

Ao6

Questa ricerca e la sua pubblicazione sono state finanziate (parzialmente o integralmente) dall'Università Cattolica del Sacro Cuore nell'ambito dei suoi programmi di promozione e diffusione della ricerca scientifica.

Anto Čartolovni

**Ethical and anthropological aspects
of the emerging field of neuroprosthetics**





Aracne editrice

www.aracneeditrice.it
info@aracneeditrice.it

Copyright © MMXVI
Giacchino Onorati editore S.r.l. – unipersonale

www.giacchinoonoratieditore.it
info@giacchinoonoratieditore.it

via Vittorio Veneto, 20
00020 Canterano (RM)
(06) 4551463

ISBN 978-88-255-0320-3

*No part of this book may be reproduced
by print, photoprint, microfilm, microfiche, or any other means,
without the publisher's authorization.*

I edition: May 2016

Contents

- 7 *Acknowledgments*
- 9 *Table of Abbreviations*
- 11 *Foreword*
Antonio G. Spagnolo
- 13 *Introduction*
- 17 *Chapter I*
Neuroprosthetics technology “state of the art”
- 1.1. Brief historical background, 19 – 1.2. The connection between machine and body, 21 – 1.2.1. *Technical limitations of electrode implantation and relating issues*, 23 – 1.3. Plasticity and cortical reorganization, 28 – 1.4. Neuroprosthetic systems, 29 – 1.4.1. *Sensory neuroprosthetics*, 30 – 1.4.2. *Motor Neuroprosthesis*, 43 – 1.4.3. *Mental function prosthesis*, 52 – Conclusion, 58.
- 61 *Chapter II*
Phenomenological and anthropological implications of the neuroprosthetics
- 2.1. Anthropocentricity in the technological society, 61 – 2.1.1. *The difference between artificial and natural*, 63 – 2.1.2. *Human– technology relationship*, 66 – 2.2. The phenomenological aspects of acceptance of otherness within human body, 75 – 2.2.1. *The symbolic character of the body with an implanted technology and its cultural implications*, 81 – 2.2.2. *Social implications of technology implanted into human body*, 86 – 2.3. Ontological issues in the neuroprosthetics implementation, 91 – 2.3.1. *Ontological status of the person with incorporated technology, Cyborgisation issue*, 91 – 2.3.2. *Ontological status of people with disability and its possible endangerment by neuroprosthetics implementation*, 101 – Conclusion, 113.

115	Chapter III <i>Ethical issues in the development and implementation of neuroprosthetics</i>
	3.1. Particular neuroprosthetics issues, 118 – 3.1.1. <i>Memory prostheses and identity</i> , 118 – 3.1.2. <i>Responsibility and liability in the case of motor neuroprosthetics</i> , 125 – 3.2. Societal issues, 132 – 3.2.1. <i>Social ethics issues regarding neuroprosthetics</i> , 132 – 3.2.2. <i>The delicate line between therapy and enhancement</i> , 143 – 3.2.3. <i>Risks regarding privacy and data protection</i> , 149 – Conclusion, 153.
159	<i>Bibliography</i>

Acknowledgments

This Acknowledgment section is not enough to show my immense gratitude to many people who have helped me to realise this book and have enabled me to bring forth the best of ideas for and from my research. Therefore, I wish to mention my gratitude to the ones that have contributed the most in the creation of this present work.

Firstly, I want to thank, with immense gratitude, my PhD supervisor Prof. Antonio G. Spagnolo for his guidance and supervision of my work and for the significant advice that he has provided me for the structuring of this work. During my PhD triennium, his understanding and openness for collaboration and novelties in the emerging technologies were my main motivation to bring forth this presented work.

Secondly, I want to thank to all the professors and researchers that have helped me with their advice and suggestions:

- Prof. Maurizio Faggioni (Accademia Alfonsiana);
- Prof. Maria Luisa di Pietro (Institute for Public Health UCSC);
- Prof. Paolo Maria Rossini (Department of Neurology, Policlinic A. Gemelli UCSC);
- Dr. Giuseppe Granada MD (Department of Neurology, Policlinic A. Gemelli UCSC);
- Prof. Françoise Baylis (Dalhousie University);
- Dr. sc. ETH Markus Christen (Centre for Ethics — University of Zurich);
- Prof. Silvestro Micera (Centre for Neuroprosthetics — EPFL Lausanne);
- Dr.sc. Vincenza Mele (Institute of Bioethics UCSC);
- Dr. sc. Francesca Giglio (Institute of Bioethics UCSC).

Third, I want to thank Brocher Fondation (Switzerland) for providing me with a junior scholar Fellowship and place to work, where I spent two beautiful months at the lake Léman finishing here presented work.

My special gratitude goes to Dr. sc. Nina Hallowell (Ethox Centre — University of Oxford) and Jennifer Singh who have helped me with proof reading the text, critical content and structure revision.

Last, but not least, I want to thank my parents and my brothers for their support and encouragement. Special thanks go also to my two PhD colleagues Carla Morán and Luisa Villari who have been real friends through this time, and with whom I have shared all the up's and down's during my PhD adventure!

Table of Abbreviations

NBIC	Nanotechnology, Biotechnology, Information technology and Cognitive Science
DBS	Deep Brain Stimulation
STOA	Science and Technology Options Assessment
HE	Human Enhancement
TE	Therapeutic Enhancement
BCI	Brain Computer Interfaces
BMI	Brain Machine Interface
CNS	Central nervous system
PNS	Peripheral nervous system
FDA	Food and Drug Agency
ECoG	Electrocorticogram
EEG	Electroencephalography
IHD	Implantable hearing devices
NIH	National Institute of Health
RP	Retinitis pigmentosa
MPDA	Multiphotodiode array
CE	Conformité Européenne
FES	Functional electrical stimulation
PMCU	Prosthetic Master Control Unit
DOF	Degree-of-freedom
EMG	Electromyogram
TMR	Transfer or targeted muscle re-innervation
LIFE	Longitudinal intrafascicular electrode
TIME	Transverse intrafascicular multichannel electrode
PTSD	Posttraumatic stress disorder
OCD	Obsessive compulsive disorder
TBI	Traumatic brain injury
MIMO	Multi-output model
MEA	Micro Electrode Array
RFID	Radio-Frequency-Identification
FEID	Full essentialist individual deficiency
PEID	Part-essentialist individual deficiency interpretation
POD	Politics of disablement
EC	Ethical Committee
RCT	Randomized control trials
EF	Executive Functioning

CI	Cochlear Implant
NH	Normal Hearing
WMA	World Medical Association
CIOMS	Council for international Organizations of Medical Science
LAR	Legally authorized representative
ELSI	Ethical, legal and social issues
IMD	Implantable medical devices
ICT	Information and Communication Technologies
AI Artificial	Intelligence
iTA	Interactive technology assessment

Foreword

ANTONIO G. SPAGNOLO*

This book it is not just another book about the expanding area of Neuroscience, but it is a quite novel contribution which shines the light of ethical reflection on innovation in the field of Neurotechnologies. It is an honour for me to present the following work of Dr. Cartolovni, entitled *Ethical and anthropological aspects of the emerging field of neuroprosthetics*. Being unable to keep up with the fast growing and expanding field of Neurotechnologies might give the impression that no ethical or anthropological implications stand behind its development. However, the here presented work of Dr. Cartolovni provides strong contrary evidence that these technologies will have some implications not only on end-users but on society as well. The work itself is the product of extensive research, which can be perceived in the vast bibliography used by the author.

The book starts with an updated overview of key aspects of neuroprosthetics, from which afterwards the author outlines all implications that might be discovered during the development and implementation stage. These implications, as the author shows, have social character; therefore, this work's originality can be seen in its integrative approach, trying to provide a complete synthesis of currently foreseeable implications. Some of these technologies question the idea of a "human being" such as we already know it, with some interpretations connected with neurotechnological devices looking to redefine the idea of being 'human'. These attempts at redefinition represent an anthropological problem that is perfectly outlined in this book. However, the implications that follow from the implementation are not only anthropological, but also ethical, and that are moreover embedded in the social context where we live.

* Director of the Institute for Bioethics and Medical Humanities (IBioMedH), School of Medicine and Surgery A. Gemelli, Università Cattolica del Sacro Cuore, Rome.

The following work has been performed with a certain dose of scientific rigor and methodology and contains scientific validity, and as such I maintain that it deserves to be offered to the public as a publication for several reasons. First, despite the complexity of the topic it has been here elaborated in simple language, providing a good introduction, demonstrating the relevant arguments to back up the conclusion. Second, taking into consideration that this technology is still emerging and developing, and that it is still in the development stage, the book offers a significant and important source for ethical and anthropological analysis. Third, certainly one of the many positive elements of this book is the originality of the scientific contribution that emerges from the approach through which the problem of neuroprosthetics has been confronted; not only technology *per se*, but analysing the technology *in situ*, in other words observing the technology immersed in a social context. Fourth, the interdisciplinary character gives to this book a special quality, which provides insight into neuroprosthetics technology from different disciplinary perspectives.

Therefore, I heartily recommend this book to anyone interested in ethical and anthropological implications of emerging technologies and especially to those that are interested in an intersection between bioethics and neuroscience. This book is a great example of how various scientific fields can significantly contribute to the unravelling and outlining of ethical problems that might not be perceived at first sight.