCS can have that kind of enhancement effect beyond the norm? Because there's debate about that as well. Yeah. You can only optimise but there will be a trade off and you only optimise within certain biological constraints. The game is already very well-

THOMAS
Well, I would agree. You're starting with the brain as it is, obviously, by definition, I don't think there is any reason that you couldn't do a lot better. I mean, like I said, a tool. It sounds like it's a completely different thing. But it's not I mean, say a calculator lets me do sums very quickly, or it's a very good calculator. It's a basically it's all computer general purpose, then I could do probabilistic inference with it that I can't do in my head. Well, is it suddenly part of me if I tape it to my head? Is it suddenly part of me if I put it inside my head? Is it part of me if I don't need to type in stuff? I can just think about it. You could do any one of those steps with more or less difficulty.

IB
Like implant it in your head?

THOMAS
Well, I don't... I'm not planning to, I think that's quite a way off, but a crude way to do it, etcetera, etcetera. But you see my point? Well, I mean, there is a continuum. There is also a huge difference practically speaking, given that nowadays, it's really unsafe to do that. There's a huge infection risk, if it's near the brain, there's a terrible risk. But yeah, I don't see actually any philosophical issue, I just see a practical issue.

IB
Yeah. That's interesting, because in the discussion, they tried to make a very big difference out of the level of invasiveness of a procedure, as long as something is external, the ethical issues are considered to be very different from when something is, breaches the skin. Yeah. Well, you'd say that tool use of the external sort and things moving into the body, there is not like a continuum when there is no- Do you think there's anything that would be really important to say about this topic that we completely ignored or didn't touch upon?

THOMAS
Almost certainly is but I can't think of it.

IB
Something else you would like to say?

THOMAS
I dunno. I guess that, from my perspective, at least, people are either very excited or very panicked about this. And I suppose that's understandable, but I don't think it's really warranted. Even if excitement or warranted panic isn't really going to help things, so.

IB
That was really helpful.

THOMAS
I hope so. Cool.

Ray

IB
I think this will be very basic. And it's mostly about your experience and your thoughts around brain stimulation. Research, not necessarily in the academic context, but in the work that you do outside of academia. But I'm happy to talk about-

Ray
A little bit about, more of a kind of summary, fine. Yeah, okay.

IB
So just to ease in, tell me a bit about yourself, who you are and your background.

RAY
Sure. Yes. I'm Ray. I'm a PhD student at {...}. I'm a second year PhD student. I research as you know, brain stuff, specifically sustained attention. And I use EEG and fMRI partially. But I do yeah, I do computational modelling and of the brain and so on.

IB
And you're also active in tDCS? Research?

RAY
Yeah. And I have, yeah, and I do some stuff. With tDCS. I've done some stuff with tDCS professionally, but with with tDCS, some I'm more involved with not nonprofessionally than professionally.

IB
What do you mean by nonprofessionally?

RAY
Like non, outside of academia? Outside of my work, when I'm getting paid for it.

IB
Can you tell me how you kind of became interested in tDCS? Or how you first heard about this, or you first encountered the whole topic?

RAY
Sure. Well, I was been interested, I've been interested in brain stuff for a very long time. And so I knew about and studied EEG and stuff, other things from fMRI, so on. And naturally, when when, why you started reading, when I was reading stuff, I came across, you know, different ways of, as opposed to just reading the brain, also stimulating and acting upon the brain. Kind of brain, you want brain input and output, not just brain input.

IB
Okay, and so what can we see, given given the uncertainty around tDCS? What concerns you that it's a good thing to try it in a non academic context? And by uncertainty I mean about the debate that's going on.

RAY
I was gonna ask about that, yeah. Which parts of the debate you refer to? Because, okay, let me start answering it. But then you can maybe clarify that point. I started being interested in tDCS, because I looked up the numbers, and I did some math and saw, it cannot acutely, at least in the short term, do

any damage. Like it's not possible, it's physically impossible. The numbers just don't add up for you, you know, there isn't enough current and voltage, there isn't enough electrical power. So that was the first thing and that was kind of interesting. And of course, we've all heard of kind of, we've, we've all heard of electroshock therapy, and so on, which is completely different, right? I mean, so some people think there's a controversy because it's like electroshock therapy, it's not, it's like 10,000 times weaker. And that's the difference in weight roughly between an iPhone and a car. To kind of give, it's a pretty huge difference. So it's, it's a relatively non, it's a pretty non invasive, and acutely, at least completely safe method for altering brain brain function. So that's pretty interesting. And so of course, I'm gonna look into it; I'm looking at all sorts of things about the brain and so on.

IB
Okay, cool. Can you tell me about the kind of research that you do as you described it? Non professionally or non academically?

RAY
Sure. So I well as well, yeah, I play around with tDCS. But also other stimulation methods. I've looked at magnetic stimulation, both high and low field magnetic stimulation and tACS, which is just AC and DC. And what I do I've, I'm looking at things like doing these things cheaply in a DIY way, because equipment can be can be kind of costly, even the cheaper, cheaper ones are kind of a couple of 100 pounds, let's say, there is no reason they should cost that much. You can build them so much cheaper. And I'm interested in the personal experience, also, how does it feel? It's one thing to read. It's one thing to read about a sample size of 50 and some kind of statistical result. And another thing is actually feel the experience. And judging that it's at least acutely, completely safe, maybe not chronic if you do it chronically. which we could talk about? I will have on occasions, you know, tried some tDCS. Yes, yes, yes.

IB
Yeah. So can you say more about than what it actually feels like? Or what the experience is that you tried to-

RAY
Sure, I could, I could. It really depends on the protocol. So with tDCS, or many of really any of these methods. There is something called the protocol of how you do it. So where do you place the stimulating electrodes? How exactly do you stimulate? How much current do you run? How much voltage? In the case of AC, what kind of frequency and phase offset stuff like that? So it does depend on that. But I usually use two or three protocols or montages and kind of stick to those because there's most evidence and most research into those. And I do like keeping playing it safe.

IB
And can you say something about the protocols like what do they target, and what would be the intended outcome of that?

RAY
Yeah, sure. So So one I've tried is kind of a feel good protocol, which is kind of lifts up your mood. There is another one, which is kind of improving your focus, well kind of improving your focus being able to sustain your attention longer. And yeah, those are two main ones, but there's a few other ones.

IB
And what have you, what have you experienced? Like in your personal experience? What's it like? Does it work?

RAY

Yeah, yes. I mean, the short answer is yes. To elaborate, the short answer is yes. It really, I mean, it really varies and how for so you can the main parameter with tDCS once you've set a specific montages is really the current. So the voltage, kind of also, but the current is more important. And, and if you're doing it properly, kind of at a study level of roughly two mA, two milliamps, you can really feel the effects and does a point of comparison. It's it's not super extreme, but it's kind of it does... I mean it's hard to quantify because it's such a different experience, but it does roughly maybe correspond to drinking a strong cup of coffee or having a beer or two, but without kind of actual intoxicating effects of alcohol, the kind of feel good effects. So it's not you know, it's not mind blowingly powerful. But that's also good, in a sense, isn't it?

IB
When you're comparing it to coffee, do you also get all the other side effects?

RAY
I don't, I don't, yeah, I don't and that's, that's the nice thing about it, you don't really get that. I mean, that really the only side effect is, is in the beginning, it kind of burns your skin a little bit, it itches, and that's kind of uncomfortable. You get used to it and if you well if you specifically if you do it for about 20 minutes as you should, after a few minutes, you don't feel it anymore, and afterwards, it might itch a little bit but there is no damage to the skin.

IB
Okay, can you say something about what kinds of situations have you used it? Which was not a research kind of thing? Like this-

RAY
Well most situations I've used that are non-research, yeah.

IB
Oh, okay. Can you give me a few examples when you wanted to do-

RAY
Okay, it's not it's not a target, it's not that you use this for a particular goal, let's say when you want to prepare for something when you want to do some focus work. Sure, say I've I tend to find time mostly on the weekend, so I would kind of just wake up and I might my usual tea or breakfast and then I do a session. Not every weekend, by the way, but just when I have and yeah, and then I do work or something or whatever. Yeah, not not not... okay. Yeah, not not so much actually. I suppose I kind of use it more when I'm feeling sub optimal or sub normal? As in what is normal feeling for me. So what's my normal level of attention or kind of mood? And if I'm feeling like I'm a little bit below that, I might actually use these to bring myself back up, not unlike how I might use again, coffee or something, which I know that's kind of why people drink it as well.

IB
It's interesting, you comparing it to coffee. So how would you-

RAY
I do, I do.

IB
How would you differentiate them, and how would you actually compare them? What are the differences or some of their similarities?

RAY

Well, I have more experience with caffeine as as do everyone. and so, in a sense some, understand and know what the effects feel like and so on much better, you know? And there's obviously something there with tDCS. But it's, it's a little bit different. And it actually it's actually, it's like in every way it's better.

IB
In every way it's better?

RAY
Yes.

IB
Okay. And can you say something about the kind of non academic research that you also do with tDCS? Yes, sure. What's the goal?

RAY
Okay, couple of things there. I guess. One is I like I said, I am interested in trying to make these things more widely available and cheaper and better understood.

IB
Why?

RAY
So that the tools are there, kind of like, I write software, why do I write software libraries? Why do you share software online? It's because software is best written if you have lots of reusable components. And, and there's this whole sharing thing, and if someone creates it, you don't reinvent the wheel. And so it's nice to have the tools available. And then And then, you know, people can then do even better research and, and so on. That's one thing I'm quite interested in. Right research also, second thing is, like, in a kind of non academic, non professional, if you were way, me and some people, some of which you know, we collect data, do little experiments and are trying to just see kind of really do research, but outside of our paid jobs. And why do that? Well, why not? I mean, it's, it's fun, mostly, so.

IB
Is it the fun part of it that dominates, that it's like a cool thing to play around with these devices and to tweak the brain and to learn about the brain? Or do you have kind of questions that you want to address, and you try to do it in a controlled manner? So is it more fun or-

RAY
There are obviously specific questions that I and others are interested in. I wouldn't say that's always the overarching kind of thing, that the reason that me and other kind of more, me and others have kind of do these things, and non academically do them for, but it is a reason that sometimes, you know, there are specific questions, both big and small. And, but that's not the only reason. I mean, just kind of, I suppose as you just do things, you discover things anyway, so the process of playing around is a process of discovery. Anyway, and there's so much to discover, I mean, it's the brain. I should've spoke there, I shouldn't gesture. Can you can you give some examples, the kinds of things that you stumbled upon this way? That was like an interesting find, or an interesting experience? There's quite, there's quite a few details on technical and kind of practical details of setting up the kit and getting the best type of signal or the best placement, lots of practical little things like that, in terms of technique using it. There are some potentially interesting scientific findings, but nothing I would comment about because it's all very preliminary. There's some things that pop out, that have popped out and that are, I haven't looked at them in detail and, but there are some vaguely interesting things that we've also I and others have come across like that. I can talk about them if you like.

IB
Do you think they're very technical in nature?

RAY
Yeah, kind of. Like interesting, unusual signatures and time frequency plots or things like that.

IB
Okay, good. Can you can you like explain to me how, how you run these experiments when you try to do an experiment, let's say, I imagine the scenery for this is a Hackspace?

RAY
Sure, the Hackspace I'd say yeah.

IB
Yeah. Or do you like, what other scenes do you guys use to run experiments?

RAY
Yeah, I mean, it's mostly the Hackspace, but not only I mean, we've set up outside at home for example, at my place or someone else's place. Yeah. The setup of it's quite simple. It's quite informal and I yeah, I guess what you're getting at is that-

IB
What I'm interested in is how experimental do you try to make it? Compared to, for example, your academic work in the lab, which is obviously different in many ways.

RAY
Yeah, well, I'm very interested in keeping things as controlled as possible. But that's not necessarily the view of everyone involved in this field outside of academia. So, typically, it's not as controlled as it should be to really get good results. But it's not entirely uncontrolled, either. Yeah.

IB
Was that something that you guys that you specifically seem to care about? A lot?

RAY
No, I specifically care about it quite a lot. I do I do. But I probably in terms of time and effort, I do most of my work within academia, anyway. And there, it's all about that anyway. And so for me, a lot of the stuff outside of academia is kind of a lot more of like exploratory nature. And it's less controlled, but that's also kind of okay, I think.

IB
Have you found out things, or have you come across things in this context that you think would be interesting or valuable to pursue in a more rigorous kind of academic setup, something that you do stumble upon, in this more exploratory space? And you think, oh, you know, that's kind of interesting. We should pursue that within a more controlled environment.

RAY
Yes. I mean, I haven't yet pursued them, at least academically, but some things for example, I'm trying to pursue more commercially or entrepreneurially. I can't say it. I've never been able to say it.

IB
Entrepreneurially.

RAY
Nice. Very good. Very good, Imre. Yeah, so So yeah, I mean, so some things. So okay. What things? For example, a big interest of mine is actually combining recording and stimulation. So these two are kind of two separate things. You can record brain activity and stimulate. But actually doing them at the same time is not necessarily trivial. You can't just take a stimulating unit and a recording unit, put them together and it works. It doesn't, there's a bit more work involved. And even if you so these things do exist already, but they're either very expensive, or Well, that's actually it, that's the only case, they're very expensive, and they need not be. So that's kind of one thing I've found through these exploratory stuff, that you can actually make them cheaply, and you can make them work. And that's kind of this whole again, going back to kind of tool making, and making the tools available.

IB
And what do you think? Why are? Why are those devices so expensive? When you say there's no reason?

RAY
Well, there is no technical reason, I'm not saying that it's not entirely justified, there are licencing and so on, all sorts of stuff like that going on. certifications, like the one I'm thinking of is actually medically and clinically certified. So that costs money. That's interesting and nice. And they may go in that direction, but I might not and it's something you know.

IB
So what's your what's your vision or your goal with with the product, which I imagine is simultaneous EEG?

RAY
Yeah, that's, that's a big part of it. Yeah. Not entirely. Okay. Now, so what's the question?

IB
Well, what's your what's your aim? Or what's your vision with that particular thing? Bringing it out into the world?

RAY
Well, to have to have a brain input and output, really. So we have, well we already have brain input and output, but it's indirectly so it's through our keyboard or mouse or through your touchscreen. But it would be nice to be able to, you know, it's, look, look ma, no hands. That would be cool. And, you know, it's technically now, we actually have the technology to make these things widely available rather cheaply, affordably, most affordably, but they're not. So someone has to just come along and do it. And I'm kind of trying that.

IB
And who do you think who do you have in mind that the potential market for this thing, like it should be made available to who? So who's interested, who do you have in mind as the target audience of this product? How are you trying to sculpt that?

RAY
Okay, couple of yeah, a couple of groups. One is definitely users of smart drugs, for example. Another would be academics, but not only. Kind of people and in high intensity jobs, maybe lawyers, doctors and all that. One image I've been I've been one kind of kind of a metaphor, not really much of a metaphor, but that I've been using, it would be really nice, you know, you go down, when you wake up in the morning, you go to your coffee machine, if you have one, and you just make your coffee and you drink. And that's there's a certain enhancement there. That's very easy to do. And it's very cheap

and affordable. And it would be nice if you can wake up, put this on, turn it on. And it's hopefully by that time really polished up and safer and actually cheaper than coffee even more and more more renewable, if you will, and more sustainable. Okay, in the sense that, you know, just electricity, that's all you need, is relatively sustainable.

IB
That's interesting, because what I had in mind, when you were talking earlier, was more of a kit geared towards people who are experimenting or interested in experimenting with this thing and trying things out and creating applications with it. What you just described is more like a consumer product that is very easy to use.

RAY
I want. Yeah, I want both. I want both ideally, yeah. For example, you have, you can buy computer today, and in most people in developed countries have computers, obviously a kind of general purpose computer isn't. And potentially if anyone wanted to, they could start programming it and do you know, incredible things that it otherwise can't do. And they can even become millionaires or billionaires, some people have become and that, but so you so the computer can be used for very kind of everyday things by everyday people, if you will. But the same machine could be used by more technically inclined people trying to do more innovative, potentially. Yeah, potentially innovative things. That's the kind of the same idea. I think so I just, I think, yes, it'd be great to have tools for, you know, experimenters and so on, but also for as a kind of a kind of coffee machine, if you will.

IB
I have loads of questions but they kinda slipped. Do you see something like the Think device as being very much in line when you're imagining or when you have in mind? Or Focus, or the other companies or the other products that have brought commercial tDCS?

RAY
I think this kind of analogy to the beginning of the computer era is not too bad. I think they're kind of like the first very, they're quite specialised machines doing rather specific things and not necessarily very well and never really yet very well. But they're getting there. You know, they're getting better and better. And yes, that's kind of in a direction of things I want to do. But it's not very good yet. It's not, as you've commented a couple of times in different context well in in different situations. You know, there are big roadblocks to having these things become widespread, potentially. I mean, they're not widespread right now. These guys are not widespread, but they should be.

IB
What do you think? Why not? Why not widespread?

RAY
For one, they're quite complex right now. Even the even the relatively simple ones, which you just put on. Well, either they don't do much, and they're not very good. Or even if they can do something, they're not that easy. They're just not easy to use, you know, you get the data, what do you do with it? Well, like a normal random person, a random Joe from the street wouldn't know what to do with it. Like you give them the device, you tell them to do something, no idea how to start. Right. So yeah, I guess that's that's one thing. And the second thing is they can be a little bit pricey still, I think they have to get cheaper, they will get cheaper.

IB
And you you think that there is like a readiness on the part of the wider public to use these kinds of devices? Like there is a willingness and readiness to take a device and put it on their heads and pass low amounts of electricity through their skull.

RAY
Ah, so you're asking about the acceptance of these things.

IB
Yeah, do you think that the image of using electricity to interact with the brain is that a hindrance or is that-

RAY
Well, of course no, of course it would. Of course it's a hindrance factor at present because people do associate it with electroshock therapy, for example, which again, it's just not. Yeah, I mean, the especially the, I mean, the recording is not particularly controversial, right recording brainwaves, though even that's already, even that's a little bit make some people kind of uncomfortable or something is reading my mind. No, it's reading my brainwaves. What about privacy? And some of those are valid questions. Yeah, I mean there are especially with stimulation, I guess there are a lot of irrational fears around it. And I'm not sure how exactly you'd get by that. But I guess the kind of strong educational campaign as part of could could could successfully breach psychological defences.

IB
You mentioned that the people who are using smart drugs at the moment might be an interesting target. How would you, how would you identify the differences or the similarities between tDCS and let's say current smart drugs?

RAY
Well smart drugs just like tDCS, they both are quite well explored but not... they have like a few decades, most of the smart drugs anyway. And tDCS have a few decades of deep good research behind them now. So there there is a decent safety profile for them both, but it's not like centuries it's not something like I don't know something like penicillin, which has been around for you know over 100 years now or something however long it's been around some I think it's over 100 now so I think there's there's a good safety profile, but not a long enough maybe history for for them to become as widespread as they could be given their safe, given their safety which is really high like it you know, the most smart well really all smart drugs or most/all smart drugs and tDCS are far less harmful than you know aspirin or something you can easily overdose on paracetamol as well you know, or obviously alcohol.

IB
By the way, which smart drugs do we have? Because the one I had in mind were things like Modafinil, Ritalin, Adderall.

RAY
Modafinil. Okay. Okay, fine. So, those are a little bit more on the stimulant side, though. Which is, which is fine. Well, it's fine if used properly, but there's, there's more dangers associated with them as well. And the ones I have in mind are more kind of the Piracetam family. So yeah, Piracetam, oxiracetam, aniracetam, many different ones.

IB
Do you actually take any of those yourself? Or have you?

RAY
I have on quite a few occasions? Yeah.

IB
So not not in an ongoing manner?

RAY
Sometimes for short, kind of periods of time I might I would take it, yeah. But not constantly every day. Like today, I'm not on anything.

IB
You didn't feel like you needed a boost for this interview?

RAY
Not particularly, no.

IB
Did you experience any positive? Like any benefits from taking them?

RAY
Yeah, definitely. Definitely. But I have also experienced some side effects, like minimal ones, but like, things like, I don't know, irritability or not being able to sleep as well after taking certain certain things. Maybe. These are not the stimulants. Yeah, so you could get side effects and they're very hard to predict sometimes ahead of time. I mean, some side effects or not right, so you have this common, not so common, and so on for side effects classifications. But obviously, your body is different and unique. So you're gonna have different effects, you know, depending on who you are, and so on.

IB
We get sidetracked but yeah, okay. Yeah, so it's interesting that around smart growth and mostly the I think there's most of the discussion today is about the stimulant types. And not actually the kind of-

RAY
Which is strange, because the other ones are more widely used, I think on balance. Yeah. Overall.

IB
What makes you say that? As I have no clue.

RAY
Yeah. What's what's the word from from? I suppose it's kind of an anecdote, well not really anecdotal evidence, kind of it's first person evidence but from knowing the scene, knowing people and so on.

IB
So you know a lot of people who take various?

RAY
Directly or indirectly as indirectly in person or via internet and so on. Yeah. Okay,

IB
Do you think there's a big overlap between the people who take like nootropics? People who are active in DIY brain stimulation?

RAY
No, there isn't. There isn't there should be more there is like super minimal. There shouldn't be there should be more.

IB
So it's not like a lot of people who are already into using all kinds of things to boost their cognition.

RAY
That's what I'm saying, it makes more sense, it makes sense that there should be an overlap. There doesn't. I mean, there is maybe, I guess there's higher interest among smart drug users. But I wouldn't say there's active participation with kind of brain exploration or brain hacking, if you will. And I guess the reason for that is going back to the point that it is not trivial. And so a lot of this, both brain input and output are not that easy to use yet, right? So it's very easy to just pop a pill, reading something about it. And yet, potentially, it's easy to just put electrodes on your head and just run. But the culture of taking pills as a culture is the act of taking pills is much more established, isn't it for all sorts of things, you know, fixing ailments and, and so on.

IB
But you can envision that that's going to change, as tDCS becomes more widespread, there will be a wider cultural acceptance of using this kind of intervention?

RAY
Yeah, I hope so. Yeah. I mean, eventually, yes. Certainly, eventually, certainly, yes.

IB
Eventually, kind of what timeframe do you have in mind? Roughly, eventually?

RAY
Yeah, well, not necessarily. But I really hope that the a lot of these things happen in the next few decades. for specific reasons, but I really hope it happens within the next, say actually, one or two decades even. I think it'd be bad if it doesn't, if brain cognitive enhancement, brain enhancement, more generally, kind of body enhancement in various ways. If it doesn't become more widespread, more accepted, more researched, more funded, and so on. I think that's really, really bad.

IB
Why?

RAY
Shall I

IB
Yeah please, I was looking for the right way to-

RAY
Yeah. Well, it has to do with AI. Yeah. So you know, this is this is another of my big things I work with, I use machine learning and so on a lot of my work, and I'm trying to do various things on the AI front. And so I know a little bit about it. And I, like many others are convinced that it's a matter of just a few more decades, kind of like maybe between one and 10, but not much more than 10 decades. So not, it's not super far in the future, that you're going to have an artificial intelligence that's going to be smarter than a human, potentially much, much, much, much, much smarter. And like we're really not that far. But even if it's 100 years, even if it's 200 years, that's not very far. In many, in many ways.

IB
Okay, and how does that tie into the-

RAY
Yeah, yes. It ties with... Right, let's bring back to that. Well, if you have, okay, so if you have, if you create an entity that's, let's say, smarter than you, okay, but speaking very simplistically and hypothetical values, create an entity smarter than you. And but you do not have the ability to augment your intelligence and cognitive capacities and so on, then you're left in a pretty strange position of not

understanding why this entity is doing certain things. Even if it was friendly, and it had the ability and inclination to explain itself to you, you still might not be able to understand it, even if you could, you know, even if you could have access to how it did its reasoning, you might not be able to comprehend it. I mean, hell today, we can't comprehend how AI systems work exactly, even though we make them work. That's that's kind of interesting thinking about that. I think that today, I like I do certain things, and I can train machine learning algorithms to do things. But I can look at the internals of them. But it's just a bunch of numbers, in a sense. In how they all fit together is kind of in this multi dimensional really complex way and forget it. Mathematicians don't get it. They're just about you get the theory but you don't get the specific instance of this AI or machine learning algorithm. How it's figured out how to do something. So if you have something that is really smart and much smarter than you, and you don't know how it works, that's that's not a position I think we really want to be in generally, right? Probably.

IB
So could one say that the reason why you think more emphasis should be placed on human enhancement research and funding is because AIs will eventually outsmart people and that will just create a very unbalanced, uncomfortable-

RAY
That's a big reason. That's a that's a big reason for me. That's always been a big reason for me.

IB
And do you see your work on like, the current stuff that you do on tDCS and the research on brain stuff motivated by that or tying into that?

RAY
It's hugely tied into that. Yeah. Well, yeah, so I mean, brain research and AI have been linked from the very beginning, in many ways. So a lot of AI stuff gets inspired by the brain, and then a lot of brain research gets amplified and, and, and helped by AI developments. And then on the one hand, there's what I said that if we, if we're a lot stupider than some kind of AI that eventually emerges just freaking smart, then that's, that's bad. But that means that to, for that not to happen, there are a couple of options: don't do it, which I don't think it's going to happen. Yeah, we can talk about that we can talk about that. We can, okay, so I'm just going to list some of the things that I think are obvious out possibilities or scenarios, one is don't do it, I don't think that's going to happen. There's no way that's happening unless somehow progress stops. And I don't see that happening. It's highly unlikely. So we don't do it, or we do it. And that's that's that we don't figure out the brain in time sufficiently to start augmenting and improving it. So that we can better interact, understand, and so on and make use of AI systems that are getting ever better, you know, like constantly every day, right? So that's another possibility. Or another possibility is we're just kind of an extension of the last one, which is that we figure out the brain sufficiently quickly, perhaps, actually, certainly using AI improvements and methods. And then we we actively try to actually incorporate all AI advancements into into us in kind of self improvement, cognitive enhancement, in brain augmentation, so on. The idea being that even if you enhance yourself, even if you enhance your brain, and yourself in your capacities, eventually, if you stick with biology, you kind of get outrun by by these digital AI systems, like, you know, actually, pretty soon after they appear probably anyway, even if you're slightly augmented. So the only really option I see is to not really fall behind in these things, is to kind of try as much as possible to merge and become these things.

IB
Okay, so that's very much a kind of post-humanist vision in a way.

RAY
It is, but with one difference being that a lot of people like saying, Oh, just merge with AI and the technology when it appears. The problem is, the problem is a lot of these people don't work in brain

science, for example, or in AI even. And so if you ask them a simple question, but how? Like, how do you do that? So if you don't understand the brain to do input and output sufficiently well, and we can't do that yet. I mean, we're just scratching the surface of that now, right? If you can do that very well. Then there is no way you can interface and add, you know, other capabilities in the form of chips or whatever. It doesn't work. You just take a chip, it's not gonna work magically. You need to understand you to understand things, and we don't sufficiently.

IB
Is your is your basic background like your first first-

RAY
Computer science. Yeah, computer science.

IB
And then did you do biology?

RAY
Yeah, I did a master's in bioinformatics. Yeah. Bioinformatics, which is like yeah.

IB
And then you do your PhD now which is in which?

RAY
Yeah, it's computational experimental neuroscience.

IB
And do you see, this is slightly off but I'm really interested in this, do you see like a gulf between people coming from a more a more engineering computer science background and people coming from a-

RAY
Do you have a mic here as well? Or is there anything else?

IB
So gulf between people coming from a more AI or more computer science engineering, type background and people coming from a more pharmacology, biology, biochemistry background, in terms of how they think about these visions, well not visions really, but these ideas?

RAY
Yes, I mean, there's a few pretty obvious differences. One is that computer scientists in but by their very nature of what computer science is, we tend to think more... Well, I suppose one way to describe is more reductionistically in a way. So you try to break down a system to its basic components understand those, figure out the interactions and in principle, computer science couldn't in fact theoretically in practice, you study really complex things in computer science. I mean it's kind of Applied Math, just like physics but slightly different math slightly different problems are studied in physics, whereas with biology, biologists are more biologically oriented people. How to describe it? For one they're not as typically, obviously, there's many exceptions to that. But typically, they're not as mathematically inclined. And if you are, if you can't mathematically describe systems, usually, or at least more formally describe them, as with computer programmes and simulations on then typically, you don't understand them very well, or as well as you could. And I mean, one of the best ways of understanding something is being able to replicate or build it or something, right. And you don't usually do that in biology for because it's really complicated, arguably. But but that's not a good point of view, I think to have if you're trying to understand it, your goal should be to really understand

it fully. And I think there are more biologists than computer scientists that probably think that thing that not everything is understandable, either in principle, for practical reasons, or even theoretically, about the human body or brain. Obviously, I disagree with that fully.

IB
So there are more mysterious.

RAY
Yeah, I wanted to say something like that, but don't want to get offensive. Scratch that yeah.

IB
Okay, we're gonna move on. So it's interesting, you said that, AI.. What time do you have to leave?

RAY
10 minutes. Yeah, sure. Okay.

IB
So I wanted to get back to this idea about progress that you really, briefly touched on. Unless progress halts, this thing is gonna go ahead. So what idea of progress do you have in mind there to progress towards?

RAY
Well, in a very general sense progress as in, as different aspects of society, society progress, our collective or global knowledge base also grows, right. So science progress, and so on. And it's there are kind of many different aspects of many different things that are progressing within the world are kind of interlinked. So if you start you can't really stop one without stopping or slowing down the others. And I don't see you see, I mean, I don't see the world kind of just winding down into a hole and stopping exactly the current rate, current state, rather. And from from that perspective, you know, unless there's some huge global catastrophe happens, you know, or something. And even then, I actually don't see it stopping even then, unless you're all we're all wiped out.

IB
Do you think that enhancement is as an aim or as a goal of science? If that's something that is widely accepted? Human?

RAY
Yes, I go to college, you go to college, that's an enhancement. Like I said, we're not-

IB
What about the kind of enhancement where you stick implants in your brain and augment your mental and physical capacities with logical extensions of the body. I mean, that kind of thing.

RAY
Okay, so you mean kind of the most extreme thing I said, which is literally chips, if you will, with AI stuff and kind of putting them in the brain.

IB
Not just even just that, stimulation or any kind of.. That's why I said technological extension-

RAY
Because if you're talking about the relatively relatively mild things like tDCS, or optimising when and how things are done and within computer systems, based on your brain state using something like

EEG, and that's, you know, that's relatively mild. You're just reading the, it's like reading the heart or something, you know, or using tDCS. That's more mild and most likely the, well maybe if you've if you really optimise these methods in these systems, maybe the changes you could have the potential for enhancement could be quite a bit greater than some of the currently accepted methods that we don't even think of as cognitive enhancement, like education and actually being well hydrated or being well fed, and so on, which are great ways of keeping yourself smart and so on. But well- That's more like maintenance or optimising your capabilities within your given body. Eating and drinking, maybe yes, it's kind of trying to find the optimal place. But education is not, right? Education is like its proper enhancement. If they can change it to you so much, your your brain before you go to undergrad and then after postgraduate studies, doesn't look the same? Probably for worse, in some ways.

IB
But you would say that there's no difference, for example, between education and enhancement?

RAY
No, no, obviously, there is a difference. What I'm trying to say is that I think it's in terms of the actual potential for enhancement, it's it's not much greater. It might even be smaller than some of the current ways we have for enhancement. It's not even, if it's greater, it's not much greater with some of the current kind of scratching the surface type stuff that we're doing with tDCS or not like tDCS, or EEG based stuff. It's not advanced enough that it's going to in its present state, it's not going to be kind of have game changing effects, I think.

IB
Yes, but the question was, do you see this as something that is widely accepted as an aim as a goal as a scientific goal to pursue the enhancement of humans?

RAY
Okay, so I answered, I think indirectly, actually let me answer more directly, indirectly, in the sense, I answered in the sense that if it's not more effective, or only slightly more effective than at least in terms of the effects, and in terms of the enhancement potential, it shouldn't be, it shouldn't be kind of shunned for its enhancement potential if it's not a lot greater, right, maybe.

IB
That's true, but the way I-

RAY
I mean, there's so many variables, it's hard to really give a simple response to this, there are so many parameters to take into consideration. But I do think just like, you know, coffee wasn't widely accepted either, when it first emerged, and actually, neither was things like nicotine, many things, many of these drugs actually took quite a while to get accepted. But they did gradually, but they did gradually get accepted. And now, it's really hard to get rid of that acceptance with something like tobacco. So I mean, I suspect something similar will happen, except we're more connected and more educated today. So it's going to be accelerated. So if it took maybe, I don't know, 100 years for coffee to be widely accepted, and widespread. And maybe this is going to take, I don't know, 30 or 40 years now, since it's kind of for tDCS, or something.

IB
But that's interesting, because how do you see that logic applied to the previous things that you talked about, which were much more profound in their vision, in relation to humans basically keeping keeping up with machines as they become smarter than human?

RAY

Yeah, well, that's yeah, that's a very scary thing, because I don't think there is enough societal and cultural push, understanding, acceptance, or even interest in a lot of these issues for for us to advance human brain, understanding in material science and so on to that's really important, actually being able to interface with it. You can't just understand, you have to actually literally be able to make those connections, physical connections to the brain. So I'm kind of worried about that a little bit, quite worried about that, I guess, about AI outstripping brain enhancement capabilities, I guess, moderately worried about that.

IB

At the moment, most of the brain research is, as far as I know, motivated by research for either basic understanding of brain mechanisms and basic science research, but on the other hand, huge motivation is finding treatments for various neurological or neurodegenerative or psychiatry conditions. That's interesting. That seems to be an overarching motivation. For treatment, in other words. How do you see enhancement becoming a legitimate goal of scientific endeavour, let's put it like that?

RAY

Well, for one, this is interesting with treatment, because that's one of the main reasons people get funded, scientists get funded is for treatment purposes. But actually, that's not necessarily why all scientists want to do work on certain topics. It's just that's where funding is coming from right, government and so on. Actually, especially, mostly government in many cases. And I think, yeah, and military, for example. But actually, that's interesting, because the military is more interested in enhancement, then I would say, well, proportionately more interested in enhancement than in than in treating ailments. They're obviously also interested in treating ailments, but they fund enhancement more than governments, I think, do or public funding bodies and so on. So actually, that's the answer. I think that probably it's gonna happen through private kind of avant-garde, if you will, thinkers. You know, people like Google founders, that type of people, you know, those types of people? Actually, I'm pretty sure that's where a lot of the push will is now emerging is going to be from probably that world, if you will. What do you think?

IB

Well, I kind of agree. Okay. Yeah. Fair enough. Do you think that the wider public will have? Do you think that the wider public has an acceptance for enhancement becoming a part of their everyday lives like this, they have to keep up with not keeping up with the Joneses anymore? It's keeping up with machines, which is a lot more difficult.

RAY

Yeah, I mean, on the one hand, I don't think people realise that need to keep up with machines as much as people involved with some of these fields, right. So they don't think it's an issue even though it is .They: people not involved with these things. So that's one thing. The second is that you've probably heard this argument before, but it's that if, if a lot of people start enhancing themselves and enhancing their children, and that's kind of borderline starting to happen, right, with tDCS, and smart drugs and so on. But if this, you know, and if once you get genetic engineering and more efficient ways of enhancement, then, you know, you will probably get to the point where either it's banned or outlawed, which I don't really see happening, it could could, that's gonna be a strange world to live in, because progress will continue in some kind of way anyway. It'll be interesting, or people will just go well, okay, so that child is enhanced, we don't have to enhance our child, right? If that person's enhanced at work, I don't have to enhance myself. Then I'll have to use this strange intracranial electrode technology. But then, you know, they become CEO, or they're getting straight As, or they go to college at 14, or 13, or something, you know. And, you know, people will say, Oh, well, maybe it's not that bad. After all, I think I think that's quite a likely scenario, that that would happen in the next decades. I hope it does.

IB

You hope it does?

RAY
I hope it does. Yeah. It's important that we improve ourselves further.

IB
So you wanna be at the forefront?

RAY
Yeah in some ways. Yeah.

IB
In what ways?

RAY
Well, I say in some ways, because I'm kind of, I'm quite cautious about trying new things. So I do some of these some of these things non professionally or academic outside of academia, but I'm quite cautious actually when trying new things.

IB
So you say, you're very health conscious person. Yeah, sure. Yeah. So you watch your diet, you watch your sleep, you watch your exercise.

RAY
Yeah, definitely. Definitely.

IB
Do you use any like self tracking methods as well?

RAY
Yeah that stuff, yeah. Like, like a watch that tracks me or my phone. And-

IB
So you use that as-

RAY
Yeah, actually, I should be using even more, I think, but I use them.

IB
There seems to be interesting convergence between self quantification. Yes. Yeah. I agree. Education and so using it.

RAY
I agree. I actually yeah, I think that's that's another market by the way. You're asking who I would be targeting with some of these things that I'm trying to do more commercially. Well, kind of smart drugs and kind of self enhancement type of people are people interested in that kind of thing. And a lot of those are also within kind of the quantified self movement, and that's another group right there. Well, a lot of largely the same group, but not entirely.

IB
I am conscious of the time, you gotta get going. But yeah, one last question.

IB
Okay two things. One is a lot of people think that it's ethically problematic, there are like ethical concerns around using various cognition enhancement technologies. Obviously, you probably disagree with that.

RAY
No, I think there are concerns or important things to discuss and think about definitely. I'm generally, pro these things, but there are important things to discuss for sure. If you use things chronically, or in the long term, they could be side effects. That's important to know. What happens if a child is enhancing themselves and they become way smarter than their parents that could cause issues or way smarter than their peers? Even that would cause issues. So yeah, there are things obviously to think about, and it's just two examples, there are many more, yeah.

IB
Okay, we've gotta cut it short. So, do you think that there's anything really important that you would like to say, but that we completely didn't touch on, which is something that you think is really important in relation to something we just didn't even mention it or not? To an extent do you think would be?

RAY
Yeah, there is one thing we did talk about it, but not explicitly, I think, which is, people are even today, actually, which is kind of a little bit surprising to me these days, even today, people are not sufficiently multidisciplinary. And so you get neuroscientists doing neuroscience work, and then being aware of issues with neuroscience or computer scientists even doing computer science work. But that's, again, just two examples. But this applies to most fields. I think there's a lot of these issues are very multidisciplinary in nature, you know, and it's best if you have non technically inclined or non scientists discussing with scientists, which is, for example, what we're doing now, I guess. Yeah, it's there is no clear dividing line saying, Oh, this shouldn't be looked at by an electrical engineer to look at the current stuff, this should be looked at by a physicist, they should be looked at by a medical doctor. Yes, some issues are more suitable for this profession or that but you need more multidisciplinary people, you need more I think people mediating things between, not necessarily multidisciplinary people, but I'm not sure what that would be called. People kind of who are not necessarily themselves able to do things from multiple fields, but they mediate interactions between people from multiple fields, I guess it kind of kind of multidisciplinary thing. And I think that's really important. Like for a lot of these issues, there are so complex that you you know, with AI and with brain sciences, obviously, the two things I am most interested in and do the most. There is a lot of multidisciplinary stuff going on, but still I don't think it's enough.

IB
So this kind of mediation would be important in terms of achieving the goals in a particular endeavour or important in terms of communicating?

RAY
Both. Yeah, Thanks for that.

Appendix C

Appendix C1. North Sense Interview Topic Guide

Warm-up

How did you find out about the NorthSense?

First impressions?

Why did you decide to get one?

What was appealing about it? Is this something you always wanted, or did it just seem cool?

Have you thought about or looked into the topic of a magnetic sense before getting NS?

Any concerns?

How long did you think about it before you decided to buy one?

How good would you judge your sense of direction/spatial awareness before attaching NS?

Expectations

What were your expectations about NS?

BodyMod

Do you have any other implants/bodymods?

Are you an active member of the bodymod community?

Views of Others

How have others reacted to you getting one?

Do you know anyone else that has one?

Process of application

Could you walk me through the process from ordering to attaching the NS?

Where did you place it on your body?

Daily use

How has it affected your everyday life?

Do you use it *for* something?

Sleep, sex, shower?

Have you tried different places/activities in order to test the NS?

Do you wear it every day?

Do you take it off at all?

How/when do you charge it?

Does it motivate you to test its capabilities?

Has it discouraged you from any actions/activities?

Effects on perception

What effects have you noticed?

Have you noticed any changes to
your perception?

IF relevant: In which way is a new kind of
spatial perception noticeable?

How long did it take for you to get used to using it?

Qualia

What does the NS feel like?

Do you perceive the signal as a vibration?
If not how would you describe it?

How aware are you of the device during the day?
- do you forget that it is there? (like you would a piercing)

***Cyborgism /
sensory augmentation***

Do you see yourself as a cyborg?

How would you define a 'cyborg'?

Why become a cyborg?

Why enhance/create a magnetic sense?

What other sense do you want to expand? Why?

Do you think this could be the next step in human evolution?

Do you feel like you got a ‘new sense’?

NS Installed Final Qs

Are there any other effects that you have noticed since using the device?

Are you planning to keep it on?

Any other comments?

Follow-up

At Timepoint 2 - ask for a general status update and query aspects that have not been addressed before.

Appendix C2. North Sense - Participant information

Participant ID	Status @ T1	Status @ T2	Country	Age	Gender	Magnet implant	RFID implant	Other bodymod
PT02	Stage3	Stage 4	Hungary	24	Male	No	No	none
PT04	Stage3	Stage 3 (taped)	Austria	21	Male	Yes	Yes	none
PT05	Stage3	N/A	USA	24	Male	No	No	none
PT06	Stage3 (taped)	Stage 3 (taped)	UK	48	Male	No	No	none
PT07	Stage 1	Stage 4	USA	24	Female	Yes	No	IUD
PT08	Stage2	Stage 3	UK	36	Male	No	No	insulin pump
PT09	Stage 3/4	Stage 4	Mexico	34	Male	No	No	none
PT10	Stage3	Stage 3	USA	34	Male	Yes	Yes	none
PT11	Stage1	Stage 4	Germany	38	Male	No	Yes	none
PT12	Stage 3	Stage 3 (taped)	Canada	20	Trans	No	No	takes testosterone for their transition
PT13	Stage4	N/A	USA	42	Male	No	No	none
PT14	Stage2	N/A	USA	21	Female	No	No	none
PT15	Stage2	Stage 4	Ireland	28	Male	No	No	none
PT16	Stage3	Stage 3	USA	32	Female	Yes	No	none
PT17	Stage4	N/A	Poland	33	Female	No	No	none
PT18	Stage2	Stage 3/4	USA	47	Male	No	No	several body mods
PT19	Stage1	N/A	USA	41	Male	No	No	none
PT20	Stage1	N/A	France	27	Male	Yes	No	none
PT22	Stage2	Stage 4	Spain	31	Female	No	No	a few piercings
PT23	Stage3 (taped)	N/A	USA	29	Male	No	No	none
PT24	Stage 1	N/A	UK	19	Male	No	No	none
PT25	Stage 4	N/A	Israel	20	Male	Yes	Yes	split tongue, scars, tattoos, piercings
PT27	Stage 4 (taped)	N/A	Netherlands	62	Male	No	No	none

Appendix C3. North Sense interview sample - PT02

Interviewer
So let's get started. How did you find out about the North Sense?

PT02
I've been following Neil Harbisson online presence for about two years now. And that's how I came across the Cyborg Foundation. And actually, I think, like, since the Cyborg Nest was founded, I've been following them, because I'm really into, like, cybernetic augmentations. And, of course, I was really, really psyched when I you know, when I got to know that they are making this project, and it can actually be a product that you can buy and amplify your senses and get a new sense.

Interviewer
So how did you find out about Neil Harbisson and the whole sensory augmentation topic?

PT02
it's really funny. Um, I'm really into comics, and like superhero movies and all that I just kept thinking, like, is there a way to, you know, like, we have smartphones, we have this amazing world full of technology, there must be a way to get like, some sort of superpowers or anything close to it. So so like, I just read a lot of articles about like DNA editing, and CRISPR and all kinds of projects. And I've been I found a Kickstarter company, where they make like glowing plants. Like they added the genes of bacteria and they they give it to the plants so that they can glow in dark. So I've read like loads of loads of articles about it. And that's that's how I found Cyborgism and Moon Ribas as well. So I just really got into their how they you know, perceive the verb what extra senses they have. I just, I just basically started Googling like sensory augmentation or is there any way any product that I can obtain and become something more? And the more I started, know about this project and the entire movement of the Cyborg Foundation, and I really think the more excited I became because it kind of like shifted in my mind from, you know, this kind of like childish desire to become a superhero. From to, to a point where now I can see that this is probably the future of humanity. And I continued, you know, watching TED talks and all that kind of stuff. And I just, I just got went with it.

Interviewer
Do you have a lot of friends who are like into this topic as well?

PT02
I'm not really.

Interviewer
Not really. Yeah, the other lonesome human enhancement aficionado? Right? Okay. And so what were your first impressions about the North Sense when you first saw it? I'm,

PT02
like, on the website?

Interviewer
Yeah. Basically, when you first found out about kind of a sensory augmentation as a product.

PT02
I, I'm thrilled, like I knew that they are going to launch the project. and when I saw the first pictures, I was like, Oh, my God, this is actually happening. Like, this is it. I can, I can do it now. Before that, the only way is probably that I had, would have had are the NFC RFID tags. Because I'm not a programmer. And I'm not really into, like, doing my own electronic stuff, like, you know, switching, changing the light switches or the locks to be able to turn them on and off by NFC. RFID tags. I, I'm, I'm not really, you know, I don't have the qualifications to do that, or I don't have the experience and knowledge. The other one was the neodymium magnets that you can see around. Yeah, they are pretty cool as well. And I'm still thinking about, you know, buying one and installing one. But that's, I think that's the next step. When when I have something in my arm or in my body, this is partially out of my body. So if I decided I don't want to be the part of this anymore, I can just unscrew the screws and pull them off. So

Interviewer
could you also remove the mount? Because I mean, yes,

PT02
yeah, yeah, um, I'm pretty sure you would need a professional or piercer to do that as well. But you can do them like it's the same way that it went in. You can just you have the four screws that you can unscrew and pull them out.

Interviewer
And have you have you like looked into this whole magnetic like Magneto reception before? Or Or was it just like, oh, that's what the first sensory augmentation is doing? I'm going to get it. So were you interested in in a magnetic sense before? Or was it just this happened to be the first product?

PT02
Absolutely, absolutely. I think the guys from Pittsburgh the Grindhouse Wetware guys, they were doing their own version with the leg bracelet when it was constantly buzzing to towards North. I think that was called the nurse Paw. Yeah. And I have a friend who's really into Arduino, and those kind of projects. So I actually purchased an Arduino and was about to build my own North Paw as well. So I, I had this idea that I would do this. And then a few months later, I just I just realised that this is actually being made a much smaller version.

Interviewer
All right. Cool. Cool. And when you first saw it, did you have Did you have any concerns? Or was it just like, Oh, this is cool. I want to get one. So kind of what? What What was your thinking process?

PT02
It was like, I'm just gonna get it. I don't, I don't care how much it costs. I'm gonna save up, and I'm gonna get it.

Interviewer
Okay, cool. That's so funny, because the next question I was gonna ask is, how long did you think about buying it before you decided to do so but I guess it was like, it wasn't

PT02

it wasn't. You know, like, because I knew that I will move towards this. Modifying my body in a in a certain extent. I knew that I was going to buy it. So it wasn't. If I were gonna buy it was when I was able to afford it. .

Interviewer
All right, that sounds cool. So how good would you say would you judge your sense of direction and or spatial awareness in general? Do you think you're a guy who gets lost? All the time, or are you a military navigation Pro, or somewhere in between?

PT02
I'd say somewhere in between I travel a lot. So and I usually do urban travelling. So I'm kind of forced myself to, to be able to navigate in a new environment in new urban environments. So I go for, you know, different sizing sports, and I just have to go there on my own because I do solo travelling a lot.

Interviewer
And so what kind of expectations do you have about the North Sense?

PT02
Well, I think it's gonna be like that, it's that my brain will actually accept it, and I am, then it will become a natural sense, not just that gadget that I put on every morning. Um, I'm in a really early phase of actually wearing it. Since like, two weeks,

Interviewer
oh, you already have the North Sense on?

PT02
Yeah, yeah.

Interviewer
Okay. So when we first contacted you, I think you only had the mount?

PT02
Yes.

Interviewer
In between you actually got the…

PT02
Yes, indeed. Yes. So what happened? I got the anchoring in I think it was end of April, early May, something like that. And then I had a little bit of problem with my phone, because I had an old dumb smartphone. Dumb phone. Yeah. And it couldn't it didn't have the Bluetooth three version. So I couldn't you know, calibrate the sense and everything else. And so I ended up buying a new phone. With the help of Liviu, I was able to calibrate it. And when I started wearing it, I had this kind of like painful feeling in the anchoring. So he said that I would better wait a few more weeks until it's entirely healed. I didn't notice any scarring or any reddish kind of, you know, skin changes. But when I put it on the four silicone rings actually pulled it like inwards constantly. And it was really painful after a while. So I was only able to do like two-three hours.

Interviewer
Right. So what was the solution? Did you just have to wait and then it was fine?

PT02
Yes, yes. I just had to wait. And also I had to learn how to calibrate it because based on the website and the video's description, I just wasn't able to calibrate it correctly. So I did a live Skyping with Liviu and when he was actually in Las Vegas, and he helped me to understand how the sense itself actually works and how I have to calibrate it.

Interviewer
I see I see. Okay, do you have any other implants or body mods? You don't have like the magnet yet? But do you have like tattoos piercings.

PT02
I have a full sleeve tattoo and a half sleeve tattoo and I have some on my back. But that's for completely different reasons. For me, this is like I think of my skin as a canvas. And I paint like, life memories on it. So based on my travels, that's the primary reason I have my tattoos.

Interviewer
Okay. Okay. And do you kind of follow the news and the forums and what's going on in the body mod community, because you mentioned Grindhouse Wetware and, and the magnets, so it seems you're in the community in a way.

PT02
I do my best to be so yeah. But there is not much going on here in Hungary. So I'm actually, as far as I know. And as far as the news is concerned, I'm the first person in Hungary to acquire the North Sense.

Interviewer
Oh, cool. Cool. It's great that you signed up for the interview. So how have others reacted to you getting a North Sense? What did your mom say? How have others responded?

PT02
Well, they don't really understand it. Like, they...so when I try to explain why I'm having this, they seem to focus on one problem that they don't like, they think that I'm going to use it for one thing only, like navigating. And they keep asking me 'do you go out to the woods, do you go to new places, where really do you use it?' And they and the key bringing up examples, like if I would hike a lot, but I would use it more. So they only seem to think about like this one narrow, like, they think it's a compass. They keep thinking about this as a tool. And I'm just telling them that this is a sense and for me, this, this is a spatial information that I hope to gain soon. Yeah. It's it's like they, they accept that I have this. Because like, like, I have all the tattoos and I don't seem to have much problem with it. Some people say that it's really cool that I'm doing this, but some people just don't understand it. They are not against it. They're not against it, but they don't understand why I'm doing this.

Interviewer
Do you know anyone else personally who has one?

PT02
implants?

Interviewer
Yeah, no, North Sense?

PT02
No.

Interviewer
Okay. Could you walk me through what the process was like for you from the moment when you ordered the device to the point where, where you actually had it attached?

PT02
It was really, really complicated. Because I kind of messed it up big time. I ordered it for myself to my address. And because the Cyborg Nest sends it, via DHL, when they entered Hungary, the DHL automatically transfers all their American origin products and all that to the customs. So I had to pay that and I had to pay customs, which was an additional, almost half price of the North Sense. Now I know that if I were to buy one, I would just ordered it to a friend of mine in the US, and he would just with a regular post, he would send it to me, and I would have saved a lot of money. And also the customs withheld the product itself for about three, four weeks, actually, so I had to prove what it is.

Interviewer
How did you prove what it was? It's sort of an interesting product that doesn't fit any regular categories. No?

PT02
yeah, yeah. I said, I told them that it's a medical device. All right. Um, and then I don't really remember why. But I also had to prove something else. Like, I think when I paid the extra shipping fee to the company. I got an invoice of that. And I had to prove that it's an invoice for the shipping. So, it's like it was a mess. It took me a lot of phone calls, a lot of emails, and plenty of headaches.

Interviewer
Okay…

PT02
yeah. And then when I got it, I went to my tattoo artist, if she knows anyone, and she pointed out to a few guys in my city where I am, and they were not willing to do it at all, because they said it's too like… the girl who is a piercer, she said it would be a butcher work actually, like she needs to pierce through my skin. And she, she wasn't willing to do that. But they sent me to the best guy here in Hungary who does body modification, tattooing and basically everything you can imagine. His name is Gabor Zagyvai. And I contacted him and I when I started explaining he was like, You mean the North Sense, right? I was like yeah, oh my god, this is amazing. Like he actually knew what it was and I was so relieved because I was scared. He will have no idea and then there's gonna be a stranger who will modify my body. But from the very first moment when he when he told me that he knew what it is. I was still in my comfort zone. So I had to go up to Budapest to his salon, and basically he applied a large dose of anesthetics to my body to my chest area, and he pierced through the skin, installed the anchoring. And then, for the sake of some photos, he put the North Sense and so on, but it wasn't awake yet. So it was just a piece of thing.

Interviewer
W it very painful? What was the whole process like?

PT02
I didn't, I didn't feel a thing. I was so terrified, like, I was so scared. But he actually gave me two doses of anesthetics, so I didn't feel anything. And I was really scared. When the meds go off, I will start to feel a huge amount of pain, which I did not for my surprise. So, it was a really, actually a pleasant experience for me.

Interviewer
Okay, cool.

PT02
So wasn't painful at all. Even during the healing time, I did not have any pain. Of course, I had to get used to it. So sometimes when I put my T shirts on, I would, you know, like, the small hooks would just like, my T shirt would go up, and it would be really painful. But it's just the learning progress. I have to learn it. And then I think I had to apply salty water every like twice a day or three times a day. I had to soak the entire, like, scarred area in salted water, in order not to get infected. And that was that was also for me a really - I wouldn't say stressful, - but I was really nervous that my body would reject the anchoring. But luckily, it did not.

Interviewer
So how long was the whole healing process? How long did it take?

PT02
if we, if we take into consideration that I just started wearing it about one week ago then basically from the end of May, sorry, end of April, early May until this so like to two and a half month.

Interviewer
Oh, wow. Then you actually had it installed you actually installed the North Sense quite quickly?

PT02
I kind of know my skin. So when I get new tattoo it will be healed. All the pain will go away in three days, right? And then and when they do it, I would never get you know, skinny fever, it would never be extremely painful. And whatever. If I have any, like if I cut myself and accidentally I would notice that I'm like, it's not really that sensitive. So I heal up quite fast. So I of course monitored the heals and my mom works in health care. So she was taking care of it as well. Like she took a look and she was like okay, it's gonna be alright.

Interviewer
All right, Okay, so you have it in the middle of your chest. Did you think about placing it anywhere else?

PT02
Um, I've seen a few people putting it on their left like, area above their chest? Which now I'm thinking probably like, I don't I don't know. Like, what, what sort of benefits of having it here are. But I don't plan to do anything.

Interviewer
Yeah, not any more

PT02
No, no more tattoos. No more implants here. For now, but I'm getting tattooed on my rights shoulders in September, so I didn't want to put it here. ,

Interviewer
Okay. So, from a user perspective, would you say that it's easy to use. It's easy to live with or difficult?

PT02
Um, since I'm just getting started to get used to it. The beginnings are not that easy. So I go to work really early. So if I want to wear it during the day, I would need like 10 minutes to calibrate it and then put it on. I'm actually using like sharp tweezers to put it on. I don't know how people like put them on like maybe with their like, I tried to it with my fingers, but I just couldn't. I'm using sharp tweezers to put it on. And then I have to connect to my phone, I have to calibrate it quickly so that it regains all the data that my phone stores and then I'm good to go. But once it's on, it's pretty easy because you don't have to pay attention. Sorry, I don't I don't hear

Interviewer
Oh, sorry. Is it okay now? Yeah, it's okay. So do you need to calibrate it every morning.

PT02
Um, so the way it works, is if it runs out of the battery, and if I recharge it, then the device itself holds no memory, like it has no memory storage, so it'll, forget the calibration. So what I have to do is I have to connect it to my phone via Bluetooth. And then I just tap calibrate, and it will basically like sync up all the data and regain all the data from my phone because the application stores the calibration data. And that was that was one thing that Liviu told me, which is not on the webpage, for example. So that's why I had these rough starts. And also, it was very, very important to decide what body angle I'm usually having. Because when I first started calibrating it, I was I would stiffen up and like, you know, stand up like a soldier and really straight. But then usually during the day, when I'm working, I would be in a really relaxed shoulder position. And my entire body kind of like just like a bit frontwards and a bit like even downer and has a little angle. And that angle is the most important thing when you calibrate the Sense. Because based on that, will it buzz or not.

Interviewer
I see. I see. Okay, yes. So I know it's been kind of recent for you, but has it like, has it affected your life in any way? Have you changed some behaviours or the way you do your everyday things? Yeah, I mean, already mounting it every day is a change. But, how would you say it affected your everyday routines?

PT02
I'm turning around like a small kid, every time I go to a new place. I'm serious, like I'm really excited to learn. We're the North is. And it was really, really, really funny. Because the very first day, the very first entire day I would have my Sense on. We went to a small tunnel, around where I live now with my girlfriend. And it's like this ancient tunnel system, so constantly, and we are inside the hill. And I know where the hill was facing and where my house is facing. But we were really deep inside and turning around everywhere in small chambers. So I was just like constantly feeling where I am. And it was really interesting to gain this kind of knowledge that I was able to place myself vertically deep inside a mountain. Like I knew where I was, I knew everything, which was surrounding me how dark or light it was all the stone textures, the temperature, it was quite cold. I knew that I'm standing in a flat surface because of my inner ear liquid. But I didn't know where I was facing. So when it when it was buzzing. I was like, Yeah, I know where I am now. And I know where the rest of the city is, I know where the mountain is. So it was a really cool experience.

Interviewer
Nice. And do you do you, like use it for something? You spoke about this briefly how your friends and other people look at it as a tool. But do you? Do you like, try to use it for something specific?

PT02
No, no, I don't. It's, um, well, I could say I do because I just moved to this new city about two months ago, and I'm still learning the city itself. So when I go to a new room or a new street or a new place, for example, I kind of map it with my brain and with my senses. So that I know more information where I am. And that's the one of the main things that I use it for, but mostly it's about understanding more about my surroundings and the planet itself.

Interviewer
And just about a little bit about the everyday What's it like? How does it interfere or not interfere with your everyday activities like hugging someone, having sex, all these everyday things? With a little device on your chest? What's that, like?

PT02
um, I don't sleep with it, because for the night, I take it off and recharge it, the rest I can do. Because like, it's, it's, you know, it's not bulky, and it's waterproof. So everything I can do like, it was two days ago, we went to this small city, small town. And they have a really charming lake and I just had a swim. And I found it on the water that it buzzes. And it's crazy like that it actually does it. And I'm a little bit worried because the micro USB charger is free like it, I don't need to, you know, plug in a small waterproof silicone thingie it just, it just sits there. So I'm having like, second thoughts when I'm showering that maybe if any water goes in that it might, you know, malfunction. But I went underwater and it had no problem at all.

Interviewer
Wow.

PT02
Yeah, so it has no negative effect on my everyday life. It's really, really like, um, you know, like, I think nowadays in our, especially our generation, when we feel a buzz in our body, we think that it's a notification on our phone. And it's really, really weird. It's a really strange experience for myself, observing my brain behaviour, how my brain thinks, when, for

example, I'm busy working, and I would just turn and I feel a buzz. And sometimes it's conscious, sometimes it's not. And when it's conscious, and I get surprised, I would actually reach for my pockets, even though it buzzes in the middle of my chest. So I would reach for my pocket, or I would, you know, grab there. Because it buzzes, and then and then you know, like it's really weird. And also, sometimes when it does, and I still think that it's my phone, I kind of feel like something's happening. Like, you know, I get a text I get excited. Oh my god, I get an email. Like I'd get a notification, you know, that, like, tiny, weird thrill that you have when your phone is buzzing, like oh my god, what's happening? And that's what I feel when it buzzes, but it's still like this transition of learning that it's the device itself and my sense not my phone.

Interviewer
Okay, did you get like Phantom vibrations with the North Sense or not really?

PT02
Uhmm? No, but I couldn't tell because I work as a barista. So during my work days, I'm really busy. You know, I'm doing coffee, I'm serving guests. And I turn around a lot. And sometimes if I can I pay attention to the device. But sometimes I just can't do it. I would, I couldn't say what or whether it's, you know, when I'm speaking maybe the voice and the kind of like the bone air conduction that my lungs filled up with air and that buzzes a little bit or I have to pay attention. And it's the Sense. Maybe I had but I just don't know.

Interviewer
Right, right. So do you wear it every day?

PT02
Yes. Um, I try to wear it now as much as I can so that I get used to it, and then it becomes more than a device. Sometimes, if I would get home from work, I would take it off, because my skin gets tired. Okay.

Interviewer
What do you mean your skin gets tired? What does that feel like? Does it stay sore?

PT02
So it's the same, same unpleasant feeling at the moment when I had it on when I couldn't, or whatever it was unbearable. So like the, the flat bars under my body kind of like can move sideways and that hurts, if they go upwards and downwards that's alright. But if we twitch like this, that's kind of painful. So during the day, I would you know of course move a lot, and they would move a lot as well. So the end of the day, it just gets tired. And it was a few days ago, when also my brain got tired because I just moved so much. And it was a little bit overwhelming. But I tried to force myself to not to take it off so that I get so tired that I can just stop caring. And I think that's the transition that it becomes sense.

Interviewer
That's, that's fascinating. So has it discouraged you from doing certain things? Are you more cautious about doing some things since you've had it on?

PT02
Not really. No. I mean, yeah, the shower parts. Sometimes I would take it off, and then go to the shower. Or I would already have taken off to start recharging it. Yeah. But not really.

Interviewer
No. And you mentioned the thing with the clothes kind of getting in the way but okay. I think I see what you mean. And in terms of its effects on your perception, have you noticed any changes to how you perceive directions or space?

PT02
Um, the ones that I told before, so I get excited when I go to a new location. Yeah. And, and, and, like how I can, I can feel where I am. But I'm, like, I don't think that it's gonna happen right away. It's gonna be a long term experience.

Interviewer
And so when you walk into a room, do you try to map it and try to locate it in objective space?

PT02
Yeah, yeah. It's like a 3d sonar thingy. So I walk around, I scan my environment. And I just know where north is. And also, because where I live, now we have a big, like a big hill that faces north. So I can compare the house in the room and my environment, face where it's facing north, compared to the rest of the city. So I have a larger map in my brain that I compare it to, so I can place like, it's a puzzle, so I can place that room into the big picture.

Interviewer
I see. Okay, so did did you start to think about space differently? Because of this?

PT02
Um, I think so. Yeah.

Interviewer
Okay. So could you say something about what it actually feels like? The vibration, if you perceive it as a vibration? What does it feel like when the North sense is active?

PT02
it's, I mean, it's a small, like, you know, like, I don't know, like a bee having attached to my chest. And it just tells me where north is, which is really interesting, because just yesterday, I read an article about how maybe also bees have this sense as well. And bumble bees as well. So it would be really funny to have an actual bee, or a bumblebee. And it just, you know, points at you like, that's north. Yeah. It's because of the app, I can set the intensity and the duration of the vibration. So I have it, the duration is a medium long enough that I notice it and then becomes conscious. But I noticed that if it's too long, then I will enclose a larger angle in which it's vibrating. So for example, if north is there, and I turned around and I got here, it starts vibrating, but if I keep turning, it wouldn't stop here, just only here. So I have a wider angle in which it would buzz. So I have to shorten it down to narrow the angle and have a more precise sensing. Yeah, the intensity of the vibration is actually almost the highest, so that I notice it because I'm still experimenting the positioning of the four rings and the strings on my body and on the, the anchoring, because sometimes if I don't position it correctly, there is a small space in between my chest and the device itself, so, that it's not directly touching my chest and I need to adjust it.

Interviewer

Alright, I see. So at the moment you say that you perceive it as a vibration as a kind of buzzing?

PT02
Yes. I don't know how people, like the other cyborgs? Well, I don't consider myself Cyborg yet.

Interviewer
No? That was going to be my next question. But before we get there, so how, how aware are you of the device during the day? Do you forget that it's there or how is that?

PT02
Yes, I do. I do. Like if I if I, if I'm facing one direction, and it's not north, that I can easily forget it's there. Because, like it's a constant touch that my brain ignores. And filters are like censoring noise. So I hope that kind of happens with the buzzing itself as well, I think that would be the aim.

Interviewer
Okay, so do you see yourself as a cyborg?

PT02
Not yet.

Interviewer
All right, why not?

PT02
Because now it's only a device. Now it's a wearable device that I have. And I hope that by the end of this year, as I go on, and I wear it more and more, it's going to be a sense. I think what keeps me at the moment from getting really immersed into this sense thing is the routine I have to do.

Interviewer
Okay…

PT02
so, the charging the calibrating the fitting it on, all that daily routine that I have to do keeps me from having this immersive, sensory feeling. Now it's, it's a, it's a device, it's like a smartwatch that I have to charge put it on in the morning and go. So in order to, to kind of like play this, I fool my mind and think of it as you know, like brushing your teeth, washing your face, take the sleepers from your eyes, clean your ears and all that. That's how I see this procedure as well. So that I'm maintaining one of my senses, like washing your skin so that you feel more touch and pressure and temperature. And I would actually when, for example, sometimes I would misjudge the direction I'm facing. Like the Sense itself. Sometimes it's a little bit silly because it buzzes even though I know I'm not facing north. So right now north is that way, but for some reason, while I'm sitting in front of this very computer, it would start buzzing that way as well. Which is really weird. I don't know the reason I will have a Skype session soon. Well, tomorrow actually with Liviu and I will ask him about this but I tried to think of it when it happens I forced myself to instantly think of it that it's not a malfunctioning in the device. But it's like if I have you know like something went into your

eye or when you know when there's some problem with your ears and you don't hear correctly. Or you know when you have a numb feet or numb finger or something like that. Yeah. So that's how I tried to name the problems and the feelings kind of like medically or try to fool myself to, to force myself to think of it as sense.

Interviewer
All right, I see. Okay, so for you it's just like one of your senses has a part outside your body. It's kind of like having contact lenses almost.

PT02
Yes. Like or like the, the, the ears, you know, the actual, like ear canals that you have. That's how I tried to think of it. I would love to upgrade it in the future, if it's possible to have it not having to charge it every day. That would be a great leap in order to immerse myself more into the actual sense feeling. Or if it were, if it wasn't transdermal, but it was actually subdermal. In that case, it would be more sense like for me.

Interviewer
And how do you feel about this whole idea of, of you having a piece of it's a piece of technology on your body that might need updating? So how do you feel about having to swap and exchange certain parts of your body as time as time goes on?

PT02
I'm freaking excited about this. Like, it's, it's crazy like this is it's like what Neil said is, the older we get, our senses get better, we are at that age that it's possible if you're willing to do so, the older you get your senses get better. A few years ago, I read about this Canadian eye surgeon, who invented a method with the simple routine procedure with the laser cut eye lens, he basically installs an artificial eye lens into your eye. And it's the same procedure as like a laser surgery, which is like a routine surgery, and you get more than 20/20 vision. So just the idea of being able to upgrade yourself to become something much more. It's, it's amazing. Because like, let's face it, I was born with this shitty body that I can either accept to have it or, you know, the, like exercise to become better. Or eat healthier. Or I could do those as well. But I'm really like lazy, so I would just update the ones that I can. Like it's it's I see exercising and having an implant kind of like on the same level because you're upgrading your body from the natural state.

Interviewer
So you see no difference there that in the one you're like active and the other one, you take an add on. You think they're essentially the same thing?

PT02
Um, well, yeah, I mean, I mean, of course the outcome is different. But it's, it's kind of like the same level I'd say.

Interviewer
So would you like in the future, consider swapping your parts for better ones which are technological, like if there was an eye like a bionic eye that is better than the organic one. Would you consider swapping?

PT02

Um, probably, yes. I don't, I don't know. Like, I think many people will do. I spent a few weeks in South Korea and I would see how 18 year old girls as soon as they have their birthday, almost the next day would go to plastic surgery. And do essentially body modification and it's socially accepted. And I have this view that as soon as prosthetics and the technology gets there, that the senses and the artificial prosthetics get to that point that it's the same level as our, you know, original ones, people will start to swap their existing body parts to artificial ones. Because as soon as they get to the same level, they get better, because you can upgrade them. I will not stop that's for sure. Like I want to get the magnets, I want to read a few more articles and I ask people who already have the magnet itself. I'm a little worried about how the coating on the magnet will break down because I've heard that some and I've seen some people having to say that it broke down over a few years. But if I can wear them and have them in longer, like, I don't know, three, four or five years in my body, I am willing to do that. I also want to eventually get an RFID tag into my body as well to amplify not only my sensory Cyborgism, but my cognitive Cyborgism as well. So be able to communicate with machines and, and different electronics.

Interviewer
So, as a kind of general question, why do you want to do that? Like, why become Cyborg?

PT02
I don't understand why not become a cyborg? We've been we've been modifying ourselves since the dawn of humanity. We put on makeup to look prettier. We wear clothes to be able to survive and you know, stay out longer during the winter. Girls wear high heels to look higher. We wear glasses, we have pacemakers. We have hearing aids, we have smartphones. People nowadays cannot exist without their smartphone. But I'm pretty sure that the next and the new generation that is being raised now, by smartphones, they won't be able to just go out and ask people like Hey, excuse me, where is this statue or how they get there? It's, it's, it's an inevitable part of their lives. And it become their part. And people have been doing this for 1000s of years, even more. You know, I just took it a little bit more extreme. Because I have it attached it's like, I don't know, if someone would get like, you know, the, I think the very first eye surgery, which helped them to see better would have been considered weird as well, if they were to get like, eyeborgs or you know, like, but because they get glasses with which people are familiar with, or, you know, it's just a random surgery. That it's accepted. It's a new thing. That's why it's weird. You can see people with hearing aids, artificial pancreas. pacemakers everywhere.

Interviewer
And do you have any, like, concerns about the enhancement of human capacities? Do you think there are any, do you have any concerns about this space? Because you seem very enthusiastic.

PT02
In terms of security?

Interviewer
For example? I mean, if that's a concern, then Yeah. Are you concerned about security?

PT02
Not really, um, I mean, I know that everything is a double-edged sword. And just as technology can be used for good it can be used for bad as well. And you know, like, people

are saying like, yes, but you can be hacked like your body can be hacked. Yeah, but so does your iPhone. So does your car nowadays. Smart homes are more and more popular, we are producing and putting an enormous and unbelievable amount of data on ourselves online. But I'm just a regular guy. You know, like, I know some people would say that everyone says that but I'm not the target. You know, I'm not the president of the US. Why would anyone want to hack me? And if they truly want to hack me, they will no matter what, they can get my Facebook number, my second social security number my bank accounts, my passwords. Everything. Without even putting a bigger effort into it. You know if they really wanted to, if I really wanted within one year, I suppose, of hard working, I could attack you, and all of your data if I really want it. That's possible.

Interviewer
Yeah.

PT02
So if people really want to do that, they will. So if you if I think if you're cautious and conscious about what you do, and what data you give up, then it should not be any problem. I don't hold military secrets and launch codes and things like that. I'm not worth hacking. Yeah. And since there is no software in the device itself, the software is my brain. So there is nothing that can be hacked. It's not even like Neil's implant. I've heard there was this guy who hacked his eye and he just kept sending selfies of his face and he felt his face. That's weird, but it's funny as well. Like, there is no internet connection to the device itself.

Interviewer
So if you could if you can have any ability enhanced what would you like most?

PT02
any existing sense or any new sense?

Interviewer
Pick whichever.

PT02
If I were to go existing, I would enhance my eyes. Also to get like 20/20 and widen the wavelengths that I can see going to ultraviolet and infrared more like infrared because that's the critical if I were to add new senses, feeling electricity, probably that would be really, really amazing. Um, one that we don't have. And I keep thinking about how to do that, is having wet receptors.

Interviewer
Having What?

PT02
Like, wetness, receptor wetness.

Interviewer
Yeah, yeah, okay.

PT02
We don't have those. And it's really weird, because I know that I'm showering my body knows that I'm showering, but I don't feel the water directly.

Interviewer
Okay.

PT02
Like, how do you feel the temperature difference between the water and your skin? You feel the touch and the pressure? Yeah. And you see and hear the water you can smell like, you know, the shampoo and everything. But there is like no wetness receptors inside your skin. If there were having a cold and a warm shower would be an entirely different experience besides temperature, of course. But you know how like the four Celsius water is the densest. You don't feel the density of water. If you were to have wetness receptors, you would know how dense that water is. fish have this. We don't.

Interviewer
Okay, and why do you want to have that?

PT02
Because why they can have it and I want that as well. Just because it's kind of cool. So, um, but for this, like, I'm really and I'm having like my own designs, if I, you know, if I had the skills, and the team, but I think this would require an artificial skin or some sort of layer that you have on top, which probably in the future, it's going to be possible, I don't know, like, people developing electronic skins now that you know, you can it's like a touch screen. So probably we're going to have that. But for example, what I've been thinking of the past few days is so we don't feel altitude. We can feel some sort of air pressure that we have. But we don't feel altitude. And the reason I'm thinking about this because as I mentioned, I just moved into this new city, and it's really hilly, compared where I lived was completely flat. So I walk a lot upwards and downwards. And I can feel it. I can see it but my body doesn't really know how high I am. So I was thinking if we were to take for example Neil's sounds part of his implant, where it conducts the electronic part into sounds into his inner ear. And we were to attach it to accelerometer, like an altitude meter, technically you would be able to feel altitude as well, like you could hear the change, the higher you go, for example, a bus ride in the hills or taking off with an aeroplane would be a completely different experience.

Interviewer
So it seems like you're interested in kind of senses which give you information about the natural world. Like the qualities of natural things like water.

PT02
Yeah. Because it's like so much information out there, that we have no idea like, it's layers and layers and layers of information that other species can perceive. But we don't. And of course, this has an evolutionary reason. But probably in 10 million years or whatsoever, we will be able to sense them naturally. But now we don't. And if I gain information about my surroundings, I gain knowledge. So that's, that's my purpose.

Interviewer
So do you think it's almost like the next stage in human evolution, the addition of these sensory augmentations to the body?

PT02
Um, not as a species. But as individuals, I don't like it would be really, and I think it's going to be one of the longest experiences ever made. If we took two groups, one that are modifying themselves and one that don't, and see them for 1000s of years, you know, how they, how they change, because evolution has not stopped. But I think it's going to be an enormous change in our species in the next 2-300 years. As soon as we become interplanetary species, which will happen by the end of this century, I reckon. Then we will need to modify our body to be able to survive in the new environments.

Interviewer
So have you have you like played around with other enhancements as well? Like brain stimulation or stimulants, things like that?

PT02
Um, what do you mean?

Interviewer
So, other kind of enhancement technologies that people have experimented with, not necessarily additions to the body, but like brain stimulation or that kind of thing? neurofeedback?

PT02
Not Not that I know.

Interviewer
Okay, cool. So I think we are coming to the end, are there are there any other effects that you have noticed that you would like to share? Or anything that you think is important that you would want to say, but we didn't touch on it?

PT02
No, I don't I don't think so. No, um, I think I have one question, though, it is about the survey itself. And, and like, what's, what's your aim with this? This group of cyborgs and weird people?

Interviewer
Ah, what do you mean? What do you mean your aim?

PT02
The aim of the research itself?

Interviewer
It's an incredibly exciting opportunity. Because Never before has a group of people attached a sensory augmentation device to their bodies for a longer period. There is Neil who has one thing, and there's a Moon who has another, and there are a few individuals. But this is really the first time that a lot of people are trying to experiment with what it's like to have a new and extended sense and it's just fascinating to understand why people want to do this what the actual effects are. How do people's perceptions change? How do you how do you perceive the world differently? What does that mean for the future of these technologies going ahead?

PT02
What I'm really curious about is what changes this will have on human interactions, like, I actually created a group, a Facebook group for North Sense cyborgs. And I would like to include everyone who has a Sense, because as you asked, I don't know anyone else who has the implant other than Liviu. So I would like to start conversations with people like me, like, will we have any changes in the language? For example, we have to invent new words. For, for this, it's gonna be my you know, like, it's I don't want, maybe now it's called Northing. But will it be in the future? Something else? Like just called, You know, like, like our eyes? It's not vision sense. It's not hearing sense. It's called ear.

Interviewer
Yeah.

PT02
Will we have new words or for example, if we were to get in together somewhere or some someplace all of us, we have the North Sense, how would we behave together that would be really cool to experience and to monitor as well.

Interviewer
Well, those are all the things that I am very interested in! Okay, thank you so much. I'll be in touch, if you're okay with that, to do a follow up for later stages of your experience.

PT02
Of course, of course, at any time. I'm pretty sure that it's gonna change a lot. Yeah, like my perception in the in the next half year.

Interviewer
I hope the pain will not be significant. I hope that goes away. And thank you very much for your time!

PT02
All right. Thank you.