Applied Metascience of Neuroethics

A Commentary on Paul M. Churchland

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This commentary is the first case study in the applied metascience of neuroethics, that is, the application of a metascientific approach to neuroethical research. I apply a bottom-up approach to neuroethics to Churchland's publication. The bottom-up approach to neuroethics is a quantitative approach (based on scientometric methods) that, among other things, allows us to outline the field from 1995 until 2012 through the development of fifteen subject categories or topic prototypes. Each subject category or topic prototype is defined by up to thirty-one keywords that appear frequently in the abstracts and titles of the publications in the Mainz neuroethics bibliography. The connection strength between two subject categories or topic prototypes depends upon the number of shared publications, that is, the number of publications that can be assimilated to both subject categories or topic prototypes. Accordingly, a keyword-based search of the abstract and title of any publication in neuroethics allows us to assimilate it to (at least) one subject category or topic prototype and, thereby, localize it within neuroethics and reveal its degrees of relevance to neuroethical research, as measured by the connection strengths between the subject categories or topic prototypes. A case study on Churchland's publication led to the following results: the publication is localized in the subject category or topic prototype *Moral Theory*, has high degrees of relevance to research that can be assimilated to the subject categories or topic prototypes *Neuroimaging*, *Philosophy of Mind and Consciousness*, and *Economic and Social Neuroscience*, and has low degrees of relevance to research that can be assimilated to the subject categories or topic prototypes *Addiction*, *Brain Death and Severe Disorders of Consciousness*, *Brain Stimulation*, *Enhancement*, *Legal Studies*, *(Medical) Research and Medicine*, *Molecular Neurobiology and Genetics*, *Neuroscience and Society*, *Neurosurgery*, *Psychiatric and Neurodegenerative Diseases and Disorders*, and *Psychopharmacology*. Such results can be fed back into neuroethical research, which, in turn, can optimize neuroethics itself and, hence, improve our pursuit of moral understanding. The take-home messages are as follows: potential follow-up studies on Churchland's publication should consider my case study results and analysis and, furthermore, future neuroethical research should be more careful to take applied metascience of neuroethics into account. This can be done at different stages of research. If this general idea is on the right track, then applied metascience of neuroethics is complementary to (and perhaps even extends) Churchland's argument, only on a different level.

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1 Introduction

In *Rules: The basis of morality…?*, Churchland points at several problems for classical rule-based accounts of moral knowledge that attempt to identify morally valid behavior-guiding rules and the sources of their authority. Those problems (all based on the fundamental assumption that rules in the literal sense require a language) show that we need a non-

classical non-rule-based account of moral knowledge. Hence, the author proposes an alternative account from computational neuroscience based on "the best hypothesis currently available for how the brain both represents and processes information about the world [...] [and] of how the brain learns" (Churchland this collection, p. 8; emphasis omitted): parallel distributed processing (PDP). In PDP, a neural network embodies a conceptual framework that contains knowledge about the world, that is, a configuration of attractor regions, a family of prototype representations, or, rather, a hierarchy of categories (Churchland 2012, p. 33): against this background, moral knowledge is a configuration of synaptic weights in a neural network. Subsequently, this insight is used to reconceive moral competence, moral conflict, and moral reasoning. Moral competence is the personal level competence to apply sub-personal level knowledge to a moral situation by assimilating it to a prior learned category or prototype. A moral conflict, however, is (at least partly) the consequence of a moral situation that has been assimilated to a category or prototype of which it is not an instance. In short, the fallibility of moral cognition leads to competing interpretations of a moral situation and thereby to a disagreement with others. Accordingly, moral reasoning is (at least mostly) not about rules and the sources of their authority but about adequate assimilation of a moral situation to a category or prototype in the first place. Finally, the author concludes: "[k]nowing how the brain works to generate and constantly improve our moral understanding will not obviate the need to keep it working toward that worthy end, though it may help us to improve our pursuit thereof" (Churchland this collection, p. 13; emphasis omitted).

Churchland's publication has my full support. I agree with what he says, as I do with his general approach. What follows is a complementary (and perhaps even extending) attempt to improve our pursuit of moral understanding, only on a different level: applied metascience of neuroethics (NE), that is, the application of a metascientific approach to neuroethical research.[1]

In this commentary, I apply the (as-yet unpublished) bottom-up approach to NE[2] offered by Hildt et al. (forthcoming)[3] to Churchland's publication. Thereby, I attempt to achieve my epistemic goal, which is both to localize the publication within NE and reveal its degrees of relevance[4] to neuroethical research; as well as my argumentative goal, which is to demonstrate that applied metascience of NE can optimize NE itself and, hence, improve our pursuit of moral understanding.

In the following, I introduce NE and present three typical examples of (disadvantageous) contemporary top-down approaches to NE. I then introduce a bottom-up approach to NE. Following this, I apply the bottom-up approach to NE to Churchland's publication and present my case study results. After this, I analyze my case study results. Finally, I conclude with some suggestions for future research.

2 Top-down approaches to neuroethics

NE, as a combination of applied ethics[5] and neurophilosophy[6] (Hildt 2012, p. 11), is an interdisciplinary field at the intersection of neuroscience, medicine, and philosophy that deals with philosophical, ethical, anthropological, and socio-cultural issues related to neuroscience (Metzinger 2012, p. 36). In 2002, this versatile field emerged in the wake of several US-American conferences that were products of the Zeitgeist, that is, the Decade of the Brain from 1990 to 1999 (Hildt

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1 In general, applied metascience is not limited to NE, but can be performed with any kind of scientific discipline.
2 A bottom-up approach to NE is data-driven, whereas a top-down approach to NE is definition-seeking.
3 I would like to thank my colleagues in the Mainz Research Group on Neuroethics/Neurophilosophy for providing me the opportunity to use the bottom-up approach to NE for the purpose of this commentary.
4 The degrees of relevance of publications to neuroethical research, as measured by the connection strengths between the subject categories or topic prototypes, indicate the probabilities that publications will prove fruitful for neuroethical research.
5 NE is neither another branch of applied ethics (Levy 2011, p. 3) nor reducible to medicine ethics, bioethics, or a subfield thereof. Nevertheless, there is much overlap (Hildt 2012, pp. 11–12) between these fields.
6 Neurophilosophy is a naturalistic and reductive approach towards a unified theory of the mind–brain that requires detailed knowledge about neuroscience (Walter 2013, p. 133).

2012, p. 9). In particular, it is common to identify the dawn of NE with a conference that was held in San Francisco on May 13th and 14th, 2002: *Neuroethics: Mapping the Field* (Marcus 2002). Before this, "most people saw no need for any such field" (Levy 2007, p. 1), but the aforementioned issues came to be perceived as far more important at this time. Nevertheless, we should ask: what exactly is NE? Alongside the first approximation given above, I present three typical examples of contemporary top-down approaches to NE (which I don't claim to be exhaustive).

From a knowledge-driven perspective (Racine 2008, p. 33), Roskies divides NE into two divisions: the ethics of neuroscience and the neuroscience of ethics. According to Levy, the former "seeks to develop an ethical framework for regulating the conduct of neuroscientific enquiry and the application of neuroscientific knowledge to human beings [...] [whereas the latter studies] the impact of neuroscientific knowledge upon our understanding of ethics itself" (Levy 2007, p. 1). Furthermore:

> the ethics of neuroscience can be roughly subdivided into [...] (1) the ethical issues and considerations that should be raised in the course of designing and executing neuroscientific studies and (2) evaluation of the ethical and social impact that the results of those studies might have, or ought to have, on existing social, ethical, and legal structures. (Roskies 2002, p. 21)

This top-down approach to NE emphasizes the philosophical challenges posed by neuroscience (Racine 2008, p. 34), for example, for "philosophical notions such as free-will, self-control, personal identity, and intention" (Roskies 2002, p. 22).

From a technology-driven perspective (Racine 2008, p. 33), Wolpe identifies NE with "both research and clinical applications of neurotechnology, as well as social and policy issues attendant to their use. [...] [Thus, it is] a content field, defined by the technologies it examines rather than any particular philosophical approach" (Wolpe 2004, p. 1894). This top-down approach to NE emphasizes the ethical challenges of using neurotechnology (Racine 2008, p. 33), for ex-

ample, in healthcare and social practices (Racine 2008, p. 32).

From a healthcare-driven perspective (Racine 2008, p. 33), Racine & Illes (2008) propose a definition of NE that "profiles the field as at the intersection of neuroscience and bioethics defined by a general practical goal, that of improving patient care for specific patient populations" (Racine 2008, p. 34). This top-down approach to NE emphasizes the field as "both a scholarly and practical endeavor, akin to medicine, which attempts to understand and intervene" (Racine 2008, p. 34).

In sum, each of the three top-down approaches to NE comprises (despite their convergences) different issues in different subject categories or topic prototypes with different relations to each other. Seemingly, there are as many top-down approaches to NE as philosophers in the field (e.g., Farah 2012[7]; Gazzaniga 2005;[8] Giordano n. d.;[9] Moreno 2003;[10] Safire 2007[11]) but probably even more.[12]

This unsystematic versatility is disadvantageous for any attempt at a precise localization of Churchland's publication within the field because it suggests that the aforementioned top-down approaches to NE are necessarily incomplete or even inconsistent. Hence, their application can lead to unsatisfactory results—for example, a localization of the publication that depends more on a research agenda than on facts.[13] The bottom-up approach to NE attempts to provide a solution to this problem.

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7 Farah characterizes NE as "a broad range of ethical, legal, and social issues raised by progress in neuroscience" (2012, p. 572).

8 Gazzaniga understands NE as "the examination of how we want to deal with the social issues of disease, normality, mortality, lifestyle, and the philosophy of living, informed by our understanding of underlying brain mechanisms" (2005, p. xv).

9 Giordano identifies NE with "(1) the study of neurological bases of moral cognition, sense and action[,] (2) the field of study that addresses the moral issues that arise in and from neuroscientific research and the clinical practices and social effects/implications that evolve from these investigations[, and] (3) the reciprocal interaction(s) between neurological research/clinical practices and other ethically relevant areas of biomedical sciences" (Giordano n.d.).

10 Moreno argues that NE "is in some ways old wine in a new bottle" (2003, p. 153).

11 Safire defines NE as "the examination of what is right and wrong, good and bad about the treatment of, perfection of, and welcome invasion or worrisome manipulation of the human brain" (2007, p. 8).

12 Buniak et al. "provide an iterative, four-part document that affords a repository of international papers, books, and chapters that address the field in overview, and present discussion(s) of more particular aspects and topics of neuroethics" (2014, p. 3).

3 A bottom–up approach to neuroethics

The bottom-up approach to NE is a quantitative approach (based on scientometric methods) that, among other things, allows us to outline the field from 1995 until 2012 through the development of subject categories or topic prototypes.[14] Although similar work has been done before, for example, by Gooray & Ferguson (2013), Garnet et al. (2011), or Seixas & Basto (2008), no bottom-up approach to NE based on such a comprehensive database as that of Hildt et al. (forthcoming) has yet been attempted.[15] To be more precise, they use the Mainz NE bibliography.[16]

The Mainz bibliography (launched in 2006) is an open-access online bibliography compiled and provided by the Mainz Research Group on Neuroethics/Neurophilosophy.[17] Currently, the bibliography, as a multimodal compilation of NE publications (e.g., anthologies, edited volumes, journal articles, and monographs), contains about 4095 entries produced between 1949 and mid-2014. On the one hand, the bibliography is based on regular scans of relevant journals from neuroscience and medicine (e.g., *Cortex*, *Der Nervenarzt*, *EMBO Reports*, *Journal of Neurology*, *Journal of the American Medical Association*, *Nature*, *Nature Neuroscience*, *Nature Reviews Neuroscience*, *Neurocritical Care*, *NeuroImage*, *Neurology*, *Neuropsychology Review*, *Psychopharmacology*, *Science*, and *Trends in Cognitive Sciences*), philosophy (e.g., *American Journal of Bioethics Neuroscience*, *American Journal of Bioethics*, *Bioethics*, *Cambridge Quarterly of Healthcare Ethics*, *Consciousness and Cognition*, *Journal of Applied Philosophy*, *Journal of Medical Ethics*, *Medicine, Health Care and Philosophy*, *Neuroethics*, *Philosophy, Psychiatry, & Psychology*, *Science and Engineering Ethics*, *Hastings Center Report*, *The Journal of Law, Medicine & Ethics*, and *Theoretical Medicine and Bioethics*), the humanities, and social sciences.[18] On the other hand, the bibliography is based on regular searches of both relevant citation (meta-)databases such as *Web of Science*,[19] *PubMed*,[20] and *Scopus*,[21] and relevant bibliographies such as the *Brainstorm*[22] newsletter of the Canadian Neuroethics and Mental Health Interest Group. The bibliography also incorporates irregular additions of relevant publications (mainly anthologies, edited volumes, and monographs) as soon as the Research Group on Neuroethics/Neurophilosophy becomes aware of them. Regarding the selection criteria for publications from the various sources, publications from neuroscience or medicine are selected if they refer to the philosophical, ethical, anthropological, or sociocultural impact of the presented results,

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13 For example, facts that are necessary for an adequate mapping of the field may have been (un-)intentionally overlooked.

14 In Hildt et al. (forthcoming), the developed subject categories or topic prototypes form the basis for further scientometric analysis of the data. For example, the subject categories or topic prototypes allow us to examine the development and institutionalization of NE (e.g., temporal development, structure and disciplinary institutionalization, and reciprocal shaping of NE and related disciplines).

15 For example, Gooray & Ferguson's (2013) database contains about 205 entries dating from 2000 to 2012. The database is based on books and articles from the following twelve journals: *Neuroethics, American Journal of Bioethics Neuroscience, Nature Reviews Neuroscience, Annual Review of Neuroscience, Behavioral and Brain Sciences, Molecular Psychiatry, Nature Neuroscience, Neuron, Trends in Neurosciences, Frontiers in Neuroendocrinology, Annals of Neurology,* and *Progress in Neurobiology*. In contrast, Hildt et al.'s (forthcoming) database contains about 2296 entries dating from 1995 to 2012. It is based on books and articles from more than 700 journals.

16 https://teamweb.uni-mainz.de/fb05/Neuroethics/SitePages/Home.aspx

17 http://www.blogs.uni-mainz.de/fb05philosophieengl/further-institutions/research-group-on-neuroethics-and-neurophilosophy/

18 The aforementioned selection of twenty-nine journals comprises those journals that had added at least twenty publications to the Mainz NE bibliography before mid-2014. The number of publications ranges from (at least) 352 publications (*American Journal of Bioethics Neuroscience*), 298 publications (*American Journal of Bioethics*), 211 publications (*Neuroethics*), 91 publications (*Nature Reviews Neuroscience*), 68 publications (*Der Nervenarzt*), 61 publications (*Nature Neuroscience*), 58 publications (*Journal of Medical Ethics*), 57 publications (*Journal of Neurology*), 54 publications (*Nature* and *Neurology*), 46 publications (*Bioethics*), 40 publications (*NeuroImage* and *Science and Engineering Ethics*), 37 publications (*Trends in Cognitive Sciences*), 35 publications (*Hastings Center Report*), 31 publications (*Journal of the American Medical Association, Medicine, Health Care and Philosophy,* and *Philosophy, Psychiatry, & Psychology*), 28 publications (*Science*), 26 publications (*Cortex* and *EMBO Reports*), 23 publications (*Neurocritical Care* and *Neuropsychology Review*), 22 publications (*Cambridge Quarterly of Healthcare Ethics, Journal of Applied Philosophy,* and *Psychopharmacology*), 21 publications (*The Journal of Law, Medicine & Ethics*) to 20 publications (*Consciousness and Cognition* and *Theoretical Medicine and Bioethics*). This selection of twenty-nine journals could be a fruitful starting point for future scientometric research related to NE. Besides this, the Mainz NE bibliography comprises journals that have added less than twenty publications (e.g., *Behavioral and Brain Sciences* and *Philosophical Psychology*).

19 http://www.webofknowledge.com

20 http://www.ncbi.nlm.nih.gov/pubmed

21 http://www.scopus.com

22 http://www.ircm.qc.ca/LARECHERCHE/AXES/NEURO/NEUROETHIQUE/PAGES/GROUPE.ASPX?PFLG=1033&lan=1033

whereas publications from philosophy, the humanities, or social sciences are selected if they refer to empirical results from neuroscience or medicine. Moreover, non-transdisciplinary publications are selected if the Research Group on Neuroethics/Neurophilosophy considers them to be relevant to NE.[23]

Subsequently, Hildt et al. (forthcoming) use a bibliometric analysis of the Mainz NE bibliography from 1995 until 2012 to develop, among other things, fifteen subject categories or topic prototypes on content-based criteria. Thereby, each subject category or topic prototype is defined by up to thirty-one keywords that appear frequently in the abstracts and titles of the publications. These fifteen subject categories or topic prototypes are *Addiction*, *Brain Death and Severe Disorders of Consciousness*, *Brain Stimulation*, *Enhancement*, *Legal Studies*, *(Medical) Research and Medicine*, *Molecular Neurobiology and Genetics*, *Moral Theory*, *Neuroimaging*, *Neuroscience and Society*, *Neurosurgery*, *Philosophy of Mind and Consciousness*, *Psychiatric and Neurodegenerative Diseases and Disorders*, *Psychopharmacology*, and *Social and Economic Neuroscience*. Each subject category or topic prototype represents certain issues discussed in NE[24] and, taken together, they outline the field.[25] Importantly, Hildt et al. (forthcoming) also determine, among other things, the connection strengths[26] between the subject categories or topic prototypes within NE. Due to the content-based development of the subject categories or topic prototypes, a keyword-based search of the abstract and title of any publication in NE allows us to

assimilate it to (at least) one subject category or topic prototype[27] and, thereby, localize it within NE.

In the following, I apply the bottom-up approach to NE to Churchland's publication and present my case study results. I thereby attempt to achieve the first part of my epistemic goal, which is to localize Churchland's publication within NE.

4 Case study results

The keyword-based search of the abstract and title of Churchland's publication reveals that it can be assimilated to the subject category or topic prototype *Moral Theory*, that is, a subject category or topic prototype that comprises publications on the psychology and neurobiology of moral-decision making, publications on determinism, free-will, and the function of moral theory in the neurosciences, and publications on challenges to established interpretations of morally significant concepts such as autonomy, responsibility, and human nature.

This subject category or topic prototype has strong connections to the subject categories or topic prototypes *Neuroimaging*, *Philosophy of Mind and Consciousness*, and *Social and Economic Neuroscience*, and weak connections to the subject categories or topic prototypes *Addiction*, *Brain Death and Severe Disorders of Consciousness*, *Brain Stimulation*, *Enhancement*, *Legal Studies*, *(Medical) Research and Medicine*, *Molecular Neurobiology and Genetics*, *Neuroscience and Society*, *Neurosurgery*, *Psychiatric and Neurodegenerative Diseases and Disorders*, and *Psychopharmacology*. The strong connections can be explained by a high number of shared publications, that is, a high number of publications that can be assimilated to both the subject category or topic prototype *Moral Theory* and the subject category or topic prototype *Neuroimaging*, *Philosophy of Mind and Consciousness*, or *Social and Economic Neuros-*

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[23] For example, a publication in medicine on the effects of neuroleptics, antidepressants, stimulants, or tranquilizers is selected if it could offer a contribution to the interdisciplinary debate on psychopharmacological cognitive enhancement.

[24] Combinations of the subject categories or topic prototypes are able to represent almost every issue discussed in NE.

[25] Bottom-up approaches to NE attempt to provide maximally parsimonious bottom-up descriptions of their target phenomenon (e.g., NE as a dynamical publication state-space). If the top-down descriptions of NE, provided by the top-down approaches to NE, are neither identical with nor reducible to the bottom-up descriptions of NE, then, using a superficial analogy to Churchland's eliminative materialism (1981), an interesting question is whether or not (and, if so, which of) the top-down descriptions of NE can be eliminated.

[26] The connection strength between two subject categories or topic prototypes depends upon the number of shared publications, that is, the number of publications that can be assimilated to both subject categories or topic prototypes.

[27] A publication can be assimilated to a subject category or topic prototype if its abstract and title contain (at least) one of the keywords that define the subject category or topic prototype. As such, less than ten percent of the total publications could not be assimilated to a subject category or topic prototype. An interesting questions is whether or not (and, if so, how) those publications can still be regarded as belonging to NE.

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cience. The weak connections can be explained by a low number of shared publications, that is, a low number of publications that can be assimilated to both the subject category or topic prototype *Moral Theory* and the subject category or topic prototype *Addiction, Brain Death and Severe Disorders of Consciousness, Brain Stimulation, Enhancement, Legal Studies, (Medical) Research and Medicine, Molecular Neurobiology and Genetics, Neuroscience and Society, Neurosurgery, Psychiatric and Neurodegenerative Diseases and Disorders,* or *Psychopharmacology* (Hildt et al. forthcoming).

In the following, I analyze my results. I thereby attempt to achieve the second part of my epistemic goal, which is to reveal the degrees of relevance of Churchland's publication to neuroethical research; as well as my argumentative goal, which is to demonstrate that applied metascience of NE can optimize NE itself and, hence, improve our pursuit of moral understanding.

5 Analysis

First of all, the degrees of relevance of publications to neuroethical research are measured by the connection strengths between the subject categories or topic prototypes. The connection strengths between subject categories or topic prototypes depend upon the numbers of shared publications. The numbers of shared publications can be explained by the degrees of overlap of content, methodology, or both. The degrees of overlap of content, methodology, or both, in turn, indicate the probabilities that publications will prove fruitful for neuroethical research. In short, the degrees of relevance of publications to neuroethical research, as measured by the connection strengths between subject categories or topic prototypes, indicate the probabilities that publications will prove fruitful for neuroethical research.

Based on my results, Churchland's publication has high degrees of relevance to research that can be assimilated to the subject categories or topic prototypes *Moral Theory, Neuroimaging, Philosophy of Mind and Consciousness,* or *Social and Economic Neuroscience* because of

the strong connections between the subject category or topic prototype *Moral Theory* and the subject categories or topic prototypes *Neuroimaging, Philosophy of Mind and Consciousness,* and *Social and Economic Neuroscience.* The strong connections can be explained by the high numbers of shared publications. The high numbers of shared publications can be explained by the high degrees of overlap of either content, methodology, or both.[28] This, in turn, indicates high probabilities that Churchland's publication will prove fruitful for research that can be assimilated to the aforementioned subject categories or topic prototypes. Conversely, Churchland's publication has low degrees of relevance to research that can be assimilated to the subject categories or topic prototypes *Addiction, Brain Death and Severe Disorders of Consciousness, Brain Stimulation, Enhancement, Legal Studies, (Medical) Research and Medicine, Molecular Neurobiology and Genetics, Neuroscience and Society, Neurosurgery, Psychiatric and Neurodegenerative Diseases and Disorders,* or *Psychopharmacology* because of the weak connections between the subject category or topic prototype *Moral Theory* and the aforementioned subject categories or topic prototypes. Here are some brief theoretical considerations.

Churchland's publication is highly relevant to research that can be assimilated to the subject category or topic prototype *Economic and Social Neuroscience,* suggesting that his idea of reconceiving moral decision-making in terms of PDP could prove fruitful for neuroethical research that refers to the underlying physiology of economic or social decision-making. This application might show that moral, economic, and social decision-making share important properties but differ in others. This possible result could then be fed back into neuroethical research.

Churchland's publication is also highly relevant to research that can be assimilated to the subject category or topic prototype *Neuroima-*

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28 Accordingly, publications that can be assimilated to the subject category or topic prototype *Moral Theory, Neuroimaging, Philosophy of Mind and Consciousness,* or *Social and Economic Neuroscience* are highly relevant to the subject of Churchland's publication.

ging, suggesting that his idea of reconceiving moral decision-making in terms of PDP could prove fruitful for neuroethical research that refers to imaging techniques that visualize the brain, such as cranial computed tomography (CCT), electroencephalography (EEG), magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), and positron emission tomography (PET) (Hildt 2012, p. 11). For example, it could be used to reconceive the classic distinction between off-track and truth-tracking processes in genealogical debunking arguments[29] that refer to fMRI research (e.g., Greene 2008 and Singer 2005). This application might show that the classic distinction is neurobiologically implausible, which would mean that arguments relying on this distinction are implausible as well. This possible result could then be fed back into neuroethical research.

Moreover, the possible (yet unrecognized) relevance of Churchland's publication to research that can be assimilated to the subject categories or topic prototypes *Addiction*, *Brain Death and Severe Disorders of Consciousness*, *Brain Stimulation*, *Enhancement*, *Legal Studies*, *(Medical) Research and Medicine*, *Molecular Neurobiology and Genetics*, *Neuroscience and Society*, *Neurosurgery*, *Psychiatric and Neurodegenerative Diseases and Disorders*, and *Psychopharmacology* could have been emphasized more strongly by including keywords in the abstract and title that define the aforementioned subject categories or topic prototypes, which, in turn, could have increased the connection strengths between those subject categories or topic prototypes and the subject category or topic prototype *Moral Theory*. A possible outcome of this could have been the revelation of a systematic overlap of content, methodology, or both that has been neglected so far. And this possible result could then have been fed back into neuroethical research.[30]

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29 According to Kahane, the general form of a genealogical debunking argument is the following: S's belief that p is explained by x. But, x is an off-track process, that is, not a truth-tracking process, with respect to p. Therefore, S's belief that p is unjustified (Kahane 2011, p. 106).

30 Of course, this theoretical consideration is not meant to be a serious criticism of Churchland's publication, because the bottom-up approach to NE was not available to him at the time of writing. It rather shows that applied metascience of NE can help us discover new pathways and directions for future neuroethical research.

This feedback process, in turn, can optimize NE itself and, hence, improve our pursuit of moral understanding because it can help to "produce better ethical theories […] and contribute toward the great project of better understanding ourselves" (Levy 2011, p. 8). Apparently, a recurring pattern emerges: the bottom-up approach to NE can be applied to neuroethical research, which, in turn, can led to such results that can be fed back into it, which, in turn, can optimize NE itself and, hence, improve our pursuit of moral understanding.

6 Concluding remarks

In this commentary, I applied the bottom-up approach to NE to Churchland's publication. I thereby attempted to localize the publication within NE and reveal its degrees of relevance to neuroethical research, and to demonstrate that applied metascience of NE can optimize NE itself and, hence, improve our pursuit of moral understanding.

Assuming that I have achieved the former, which was my epistemic goal, the first and more specific take-home message is that potential follow-up studies on Churchland's publication should consider my case study results and analysis, that is, they should both bring together research that can be assimilated to the subject categories or topic prototypes *Moral Theory*, *Neuroimaging*, *Philosophy of Mind and Consciousness*, and *Social and Economic Neuroscience*, and build bridges to research that can be assimilated to the subject categories or topic prototypes *Addiction*, *Brain Death and Severe Disorders of Consciousness*, *Brain Stimulation*, *Enhancement*, *Legal Studies*, *(Medical) Research and Medicine*, *Molecular Neurobiology and Genetics*, *Neuroscience and Society*, *Neurosurgery*, *Psychiatric and Neurodegenerative Diseases and Disorders*, and *Psychopharmacology*. Assuming that I have achieved the latter, which was my argumentative goal, the more general take-home message is that future neuroethical research should be more careful to take applied metascience of NE into account because it can optimize NE itself and, hence, improve our pursuit of moral understanding.

In the case of the bottom-up approach to NE, this can be done at different stages of research. First, while seeking inspiration for research, researchers and students can bypass well-trodden paths in NE and identify (as yet) unorthodox ones from the very beginning. Second, while pursuing these (or already well-trodden) paths, scholars can optimize the efficiency of their own research. Third, while preparing their research for publication, they can prepare abstracts and titles in such a manner as to optimally reflect the publications' (real or intended) degrees of relevance to specific subject categories or topic prototypes. Fourth and finally, when taking it into account, they shape NE in such a way that it provides input for more fine-grained follow-up models in the metascience of NE.

If this general idea is on the right track, then applied metascience of NE is complementary to (and perhaps even extends) Churchland's argument, only on a different level: "knowing how the brain works to generate and constantly improve our moral understanding will not obviate the need to keep it working towards that worthy end" (Churchland this collection, p. 13; emphasis omitted), just as knowing how to optimize NE will not do this either, though both "may help us to improve our pursuit thereof" (Churchland this collection, p. 13). Only time will tell.

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