**Advances in Neuroethics**

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L. Syd M Johnson
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Adam Shriver
*Editors*

# Neuroethics and Nonhuman Animals

Springer

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# Neuroethics and Nonhuman Animals

Springer

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ISSN 2522-5677 ISSN 2522-5685 (electronic)
Advances in Neuroethics
ISBN 978-3-030-31010-3 ISBN 978-3-030-31011-0 (eBook)
https://doi.org/10.1007/978-3-030-31011-0

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# Acknowledgments

Thanks to MacGregor Malloy and Robby Berman for their assistance in preparing the manuscript for publication.

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# Introduction to Animal Neuroethics: What and Why?

## 1

L. Syd M Johnson

**Abstract**
The emergence and development of neuroethics over the last two decades has occurred in parallel with progress and advancement in several separate sciences, including various neurosciences, comparative psychology, comparative cognition, and ethology. The rapid growth of knowledge about animal brains, minds, intelligence, culture, behaviors, and capacities made by these sciences continues to be integrated into the philosophical discourse on animal ethics, but has thus far had little impact on animal research regulations. Our aim is to bend what have heretofore been more or less parallel tracks into convergence and intersection, and examine the implications of neuroscientific research for our understanding of the minds of other animals, the moral status of these animals, and our moral obligations to them. We challenge neuroethics to adopt a less anthropocentric focus and explore how growing knowledge of nonhuman minds challenges human supremacy.

**Keywords**
Animals · Neuroethics · Anthropocentrism · Human supremacy

## 1.1 Introduction

The emergence and development of neuroethics over the last two decades has occurred in parallel with progress and advancement in several separate sciences, including various neurosciences, comparative psychology, comparative cognition, and ethology. The rapid growth of knowledge about animal brains, minds,

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_1

intelligence, culture, behaviors, and capacities made by these sciences continues to be integrated into the philosophical discourse on animal ethics, but has thus far had little impact on animal research regulations. In this volume, our aim is to bend what have heretofore been more or less parallel tracks into convergence and intersection, and examine the implications of neuroscientific research for our understanding of the minds of other animals, the moral status of these animals, and our moral obligations to them. In so doing, we aim to challenge neuroethics to adopt a less anthropocentric focus and integrate new knowledge, a more inclusive ethics, and emerging scientific and technological innovations so as to expand its scope. So positioned, neuroethics can envision how a shift away from anthropocentrism could expand its role in critical discussions of our treatment of other animals and explore how growing knowledge of nonhuman minds challenges the human supremacy currently threatening our planet.

## 1.2 What Is Animal Neuroethics?

As this book demonstrates, some of the classic problems and concerns of neuroethics, such as cognitive enhancement, and the ethics of neuroscience and neuroscientific research, are reiterated in an animal-focused neuroethics. The traditional bifurcation of neuroethics, described by Adina Roskies as *the ethics of neuroscience* and *the neuroscience of ethics* [1], is certainly echoed in an animal-focused neuroethics. In the former category, the creation and use of nonhuman animals in neuroscientific research prompts questions that are obviously important to any animal-focused ethics, including neuroethics. A variety of animal species are used in neuroscientific and brain research, including basic research that seeks to map the brain, and understand brain cells and structures as well as their functions. Applied research uses a variety of animal models to understand diseases and disorders of the brain and mind, and to discover and test therapies. For example, some of the global big brain projects, like Japan Brain/MINDS, are currently focusing their efforts on the development and use of genetically modified nonhuman primates (NHPs), specifically marmosets.

Although the animal research industries as we know them began in earnest after the Second World War, research with animals and the use of animals as model organisms dates back centuries. To consider the ethical permissibility of using them in research challenges a well-entrenched scientific establishment built on the nearly unlimited use of animals [2]. Research ethics, at its best, is in the business of questioning and reevaluating the established use of certain (human) populations as research subjects, including children, and institutionalized populations such as prisoners and patients. An ethically and scientifically informed reevaluation of the use of animals cannot be beyond consideration simply because of the potentially enormous practical implications for the research enterprise. In a very real sense, this is an ethical problem that the behavioral and neurosciences have created—the success of the scientific study of animal brains and behavior in expanding our understanding of animal brains and minds, and the myriad ways that they are structurally and functionally similar to human brains and minds, itself weakens longstanding scientific and ethical assumptions and presumptions about the permissible use of animals in neuroscientific research. In that way, an animal-focused neuroethics is both an *ethics of neuroscience* and a *neuroscience of ethics*—knowledge gained from the study of animal brains and minds can and must inform animal ethics.

While the use of animals in research has long been an important focus of animal ethics, research ethics, as well as the guidelines and regulations that govern research with animals, an animal-focused neuroethics must be more comprehensive and look beyond questions about the use of animal models in neuroscientific, cognitive, and psychological/psychiatric research. Just as a human-centered neuroethics is more than the ethics of brain research, an animal-focused neuroethics can look beyond research ethics. We anticipate that an animal-focused neuroethics will be uniquely positioned to push the boundaries of what neuroethics does and what issues it takes up. A number of novel concerns and themes emerged as this book took shape, pointing to the ways that an animal neuroethics is truly not just more of the same *with animals*, but rather something that promises to lead to an expansion of the scope of neuroethics. The diversity of the authors of the chapters in this collection also points to a promising expansion of the scientific disciplines that a more broadly focused neuroethics—already quite multi- and interdisciplinary—can and should welcome into the fold.

These novel (for neuroethics) themes, concerns, and disciplines include *comparative psychology* and *comparative cognition,* or research that compares the brains, minds, cognitive capacities, and behaviors of different species. Our focus in this book is primarily on what studies of animal behavior and cognition tell us about those animals, particularly with respect to whether they have the capacities commonly thought to confer moral status or moral concern. As noted below, however, viewing neuroethics in a less anthropocentric light will lead us to consider a variety of nonhuman entities, including those that are not biological organisms.

## 1.3 Animal Neuroethics: The What and the Why

In "Sentience and Consciousness as Bases for Attributing Interests and Moral Status: Considering the Evidence—and Speculating Slightly Beyond" [3], philosopher David DeGrazia begins with the assumption that sentient beings have interests and that having interests is sufficient (but perhaps not necessary) for moral status. He considers the state of the evidence for sentience in mammals and birds, reptiles, amphibians, fish, cephalopods, and arthropods (in particular, crustaceans and insects). In considering the possibility that insects are conscious but not sentient, DeGrazia goes farther afield and considers whether human-made robots might also one day be conscious but not sentient, eliciting implications for their moral status.

Philosopher Gary Comstock considers the cow in "Bovine Prospection, the Mesocorticolimbic Pathways, and Neuroethics: Is a Cow's Future Like Ours?" [4]. Like many farmed animals, cows get little respect and little recognition as thinking, feeling creatures. Comstock considers the scant evidence for bovine cognition and asks what neuroscience can tell us, if anything, about the capacities of cows to think about the future. The question is important if having the right to a future—and a right not to be slaughtered—requires the ability to *think* about one's future. Comstock distinguishes several kinds of prospection and surveys what is known about the neuroanatomy of future-directed bovine beliefs and desires to ask whether a cow's prospection is *like ours*, where that is understood to include *all* human beings.

If cows get little respect, fish get even less, and their mental lives are quite poorly understood. In "Mental Capacities of Fishes," fish researchers Lynne Sneddon and Culum Brown [5] review the evidence for sentience and cognitive abilities in fishes to highlight the growing empirical evidence of their mental capacities. The evidence for pain, and for the capacities to experience positive and negative welfare states such as fear and stress, are still debated when it comes to fishes. Fish models are increasingly used in a wide variety of experimental contexts and their adoption is growing globally, although they are too frequently excluded from animal welfare regulations. But if fish are sentient and can suffer, this has ethical implications for their use in scientific studies and for current regulatory schemes that exclude them from welfare considerations.

In his chapter "The Four Cs of Modern (Neuro)ethology and Neuroethics: Cognition, Complexity, Conation and Culture," canid neuroethologist and neuroendocrinologist Simon Gadbois [6] critically engages what he sees as the *over-use* of certain kinds of mental state ascriptions to explain or model animal behavior. Though Gadbois rejects the traditional Behaviorism and early Ethology that each shunned the use of mentalistic terms in their scientific analyses of animal behavior, he reminds us that what looks to be quite complex behavior can arise from very simple psychological mechanisms or neurological processes. What's more, for Gadbois, much behavior need not reflect complex or *any* mental representations beyond that which permits an animal, based on past experience, to see what uses objects or individuals in their environment afford them and to be moved to behave accordingly. Rather than emphasizing cognition, Gadbois suggests a return to explanations that either do not require the ascription of mental states or foreground the role of emotions, innate motivations, and preferences.

In "Speciesism and Human Supremacy in Animal Neuroscience," philosopher Robert C. Jones [7] contends that the kinds of scientific and philosophical arguments used to deny the moral considerability of nonhumans reflect a kind of anthropodenial embedded in speciesism and, specifically, human supremacy and neurotypicalism. Skepticism regarding animal minds, cognition, and experience (e.g., reluctance to attribute thoughts, beliefs, phenomenal consciousness, and sentience) is frequently justified by reference to what we might call physiological heterologies in neural structure as well as differences in cognitive complexity when comparing humans and other animals. Underlying such claims are nonscientific, normative assumptions about human supremacy. Jones argues both that there is good reason to believe that vertebrates such as fish—and even invertebrates such as some crustaceans, insects, and arachnids—are experiencing beings and that these conclusions have ethical implications.

Another theme that emerged in a substantive and interesting way in the book is *captivity*. The ethics of using captive populations in research has long been a concern of research ethics, given the dark history of exploiting vulnerable, easily accessible, captive populations like institutionalized children and incarcerated persons. Captivity for animals used in research, and the way it affects both the quality of life of the animals and the quality of the science [8], is an important issue for both neuroscience and neuroethics. The effects of captivity and social deprivation on both animal welfare and the ecological validity of cognitive and brain research are important considerations that bear on the value of such scientific research with animals [9–11]. Other captive animals—those in zoos and aquaria, for example—have not been a traditional concern for neuroethics. Several chapters look at the psychosocial, neurological/neurodevelopmental, and health effects of captivity on animals, as well as the deleterious effects of captivity on the quality and value of research.

In "The Human Challenge in Understanding Animal Cognition," primatologist Christophe Boesch [12] critically examines the emphasis on controlled experiments with captive animals in comparative cognition studies. Animals raised in captivity and living in laboratories, he argues, are completely detached from species-typical socio-ecologies, and studies of captive animals limit the progress of science. While studying free-living animals in their native environments—like the chimpanzees Boesch studies—has provided a wealth of detailed observations on sophisticated cognitive achievements, captive experimental studies have for too long concentrated on the "failure" of nonhuman species to demonstrate so-called uniquely human cognitive skills. If we want to understand the evolution of human and human-like cognitive abilities, Boesch argues that we must integrate information about brain plasticity and consider ecological validity and population differences.

In "Large Brains in Small Tanks: Intelligence and Social Complexity as an Ethical Issue for Captive Dolphins and Whales," neuroscientist Lori Marino [13] examines the effects of captivity on cetaceans, who are highly complex, large-brained social mammals. While dolphins have been used in research and for military purposes, the primary reason dolphins and whales are kept in captivity is for entertainment—thousands are kept in concrete tanks in marine parks and aquaria around the world. In these environments, these animals experience a lack of control, a lack of stimulation, a diminished social world, and the loss of the ability to engage in activities necessary for them to thrive. That they are such complex, self-aware, intelligent beings makes it more difficult for them to cope with artificial environments, Marino argues, resulting in stereotypies, self-harm, reduced life expectancy, and negative short- and long-term health effects. Marino thus establishes that traditional concerns of the animal rights and animal welfare communities—animal captivity and exploitation for entertainment—are also neuroethical concerns insofar as it is the effects of captivity on the cognitive capacities and psychological lives of cetaceans that amplifies the harm experienced by these social creatures. Marino concludes that the only ethical response is to phase out the captivity of dolphins and whales for entertainment and move those in commercial facilities to sanctuaries that can better meet their needs.

Political philosopher Robert Garner explores what animal ethics has to say about the issue of captivity in “Animal Rights and Captivity in a Non-Ideal World” [14]. The best-known theories of animal rights are prohibitionist and/or abolitionist when it comes to using animals and keeping them captive. This would, of course, have significant implications for human use of and interactions with animals, including in science. One response is to reject animal rights in favor of welfarism, which permits use and captivity within limits related to animal welfare. Garner considers whether a more nuanced, interest-based rights theory would allow the claim that at least some animals do not have a strong enough interest in liberty to be accorded a *right* not to be kept in captivity. Another approach would involve the adoption of a non-ideal theory of animal rights, which would bracket liberty—and the issue of captivity—as a component of an ideal theory and therefore not of immediate ethical concern.

The position of animals within society, as well as within science, is mirrored, for better or worse, in certain human populations as well. The psychosocial and neurological/neurodevelopmental effects of captivity on *humans* are a concern for neuroethics to take up in a way that is informed by the brain sciences and driven by important sociopolitical considerations [15]. It’s an area where neuroethicists—as philosophers, legal scholars, social scientists, neuroscientists, and animal scientists—can actively participate in a critically important public discourse as human mass incarceration and the use of solitary confinement become the focus of social and political attention and activism [2]. Studying the effects of captivity on animals in a way that is attentive to how captivity itself frustrates the fulfillment of important needs, alters behavior, and alters the brain and mind can inform our ethical, social, and legal thinking about the ethics of human captivity. What we learn about captivity in humans can also inform the way we view the captivity of nonhuman animals in the various settings in which they are kept. This is especially true of the large, social mammals most like us, including many NHPs used in research and for entertainment, and the elephants and cetaceans held in zoos and aquaria.

Animals used in *agriculture*, and neuroethical questions related to agriculture and agricultural research, are themes present in several chapters of this book, which consider the numerous species that are farmed, captured, and killed for food. Agriculture and the agricultural sciences have never been a part of neuroethics as it has heretofore been framed, and this new avenue promises interesting and fruitful intersections with the ascendant field of food ethics.

The aforementioned chapters on cows and fishes consider the cognitive capacities of species traditionally farmed and killed for food. Chapters by Edison and Esvelt, and Fischer, consider a traditional neuroethics question—enhancement—in the context of agricultural animals. Both chapters consider how animals might be genetically altered to enhance their welfare within intensive farming environments—genetic versions of what Bernard Rollin has referred to as *technological sanders*. “Under industrial conditions . . . animals do not naturally fit in the niche or environment in which they are kept, and are subjected to 'technological sanders' that allow for producers to force square pegs into round holes—antibiotics, feed additives, hormones, air handling systems—so the animals do not die and produce more and more kilograms of meat or milk" (p. 106 in [16]). Edison and Esvelt, and Fischer, examine using genetic modifications not to enhance productivity per se, but rather to reduce animal suffering as those square pegs are forced into round holes.

In "On Mitigating the Cruelty of Natural Selection Through Humane Genome Editing," gene drive researchers Rey Edison and Kevin M. Esvelt [17] consider the possibility that future insights into the genetics of mood will enable us to substantially improve the lives of trillions of agricultural animals. Breeding and artificial selection already govern the genetics of billions of domesticated animals, as well as their predisposition to well-being. Edison and Esvelt outline the moral responsibilities of those who choose to engage with the problem of enhancing the welfare of farmed animals and discuss possible approaches for evaluating the efficacy of genetic methods. They address the concern that over-optimizing for indirect measures of well-being may reduce the extent to which we can be confident that those phenotypes are still meaningful indicators of what we are trying to measure. Given that animals used in agriculture are already selectively bred, what are the implications of using genetic methods to improve animal well-being in intensive farming environments?

Philosopher Bob Fischer takes up that question as well in his chapter "In Defense of Neural Disenhancement to Promote Animal Welfare" [18]. Fischer argues that animal welfare advocates don't act wrongly if they promote research into ways of neurally disenhancing animals. Whereas neuroethics has traditionally considered the implications of neural or cognitive *enhancement* in humans, Fischer focuses on *disenhancement* and contends that, while it may be a less than ideal solution to welfare concerns related to agricultural animals, it has the potential to reduce a tremendous amount of suffering. Disenhancement is not as bad, morally speaking, as it can initially seem to be, Fischer contends, and is a promising way of mitigating the suffering of animals who live in confinement in intensive agricultural operations.

Neuroethical concerns about the creation of chimeras—particularly mice with human brain cells—have frequently focused on the possible "humanization" of these creatures, with ethical implications for their welfare and use in research. That is, one of the concerns about research that creates chimeric animals is that the research itself might result in animals that it would be wrong to use in research because they could develop human-like intelligence or other capacities that might enhance their moral status. In "Nonhuman, All Too Human: Towards Developing Policies for Ethical Chimera Research," philosophers G.K.D. Crozier, Andrew Fenton, Letitia Meynell, and David M. Peña-Guzmán [19] address the ethical challenges raised by chimera research policy, using as a case study the National Institutes of Health proposal to change its policy governing the funding of human-nonhuman animal chimera research. The authors find a troubling shift from a focus on nonhuman animal *welfare* to poorly thought-out concerns with *humanization*. They raise concerns about modifying animals in ways that could significantly impact neurological functions and behavioral capacities, with serious implications for the welfare of research subjects. The authors endorse robust restrictions on chimera research, particularly in the face of a growing globalization of research in varied and inconsistent regulatory environments, and argue that policies should not be based on beliefs about inherent human uniqueness. Instead, at a minimum, they should conform to the widely accepted 3Rs framework for research involving nonhuman animals, our best welfare science, and our best understanding of the capacities of other animals, unspoiled by a denial of relevant similarities.

In many societies it is commonplace to save or spare some animals at the expense of others, and to make judgments accordingly in ways that would be unconscionable were the relevant individuals humans. Philosopher Adam Shriver's chapter "The Role of Neuroscience in Precise, Precautionary, and Probabilistic Accounts of Sentience" [20] indirectly engages policy and applied ethical discussions that touch on anything from animal rescues in disaster zones to the use of animals in science. Shriver's chapter provides a critical discussion of minimizing harms to animals in the face of uncertainty about which animals are sentient. He examines three possible accounts that purport to guide decisions to that end: precise, precautionary, and probabilistic accounts of sentience. One challenge faced by policymakers and ethicists in the domain of animal welfare is that there is little consensus about what constitutes *good* evidence for sentience and how research from the neurosciences might add to evidence of sentience. Where it's possible to save or spare many animals, and erring on the side of assuming sentience is not overly costly, Shriver suggests that applying the Precautionary Principle—taking precautionary measures when sentience is not scientifically confirmed—is the right approach. The implication is that neuroanatomical similarities—and confirmatory neuroscientific evidence—may sometimes *not* be required where there are concerns about animal life or welfare. Many other cases, however, would require a weighting principle that incorporates an assessment of the likelihood of sentience into decisions about use or intervention. Precise accounts of sentience, Shriver argues, are not directly relevant for ethical decision-making, but nevertheless must be pursued in order to better refine the other accounts.

The final section of the book looks at questions about the *ethics of neuroscience* and specifically the use of animals in brain research. These chapters variously explore how research regulations can respond to the global increase in the use of nonhuman primates (NHPs) in a way that aligns with moral concerns about these animals, how a scientifically informed and enhanced understanding of animal welfare and well-being can refocus animal research ethics, and how brain research on animals has frequently failed to deliver benefits for humans—the very benefits used to justify harmful, invasive research.

In "A Threshold Standard for Regulating Invasive Nonhuman Primate Research in the Age of the Major Brain Projects," philosopher Tom Buller [21] examines animal welfare regulations in several countries that are currently ramping up their use of NHPs in brain research. Concern about the use of NHPs—who have complex social and environmental needs that are impossible to replicate in captive, laboratory settings—has increased as more is understood about these animals. At the same time, the genetic modification of NHPs, and their development as models of human brain disorders, is a significant part of some of the national big brain projects, especially in Japan, China, and the United States. There is considerable variety in the national and international regulations governing the use of these animals. Buller examines these regulations and argues that in order for the various national projects to gain broad public support *and* provide adequate protection for NHPs, it is important that the regulations are harmonized and set an appropriate balance between protecting animals while encouraging scientific investigation and progress. Buller considers a number of approaches to tightening the regulations and concludes that the most satisfactory approach is to adopt a threshold standard of invasiveness.

Physician and human and animal rights advocate Hope Ferdowsian, in “The Right to Bodily Sovereignty and Its Importance to Mental and Physical Well-being” [22], describes how respect for bodily liberty and integrity (or bodily sovereignty) have driven the creation and enforcement of relevant rules and regulations in human subjects research, as reflected in documents like the Belmont Report. Little to no attention, however, is given to respect for the bodily sovereignty of nonhuman animals in research or other areas of society, despite its importance in determining health and well-being. As our understanding of well-being and the welfare needs of all animals grows, a more nuanced view of autonomy and vulnerability in both human and nonhuman animals is called for. Freedom from bodily trespasses and freedom of choice are critical to health and well-being in both human and nonhuman animals, and Ferdowsian argues that rules and regulations governing the protection of nonhuman animals should be updated to reflect our scientific understanding of these needs.

Philosopher and neuroethicist L. Syd M Johnson’s chapter “The Trouble with Animal Models in Brain Research” [23] focuses on two problems with animal models used in neuroscientific research: the failure of many animal models to yield useful and beneficial information, and the ethical dilemma built in to claims about the similarity-based usefulness of an animal model, which is especially acute in the context of brain-related research. The chapter uses as a case study the well-known and well-studied failure of animal models in stroke research. The ethical dilemma arises because the similarity of the animals to humans is part of the scientific justification for using them—but their similarity to humans is also a reason to acknowledge their moral considerability. Indeed, as we learn more about animal minds and brains through neuroscientific research, as well as psychological, ethological, and comparative psychology research, the problem becomes only more acute. The successes of these sciences are themselves working to undermine the justification for further use of animals in research.

The essentially Utilitarian cost/benefit claim that human benefits justify harms to animals in research is undermined if those benefits consistently fail to materialize. Matters are even more serious if there is the potential for significant harm to humans, including opportunity costs, wasted resources, and risks to human research subjects. Considering the costs, harms, and benefits of animal research is foundational to regulatory approvals of animal research and the basis of animal research ethics as it is currently practiced within the scientific and regulatory community. But the balance of harms and benefits is heavily tipped to favor human interests. An honest reckoning of the costs and harms to animals *and* the purported benefits to humans is unlikely to support the *status quo* because very little research will be useful or needed, and thus very little will be ethically justifiable.

Medical sociologist Pandora Pound examines the impact of preclinical animal research on the treatment of human traumatic brain injury in "Animal Models and the Search for Drug Treatments for Traumatic Brain Injury" [24]. Pound describes several scientific problems with the use of animal models, including poor internal and external validity, the difficulty of replicating human pathophysiology, and the near impossibility of recapitulating the human clinical context in animals. She argues that the evidence suggests that animal research into traumatic brain injuries is crude, harmful, and ineffective. Pound concludes that it's highly unlikely that modifications to preclinical studies can solve these problems and that animal models will never be fully scientifically valid, no matter how many improvements or modifications are attempted. Like Johnson, Pound argues that the Utilitarian harm/benefit calculus that provides the dominant ethical framework for justifying research with animals is undermined when the shortcomings of animal research, and the failure to yield benefits for humans, are accurately calculated.

## 1.4 Concluding Thoughts

The refocusing toward a less anthropocentric neuroethics is already beginning, as neuroethicists have considered the ethical questions raised by the development of engineered organisms, engineered neural circuitry, and the possibility of sentient machines. These organisms include neural organoids (also called cerebral organoids, or "mini-brains"). These small clusters of cultured, in vitro brain cells are important models for studying brain function, development, and brain disorders. As more complex organoids [25] and networks of organoids that could link different cell types—more closely approximating the functions of a whole brain—are created, urgent questions arise about the ontological and moral status of these organisms, as well as the philosophical implications of the existence of living, extracorporeal brain-like and brain-origin organisms. Ex vivo human brain tissue can currently be maintained in culture for months, perhaps even years. In 2019, researchers at Yale announced that they were able to restore circulation, cellular and electrical function, and perfusion in pig brains taken from slaughtered animals that had been dead for several hours [26]. Human-animal chimeras are engineered for a number of purposes, including for use as models of human disorders. The ethical implications of creating human-like characteristics in mice with human neuron cells have been among the neuroethical issues such research has raised [27], but as human-NHP chimeras are created, such concerns promise to be resurrected. Neuromorphic computing can simulate and investigate dynamic neural processes and identify more efficient approaches for computing [2, 28]. As these machines become more complex, the possible emergence of properties like self-awareness could challenge longstanding assumptions that only biological systems—specifically humans—can possess such characteristics, and that only biological organisms warrant moral consideration.

All of these entities, whether they are human-engineered, of human origin, or of animal origin, are of neuroethical interest because of the unique philosophical, social, and cultural status of the brain and mind as the locus of personhood, rights, and moral status. As an interdisciplinary field, neuroethics is positioned to interrogate longstanding scientific and ethical assumptions about the special significance of humans and humanity. Neuroethics has established itself as a discipline that is forward-looking—sometimes to a fault as speculative outcomes and consequences of neurotechnologies fail to materialize. But looking and thinking ahead, and carefully, about the creation and instrumentalization of neural, neural-origin, and neural-inspired entities must be part of the remit of a forward-looking neuroethics.

And a neuroethics that looks beyond straightforwardly human entities must necessarily include nonhuman animals. There is a diverse, deep, and rich body of philosophical literature on animal ethics, but a specifically "animal neuroethics" has yet to emerge, although there have been efforts to connect the two [29]. Our aim, in this book, is to introduce the questions, concerns, and challenges of an animal-focused neuroethics and to point the way forward to a neuroethics that is altogether less anthropocentric. Such a neuroethics will be pushed as a field to move beyond some of its traditional concerns and questions. It will be better positioned to tackle both the novel and familiar problems, and engage with the intriguing puzzles and possibilities that will arise as more and more nonhuman, near-human, and human-created organisms and entities emerge as the brain sciences advance. At the same time, some of the essential issues and questions of an animal-focused neuroethics will also inform and expand our thinking about new directions and concerns regarding humans and human-centered neuroethics.

Finally, our understanding of animals and what makes them matter (or not) will help shape and inform our understanding and thinking about other near-human and human-origin organisms and entities, including neural organoids, synthetic embryos, human-animal chimeras, robots, and artificial intelligence. In the best case, it may clarify our thinking about those entities, but there is also the possibility—one neuroethics should be prepared to grapple with—that it will further *complicate* our thinking about them.

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# Part I

# Neuroscience of Nonhuman Minds

# 2

# Sentience and Consciousness as Bases for Attributing Interests and Moral Status: Considering the Evidence and Speculating Slightly Beyond

David DeGrazia

**Abstract**

Sentient beings are capable of having pleasant or unpleasant experiences and therefore have interests, which I assume to be necessary and sufficient for moral status. But which animals are sentient? While sentience is sufficient for having interests, maybe it is not necessary. Perhaps some creatures are conscious—having subjective experience—yet are not sentient because their consciousness contains nothing pleasant or unpleasant. If so, do they nevertheless have interests and moral status? This chapter addresses both questions. After identifying several methodological assumptions, it proceeds to consider the state of the evidence for sentience in mammals and birds, reptiles, amphibians, fish, cephalopods, and arthropods (in particular, crustaceans and insects). It then takes up the possibility that insects are conscious yet not sentient. In exploring the mental life of insects, the discussion considers the possibility of robots who are conscious but not sentient, eliciting implications for moral status.

**Keywords**

Sentience · Consciousness · Interests · Moral status · Animals · Robots

## 2.1 Introduction

Sentient beings are capable of having pleasant or unpleasant experiences. This capacity entails having a quality of life or experiential welfare, from which it follows that sentient beings have interests. The possession of interests, I assume, is both

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_2

necessary and sufficient for moral status. So sentient beings have moral status. But which animals are sentient?

While sentience is sufficient for having interests and moral status, perhaps it is not necessary. A fascinating possibility prompted by recent research on insects is that some creatures are conscious—that is, have subjective experience—yet are not sentient because their consciousness contains nothing pleasant or unpleasant. If so, do they nevertheless have interests and moral status?

This chapter addresses both questions. After identifying several methodological assumptions, it proceeds to consider the state of the evidence for sentience in mammals and birds, reptiles, amphibians, fish, cephalopods, and arthropods (in particular, crustaceans and insects). It then takes up the possibility that insects are conscious yet not sentient. In exploring the mental life of insects, the discussion considers the possibility of robots who are conscious but not sentient, eliciting implications for moral status.

## 2.2 Methodological Assumptions

Sentience is the capacity for having any pleasant or unpleasant experiences—or, as I use the term, any *feelings*. So evidence for the possession of any feeling is evidence for sentience. In this chapter, I will focus on one feeling: *pain*. By way of a working definition, pain is an unpleasant sensory experience that is typically associated with actual or potential tissue damage.[1] The capacity to experience pain presumably evolved—assuming it conferred a selective advantage to its possessors[2]—to help animals avoid or minimize harm, thereby increasing their chances for survival and reproduction. In considering evidence for pain in animals, I will mainly examine behavioral and neuroanatomical evidence. Although evolutionary considerations can favor or disfavor the attribution of a particular type of mental state, I will deemphasize such considerations because they are somewhat speculative and, relatedly, there are widely varying accounts of the selective advantage (if any) that consciousness—as compared to unconscious information processing—confers on an animal. We are not in a strong position to say which of these accounts is correct, so I won't rely on any such account.

In asking about animal sentience I will assume that there is no "problem of other minds" with respect to active human beings. While we might reasonably ask about *the basis* for our knowledge that human beings with whom we interact and converse have minds (and are sentient), it is not reasonable to doubt *that* they have minds. As for the basis of our knowledge, I assume it takes the form of an inference to the best

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[1] Roughly this definition may be found in various sources. See, e.g., [1].

[2] This qualification is motivated by the possibility that consciousness and particular conscious states such as pain have no selective advantage over their unconscious, similarly information-processing counterparts.

explanation of other people's behavior—against the background of knowledge about common species membership and similar neuroanatomy.[3]

We know that ordinary human beings are capable of experiencing pain and many other feelings. Claims of knowledge are more interesting with respect to nonhuman animals, whose behavior and neuroanatomy are similar to our own only to varying degrees. In considering different types of animals, I will consider evidence for the following features and phenomena to be significant in supporting an attribution of sentience.

1. *Nociception or similar responsiveness to noxious stimuli.* Nociceptors are receptors, specifically neural end organs, that respond to potentially tissue-damaging (mechanical, thermal, or chemical) stimuli. Stimulating them causes an organism to withdraw a body part, displaying an immediate and very basic defense against harm. In humans, nociception constitutes part of the neuroanatomy of pain, but pain also requires processing in parts of the cerebral cortex (with rare possible exceptions[4]). Nociception—or something functionally similar—is ordinarily necessary, but is not sufficient, for pain.
2. *A central nervous system with a (suitable) brain.* A central nervous system seems necessary for pain and other feelings in order to process information from the environment to a central control system, the brain, which then sends information via the nervous system to various body parts to enable effective motor responses. A good reason to doubt that plants and extremely primitive invertebrates such as protozoa and sponges are sentient is that they lack a central nervous system and brain. On the other hand, lack of a brain that includes a *cerebral cortex* (as mammals have) is a contentious reason to doubt that an animal can feel pain, because in nonmammalian species some other brain part—such as the dorsal ventricular ridge in birds—may play an analogous role in transforming a nociceptive event into the experience of pain.
3. *Protective behavior toward injured body parts.* When we are injured or subjected to highly painful stimuli, we frequently experience not only immediate pain but also residual pain or soreness. In these circumstances we typically guard our injured body part—for example, by limping (thereby protecting a hurt leg), holding an injured arm, or favoring a healthy hand over an injured hand. We also sometimes rub an injured body part in an effort to reduce painful sensations. (In calling such behavior "protective," I expand the ordinary use of the term.)

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[3] My approach may be inconsistent with classic foundationalism, since I help myself to knowledge of species membership and of the hardware in other people's heads when I haven't looked inside. For the record, I regard classical foundationalism as a time-dishonored approach to epistemology that leads, uselessly, to global skepticism. My approach to epistemology is consistent with both coherentism and moderate foundationalism.

[4] There is reason to believe that some human beings, despite being born without a cortex, nevertheless have conscious experiences [2]. If so, perhaps their experiences include pain, in which case there would be some exceptions to the rule that human pain requires cortical processing.

4. *Learned avoidance.* If a creature learns to avoid a noxious stimulus, this behavior indicates some form of memory of past encounters with the stimulus. It is possible, in principle, for such recording of and learning from past noxious instances to be unconscious—an automatic associative learning with no pain. But I will take learned avoidance to constitute one piece of evidence in favor of attributing pain, the idea being that in ordinary cases of learned avoidance an animal felt pain, remembered it, and was thereby motivated to avoid the stimulus.
5. *Opioid receptors, endogenous opioids, and/or behavioral responsiveness to anesthetics, analgesics, and opioids.* In humans, these compounds relieve pain or, if administered prior to an injury or noxious event, might prevent pain altogether. When pain causes guarding of a body part or motivates avoidance of a situation that has caused pain in the past, the administration of pain-relieving compounds often reduces such pain behavior. Thus, a football player with a leg injury might be willing to run and even run normally after receiving an analgesic. When an animal's behavior is *prima facie* pain behavior but becomes more "normal" in response to anesthetics, analgesics, or opioids, the behavioral difference provides some evidence that animal can indeed experience pain and therefore relief from pain. For example, following an injection of bee venom in the lips, a fish might rub its lips against a surface but discontinue rubbing after receiving morphine.
6. *Trade-offs between noxious stimulus avoidance and other health-promoting behaviors.* Nociceptive responses to noxious stimuli, as noted, are automatic and inflexible. Behavior that displays a willingness to endure a noxious stimulus in order to meet some other requirement such as obtaining food or water is more flexible. For example, a rat might endure an electric shock in order to reach desperately needed water. Such behavior suggests a mind that can weigh motivations—here, to avoid pain and to obtain water—in terms of urgency or importance rather than simply responding automatically to immediate stimuli.[5]

In the discussion that follows, I will assume that evidence of these six kinds are highly relevant in attributing pain and therefore sentience. (Occasionally, the discussion will also consider other suggestive phenomena such as sophisticated intellectual capacities and physiological responses associated with stress.) More specifically, evidence of the first two kinds—nociception and an apparently suitable nervous system—is necessary but not sufficient for a strong case; evidence of all six kinds constitutes a very strong case; and evidence of the first two kinds and some but not all of the other kinds of evidence constitutes a case of some intermediate degree of strength for attributing pain and sentience. My assumption that the six kinds of evidence together present a very strong case is not trivial, because it is possible in

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[5] Gary Varner [3] influentially presented a table of types of evidence for sentience. The types of evidence he catalogues overlap with my list of six criteria. I prefer my list because it combines several of his neurological criteria concisely into "a central nervous system with a (suitable) brain" and offers considerably more specificity regarding behavioral criteria.

principle that all six criteria could be met in an insentient creature that possessed a highly complex system of unconscious information processing. While this sort of conjecture is possible, it seems to me less reasonable than the assumption that a creature displaying the foregoing six features and phenomena is sentient and can experience pain. Hence my assumption.

## 2.3 Evidence of Sentience in Different Animal Classes

### 2.3.1 Mammals and Birds

The case for attributing the capacity to experience pain—and therefore sentience—to nonhuman mammals is overwhelmingly strong. Human pain features two largely discrete systems: a sensory-discriminatory system, which conveys information about the intensity and bodily location of a noxious stimulus to the somatosensory cortex, and a motivational-affective system, which registers unpleasantness and motivates adaptive action through the anterior cingulate cortex to the frontal lobe [4].[6] As human experience is our familiar starting point for asking about animal experience, our everyday concept of pain includes both dimensions: pain involves (1) information about the bodily location of a noxious event and (2) unpleasantness. One reason the case for attributing pain to some nonhuman animals is overwhelming is that mammals share the basic neurological architecture—the thalamocortical (thalamus-to-cortex) complex—in which pain processing occurs in humans [5, 6]. In addition, mammals as a class have nociceptors, display protective behavior toward injured body parts, have an endogenous opioid system similar to that of humans, and meet the other criteria listed above. That mammals meet these criteria is not controversial.

The thesis that birds can experience pain and are sentient is less obvious at first glance because avian neuroanatomy differs significantly from mammalian neuroanatomy. Birds lack a cerebral cortex, prompting the question of whether they have a brain part that functions in a relevantly similar way so that nociception can generate the conscious experience known as pain. An affirmative answer seems justified. Like mammals, birds do have a cerebrum, or telencephalon, even if not a cortex on its outer surface [7].[7] Moreover, as Edelman et al. state it, “the somatomotor circuitry within the avian dorsal pallium appears to be homologous to the mammalian basal ganglia-cortico-thalamic loop…” (p. 173 in [8]).[8] In addition, it seems plausible to hypothesize that the dorsal ventricular ridge in birds plays the same role as the cortex in mammals (p. 122–24 in Tye [9]). Birds appear to have a suitable nervous system and brain for sustaining conscious experiences, including pain.

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[6] It is worth noting that these two systems are unlikely to be *entirely* discrete.

[7] The cited article is also illuminating about some of birds’ more impressive intellectual feats, as discussed in the next paragraph.

[8] The authors cite Medina and Reiner [7]. See also Tye (p.124 in [9]). Tye cites Dugas-Ford et al. [10].

Birds also satisfy nearly all of our other criteria for animal pain: nociceptive and endogenous opioid systems (see, e.g., p. 63 in [11]; p. 113–6 in [12]; p. 211–4 in [13]), protective behavior ([9], p. 127–8), and learned avoidance [14]. However, I am not aware of evidence one way or another regarding trade-offs between noxious stimulus avoidance and other health-promoting behaviors. At the same time, the thesis that birds are sentient seems indirectly confirmed by evidence that they are capable of remarkable intellectual feats.[9] (More precisely, these intellectual feats are suggestive of consciousness; but given the aforementioned evidence for sentience, evidence for these feats strengthens the overall case for sentience.) These include crows' fashioning tools to help them accomplish goals [16]. They also include birds' storing "food of different kinds in hundreds of distinct places to retrieve later, [remembering] not only where they have put food but *what* was put in each place, so the more perishable items can be retrieved before the longer lasting ones" (p. 141 in [17]), [18, 19]. Now, it is conceivable that an entirely unconscious creature could perform such feats, but this seems unlikely in the world as we know it, especially when the creature has neural systems for nociception and endogenous opiates and exhibits protective behavior and learned avoidance. Overall, the case for avian sentience seems extremely strong. Based on what we currently know, it is far more reasonable to believe birds are sentient than to believe they are not.

### 2.3.2 Reptiles

Mammals and birds are warm-blooded, highly social animals. Nearly all other animals are cold-blooded and either asocial or social in ways that seem less likely to include emotional attachment. These and other differences tend to make reptiles and amphibians seem more alien than birds and nonhuman mammals. An impression of being alien, however, is not a reliable basis for denying mental states. So let us consider available evidence, beginning with reptiles, who share a common ancestor with mammals, birds, and the extinct dinosaurs, and with all of these animals fall under the general clade known as amniotes.

Reptiles satisfy at least several of our criteria for attributing pain. They have nociceptive systems, central nervous systems culminating in brains that bear substantial structural similarity to avian brains, and endogenous opioid systems.[10] Some further evidence comes from Michel Cabanac and colleagues, who contend that consciousness first evolved in early amniotes—with the implication that present-day reptiles, birds, and mammals are conscious creatures whereas amphibians, fish, and invertebrates are not [21]. (Note that the authors' inference that amphibians, fish, and invertebrates are insentient assumes that the evolution of consciousness has not

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[9] The two examples that follow involve corvids and tits. The examples presented by Gunturkun and Bugnyar [15] involve corvids and parrots. So the claim that impressive intellectual feats bolster the case for sentience might apply only to corvids, tits, and parrots.

[10] For a helpful review of the scientific literature on these topics, see [20].

occurred two or more times in different animal lines.) They hypothesize that as land-based lifeforms evolved, “existence required more and more stimulus-response pathways; eventually, a point was reached where it became more efficient, in terms of speed and flexibility, to route all decision making through a single mental space ... according to the criterium [sic] of maximal pleasure” (p. 267 in [21]). These newly conscious creatures were capable of pleasure and pain, which afforded them a single hedonic currency for selecting behaviors. Consistent with the hypothesis that consciousness and sentience emerged with amniotes, the authors conducted trials involving “taste aversion learning”—in which animal subjects could learn to associate a food’s pleasant taste with the unpleasant indigestion that followed, thereafter avoiding the food (an analogue to learned pain avoidance and an example of trade-off behavior)—and found reptiles but not amphibians to demonstrate such learning [22]. Further, the authors cite literature suggesting that reptiles, when handled, produce characteristic physiological responses that indicate stress (an emotional response)—similar to those found in mammals and birds—whereas amphibians and fish do not (p. 268 in [21]).

The case for reptilian sentience seems rather strong, though not quite as strong as the case for mammalian and avian sentience. Of the six kinds of evidence we are looking for, we have confirmed at least four of them in reptiles and, if we allow taste aversion learning to count as learned pain avoidance, five. Moreover, we don’t have counterevidence with respect to protective behavior—just no evidence either way. What about Cabanac’s interesting thesis that consciousness and sentience emerged with amniotes? Once again, we need to consider available evidence.

### 2.3.3 Amphibians

Descendants of fish, the amphibian class comprises such animals as frogs, newts, and salamanders, which live first in water and then, following a physical metamorphosis, the rest of their lives on land. There is reason to believe that amphibians lack an integrated perception or mental model of the world. Frogs, for example, apparently have one visual stream that allows them to detect and snap at moving objects such as flies and a distinct visual stream that enables them to walk around barriers. The lack of unified visual perception was demonstrated in an experiment in which surgical rewiring in a frog’s brain resulted in a left-right reversal of prey detection while leaving untouched the ability to perceive right and left for purposes of walking around objects (p. 89 in [17]), [23]. Perhaps amphibians in general lack an integrated consciousness of the environment.

Would it follow that they are not conscious at all or that they lack sentience? It would not. The experience of pain is sufficient for sentience. Perhaps creatures like frogs and salamanders have certain sensations such as pain, hunger, and thirst and respond directly to these sensations in adaptive ways—escaping a noxious stimulus, finding and eating food, finding water and drinking—without any single representation of the world and of themselves within it. Unified consciousness might permit more efficient trade-off behavior such as tolerating pain in an effort to access needed food, but perhaps amphibians never evolved this sort of cognition. They might nevertheless be sentient.

On the other hand, if amphibian behavior appears consistent with simple reflexive behavior, it would be more doubtful that amphibians actually experience feelings. Maybe, for example, frogs' two or more visual systems involve unconscious visual perception. Maybe their nociceptive responses to noxious stimuli are never attended by pain. What does the evidence suggest?

My reading of the literature suggests a case of intermediate strength for amphibian sentience and, specifically, the capacity to feel pain [24–26]. It is well-established that amphibians possess systems for both nociception and endogenous opioids, but it is unclear whether their brains include anything functioning like a cortex that can allow nociceptive signals to be experienced consciously as pain. I am not aware of evidence of protective behavior toward injured body parts, of learned avoidance, or of motivational trade-offs. Indeed, the aforementioned reasons to believe that amphibians lack a unified perception of the world make it seem unlikely that they engage in motivational trade-offs. It is far from clear whether amphibians are sentient.

### 2.3.4 Fish

There seems to be more evidence for fish sentience than for amphibian sentience, but perhaps only because fish—a major food source for human beings—have been studied more extensively. Yet, in speaking about fish one has to be careful due to the enormous range of species this term covers.[11] Fish are gill-bearing aquatic vertebrates that, unlike amphibians, never live on land. They divide into jawless fishes such as lampreys and hagfish, cartilaginous fishes such as sharks and stingrays, and bony fishes, which include most extent fish species. It should not be surprising if different types of fish have significantly different cognitive and sensory capacities.

There is stronger evidence that bony fishes—or at least teleost (ray-finned) fishes, which comprise the vast majority of bony fishes—are sentient than the evidence for sentience in the other, more primitive (evolutionarily ancient) types of fish. In fact, there is some counterevidence in the case of the more primitive fishes. For example, careful efforts to identify nociceptors in stingrays have been unsuccessful and, in the case of lampreys, the evidence was ambiguous [28]. Sharks, meanwhile, appear to lack nociceptors and, as a result, are able to feed while being torn to pieces by other sharks and to feed on noxious prey that leave large numbers of barbs in their mouths [9, 26]. At the same time, the evidence is unclear as to whether some jawless and cartilaginous fishes have opioid receptors [29]. My overall sense is that the case for sentience in these more ancient types of fish is somewhat weak. Bony fishes, at least teleosts, are a different matter.

Let us consider the evidence. Rainbow trout, a commonly studied species, have been found to have nociceptive and endogenous opioid systems [28];

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[11] Colin Allen makes this point persuasively; see (p. 26 in [27]).

moreover, rainbow trout injected with acid rubbed the affected area against a surface (unlike controls who were injected with saline)—displaying a type of protective behavior—and decreased this behavior when given morphine [30]. Goldfish learned to avoid electric shock unless they were given morphine beforehand (p. 126–7 in [28]). In addition, goldfish have been found to engage in trade-offs between the need to feed and the avoidance of electric shock. As Tye describes the finding, "the number of feeding attempts decreased with increased shock intensity [whereas] with increased food deprivation, the number and duration of feeding attempts increased. . ." (p. 98 in [9, 31]).

So far, then, representatives of teleost fish species have been found to meet five of our six criteria. The remaining criterion, possession of a central nervous system and a brain suitable for pain experience, has been a topic of dispute. Do teleost fish brains contain structures suitable to transform complex information processing into conscious experiences such as pain? James Rose has argued that fish—and other nonmammalian animals—are incapable of conscious experience (which is necessary for sentience) because they lack a neocortex (cerebral cortex) [32]. But, of course, the question is not whether fish have a neocortex but whether they have something that functions in a relevantly similar way. Recall that neither birds nor reptiles have a neocortex yet the case for their sentience is strong; presumably circuitry in their dorsal pallium can function analogously to the thalamocortical system in mammals. Several scholars have suggested that the fish forebrain may have evolved to support conscious experience (see, e.g., [33, 34]). Interestingly, there is reason to believe that even some human beings who lack a cerebral cortex are capable of conscious experiences (though not of a normal range or complexity) and purposive action; the author of an influential study suggests that midbrain and thalamic functioning are most crucial for basic consciousness in vertebrates, including humans, though it must be stressed that his thesis is controversial [2]. In any case, it would be unreasonable to require a cortex for an attribution of consciousness in nonmammalian animals if some other brain part or system appears to play an analogous role. Returning to teleost fish in particular, the case for sentience in these animals is not defeated by the absence of a cortex and seems fairly strong overall—stronger than the case for sentience in amphibians and the more primitive types of fish and perhaps as strong, or nearly as strong, as the case for reptilian sentience.

### 2.3.5 Cephalopods

Our discussion thus far has focused on vertebrates. While it is sometimes assumed that invertebrates are more primitive and less likely to be sentient than vertebrates *across the board*, this assumption is oversimplified. Probably the strongest candidates for invertebrate sentience are the cephalopods, a type of mollusk that includes octopuses, squid, and cuttlefish. Because mollusks and vertebrates developed from more primitive animals that branched apart some 600 million years ago, cephalopods present a compelling case of the evolution of consciousness and sentience that occurred in parallel with vertebrates [17]. In other words, conscious minds appear to have evolved independently at least twice.

Considering the phenomenon of parallel evolution, it would be unreasonable in looking for evidence of sentience to require cephalopods to have a nervous system that is very similar, structurally, to the mammalian nervous system. Indeed, cephalopods have more neurons in their semiautonomous tentacles than in their brains.[12] Instead of similarity, it is appropriate to look for complexity—which is consistent with the criterion "a central nervous system with a (suitable) brain"—and perhaps to give a bit more weight to behavioral criteria. With these points in mind, the case for sentience in cephalopods seems very strong.

To begin, cephalopods have a nociceptive system and, when they withdraw from a noxious stimulus, usually change bodily color and often produce a cloud of ink [26, 35, p. 26]. Speaking to the apparent suitability of their nervous system for conscious experiences, Edelman et al. state the following: "Cephalopods, particularly the octopus, have complex sensory receptors and nervous systems that, at least in numbers of constituent neurons alone, rival those of some vertebrates" (p. 177 in [8]). The cephalopod brain has a hierarchical structure with the higher centers dedicated to sensory analysis, memory, learning, and decision-making [35]. Although there is not clear evidence one way or another regarding whether cephalopods have an endogenous opiate system,[13] Elwood reports that they have "an adrenal system that releases adrenal hormones when the animal is exposed to noxious, potentially painful, stimuli, and noradrenaline and dopamine are released when the animal is disturbed…" (p. 178 in [37]), [38]. Because cephalopods, especially octopuses, have demonstrated a remarkable capacity to learn, it is difficult to be skeptical that they can learn to avoid noxious stimuli. Octopuses display the ability to learn mundane lessons such as how to pull levers to obtain food in a laboratory setting. But their learning ability is revealed more impressively when octopuses work out creative means to achieving their own ends—such as escaping from a tank when (and only when) nearby humans are not looking, unscrewing a jar from the inside, and squirting water at bulbs to turn off lights [17]. Octopuses have also been found to engage in motivational trade-offs between noxious stimulus avoidance and other requirements such as food intake [37]. There is, on the whole, a very strong case for cephalopod sentience—perhaps comparable in strength to the case for reptilian sentience.

What about other invertebrates? The most likely candidates for sentience, after cephalopods, are certain arthropods.

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[12] Many people who reflect on octopuses' mental lives have wondered what it is like to be an octopus. I suggest an additional question: What, if anything, is it like to be an octopus tentacle?

[13] For a discussion of ambiguous evidence, see della Roca et al. (p. 79 in [36]).

### 2.3.6 Arthropods

The largest phylum in the animal kingdom, arthropods include crustaceans such as crabs and lobsters; insects such as bees, ants, and flies; and spiders of myriad varieties. All have segmented bodies and exoskeletons. Given the fact that sentience evolved in vertebrates and apparently evolved in a separate mollusk line that includes cephalopods, the possibility of arthropod sentience suggests the possibility that sentience evolved independently in at least three different animal lines. Despite the enormous range of animals in the arthropod phylum, due to space constraints I will confine my discussion to crabs and to insects, especially bees.

It is uncertain whether crabs are sentient. On the one hand, there have been conflicting reports regarding nociceptive behavior or its absence; and as Lynne Sneddon comments in a review of evidence for pain in aquatic animals, little is known about the neurobiology of crustacean nociception [39]. Since nociception is generally a necessary condition for the capacity to experience pain, these concessions might seem to doom any case for sentience in crabs. Yet other evidence is fairly strong. For example, hermit crabs have exhibited grooming following electric shocks and trade-offs between shock avoidance and access to preferred shell types; shore crabs have demonstrated avoidance learning and trade-offs similar to those found in hermit crabs [37, 39]. Moreover, morphine reduces apparent pain behavior in crabs, while glass prawns engage in rubbing or grooming if treated with acid but reduce such behaviors if administered a local anesthetic [37]. On the whole, there seems to be an intermediate case for attributing sentience to at least some crustaceans including crabs.

Turning to insects, the evidence is consistent with the intriguing possibility that at least some—such as bees—are conscious but not sentient. Bees appear to lack nociceptors but do respond to noxious stimuli and so may be said to engage in nociceptive behavior. But other aspects of their behavior—learned avoidance but no clear instances of protective behavior—seems ambiguous with respect to whether they feel pain [9].[14] I remain agnostic on this matter. Yet it will be instructive to suppose, for the sake of discussion, that bees cannot feel pain or any other feelings, entailing a lack of sentience.[15] If this is true, then some real-world creatures are insentient yet conscious.

Consciousness is subjective experience or awareness. It is more basic than sentience, which requires awareness that involves feeling, that is, experience with a hedonic tone. Recently Andrew Barron and Colin Klein have advanced a powerful argument that insects are conscious [41]. In the case of vertebrates, they argue, the capacity for subjective experience is supported by integrated midbrain structures that

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[14] One especially noteworthy aspect of insect behavior is an apparent lack of protective behavior toward injured body parts [40].

[15] Although Tye believes bees may not experience pain, he argues that they experience fear and perhaps anxiety [9]—unpleasant feelings that would entail that bees are sentient after all. So Tye would not accept the present supposition.

create *a neural model of the state of a mobile animal in space*—a thesis consistent with the claim that a mammalian neocortex is not necessary (even in humans) for basic consciousness. Structures in the insect brain function analogously, according to the authors. (Here it is noteworthy that the tiny brain of a bee has almost a million neurons, making it far denser in neurons than the human cortex [9].) In both vertebrates and insects this sort of integrated control system evolved to deal efficiently with the challenges of (1) sensory reafference (in which a creature needs to distinguish sensory data produced by its own actions and those produced by the external world), (2) multiple sensory inputs, and (3) navigating through space to locations outside of immediate sensory range. As the authors state, "[f]or active animals with well-developed spatial senses, it is computationally more effective to resolve the reafference problem once for a unified sensory model than to resolve it in a dispersed and peripheral way for each sense independently" (p. 4902 in [41]). They also contend that the midbrain's integration of different types of relevant information "provides the capacity to resolve competing behavioral priorities or motivations and rank needed resources by both urgency and availability" (p. 4902 in [41]). In view of both the authors' functional-neuroanatomical reasoning and the background understanding that bees are capable of remarkable communicative and navigational feats, I find the thesis that bees are conscious more reasonable than the thesis that they are not. Perhaps, as the authors contend, insects as a clade are conscious creatures. They may or may not be sentient as well.

## 2.4 Conclusion: From Bees to Bots and Back

At this point I would like to explore implications of the possibility that some animals—let's stick with bees—are conscious, even intelligent in some ways, yet insentient. This possibility motivates a question that brings us back to ethics: If bees are like this, do they have interests and consequently moral status? We assume, for the sake of discussion, that the bees cannot feel pain or experience other pleasant or unpleasant feelings. If they have interests, in what are they grounded?

Bees' efficient, complex navigation through space demonstrates that they have *aims* of some sort. They endeavor to do things, like find their way to food. But the idea of an aim is ambiguous. It might mean a built-in goal that, in itself, implies no *caring or concern* about its achievement. An autonomous vehicle presumably has the aim of reaching its assigned destination intact, but at least as I envision such machines they do not care about achieving this goal because they are not conscious and cannot care about anything. But now imagine an autonomous vehicle—or, if this is easier to imagine, a robot—that possesses not only built-in aims but also a type of consciousness that processes information about its environment (senses), about its own location and state (self-awareness), about its previous actions and their consequences for its system (memory), etc. There is something that it is like to be this machine. It has subjective experience of some complexity. Does it have interests? This, I submit, depends on further detail.

Suppose that the robot not only has built-in aims, but cares about, or desires, their achievement such that the robot tends to *feel* frustrated at the frustration of its aims and to *feel* satisfied at the satisfaction of its aims. This robot, it turns out, *is* sentient because, whether or not it can feel pain in response to noxious stimuli, it can experience the pleasant feeling of satisfaction and the unpleasant feeling of frustration. Clearly, then, the robot has interests and moral status.

Suppose, on the other hand, that the robot does not care about, or desire, anything, including achieving its aims. Indeed, unlike HAL in *2001*, this robot does not mind the prospect of its own destruction. Suppose, then, that its experience is limited to perceptions, thoughts, and memories. And it simply does what it was built to do. This robot, I suggest, has no interests and no moral status. We might admire it, as we might admire a beautiful rainbow or oak or painting, but we cannot sympathize with it—since it has no conative point of view to appreciate and take on. This robot may strike us as very strange insofar as it has a point of view on reality but no interests to make it matter, from its point of view, what happens to it. Maybe bees and at least some other insects are like this.

But I suspect they are not, and here's why. (Admittedly, the following discussion is highly speculative.) If we can build an insentient yet conscious robot to perform certain tasks, it is plausible to suppose that it will become more proficient at avoiding destruction and performing its tasks, other factors being equal, if it acquires *motivation*—in the form of feeling—beyond its original software-determined compulsion to perform its tasks. After all, I suggest, if it is conscious and intelligent it will more reliably remain intact and do its job if it *cares* about these things rather than being blasé about them. Now consider bees. If they are conscious and have certain action tendencies or general aims built into them through natural selection, and if they don't care whether they can achieve them, then a better biological model could emerge through random mutations in which creatures have the same abilities but care about achieving their aims—that is, have desires that tend to keep them and their hive mates alive and available for reproduction. This model would seem to have a selective advantage. And bees have existed for something like 100 million years. Moreover, as noted, their brains are extremely dense in neurons. My guess, then, is that if bees are conscious, they are also sentient—having at least some capacity for feelings whether or not they include pain—in which case they have moral status.

If it's slightly difficult, as I am suggesting, to imagine that present-day bees and perhaps some other insects are conscious yet insentient, it is easier to imagine that some robots will be conscious but insentient—assuming (as I think we should) we can imagine robots being conscious at all. In that case, all we have to imagine is that we didn't design them in a way that generated feelings. Then they would have no moral status, with the important implication that we could use them for our own purposes without exploiting them in any morally relevant sense. But our dilemma might be that we *could* produce, for selfish purposes, more efficient robots who would need feelings for their increased efficiency, but then, having done so, we would need to acknowledge their moral status and stop regarding them simply as tools or resources for our own use.

What if we created robots who could have pleasant feelings but not unpleasant ones? Would that eliminate the dilemma? That might help, morally, insofar as their quality of life would be good, but it might entail a cost in efficiency if the capacity for negative affect conferred additional motivation to achieve aims. Also, while increasing quality of life, such an engineering feat might leave untouched ethical issues concerning *respect for beings with moral status*—an area of deep uncertainty in cases, such as we are imagining, in which the beings with moral status seem to lack (given their built-in aims) even the potential to become autonomous. Further exploration of these fascinating issues will have to await another occasion.

Some philosophers and scientists treat sentience and consciousness as interchangeable and therefore as equally good bases for moral status. I have distinguished the two concepts, understanding sentience as involving not just consciousness but also the capacity for feelings—experiences that are pleasant or unpleasant. I have also argued that while sentience is sufficient for having interests and moral status, consciousness is sufficient for neither. This claim, of course, is independent of the empirical investigations on which most of this chapter focused before turning to speculations about bees and future robots.

To close on a personal note, if someday we are able to create conscious robots, I would prefer robots that are also sentient. Such robots would be more interesting and, in a sense, more "complete." I would love in my lifetime to befriend such a being. In the meantime, I need to figure out the best way to interact with the living animals of whose possible or likely sentience I have only recently become aware.

**Disclaimer and Acknowledgments** This work was supported, in part, by funds from the National Institutes of Health (NIH) Clinical Center. The views expressed here are the author's own and do not reflect the position or policy of NIH or any other part of the federal government. The author would like to thank Syd Johnson, Adam Shriver, Andrew Fenton, colleagues in the Department of Philosophy, George Washington University, and attendees of a talk at the 2018 Rocky Mountain Ethics Congress at the University of Colorado-Boulder for feedback on a draft.

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# The Human Challenge in Understanding Animal Cognition

# 3

Christophe Boesch

*How is it that wild-born captive chimpanzees often show immediate and apparently intelligent solutions of laboratory tests of tool-using, whereas chimpanzees that have been separated from the mother at birth and raised under controlled conditions in an experimental nursery acquire the same performances slowly or not at all?*

Menzel et al. (Folia Prima 12:273–83, 1970)

## Abstract

Animal cognition studies have progressively moved themselves to an impasse due to an overemphasis on controlled experiments on captive animals that are completely detached from species-typical socio-ecologies. If progresses in studies on wild-living animals have provided a wealth of detailed observations on sophisticated cognitive achievements, captive experimental studies have concentrated on the "failure" of nonhuman species to demonstrate so-called uniquely human cognitive skills. In the present chapter, I stress the need to better understand what "cognition" is and to perform valid comparisons on chimpanzees if we want to understand the evolution of human cognitive abilities. Cognition is not just an innate property of a species, but an adaptation of individuals to their living conditions. As such, cognitive studies need ecological validity to explore the adaptations to the environments typical to the studied species. New understanding about brain plasticity and the effect of environmental enrichment in different species, including humans, confirm the importance of environment on the development of cognitive abilities. This invalidates the assumption of most experimental captive studies that one can generalize from such atypical conditions to the whole of the species. Furthermore, observations on

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_3

wild chimpanzees stress the importance of population differences, thereby illustrating how cognition develops over the lifespan as individuals solve the daily challenges faced in their social and physical environment. Combining the information about brain plasticity, environmental validity, and population differences will permit cognitive studies to progress and finally contribute to our understanding of the evolution of human and human-like cognitive abilities.

**Keywords**
Comparative cognition · Ecological validity · Environmental influences · Chimpanzees · Anthropomorphism

## 3.1 Introduction

Fifty years ago, Emil Menzel et al. [1] pinpointed a peculiarity that has been at the core of our difficulties in understanding animal cognition, namely, that wild populations tend to reveal an array of behavioral diversities and cognitive abilities unequalled by captive populations. Menzel's observation echoes with many field primatologists as we follow our subjects in the forest and see how hard it is for them to find their way, and find the food they need to survive. This image of primates searching for food every day for hours, in a mostly forested environment where no direct visible clues to the location of food exist, is at the center of our understanding of the lives of wild animals. It is in total contrast to the life of captive animals, whose food is provided at regular daily hours and who have plenty of free time in the limited space of their enclosures. Could it be that by concentrating most of our effort on studying the cognition of captive animals, we are missing the most important aspects of what animal cognition is? Do humans have a basic problem in understanding animal cognition due to the mere fact that they are humans? If we answer these questions in the affirmative, then what should a better comparative cognition field look like?

There are several reasons to study animal cognition: One reason is simply to satisfy our curiosity about the other creatures who share our world. Another major scientific reason is that we will gain important insights into human cognition only if we know what animal cognition is, including its evolutionary roots and progress, and how various social and environmental factors, such as upbringing, affect cognitive development. An additional reason is that studying the minds of other animals may provide us with information that could benefit those animals. In the case of endangered species like chimpanzees, for example, insights into their cognition could provide information about what kinds of environments they need to not only exist, but to thrive. In the case of captive animals, we may gain information that will improve their welfare in captivity, such as how to provide ethologically appropriate housing and an enriched environment. Finally, there are those who, by studying the intelligence of so-called inferior animals, hope to demonstrate the natural superiority of humans.

Harmful research—which includes research with captive primates—is generally justified by its benefits for humans, in a calculus that seeks to balance harms and benefits. Keeping nonhuman primates in captivity is inherently harmful to them, but, as will be explained in detail below, it also results in impoverished cognitive science because of a number of important differences between wild and captive animals. Therefore, looking in turn at the four reasons for studying primate cognition in captive animals, it becomes clear that such research is inadequately ethically justified. Satisfying our curiosity about other creatures doesn't justify keeping those creatures in captivity—not only will we fail to understand what those animals are truly like in their natural state, but we will have caused them harm for a purpose with limited benefits. While studying other primates may indeed provide important insights into human cognition, it is again the case that our understanding will be at best diminished and at worst misled when we study captive animals, for those animals may well be cognitively impaired by the living conditions of captivity. Similarly, studying captive animals will provide us with limited insight into the needs of wild, endangered animals. It may be possible to enhance the welfare of captive animals, but this justification begs the question. If it is already understood that the welfare of animals is diminished by captivity, studying captive animals as a way to enhance their welfare in captivity would appear to justify experimenting on captive animals only by subjecting them to captivity, without questioning the ethics of captivity. Finally, making a normative claim about the superiority of humans can neither be confirmed nor falsified by empirical evidence without a clear and quantifiable understanding of cognitive complexity. In any case, if it is only captive animals that are being studied, in experiments that do not capture their actual intelligence, then any results will be tainted by selection bias.

## 3.2 Definition of Cognition: One or Many Cognitions?

The nature-nurture discussion is closed in the sense that most people would disagree with a purely innate determinism, but there remains heated discussion about the relative contribution of the genotype compared with the environment in producing the phenotype, including cognition. The belief that animals growing all their lives in artificial and deprived captive conditions can be considered as representative of the whole of the species suggests a deterministic approach. Therefore, the blind faith in captive experiments rests on the assumption that cognitive development in nonhuman animal species follows a rigid course and is only marginally, if ever, influenced by the conditions under which an individual grows up. As if to confirm this, most publications on captive experiments contain no discussion about the representativeness of the subjects included in the study and happily generalize their results to the whole of the species [2, 3].

Furthermore, progress in our understanding of animal cognition has been slowed by Morgan's Canon, the rule of animal behavior that suggests that the most parsimonious explanation should always be favored until the cognitively more complex one has been demonstrated. This proves detrimental to science as you cannot obtain evidence of complex cognitive processes if you do not include them as one of the alternatives in your data collection protocols *before* collecting your data. Such a priori denial of the mentalistic in animals has tremendously hampered our ability to understand the evolution of cognition in both animals and humans (see Kummer et al. [4] presenting such an argument).

Menzel's question represents a real challenge for those who consider cognition as largely an innate attribute of the species that is barely affected by living conditions and the course of development. This view makes it barely possible to reconcile the observations of different cognitive achievements in individuals of the same species living under different conditions. The common response to such a dilemma is to deny the existence of such differences and to attribute them either to mistakes in the interpretation or to lucky anecdotes (e.g., [5–12]). Most experimental psychologists who view captive individuals as representative of the whole species tend to dismiss wild observations on the basis that they can *never* be conclusive, as too many confounding variables are assumed to be present that could potentially produce the differences observed. In other words, only a controlled experiment can be conclusive. This attitude ignores the richness of nature, and the reality is that our in-depth knowledge of human nature comes mainly from observations in the "wild" and not in captivity. Indeed, human psychology would be quite poor if it were reduced to what can be observed in controlled experiments.

If we now take seriously the data that have been produced on the cognitive development of animals living under different conditions, we see that "cognition" is something that develops in an individual as it grows in an environment containing different challenges. If we accept that different selective pressures are present within a species, then Menzel's remark makes perfect sense. On this view, "cognition" develops in interactions with the outside world (Fig. 3.1).

An important correlate of this notion of cognition developing in interaction with the outside world is that even within species there is not *one* cognition. In the real world, living conditions tend *not* to remain stable and fixed for generations; they often vary even across seasons and therefore require some flexibility to react to ecological variations that can be expected to provide fitness benefits to the individuals. Thus, we should expect flexibility to be selected when learning abilities are present.

Integrating ecology into our thinking about cognition has become even more important as a consensus is slowly emerging that the main driver for the development of brain size and brain organization is the ecology, particularly the challenges of finding food rather than the social life as previously postulated [13–16].

For example, individuals living in a high visibility environment with landmarks that help with orientation will need less developed spatial skills to find their food than those living in a low visibility environment where food is harder to find. When, in addition, the first environment has a small number of trees producing fruit at the same time, while the second one has a much larger diversity of food trees with rather irregular fruiting schedules, then the individuals living in the second environment will need, in addition to a precise mental map of tree locations, a way of classifying tree species in terms of synchrony and productivity (Fig. 3.2). The first environment, with higher visibility, corresponds to the one chimpanzees encounter in Gombe National Park, with an open woodland mosaic habitat (see Goodall [17, p. 2], [18],

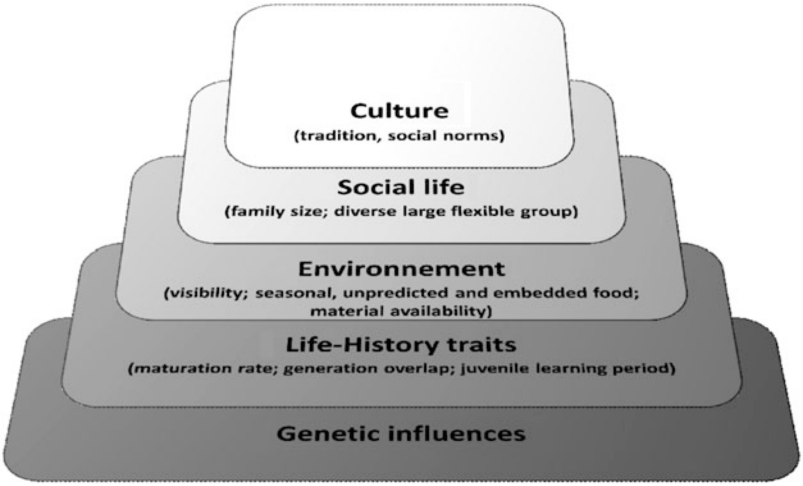

**Fig. 3.1** Schematic illustration of the influences that mold cognition in individuals. In nature, an individual is always confronted with the simultaneous influences of his genetic characteristics, his life historical traits, the environment he inhabits, and the social life of his group (for social species). If the first two present limited variations, the last two can be highly variable within a species whose distribution covers different environment types. Finally, in some species, cultural aspects are also among the factors that may affect the development of cognitive abilities. For some influences, I provided in brackets some of the dimensions of the influences expected to more directly affect cognition

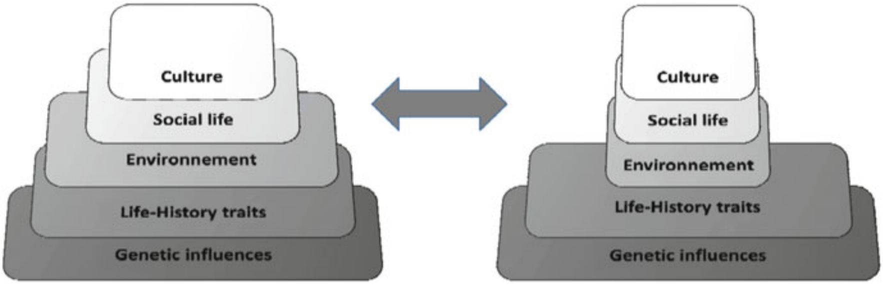

**Fig. 3.2** The different sizes of the layers represent the selective pressure they impose on the individuals. In wide-ranging animal species, the environment may differ quite importantly and will directly influence the complexity of the ecological challenges experienced by the individuals. The diagram on the left illustrates a complex and challenging environment, as shown in Fig. 3.1. The diagram on the right represents a comparatively simple environment where the selective pressures of the environment and social life are more limited

[19, 338] for pictures), while the chimpanzees living in the Taï forest or Loango National Park encounter an environment more like the second one [20].

## 3.3 Ecological and Social Drivers of Cognition in Chimpanzees

What are the main drivers that select for higher cognitive capacities? The natural environment where chimpanzees live is tropical Africa, ranging from some rather open mosaic savanna-gallery forests to dense tropical rainforests. In such a diversity of forested environments, many challenges are present that force the individuals to gain some understanding of the resources important for their development and survival. Within these forests, chimpanzees have a diet based mainly on ripe fruits, some immature leaves, insects, and meat, whereas other primate species sharing their environment are generally happy to eat ripe and unripe fruits, mature leaves, and insects. So, in direct food competition with them, chimpanzees are outcompeted, as unripe fruits and mature leaves are much more abundant than ripe fruits. This has been observed in Gombe National Park, where baboon populations have thrived eating grass, stems, and unripe fruits, while chimpanzees declined due to limited access to ripe fruits [21]. To survive amid such competition, chimpanzees have to become efficient at finding their food, especially in forests with lower visibility. The three main drivers of cognitive adaptations that enhance their survival are the need to find food in dense forests, the need to extract food using tools, and the need to cooperate in hunting.

### 3.3.1 Finding Food in Dense Forests Represents a Special Cognitive Challenge

Due to their larger body size compared to other primate species, chimpanzees feed preferentially on rich, ripe, fleshy fruits to cover their nutritional needs. Fruit-bearing trees are dispersed through the whole forested territory, and fruit production in tropical forests varies greatly. In some tree species, each individual tree bears fruit at different times of the year, and others produce fruits rarely. More predictable tree species provide a high level of synchronous fruit production among the individual trees of the same species. It remains difficult for humans to predict exactly what cognitive faculties would be the most advantageous under such conditions. In a sense, the answer has to come from the animals themselves, as we should expect different species to respond differently. Baboons, who eat a lot of unripe fruits, would certainly not respond in the same way as ripe fruit eaters like chimpanzees.

In the Taï forest, it seems that chimpanzees access abundant fruiting tree species with great success using a simple straight line search strategy moving in a random direction [22]. However, the situation is totally different in forests with rare and large fruiting trees, where a similar random search strategy would be extremely costly, forcing the chimpanzees into a kilometers-long search with limited success. Within such a forest, chimpanzees are under high selection pressure to develop sophisticated spatial mapping abilities based on long-term memory and planning of routes to find these rare but large fruiting tree species [23–25]. Even so, success would be limited, and chimpanzees base their selection of trees not only on the memory of their location but also on the memory of the amount of fruit eaten during their previous visits (sometimes occurring a year earlier) [26]. Chimpanzees have another skill to ensure success: the ability to classify trees into botanical classes, sorted according to some knowledge of fruit production patterns, so that more synchronous tree species would be visited more systematically once an individual tree bearing fruit has been discovered. They would not do this for known non-synchronous fruiting tree species [24]. Finally, chimpanzees have developed a sophisticated sense of what fruit types are more subject to food competition from other species, and for the highly prized fruits, they ensure access by building night nests the previous evening, facing in the direction of the breakfast tree [27].

In Taï chimpanzees, the successful foraging for rich food sources requires individuals to possess precise mental maps, combined with long-term memory of past foraging events, a precise botanical classification of species fruiting patterns, as well as a sense of the level of competition for different fruits. Planning, long-term memory, Euclidian mental mapping, and botanical classification are among the cognitive skills demonstrated by chimpanzees in this context.

### 3.3.2 Extracting Embedded Food

Embedded foods like hard-shelled nuts and insects hidden in nests are rich food sources. For those, tool use permits access to high-quality food. If tool use is rather common in the animal kingdom, it is in most cases a specialization to access one food type with one type of tool [28–30]. Flexible tool use, where different types of tools are used for many different purposes, has been observed only in a very limited number of species, mainly humans, Caledonian crows, and chimpanzees [31]. A diet reliant on hard to extract, but rich food has been proposed as a driver of human evolution [32, 33] and the acquisition of skillful tool use. Chimpanzees have undergone a very similar evolutionary process, as they expanded their diet toward harder to extract, but richer, food sources.

Taï chimpanzees use hammers to crack five species of nuts and eat them on a daily basis for 4 months of the year [34]. It is intriguing that the nuts cracked by the chimpanzees at Taï are also present in most of the forests between Côte d'Ivoire and Gabon, but nut-cracking is only seen in Côte d'Ivoire and Liberia [35]. The selective pressure to open hard-shelled nuts is present in all of these forests, but is channeled by cultural differences, so that only the chimpanzees living in the west of the Sassandra River have been seen to crack the nuts. Nut-cracking in the tropical rainforest with naturally occurring tools is less easy than it may seem. I have regularly asked human visitors to crack nuts in the Taï forest to obtain a feeling for the challenges, and a newcomer may need up to 40 min to open one nut. As chimpanzees use natural branches and stones as hammers, they are confronted with a huge availability of potential tools. The ground in the forest is littered with branches, but only a tiny fraction possess the physical properties required of a good tool. Chimpanzees may learn to use tools to crack nuts, but they also need to have a good understanding of what a tool is and what physical properties it needs to function as a good nutcracker [36, 37].

Recently, Giulia Sirianni studied how Taï chimpanzees manage the complexity of tool selection for the softer *Coula* nuts, a challenge that at first glance seems easier. She convincingly showed that the chimpanzees consider at least five different factors when selecting a hammer to crack nuts [36]: the material, weight, hardness of the potential hammer, its distance to the anvil, and the position of the anvil (in the tree or on the ground). Choosing the optimal hammer involves comparing the properties of all available hammers, as well as their distances to the nut-cracking site. This sophisticated conditional selection of hammers is well within the abilities of the chimpanzees. The individual must renew its complex selection process each time they want to crack nuts, and reevaluate the five different factors in a very flexible decision process.

An experimentalist might have argued that the situation in the forest is simply too complex to study. Indeed, studies of the understanding of tools in captive chimpanzees have tested at most one or two properties of the tools [7, 38]. These studies were therefore able to say very little about the cognition of tool selection. The situation in nature can be even more complex. For example, when cracking hard *Panda* nuts chimpanzees use only stone hammers and those are rare in the forest. In the only study examining this behavior, Taï chimpanzees were able to select the stone with the optimal weight that was closest to a *Panda* nut tree, even when the transport distance exceeded hundreds of meters in dense forest [39]. This finding was met with skepticism because it suggested a level of cognitive achievement equivalent to what is seen in 9-year-old human children.

### 3.3.3 Hunting and Cooperation

Cooperation among non-related individuals represents an evolutionary puzzle. It has been suggested that it only truly exists in humans [40–43]. This claim originated from the assumption that such cooperation can only emerge when individuals are able to consider others as independent agents with their own intentions and motivations, and that one can only truly cooperate after taking into account different perspectives, and aligning one’s own selfish interests with those of others (also called “shared intentionality”). Such claims are supported by experimental studies with captive chimpanzees raised in human-made artificial social groups. What those experimental results really showed was that raising individuals in artificial social groups does not promote cooperation in simple and arbitrary tasks.

Meat is for humans a very nutrient-dense food source, and historically, humans in many societies invested a lot of effort and skill securing enough meat for consumption. Therefore, meat access correlates in humans with both cooperation in hunting, and in sharing food within groups [44, 45]. Similarly, all chimpanzee populations under study in Africa are known to hunt different species of small mammals, and their behavior when successful shows clearly how highly they value meat [31]. So we should expect that chimpanzees would also develop special skills for capturing prey. In the Taï forest, which is a continuous, dense rainforest, many monkey species live high up in the canopy, and hunting them is a challenge for chimpanzees.

The strongest evidence for cooperation comes from the Taï chimpanzees that have been observed hunting small arboreal monkeys in groups for 70% of their hunts; individuals perform different, complementary roles within the groups [34, 46, 47]. Thanks to meat sharing rules that favor hunters and, among them, the ones having the most important hunting roles, hunters eat more meat than individuals that do not hunt [47]. These observations have been confirmed in a study where more meat stable isotopes were found in the hair of successful hunters [48].

Cooperation to obtain meat has been observed with different levels of sophistication in wild chimpanzees, with chimpanzees in intact forest developing more sophisticated levels of social cooperation. In populations where *individual* hunting success is high, and where the forest structures allow for cornering prey, group hunting is observed less frequently, and cooperative actions among individuals seem rare, as seen in Ngogo chimpanzees [18] and Gombe chimpanzees [49]. Chimpanzees show that under the relevant selective pressures, they can develop precise social knowledge about others, what they can do, and how they can combine their actions to develop successful cooperative hunting strategies. Notwithstanding this, some experimental psychologists have reinterpreted hunting data that suggest cooperation among chimpanzees to suggest interpretations compatible with denying true cooperation in nonhuman primates [10, 19, 50].

## 3.4 Are There Real Differences Between Captive and Wild Populations?

The late Emil Menzel studied animals in captive settings and was genuinely interested in cognition. Initially, he worked with Richard Davenport and Harry Nissen to examine the effect of different social rearing experiences on social and cognitive development [1, 51–54]. This led him to realize the importance of living conditions when comparing cognitive development within one species. Menzel thereafter pioneered the study of captive chimpanzees living in social groups, with access to large semi-natural enclosures [55]. In the early 1960s and 1970s, psychologists were often concerned about the living conditions of their subjects, as work on chimpanzees had shown the drawbacks of captive living conditions on cognition [56–60]. The main lesson from that work was that the deprived socio-ecological nature of captivity had long-lasting negative consequences on the development of individuals. In a series of classic experiments following on the original Harlow maternal deprivation experiments, Mason showed that cognitive development improves in rhesus monkeys reared by live surrogate mothers [61–63]. This stressed the importance of a proactive and caring environment in the development of primates.

However, in recent years, the field of experimental psychology has become dominant in the study of animal cognition, imposing its experimental paradigm over all others when the aim is to look at the presence of a cognitive mechanism. Observations in the wild were downgraded to the level of simple anecdotes, important for formulating hypotheses about a possible cognitive process, but incapable of providing definitive evidence due to the presence of many possible alternative explanations in nature [50, 64, 65]. This new approach came along as a surprising twist, as researchers became oblivious to the negative effects of captive living conditions on the development of cognitive abilities, and no mention was made of the artificial conditions under which the subjects of those studies were kept, or of the potential negative effect those conditions might have (e.g., [7, 41]). Readers of such studies are left wondering about the developmental history of the subjects, whether they were brought up by their mothers or by surrogates, and what captive conditions they faced, as such details are mostly absent from the publications. This research has been published in some of the highest impact journals in science, however.

More recently, a renewed critical look at captive studies has developed, and concentrated on determining the effects of different social and ecological conditions on the development of cognitive processes in captive individuals. They concentrate on specific social and environmental aspects of captivity, such as being mother-raised versus human- or peer-raised, having access to social partners of different ages, or living in an enriched physical environment with many objects, toys, and food to search for, and seek to determine how such variables influence the cognitive development of young chimpanzees [66–71]. In all domains explored, mother-raised chimpanzees in richer social groups and enriched environments perform better than those raised only in peer groups or poor physical environments.

In a series of long-term studies, chimpanzees have been shown to be extremely sensitive to small changes in their social and physical environment: Kim Bard and her team have documented the negative impacts of deprived social engagements in early life on the development of social cognition skills, such as joint attention and cooperation, and shown that chimpanzees provided with enriched social engagement experiences performed equally to human children of the same age [68, 72]. Sally Boysen and her team have compared the performance of young chimpanzees living in captive conditions with some environmental enrichment and within a multi-age social group (e.g., [73–76]). In tests of tool modification and awareness of knowledge of others, the enriched-living chimpanzees did better than young chimpanzees living in small peer groups with limited environmental enrichment [6, 7].

Thus, cognition in captive settings varies relative to the conditions. Questions concerning the differences between wild observations and captive experiments remain relevant [77–80]. Outsiders to primatology find it puzzling and don’t know what to make of the conflicting observations made on wild chimpanzees, who show themselves to be an inventive species very skilled within their rich natural environment, and captive chimpanzees who are disappointingly conservative and passive.

Why do we see such differences between wild and captive populations of the same species? Some studies have recently concentrated on the developmental and abnormal behaviors observed in chimpanzees raised in captivity as compared to wild individuals [81–84]. They confirmed that anxiety and obsessive-compulsive disorders were present in 20% of the captive chimpanzees studied, while almost absent in wild individuals [83]. At the same time, 58% of captive chimpanzees surveyed showed signs of depression while only 3% of wild individuals did so [82]. In another study, the authors concluded “while most behavior in captive chimpanzees is ‘normal’ in the sense that it is behavior seen in their wild counterparts, abnormal behavior is endemic in captivity. For some individuals it may dominate much of their activity, but for the rest it is a persistent element of their everyday behavior, despite living in social groups in enriched environments” [81, p. 5]. This persistence over the lifetime of negative effects of early deprivation has also been confirmed in a study documenting the neurological effects in the brains of adult chimpanzees up to 46 years old [85], and in another study looking at the increased health consequences 20 years after such deprivation [86].

Strengthening those results, numerous studies have documented the positive effects of environmental enrichment on cognitive development in captive settings in a range of animal species, including fish, rats, and many primate species [85, 87, 88]. Basically, all deteriorations in the physical and social environment have long-lasting negative effects of different amplitude on the subjects, and those changes leave characteristic marks in brain organization, revealing an unexpectedly high level of brain plasticity. This often remained visible in adults even when the environmental deprivation happened during early phases in life.

In humans as well, deprivation can have long-lasting negative effects, as so dramatically seen in the study of children raised in Romanian orphanages where many aspects of their development were affected, with the negative impacts persisting for many years [89, 90]. This higher than expected brain plasticity can also provide positive effects, especially for those who specialize in a specific activity [91, 92]. For example, professional musicians present a higher volume of gray matter in motor, auditory, and visual-spatial brain regions compared to nonmusicians. Interestingly, these changes in the brain increase with the amount of practice of the individuals. Similar structural changes in the brain, in specific regions known to be activated by the repeated performance of specific tasks, have been found in taxi drivers [93], chess players [94], and gymnasts [95], as well as among humans belonging to different cultures when making mathematical calculations [96].

How can we explain the predominance in the field of animal cognition of an approach that has been known for decades to be detrimental to cognitive development?

## 3.5 Human Bias and Ecological Validity

We are only humans, and it is difficult for us to think and plan as a chimpanzee or a dolphin would. As such we are naturally inclined toward anthropocentrism when it comes to understanding other animal species [97, 98]. It becomes very hard for us to conceptualize the specific environmental conditions that are relevant for the development of a specific cognitive capacity in another animal species. How would we react when 20 m high up in a tree? To most scientists, this question makes no sense. But at the same time, this is exactly what we ask animals to do, when we place them in cages in front of a computer screen to perform experiments. In other words, empathy for animals is what is needed.

Some researchers intentionally search for the presence of human cognitive skills in other species, in an attempt to characterize the uniqueness of human cognition. For example, the test of self-recognition in a mirror is used, when mirrors do not exist in a species' natural environment. So-called "failures" to perform in an anthropocentric test are viewed as potentially showing a limit to other species' ability to copy humans. However, producing failures is relatively easier than proving the presence of an ability. In addition, such an approach tells us very little about the true cognitive abilities of other species. No one should expect all animal species to have the same cognitive abilities, or even all individuals within a species, and therefore, we should not merely list what humans can do better, but also what the other species can do better. A fruitful comparison needs to include both aspects.

The majority of the tests performed on animals have minimal or no ecological validity. As experimenters, we cannot envision what is relevant to a species that we have only observed in captivity, and whose daily foraging and social living experience are radically altered. For example, chimpanzees have often been asked to manipulate a complex apparatus equipped with sliding or revolving doors, pulling ropes, or raking objects outside their cages. A very similar problem arose in cross-cultural human studies, where the question was how to test humans belonging to cultures where typical Occidental objects like coins, rulers, cups, and pens do not exist [99–101]. Faced with surprising negative results in some psychological tests of conservation of length, for example, the experimenters started to wonder if the results were not due to the procedures used. In an attempt to correct this, native daily-use objects were included in the tests rather than Occidental objects, leading to much better performance in the tested subjects. Therefore, the question of ecological/cultural validity of experimental procedures has been at the center of many recent cross-cultural psychological studies allowing for much more reliable and interesting insights into the human mind [102–106]. If ecological/cultural validity has been so important in improving our understanding of cross-cultural human cognition, why has ecological validity been so neglected by comparative psychologists studying animals?

This absence of concern for ecological validity in primate research might explain some perplexing conclusions, such as the suggestion that bird tool use is superior to that of captive chimpanzees [107–110]. That the performance of birds is very impressive—and there is no doubt that they have been underestimated in the past—evidences the care taken by bird researchers to improve the ecological validity of the tests they use to study their subjects. This care is present in their choice of materials and tasks (matching those found in the wild), and by making living conditions as natural as possible, including having free-ranging subjects who come into cages only for testing (which is relevantly similar to methods for testing humans in psychological studies) [111, 112]. Such efforts by the researchers to present only ecologically meaningful objects and tasks to birds, and investing valuable effort in trying to have their subjects understand the tasks, have tremendously increased the value of avian cognition research. To such scientists, a negative result from their subjects is often perceived as a challenge to find new ways of presenting a task so that the subjects could understand what is wanted from them. They are guided by the reality that an absence of evidence is not evidence of absence. Sadly, such care and consideration has rarely been shown to primate subjects, including chimpanzees. If captive primate experimental studies have any intrinsic value, it is to show that any understanding of chimpanzees' cognition when they are subject to lifelong social and ecological deprivation is limited at best.

Recently, some researchers have started to invest important effort into going into the field and offering different tests to natural populations of free-ranging primates to understand better their social and physical cognition (for monkeys, see [113–117]; for chimpanzees, see [118–124]). This new approach will provide valuable information on animal cognition in the natural environment.

## 3.6 The Future of Animal Cognition Studies?

Unless the scientific paradigm changes, human understanding of the minds of other species will remain imbued with anthropomorphism, anthropocentrism, and ethnocentrism. It might be revealing that primate cognitive studies are mainly with captive individuals removed from their natural environment, while cognitive studies on dogs or birds are done with great care, providing the subjects with a natural social and ecological environment. Humans have long had an empathic relationship with dogs, and so we can readily understand what they need for their well-being [125, 126]. On the other side, birds are so clearly different from us that we seem to have no issue with understanding that they have very different needs from us, and a real effort has been made to provide appropriate environmental conditions to ensure the ecological validity of experiments. Primates are in many ways so close to us, and this is even more clear for chimpanzees, that we tend to think we naturally know what they need and directly transfer our preferences onto them. This is the major mistake that has been hindering primate cognition work. This unconscious anthropocentrism transfers our perceptions onto other primate species without any awareness of their very different needs and their ecology.

The second concerning aspect is that science in the 1960s and 1970s went through a phase where much more concern prevailed about the role of the environment on the ontogeny of the individuals, and on how to perform controlled experiments. This was, so to speak, the golden age of animal cognition. Now, in an unexpected twist, this knowledge has been ignored by a large segment of experimental psychology, and we are back to the old way of treating animals as programmed machines that are barely affected in their development by the external environment. This purely deterministic way of looking at animals has blocked major progress in our understanding of primate cognition, compared to the huge progress that has been made in the field of bird cognition.

The huge contrast between work in avian and primate cognition is slowly influencing a younger generation of scientists, one willing to go into the field and adapt to this complex situation so as to make precise and detailed experiments to obtain precious information on primate cognition in domains that are so important for their survival: understanding of predators [114, 127], finding their food [23, 24, 26, 128], tool use [123], hunting behavior [46], social learning [115], and communication [121].

Progress is therefore under way, but slowly. There is urgency. All over the tropics, natural environments are under attack from many different directions, and numerous wild primate populations are now in danger of extinction. If we want to understand animal cognition, it is now or never. Researchers should establish their study sites and with their presence protect the primates they are following [129]. For most primate species, we have only studied one or a few populations and we know that some species inhabit very different environmental niches where we would expect to see them develop different cognitive capacities (some examples in chimpanzees, capuchin monkeys, and macaques are very convincing; see [31, 37, 130]). This may be our only chance to understand animal cognition and through this understand the specificity of human cognition.

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# Mental Capacities of Fishes

# 4

Lynne U. Sneddon and Culum Brown

**Abstract**

Fish models are increasingly used in a wide variety of experimental contexts and their adoption is growing globally. This chapter reviews the evidence for sentience and cognitive abilities in fishes to highlight the growing empirical evidence of the mental capacities of fish. The definition of sentience is presented along with the scientific data pertinent to understanding what fishes are capable of, as well as higher order cognitive abilities such as numerical skills and the capacity for learning and memory. Being able to experience positive and negative welfare states such as pain, fear, and stress is highly debated for fishes; thus this chapter reviews the evidence for and arguments against conscious perception of pain and fear. If suffering and sentience are accepted in fishes, this has ethical implications for the way in which we use fish in scientific studies.

**Keywords**

Animal sentience · Cognition · Intelligence · Learning · Memory · Pain · Welfare

## 4.1 Introduction

The term *sentience* is vitally important in the animal welfare world where being regarded as sentient provides an animal with protection under national guidelines or legislation. In its simplest form, sentience means that an animal can detect external stimuli and experience either the sensation of perceiving such stimuli, or is aware of

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_4

how the perception alters their subjective psychological or mental states. For example, if an animal is sentient, then when exposed to a tissue-damaging stimulus, the animal experiences the associated pain and is aware that it is in discomfort. This means that animals may suffer when experiencing pain, fear, or stress, but equally may have positive experiences such as contentedness or happiness.

Animal sentience has been discussed by philosophers at least since Aristotle. René Descartes' opinion was that animals are mere "automata" or unfeeling robots. Descartes suggests that although animals may show signs of joy and fear they do so unconsciously without having awareness of what they are feeling [1]. This type of thinking facilitates the use of animals without guilt or concern that their welfare may be compromised. However, it is impossible to know what an animal feels with absolute certainty because of the other minds problem [2]. From an evolutionary perspective, if animals did not experience an adverse, negative affective state associated with painful, damaging stimuli, then they would never learn to avoid injury [3].

Contemporary thinking has now shifted to accept that perception of external stimuli goes hand in hand with consciously experiencing it [4] and that animals do have subjective feelings that are important and can be measured [3, 5]. The idea that animals have feelings has driven the welfare agenda in recent years to safeguard the well-being of animals under human care [6]. Providing empirical evidence of whether animals experience pleasurable or unpleasant affective states and are sentient beings is key to changing attitudes toward the treatment of such animals [7].

## 4.2 Definition of Sentience

Contemporary definitions of animal sentience provide clear criteria and a means of measuring empirical evidence to make sound, science-based judgments about whether an animal is sentient. The definition of sentience we employ here is adapted from Broom [8] who states a sentient being *has some ability* to:

- Evaluate the actions of others in relation to itself and third parties (i.e., form relationships within and between species).
- Remember some of its own actions (the cognitive ability to learn and recall those memories that should influence future behavior).
- Assess risks and benefits (make decisions based on the information available externally and its own subjective state).
- Have some feelings (positive or negative affective states such as pain, fear, and pleasure).
- Have some degree of awareness (often termed consciousness).

If there is evidence of some or all of these criteria within an animal group in which this can be tested, then one must conclude they are indeed sentient (Fig. 4.1). For mammals, this concept is generally accepted. However, nowhere is it more aggressively challenged than in fishes [9].

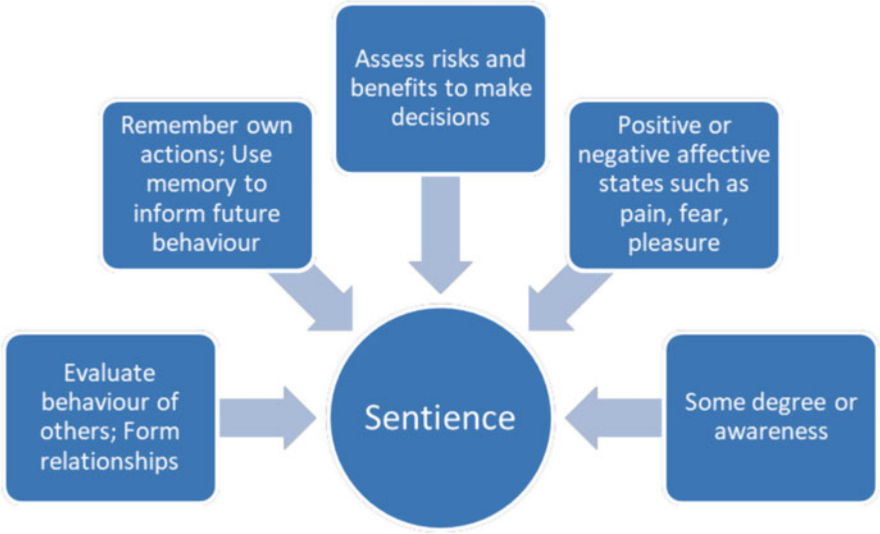

**Fig. 4.1** A diagrammatic representation of the abilities that make an animal sentient. Animals should have some of the following and not necessarily all of these: an ability to evaluate the ability of others in relationship to itself and third parties and be able to form relationships with others; remember its own actions and use memories to inform future behavior; assess the risks and benefits of its situation or its behavioral choices; experience positive and negative affective states; and have some degree of awareness or basic consciousness (Adapted from Broom [8])

Humans use fishes in a variety of ways, which may influence how they perceive the value of a fish's life [10]. Further, being cold-blooded, living in water, and not having expressive faces make fishes perhaps more difficult to appreciate. Currently, fish are used for food in fisheries and farming, for sport in recreational fishing, as companion animals, and as ornamental exhibits, but it is their prominence in scientific research that is particularly important in our discussion here. Fishes are used in increasing numbers in experiments. For example, over half a million fish are used annually in the United Kingdom in experimental procedures [11]. Here we present empirical studies that show that fish fulfil our definition of animal sentience, and discuss each criterion where there is evidence from a variety of fish species. If fishes are indeed sentient beings, this has significant implications for their treatment in research and beyond.

## 4.3 Do Fish Form Relationships?

The ability to form relationships and evaluate the actions of others in relation to oneself and to third parties demonstrates the capacity of fishes to consider how to alter their behavior in response to another being. It suggests that fishes have the intelligence to understand other individual's intentions and behavior and to match or alter their own behavior accordingly. An excellent example of this is the direct reciprocity shown in rabbitfishes, a coral reef fish [12]. Reciprocity requires complex cognitive abilities since animals must match one or more conspecifics in behavior, and it has been suggested that reciprocity is limited to animals that can meet these intellectual demands. Direct reciprocity, where animals form a very intimate relationship and alter their behavior according to their partner or group, has been demonstrated in only a few species of birds and mammals until recently. Direct reciprocity is considered important because it requires: the ability to recognize specific individuals, memory retrieval of past events, and intentions that guide an animal's future behavior in the expectation it will be rewarded. In a study investigating four species of rabbitfishes, direct reciprocity was seen between pairs where one partner would remain vigilant in an upright position, on the lookout for predators, while the other was foraging in among coral reef crevices (Fig. 4.2) [12]. Alternation between foraging and vigilance occurred frequently in these pairs so both individuals precisely matched their partner's behavior and intentions. In contrast to solitary individuals, paired fish undertook longer vigilance bouts, but were rewarded by having a partner with greater foraging efficiency; paired fish showed more consecutive bites and deeper penetration into crevices.

Fishes form a number of cooperative relationships within and between species. These include: being able to identify individuals and preferring their company [13, 14]; helping behavior in cooperatively breeding cichlids where individuals get access to resources by caring for young and defending their territory [15, 16]; parasite removal by cleaner wrasses who form cleaning stations for their client fish, some of whom travel to the cleaning station and wait in line to be cleaned by their preferred wrasse [17, 18]; predator inspection in groups of guppies [19]; and hunting between two species such as the moray eel and grouper who are more successful hunting together than alone [20]. Thus, there is ample evidence from a variety of species that fish can evaluate the intentions of others and modulate their own behavior accordingly, and can form complex relationships with other individuals.

## 4.4 Cognitive Ability and Neurodevelopment

The cognitive ability of fishes is grossly underrated, and this has flow-on effects for how fishes are treated [21]. However, research over the last few decades has shown that fishes have mental capacities on par with most other vertebrates (see [22, 23] for a review). Fish are not the mindless automatons the public generally perceives them to be. The reality is that most fishes have evolved to flourish in a myriad of aquatic niches, from abyssal marine habitats to desert springs, and their brains and behavior are suitably equally diverse. This massive diversity (there are more species of fishes than the rest of the vertebrates combined) is indicative of their evolutionary success.

Redouan Bshary famously compared the cognitive abilities of fishes to nonhuman primates and did not find them wanting [24]. In many domains, fishes perform just as well as nonhuman primates, including spatial learning, numerical skills, tool use,

**Fig. 4.2** Direct reciprocity is rarely seen in birds and mammals but here are photographs depicting this complex behavior in rabbitfishes. The foraging individual (in the head-down position) feeds in cracks and crevices in the substratum, while the vigilant individual is positioned in the water column with its head up. Note the obstructions to the visual field of the forager, suggesting high vulnerability to predation and the unobstructed field of perception of the vigilant fish. (**a**) *Siganus corallinus*, (**b**) *S. vulpinus*, (**c**) *S. doliatus*, (**d**) *S. puellus* (Taken from Brandl and Bellwood [12]; Photographs taken and owned by Jordan M. Casey, reproduced under a Creative Commons License http://creativecommons.org/licenses/by/4.0/)

social intelligence, social learning, and others. The list of fish intelligence success stories reflects a series of skills that, not so long ago, were thought to be uniquely human. It is apparent that Darwin had it right all along: The difference in mind between humans and other animals is one of degree rather than kind, and so too with fishes.

### 4.4.1 Social Learning

Social learning is widespread in fishes (see [22] for a review). Fish pay attention to the behavior of other fish around them and can rapidly acquire novel information in this fashion. For example, fish may use social information to discover an escape route [25, 26], the location of a foraging patch [27], or to identify novel prey [27]. The decision to use social or private information is influenced by the individual personality of the fish, where the propensity to take risks affects overall behavior (i.e., bold risk-takers versus shy, risk averse individuals) [28]. Information can be passed between individuals of the same generation (horizontal transmission) or between generations (vertical transmission). The latter case can lead to the generation of unique, population-specific behaviors that may be independent of an animal's ecology—in other words, culture [29]. Guppies can be trained to use specific colored doorways to access food rewards and remain faithful to these pathways even if they are maladaptive (e.g., the food reward is closer to the alternative doorway) [30]. While the development of culture has been demonstrated repeatedly in captive experiments [31], there is also good evidence from field manipulations. For example, many fishes rely on cultural knowledge to learn about the pathways to foraging locations or breeding grounds. In one study, small groups of French grunts were translocated to novel locations and the resident populations at these locations were either retained or removed. When the local population remained in place, the translocated fish adopted the local group's pathway from their daytime resting locations to their nighttime foraging grounds [32].

### 4.4.2 Spatial Navigation

Fishes are a model for understanding the evolution of spatial learning and navigation. Because there are so many species to work with, living in a wide range of niches, fishes make fantastic models for comparative studies. Scientists have been researching the navigation abilities of intertidal gobies for many years. Intertidal gobies live in the same rock pool for extended periods of time and, when displaced, rapidly return home [33] suggesting well-developed navigation and orientation skills. A very early study showed that gobies form cognitive maps of the surrounding rock pools at high tide and can thus leap from pool to pool when threatened [34]. When the spatial learning skills of species inhabiting rocky tide pools were compared with those from sandy habitats in a variety of mazes, it was revealed that rock pool gobies had enhanced spatial learning and tended to rely on landmarks rather than egocentric navigation methods [35, 36]. Examination of their brains revealed that gobies show a neurodevelopmental trade-off, investing in particular parts of their brains to suit the environment in which they live. Rock pool dwelling fish have relatively large telencephalons (equivalent to the mammalian hippocampus), a brain area responsible for spatial learning, whereas sand dwellers had a larger optic tectum [37, 38]. These results mirror classic studies conducted in birds and mammals and indicate that natural selection tends to act in a very domain-specific manner [39, 40]. When juveniles were reared in a variety of different habitats, those reared in complex habitats developed enhanced spatial skills [41]. Moreover, when fish were tested at different times of the year, males showed decreased spatial learning corresponding to the breeding season, when their activities are confined to guarding the nest. Females showed no such reduction [42]. Again, these results are similar to those seen in terrestrial vertebrates (e.g., [43]) and indicate that fish brains can be highly plastic and adaptable to suit the fishes' specific niche.

### 4.4.3 Numerical Skills

The numerical skills of fishes have been well-studied and for the most part fishes seem to use the same cognitive mechanisms to keep track of quantities as do mammals, including humans [44]. The experimental setup often takes two forms. The first utilizes the natural schooling behavior of fish where they are drawn toward the larger of two shoals for safety in numbers. By manipulating the sizes of the choice shoals one can determine when the fish can no longer discriminate between the shoals. The second requires training in which food rewards are paired with abstract objects (e.g., dots on a card). Fish can be rewarded for choosing the smaller or the larger quantity. For comparisons of a small number of objects, fish use an object tracking system which is restricted to quantities around 4 or 5. Most nonhuman animals, including fish, struggle when comparing sets of 3 versus 4 or 4 versus 5 [44–46]. However, with enhanced training experience, numerical skills can improve [47, 48]. For larger sets, fish use a comparative method that relies on ratios and is therefore subject to Weber's Law [44]. That is, as the magnitude of the two quantities increases, a larger disparity is required to obtain the same level of discrimination ability. There is some evidence that numerical abilities in humans are affected by the degree of individual cerebral lateralization [49, 50]. Cerebral lateralization refers to the preferential use of one hemisphere over the other when analyzing particular information and was once believed to be a uniquely human trait but is in fact widespread among vertebrates (see [51] for a review). Laterality has been associated with enhanced cognition in a range of animals including parrots [52] and fish [53]. A study involving guppies, using two different experimental protocols, found that strongly left and right lateralized individuals had enhanced numerical skills compared with nonlateralized individuals [54].

### 4.4.4 Decision-Making

In line with the theme that fishes are primitive animals with little flexibility in their behavior, many believe that fish behavior is largely reflexive. Contrary to this widely held belief, fish make all manner of complex decisions and often trade-off conflicting needs against one another. One of the most obvious examples of this behavioral flexibility comes in the form of predator risk assessment. Fishes can assess the relative risk of a given situation and adjust their behavior accordingly (risk-sensitive hypothesis [55]). For example, depending on the perceived risk, they adjust the amount of time spent feeding versus being vigilant, vary the size of the shoal they join, or vary habitat use [56–58]. Hungry fish are more likely to take greater risks to access foraging patches than satiated fish [59]. The trade-offs that fish make tell us much about how they perceive the world around them, but they can also provide insights to their basic needs, which may be particularly relevant in a welfare context. In the context of pain perception and avoidance, experiments show that under normal circumstances fish rapidly learn to avoid locations associated with electric shocks, but social species of fish are willing to trade-off exposure to shock (i.e., they pay a pain cost) to get access to conspecifics [60]. Similarly, fish are not willing to put up with shock and show strong avoidance if they are satiated, but after three days of starvation are willing to get shocked to access a food patch [61]. Collectively this work illustrates that the decision-making processes of fish are no less sophisticated than those of terrestrial vertebrates and are certainly not simple stimulus-response reflexes with no learning, memory, or decision-making.

## 4.5 Welfare and Capacities for Feeling: Pain, Fear, and Pleasure

### 4.5.1 Pain

When considering the arguments about sentience in animals, Jeremy Bentham (1823) famously stated "The question is not, Can they reason? nor, Can they talk? but, Can they suffer?" (p. 311 in [62]). In the animal welfare realm demonstrating that an animal may suffer during adverse events makes a powerful case for improving guidelines and legislation for the treatment of that animal. Thus, there has been a focus on proving that poor welfare is indeed detrimental to an animal, and the question of pain perception is a primary driver of changes in attitude. Nowhere is there such fierce debate over the capacity of an animal to experience pain than in the case of fish. In 2002, Rose published a review in which he denied the existence of pain and consciousness in fish [63]. His view was that animals must have a human-like multilayered cortex to have awareness of pain—negating all animals except possibly nonhuman primates. In the same year, Sneddon published the first evidence for the existence in rainbow trout of nociceptors, receptors that detect painful stimuli [64]. Subsequently, studies have demonstrated that fish nociceptors are strikingly similar to those found in mammals, the molecular mechanisms of nociception are evolutionarily conserved [65], behavioral changes during painful treatment are prolonged and are not simple nocifensive reflexes (instantaneous defensive withdrawal responses), and that pain-relieving drugs prevent the adverse changes in behavior and physiology seen in fishes [10]. Further, fish fulfil the criteria for animal pain based upon published scientific studies [3, 10].

Skeptics who deny pain in fish have been criticized for two main reasons: Firstly, suggesting that a function such as pain suddenly arises in nonhuman primates and humans with no ancestor or evolutionary precursor defies the process of evolution.

Charles Darwin referred to the capacity of animals to experience pain and the many similarities to humans. Secondly, many skeptics do not deny pain in birds even though, like fish, they possess a singly-laminated cortex. More recently, Key [66] argued that birds can experience pain but fish cannot, which is contrary to his own position on the required cortical structures. Moreover, Key puts forward evidence to support the existence of pain in mammals but then refutes the same evidence as insufficient for fish. Even in the face of identical findings demonstrating pain in both mammals and fish [67], Key denies pain in fish [66]. Scientists who use mammalian models and are experts in human brain function declared that Key's description of how the brain works in relation to pain was incorrect [68]. Bjorn Merker stated "(Key's opinion) looks more like a ramshackle structure gaping with holes and pieced together from imperfectly understood neuroscience and often faulty literature citations" (p. 3 in [69]).

Zebrafish are increasingly used as a model for pain experimentation (e.g., [70–77]), which seemingly implies acceptance that fish not only experience pain, but do so in ways similar to mammals. For ethical reasons and to ensure good welfare, it would be prudent to know if these animals experience pain and further avoid and alleviate it where practically possible. However, if one denies pain in zebrafish, then this calls into question their use in this context. There is no dispute over whether fish experience stress or fear, which are similar in their subjective nature to pain. The empirical evidence is overwhelming for pain in fish, and indeed some countries provide protection for fish in a similar manner to mammals, in the context of scientific experimentation, where legislation requires pain is minimized in fish (e.g., Europe and many states in Australia).

### 4.5.2 Fear

Fear is the activation of a defensive behavioral system that protects animals, including humans, against potentially dangerous environmental threats [78]. Three main criteria can be used to assess the capacity for fear [78]. Firstly, the systems that control the fear response should be similar (have a common neuronal basis) to those neural systems that underpin human fear and anxiety. Secondly, a variety of threatening stimuli should generate a consistent suite of behaviors that protect the animal against the threat. Finally, drugs that modulate human fear and anxiety (e.g., benzodiazepines) should show similar effects in the animal. These criteria can be used to assess the potential for fear in fish. Fear stimuli are psychological threats to survival and these motivate the animal to make defensive responses (freezing, hiding, or fleeing). Rodent models have been employed in such paradigms investigating the neuronal circuitry, and the mammalian amygdala and hippocampal regions are particularly important in mediating emotions, especially fear learning and memory. Fish have behaviors, cognitive mechanisms, and brain areas that are homologous to the fear circuitry in mammals [79–81]. For example, the dorsomedial telencephalon in the forebrain area of goldfish has identical functions in fear as the amygdala of mammals does in mediating fear responses and learning, whereas the goldfish dorsolateral telencephalon is homologous to the mammalian hippocampus, involved in spatial learning and memory retrieval [81, 82]. Measurements of startle, freezing, increased school cohesion, and other defensive behaviors occur alongside physiological parameters such as heart rate and the release of stress hormones such as cortisol.

Studies in fish have demonstrated a consistent response to threatening stimuli, such as: avoidance of novel objects, freezing to reduce conspicuousness, escape or fleeing behaviors, thigmotaxis (where the fish swims next to tank walls avoiding open, central areas), sinking to the bottom, fast start swimming, and many more [83]. Many agents decrease fear and anxiety, including benzodiazepines, opioids, and cholinergic and serotonergic drugs. When exposed to an alarm substance, minnows displayed a behavioral alarm response even when a chemical feeding stimulus was released into the water. However, when fish were exposed to high, but non-sedative, levels of chlordiazepoxide, they did not show the fright response to the alarm substance and displayed vigorous exploration when presented with the chemical feeding stimulus [84]. Rodents that have been administered benzodiazepines show similar changes in exploratory behavior [84, 85]. Piracetam is prescribed to reduce anxiety in humans. Chronic administration of piracetam also reduces fear behavior in zebrafish where fish spend more time in a white area in a scototaxic (light versus dark chamber) test [86]. Similarly, there are numerous ecotoxicological studies indicating that fish respond to pharmaceuticals such as fluoxetine (Prozac) in a manner similar to humans (e.g., [87]). These examples demonstrate the capacity for fear in fishes and clearly show that the underlying physiological mechanisms and neural substrates are similar.

### 4.5.3 Pleasure

Do fishes experience pleasure? This is an intriguing question and one that has largely remained unexplored. One of the best examples that suggest that they do is that of surgeonfish who, when given access to a moving cleaner wrasse model fitted with brushes, will voluntarily align itself with the model to receive a “massage.” Those fish who engage with this model have much lower concentrations of the stress hormone cortisol, and thus it appears that the massage has a calming effect on the fish. This relates to the massage actual cleaner wrasses give with their pelvic fins to much larger, predatory client fish during the process of social reconciliation [88]. For gregarious species, such as zebrafish, being in a group can be beneficial. For example, zebrafish held in a group recover much more quickly from fear-eliciting [89, fg. 3] and painful events [90]. This phenomenon, known as social buffering, in which individuals are more resilient in groups, also activates comparable brain regions in fish and mammals [89], and thus the mechanisms may be evolutionarily conserved, indicating some evidence for a capacity for pleasure (Fig. 4.3).

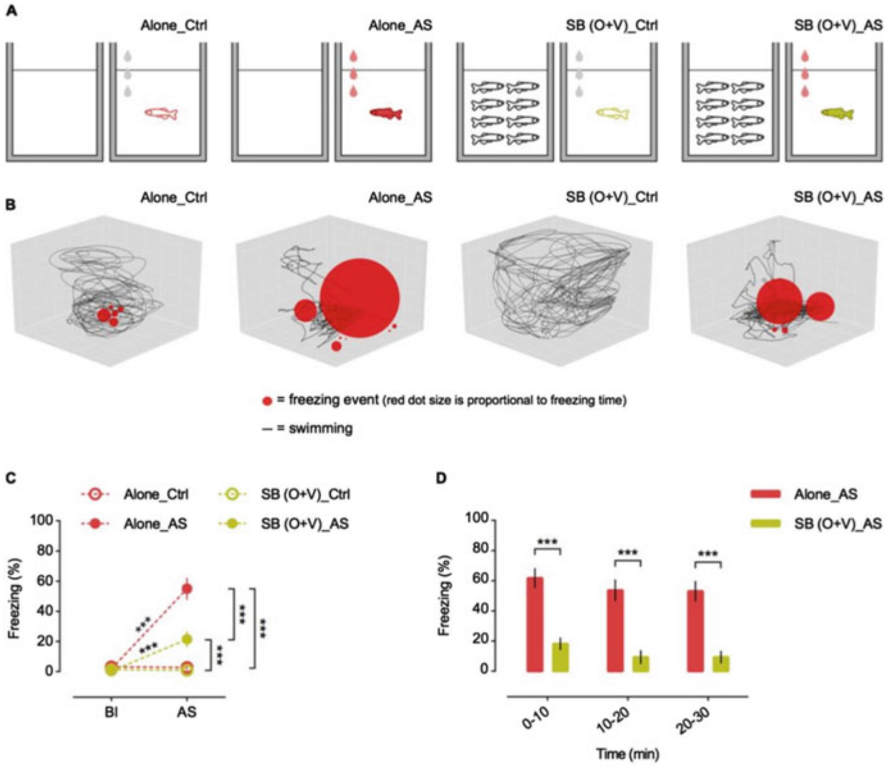

**Fig. 4.3** Social buffering of fear responses in zebrafish where the focal fish were held alone or with conspecifics and exposed to an innate predator cue, alarm substance. Freezing, an anti-predator behavior, was reduced in the social treatments compared to social isolation. (**a**) Schematic representation of the behavioral treatments. From left to right: Alone_Ctrl–alone focal fish (red outline) administered with water, Alone_AS–alone focal fish (red filling) administered with AS, SB (O + V) _Ctrl–focal fish (green outline) administered with water and exposed simultaneously to shoal water and a shoal of 8 conspecifics, and SB (O + V)_AS–focal fish (green filling) administered with AS and exposed simultaneously to shoal water and a shoal of 8 conspecifics. Gray and red drops represent water and AS administration, respectively. (**b**) 3D plots representative of each behavioral treatment. Each 3D plot represents the first 5 min after AS onset for the focal fish closest to the mean in each treatment. $n = 20$ per treatment. Total freezing percentages presented (red circles) in each 3D plot are (from left to right) Alone_Ctrl–1.95%, Alone_AS–56.24%, SB (O + V)_Ctrl–0.00%, and SB (O + V)_AS–23.32%. (**c**) Freezing % in baseline (Bl) vs. first 5 min after AS onset (AS). $n = 20$ per treatment. Mean ± SEM are shown. $*p' < 0.05$, $**p' < 0.01$, and $***p' < 0.001$. (**d**) Freezing % over the 30 min test in 10 min bins. $n = 20$ per treatment. Mean ± SEM are shown. $*p' < 0.05$, $**p' < 0.01$, and $***p' < 0.001$ (Reproduced from Faustino et al. [89] under a Creative Commons License http://creativecommons.org/licenses/by/4.0/)

## 4.6 Individual Recognition, Self-Recognition, and Consciousness

Schools of fish are seldom made up of a random assortment of individuals. Many social preferences are shaped by both familiarity and relatedness [91] using phenotype matching [92] or olfactory imprinting [93]. Fishes are capable of recognizing one another, and this has most often been tested experimentally in the context of familiarity. Flathead minnows distinguish their shoal mates from unfamiliar fish using chemical cues [94] and female guppies have schooling preferences for familiar individuals [95]. Sticklebacks can distinguish between individuals based on visual cues alone [96]. Damselfish and cichlids also use color patterns on the faces of conspecifics to facilitate individual recognition [97]. Archerfish can even differentiate between human faces [98]. Familiarity in female guppy shoals develops over a period of about 12 days [13].

Many species of fish are also capable of distinguishing kin from non-kin, and this is most often achieved through chemical means (although rainbowfish also use visual cues) [99]. In sticklebacks and Arctic char, for example, kin recognition is facilitated by major histocompatibility complex (MHC) genotypes [100, 101]. Arctic char show reduced aggression when housed in sibling groups compared with mixed groups [102] and kin recognition persists even when related individuals are reared separately, suggesting a strong innate component [100]. Stickleback kin recognition, in contrast, is facilitated by social learning rather than innate preferences [103]. Although kin recognition is often observed under laboratory conditions, it is rarely observed in the wild [104]. Embryonic fish are sensitive to chemical cues while still in the egg [105], prompting the question: At what age are fish capable of kin recognition? By observing the heart rates of embryonic damselfish, Atherton and McCormick [106] found strong reactions to alarm cues emanating from closely related individuals 7–11 days post-fertilization depending on the species.

One major question that still remains to be answered comprehensively is whether or not fish are capable of self-recognition. To date the results have been mixed. One of the standard tests often employed in mammals is the mirror self-recognition (MSR) test. Put simply, a mark is placed on the animal and a mirror is provided. When chimpanzees, orangutans, gorillas, and Asian elephants were presented with their mirror image, they notice something unusual on their body and rather than exploring their mirror image, they explore their own bodies [107, 108]. Similarly, the Eurasian magpie has passed the test [109]. This indicates that they understand that the figure in the mirror is themselves; that is, they have self-recognition, one of the hallmarks of consciousness. We still do not fully understand what fishes make of their own mirror image. Many fish species seem to treat mirror images as unfamiliar conspecifics although the responses are not the same as when they first meet a real unfamiliar fish [110–113]. Male Siamese fighters, for example, initially respond as if the image is a rival and they behave aggressively toward it [87, 114]. Many species, however, treat the image as a social companion or gradually ignore it [113]. The MSR test has been applied to cichlids but they failed it [115]. Initially the cichlids behaved aggressively toward their mirror image, but this behavior declined over a number of days as is often the case when animals are first exposed to mirrors. Following injection of a mark on one side, there was no evidence that the fish spent more time looking in the mirror, nor did they spend more time observing the marked versus the unmarked flank. A recent test using cleaner wrasse as the model species found that the wrasse passed the test showing evidence of contingency testing [116]. It should be noted that cleaner wrasses are highly motivated to pick off ectoparasites on other fishes and this fact may partially explain their success. It is important to note that the fish made no attempt to remove the mark from their mirror image; rather they scraped their own bodies in an attempt to remove it. Mirror tests have also been applied to manta rays and they showed some evidence of contingency checking (repetitive or unusual movements directed toward their mirror image) and self-exploration [117]. With so few studies conducted to date, it is difficult to tell with any certainty if fish are capable of visual self-recognition.

In contrast to the evidence for self-recognition in fishes in the visual realm, evidence in the chemical realm is far more convincing. As previously mentioned, sticklebacks use MHC genotypes to recognize kin, but they also use it for mate choice preferences [118, 119]. In both cases during the decision-making process, the fish are making references to self in order to either optimize the MHC compatibility with their partner [120] or preferentially school with related individuals [103, 121, 122]. Experiments using in vitro fertilization in sunfish have shown that males guarding nests are able to determine if they are the father of the offspring in their nest via chemical recognition. The only way this can occur is if they were using self-referent phenotype matching for kin recognition. In similar experiments and context, male cichlid fishes also showed preferences for smells from their own nest versus those of unfamiliar males and preferred their own odor to that of a familiar brother [123]. Collectively these results suggest fish have an ability to recognize themselves using chemical cues.

## 4.7 Conclusions

Clearly fishes do fulfil our interpretation of Broom’s [8] criteria for animal sentience and this has wide reaching implications for the use of fish by humans. If we consider only their use as scientific research models, there is a trend toward an increase in the use of fishes globally, driven at least in part by the 3Rs mandate to adopt “less sentient” species. We propose that the general principles of animal care, ethics, and health that are applied to experimental mammals should also be applied to fishes. Ethical justification of research should be considered and experimenters asked to consider the harms versus the benefits of the research. Further the 3Rs—Replacement, Reduction, and Refinement—can help inform whether the chosen species is the best model for the experimental question; that in vivo experiments are the best means of testing the hypothesis rather than cells, tissue preparations, meta-analyses, or in silico approaches; that the minimum effective sample size is used, that the most refined and least invasive methods and techniques are used; and that health and welfare are being safeguarded during the fish's time in the laboratory. This includes the development of humane end points and appropriate methods of humane killing or euthanasia. This naturally requires robust welfare assessment tools as well as recognizing when to intervene to improve welfare. For example, if a fish exhibits signs of pain, then the researcher can decide whether to provide analgesia to reduce suffering where studying pain is not the objective of the study. The goal of all scientists is to use healthy individuals in their experiments where practicable to ensure the validity and reliability of the outcomes. Therefore, it is in the interests of the scientific community to consider and improve the welfare of fishes.

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# 5 Bovine Prospection, the Mesocorticolimbic Pathways, and Neuroethics: Is a Cow's Future Like Ours?

Gary Comstock

**Abstract**

What can neuroscience tell us, if anything, about the capacities of cows to think about the future? The question is important if having the right to a future requires the ability to think about one's future. To think about one's future involves the mental state of prospection, in which we direct our attention to things yet to come. I distinguish several kinds of prospection, identify the behavioral markers of future thinking, and survey what is known about the neuroanatomy of future-directed bovine beliefs and desires. I suggest, in conclusion, that instead of asking whether a cow's prospection is *conscious*, ask whether it is *like ours*—with "ours" understood to include all human beings.

**Keywords**

Cow cognition · Mesocorticolimbic pathways · Nonhuman animal consciousness · Bovine prospection · Neuroethics

## 5.1 Introduction

A Holstein is locked in a stanchion at a feed trough, her eyes wide with anticipation, her neck outstretched. At the start of this YouTube video sequence [1], the cow is clearly looking forward to something. Or is she? Can cows think about their future? In this chapter I briefly explain the moral significance of the possibility that cows look forward, and offer some stipulative definitions of different modes of prospection. By prospection I mean thinking about what is yet to come. I survey what is known about human behavior and neuroanatomy when we have prospective beliefs and desires, and proceed to make some testable empirical predictions about

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_5

what we should expect to find in cows if they prospect. I propose an analogy between bovine prospective beliefs and desires and the prospective beliefs and desires of non-reporting congenitally severely cognitively limited humans, such as humans with neotenic complex syndrome. In conclusion, I suggest that we stop asking whether a cow's prospection is real or conscious and ask instead whether it is like ours—with "ours" understood to include all humans.

## 5.2 Why Bovine Prospection Matters

In North America, steers, heifers, and bullocks (for the sake of economy of expression, I will refer to all bovines, male or female, young or old, as *cows*) are typically killed at a young age for meat. Good milk producers are milked for several years and then slaughtered. Common justifications for treating cows in this way include claims that cows are not contractors [2, 3]; lack rights [4]; do not possess language, rationality, or self-consciousness [5]; and so on. The idea here is a familiar one: that animals cannot have a right to life because they cannot take an interest in their future [6, 7]. There is little justification for causing animals unnecessary pain. However, many believe it is permissible to kill animals humanely—swiftly and painlessly—because animals act only "on instinct," live entirely "in the moment," or have only "nonconscious experiences" (for discussion, see [8]). Without conscious anticipatory plans looking forward in time, cows, one may reason, only have value because they are sentient. The cow's value as an individual able to acquire pleasure is lost when the animal is killed, but the value is replaced the moment the next sentient cow comes into being [9, 10]. On the other hand, however, if an individual looks forward to her future, killing her deprives her of her ability to satisfy her desires. If killing a prospective individual is *prima facie* wrong because it robs them of all future experiences, then killing cows may be *prima facie* wrong because it robs them of their future.

These considerations show that bovine prospection matters. If a cow cannot take an interest in her future, it may be that she has no right to it. If, on the other hand, she can take an interest in her future, she may have a right to it.

## 5.3 Rights and Interests

Should cows be able to think about their future, and if we can show that they can, then we will have taken a first step—a big step—toward undermining the common justification of humane slaughter. For, according to one widely accepted view, rights require interests [11]. An individual cannot have a right to something unless they have an interest in it. And their interests must be sufficiently weighty that the interests can support saddling others with the obligation to refrain from depriving the rights holder of that to which the rights holder has the right. For example, lead-free water is essential for the healthy development of children, so the children of Flint, Michigan, have a sufficiently weighty, legitimate interest in having access to lead-free water to establish a right to have access to lead-free water. A creature that did not require lead-free water to be healthy would have no similar interest and thus no right to it. This is the presumed connection between rights and interests. Having an interest in something does not by itself establish a right to it, but having a right to something requires having a legitimate interest in it [12–14].

If having a right to *x* requires that one have an interest in *x*, then having a right to one's future requires that one have an interest in one's future. If cows have no interest in their future, they cannot have a right to it. But if they do have an interest in their future, they may have a right to it. So, much hangs on the next question.

Do cows think about their future? Let's return to the cow at the feed trough. Call her Betsy. If we run the video, the next thing we see is a youth, call him Jake, approaching Betsy with a feed tub. He dumps some grain in front of Betsy's neighbors and then some in front of Betsy. He throws the tub, presumably still with grain in it, in front of the cow two stalls to Betsy's right. Betsy stretches for it but, unable to reach it, proceeds to unlock her stanchion using her horn. After backing out, she reaches over her neighbor's neck and uses her tongue to unlock her neighbor's stall. The neighbor withdraws. Betsy repeats the procedure a second time on her second neighbor. After both neighbors have vacated, Betsy enters the second neighbor's stall, grabs the tub, and pulls it toward her.

## 5.4 What Is This Cow Planning?

Rewind to the first frame. What is Betsy thinking about her future, if anything, as she first observes Jake's approach? Here are three possibilities.

(a) Here comes Jake with our grain. When he gets here if he dumps it all in front of Babe like he did yesterday then I'm going to headbutt her out of the way. She's his favorite but that's not fair. They're both about to learn that I'm not taking it any more.

(b) BELIEF [if tub arrives, feed]
BELIEF [if tub does not arrive, no feed]
DESIRE [feed]

(c) [*blank*]

Call the first response *autobiographical* prospection. If (a) is correct, then Betsy is thinking about what the future holds and she is able to tell herself a story about it. Few objective observers of cows would attribute such human-like foresight to Betsy but, were she to possess it, she would likely have fitness advantages over conspecifics [15].

Call the second response *intuitive* prospection. In (b), Betsy has beliefs about and a desire for the future. Nonetheless, lacking the ability to form sentences and narratives, she cannot use these mental states to tell a story about her future. We storytellers can arrange her cognitive, conative, and emotional states into a narrative about her future but, according to (b), we would not be justified in thinking Betsy understands our story. Defenders of this second option find support in ethologist Wolfgang Kohler's idea that no animals have future-oriented thoughts extending beyond their present circumstances. According to the influential Bischof-Kohler hypothesis, after any animal has eaten her fill, she is unable explicitly to think about—much less plan for—the next hunger bout because she lacks the ability to represent herself and her future self, much less the temporal psychological connections between them [16, 17]. Nonetheless, at the moment, Betsy implicitly has the sense that grain is coming, that an obstacle stands in her way, and that she must find a way around it. This, at least, is one plausible story we could tell to explain her behavior.

According to (c), Betsy has no beliefs or desires at all, no thoughts about the future. Call this answer *stimulus-response*. Defenders of (c) might argue that because cows lack language they cannot form beliefs about the present, much less the future [5, 18, 19]. I will have more to say about cows and language shortly.

I'll argue for (b). Cows have intuitive prospection.

## 5.5 Prospection: Some Definitions

Here I offer some stipulative definitions of key terms I will employ.

> ***Prospection*** is any mental state directed toward the future [20]. I am engaged in prospection when I wonder whether raspberries will be genetically engineered for cold tolerance by the end of the decade.
>
> ***Nonconscious prospection*** is an unfelt bodily movement toward a future goal. I am engaged in nonconscious prospection whenever my subcortical autonomic system is making predictions about where my fingers will wind up a few milliseconds from now as I reach for a raspberry. Carruther's distracted driver steering around a double-parked lorry is engaged in nonconscious prospection as he successfully guides his vehicle to his goal without knowing or feeling what he is doing—and without the capacity to remember afterwards the details of what he has done [6]. When a blindsight patient successfully walks around an object he cannot see in order to reach the end of a hallway, he is engaged in nonconscious prospection [21]. Suhler and Churchland explore the neurobiological parameters that support such nonconscious monitoring and control [22]. Animals, like humans, have sophisticated neural and chemical processes that keep them moving toward their goals even though they are unaware of the processes.
>
> ***Intuitive prospection*** is the fast, automatic, implicit process of anticipating or bringing about a future event without analyzing or deliberating about it [23]. Unlike nonconscious prospection, in which one feels nothing at all, intuitive prospection is a subjective experience. Tulving described our ability to look backward in time and draw on implicit memories to ride a bike, for example. The bike rider automatically follows rules to keep the contraption upright but does not need to pay attention to the rules. Similarly, looking forward in time, intuitive prospection is an ability to initiate behavior in light of one's goal without consciously turning one's attention to the steps necessary to attain it. I am engaged in intuitive prospection whenever I want a raspberry and, knowing they are in the refrigerator, walk unthinkingly to the kitchen and open the fridge. Panksepp, building on Tulving, calls this

> kind of experience a part of unknowing, or *anoetic* consciousness, and the work of the "core-Self" [24–26]; Damasio calls it a state of the *protoself* [27] .
>
> ***Deliberative prospection*** is a slower, rational, explicit process of consciously directing one's attention to the future and planning the steps necessary to bring it about [23]. I am engaged in deliberative, or episodic (Tulving), prospection whenever my first-order desires and beliefs about the future are disposed to be under my conscious control. By "disposed to be under my conscious control" I mean capable of being influenced by signals coming from my frontoparietal cortical region [28]. Tulving described our ability to look backward in time and remember the who-what-where-when details of a personal event. I can perform similar simulations of future events whether those events are indexed personally to me or not. I engage in impersonal deliberative prospection when I reflect on the fact that global temperatures are rising and a child born in twenty-second century North Carolina may have a shorter life-expectancy than a child born there in this century. Panksepp calls this a part of *noetic* consciousness; Damasio, *core* consciousness [24, 27].
>
> ***Autobiographical prospection*** is a variety of deliberative prospection. Here, future thoughts are indexed to the person doing the thinking: a mindreading individual with a biographical sense of self travels mentally through time. One pictures oneself as a character playing a role in a more-or-less richly detailed story. And one then reasons backward from this future simulation to plan the steps necessary to bring the simulation into being. Autobiographical prospection requires a subjective sense of time, a theory of mind, second-order beliefs—beliefs about one's beliefs—and narrative understanding. Narrative understanding allows one to see oneself as a character in a plot [12–14, 29]. I am engaged in autobiographical prospection when I am thinking about what to serve Mom for breakfast tomorrow and, recalling that she thinks large dark raspberries are sweetest and wanting to impress her, I write myself a note to go shopping for the biggest berries I can find. Panksepp, again following Tulving [25], calls this kind of experience a part of *autonoetic* consciousness; Damasio, *extended* consciousness [24, 26, 27]; and Szpunar, Spreng, and Schachter call it "planning" [30].

What sort of prospection, if any, is Betsy capable of? Does she have second-order beliefs about her future mental states in the way required for autobiographical prospection? Or is she capable only of the lower-order intuitive prospection, non-self-consciously interpreting events to come in terms of narratives only observers can construct for her? And perhaps there is even less to it. Is Betsy always acting nonconsciously, unaware of anything she does, her mind an empty blank?

To answer such questions we must examine two linked sources of evidence: behavioral and neuroanatomical. To figure out which neuroanatomical structures, if any, are being recruited in cows for which prospective purposes, we must begin by describing the target behavior. If we don't clearly identify the prospective behavior's beginning and ending points, we won't know when to look for activated neural networks when we go looking for prospection's neural correlates.

## 5.6 Cow Behaviors

What do cows do? One is tempted to say: not much. Most of the time they graze, ruminate, and rest, standing around, staring at nothing in particular. They enjoy chewing their cud and switching their tails, lying down, sleeping, hanging around familiar conspecifics, and avoiding antagonistic confrontations [31]. They like to groom and be groomed, rub their necks on the ground, scratch, and lick [32]. Most of the time they're doing things we interpret as displays of bovine contentment. "They appear to understand patience and composure," writes Jon Katz [33], and this might lead us to think that cows aren't actually thinking at all. They're merely acting "instinctually," responding with unlearned behaviors to stimuli.

However, as Katz adds, "cows. . .haven't been allowed to be smart" [33]. Indeed, the hundreds of years of domestication have produced tame animals who are docile compared to their wild relatives. And some cows are even raised as pets, in pampered conditions that do not allow the animals to develop their native capacities. Consequently, it is easy to underestimate the intelligence of cows (for a review, see [34]). Cows can learn to do most of the things dogs can learn to do: to follow [35]; to stay, kneel, or spin [36]; to fetch balls [37]; and to gain entry to buildings by pressing buttons [1]. They can learn to negotiate mazes to find food [37]. They can learn, without training, to work a pump handle to bring up water from a well and figure out by observation how to press a lever to get extra feed [38] (but, so far, apparently cannot be trained to defecate in prescribed areas [39]). But can they foresee their futures?

Let's rewind Betsy's video yet again. In the moment she's watching Jake's approach, is she travelling mentally through time, seeing herself a half minute from now having released her neighbor and about to take her neighbor's place? Is she saying to herself, "Silly farm boy, you think you can keep this old girl out of the corn? Just you watch me"?

We have no behavioral grounds to attribute autobiographical prospection to Betsy. She gives no indication that she has conscious representations of her own mind, much less Babe's or Jake's. There's no behavioral evidence to suggest she represents herself to herself as herself, thinks about her future self, or conceptualizes herself as a psychological continuity that persists between now and the future. We have no reason to believe she has a sense of what motivates Jake to do what he does nor that she has ideas about what Jake might think about her. There is no evidence that she has a sense of what justice requires in the barnyard.

To have an autobiographical capacity one must be a self-conscious agent with the mental facility to construct narratives with plots replete with characters facing obstacles. The story needs a beginning, a middle, and a denouement; that is, some explanation of how the affair ends. I take seriously Morgan's canon, always to prefer the lowest possible level explanation of an animal's psychological state [40]. The simplicity of bovine behaviors makes it very difficult to believe that cows can take an autobiographical interest in their future. I am unaware of empirical attempts to test cows for their ability to understand plots, character constructions, or narratives or for a cow's ability to understand the requirements of morality. Experiments for such traits may eventually be devised, but I am skeptical cows will pass them for reasons I give elsewhere [41–43].

If we are to guard against anthropomorphizing cows and illegitimately ascribing human mental qualities to them, we should be cautious about ascribing to them moral states such as envy, humiliation, jealousy, pride, embarrassment, and shame. To have a virtue or vice one must be, well, a character in a narrative plot. One must understand oneself as a self and be conscious of how one's actions are affecting other selves. This kind of self-conception is what cows probably lack.

However, to avoid anthropomorphism one need not resort to a reductionistic stimulus-response view. We need not assume that animal experience is nonconscious, lacking all phenomenal qualities all of the time [6]. Nor need we become mysterians either, agreeing with neuroscientist Joseph LeDoux that "we can never know whether another animal has conscious emotional feelings" [44]. For a more plausible view is readily available, and that is this. Some animal experiences are nonconscious, some are unconscious, and some are conscious. Eventually a mature physical science may supply causal explanations of consciousness. In the meantime, many philosophers are convinced, as am I, that we must borrow the belief and desire framework of folk psychology. It's the best of the current options on offer to characterize conscious animal experiences [45, 46].

A non-anthropomorphic folk psychological description of what it is like to be a cow looking forward involves two key steps. First, determine which neuroanatomical structures humans recruit when they prospect. The prospective target behaviors include combinations of things such as squinting or widening eyes, tilting the head, favoring an ear, sniffing the air, and stretching the neck. Second, determine whether relevantly similar neuroanatomical structures are found in cows and, if they are, whether they are recruited when the cow's behavior indicates prospecting (squinting, tilting, etc.). If bovine structures are present and active during the bovine behaviors we suspect are prospective in nature, then the burden of proof will have shifted to those denying cows have an intuitive sense of their future. I am not suggesting that having such structures is necessary for prospection (and they may not be, to take just two examples, for birds or octopuses). I am suggesting that having them, and having them functioning in neurotypical ways, may be sufficient for intuitive prospection.

## 5.7 Hypothesis: Cows Have Intuitive Prospection

Let me say a bit more about what needs to be shown if we are to believe in bovine intuitive prospection. First, notice that intuitive prospection is like autobiographical prospection in that it has a narrative structure. To have a narrative structure is to have temporally encapsulated contiguous episodes integrated into a larger whole, a plot [13, 29, 47]. When my thoughts about my future have a plot, I foresee the end state as connected to my beginning point by a story that explains the entire sequence. The story explains my decisions as I look and move ahead, showing how the series of events in my past lead to the choices I am making now. I see my story, in other words, as a unified whole, unified from past to future by the agency of a character, me. *I* tie together and explain the entire sequence [48]. What is the connection between narrative and explanation? An explanation is required to show how the many features of my perspective—my memories, values, emotions, and aspirations—form a coherent account of the individual in question. A story is needed to explain *me*. Without a story, I dissolve into a series of disconnected states of affairs. Others' actions also require narrative explanations. When a mind reader is explaining someone else's actions, the mind reader employs third-person biography for the explanation. Both biography and autobiography have narrative form; both employ the four elements of what the Aristotelian poetic tradition calls tragedy: plot, character, mood, and setting [12].

If this analysis of time, narrative, and personal identity is correct, then the difference between intuitive and autobiographical prospection is not in their relative structures, for each has a narrative form. The difference is in their perspective. Autobiographies are narratives told from the first-person perspective to explain one's own actions. They require that the actor be able to say "I." Biographies are narratives told from the third-person perspective to explain someone else's actions. They do not require that the actor be self-conscious or capable of telling the explanatory story, only that some narrator or other be able to tell a veridical story about the actor. This is what it meant by the claim that intuitive prospection is biographical, not autobiographical.

Do cows have intuitive prospection? To show that they do we would need to show that a story is available to explain cows' behaviors. The next section attempts to do just that by drawing on work of Peter Carruthers concerning animal metacognition [49–51].

## 5.8 Bovine Prospection: Belief and Desire

At $t_1$ Betsy possesses three mental states:

(1) BELIEF [feed is in tub]
(2) BELIEF [if tub is reached, eat]
(3) DESIRE [eat]

(1)–(3) automatically produce movement at $t_1$ as Betsy stretches her neck toward the tub. Betsy engages in this behavior regularly, unreflectively perceiving food, positioning her body to ingest it and swallow it. If this were all there were to Betsy's behavior, then we should do away with the reference to BELIEF because we could explain her behavior more simply in stimulus-response terms.

Like most of our movements while eating, a cow's movements while eating are caused by subcortical neural networks operating below her level of attention. The external world stimulates a perception, the relevant subcortical pathways process it, and Betsy eats. In these cases, the "Betsy's mind is blank" interpretation is validated by the evidence. The sight of feed is the rewarding stimulus and Betsy's unreflective reaching for it is the response. We can always expand our explanation and interpret her behavior in terms of beliefs but, in the ordinary case, there is no need and Morgan's canon tells against the expanded explanation. Sub-threshold neural interactions suffice to explain uninterrupted eating behaviors. End of story.

However, as it happens during this particular meal, Betsy cannot reach the tub. Caught up short in satisfying her desire, she must now turn attention to what she is doing. Here, at $t_2$, she finds herself with a genuine belief; that is, one that cannot be explained by the stripped-down stimulus-response apparatus:

(4) BELIEF [feed is unreachable]

(4) introduces a matter that Betsy's automatic systems cannot handle. *Additional effort required to reach the goal! How to proceed?* She pauses. Perhaps she feels some anxiety. Perhaps she wonders if she is still committed to (3). I am not suggesting that Betsy is carrying on an internal monologue with herself conducted in the English sentences found here. But I am suggesting that she has some kind of cow-ese, some kind of representational format in which to do her thinking. The format need not be language-like; it might be more like a map, or like music, or like gestures. It might even have more to do with odors. Whatever the internal bovine representational format, Betsy must be able to use it to represent, interpret, and interact with the external world [52]. If she finds that she still wants to eat, then she must use her thinking tools to inhibit her current urge to press again, only harder, against the stanchion. She needs a novel strategy. She calculates.

At $t_{3,}$ Betsy has a new set of attitudes:

(5) BELIEF [if tub is not reached, do not eat].
(6) BELIEF [tub cannot be reached unless neighbor moves]
(7) DESIRE [neighbor moves]
(8) BELIEF [neighbor does not move unless *this* lock opens]
(9) BELIEF [this lock does not open unless head is used]
(10) BELIEF [if head is used, this lock opens]
(11) BELIEF [if head is not used, this lock does not open]
(12) DESIRE [this lock opens]

The frustration of her initial strategy combined with the causal reasoning found in (10)–(12) results in her deliberately extinguishing the instinct to push harder and harder against her stanchion. Instead, she pauses, looks around, and then backs away from the stanchion. She carefully repositions her head and slides open the lock. Backing out, she again briefly surveys the scene and turns to the next challenge, moving her neighbor.

At $t_4$, Betsy has taken on another set of beliefs and desires:

(13) BELIEF [*that* lock does not open unless tongue is used]
(14) BELIEF [if tongue is used, that lock opens]
(15) DESIRE [that lock opens]

The combination (13)–(15) produces the use of her tongue to open the neighbor's lock. This updating of mental states continues in an iterative process until she is finally able to reach the tub. At that point, at least 20 s after $t_1$, her story is complete. The obstacles that arose as she strived to bring a future state into existence have been overcome. She does not know the story that unifies her beginning intention with her final achievement, but we do.

Notice that the analysis is not autobiographical because nowhere in it do we find the subjective words I or me. Beginning with (4), a plot begins to form as an unexpected challenge comes into play and presents an obstacle the actor must confront. Unlike the combination of (1)–(3), the beliefs and desires constituting (1)–(15) represent a temporal series of desires and beliefs united by an individual's psychology grappling with a problem. To this extent, a narrative is required to explain the coherence of the set. The story, told from the third-person stance, is not autobiographical. It does not require that the actor have a theory of mind. Nor does it invoke metacognitive states such as *imagining* one's future bodily location, *regrouping* oneself after an initial defeat, *envisaging* others' emotions, or *judging* the fairness of their actions. While Betsy's story is not a first-person narrative, nevertheless, it is a narrative.

Betsy's prospection, then, is biographical. If this analysis of bovine prospection is correct, we can proceed to look for neuroanatomical evidence to see whether cows have structures to support the mental states just ascribed to them. To do this we must determine whether cows have neural pathways that support belief and desire and their selective inhibition. Since little is known about the neuroanatomic pathways in bovine limbic systems, let us begin with our own case. Localizing belief and desire in the human brain can provide starting points as we try to peer into the cow brain.

## 5.9 Neural Correlates of Human Desire

By desire I mean the positive attitudes of wanting, yearning, craving, and liking. By the satisfaction of a desire I mean the pleasurable state that accompanies desire's fulfilment. For example, hunger and thirst are desires and it's a pleasure to have them satisfied. Desires can be conscious or unconscious (although probably not nonconscious). According to MacLean's triune interpretation [53] of the human brain—a convenient approximation if no longer a sound scientific theory—unconscious desires are localized in the evolutionarily most ancient, so-called reptilian, brain: the lower, subcortical, third of the organ. Conscious desires necessarily involve the youngest, most recently evolved third of the human brain, the so-called neomammalian complex, or neocortex [53]. To have self-aware, conscious desires, then, seems to require in humans a neocortex (although, for important qualifications, see LeDoux [54], Merker [55], and Philippi et al. [56]).

The affective neuroscientist Jaak Panksepp interprets desires as part of the reward system of the brain, the approach and avoidance systems [24, 57], or what Panksepp dubs the SEEKING system. The SEEKING system animates us, moves us forward, and promotes "an energized appetitive disposition, which unconditionally promotes exploration and foraging for resources..." [57]. It can function consciously or unconsciously, operating above or below the level of phenomenal consciousness

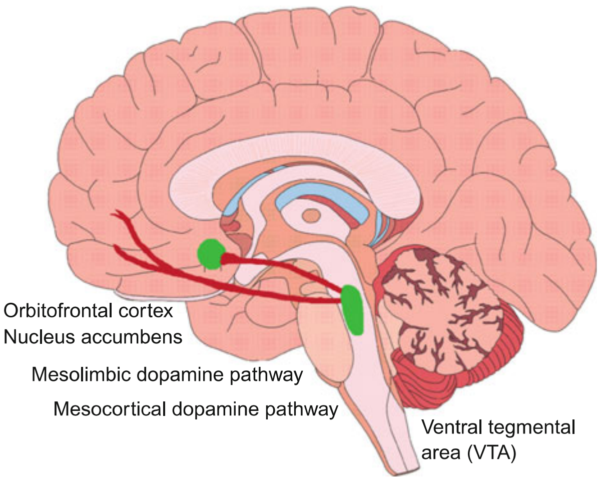

**Fig. 5.1** The reward system: liking, wanting, learning. Reprinted with permission from Elsevier [59]

and executive control. When the system involves the cortex, we consciously assess whether to move toward the pleasurable opportunity, be it an offer of companionship, protection, knowledge, affection, or sustenance. When the system does not involve the cortex [24, 58], we gravitate unthinkingly toward the reward, especially if it appears to be easily obtained. A partner of the SEEKING system is the FEAR system, which can launch us without thinking into rapid avoidance behavior. The SEEKING system can launch us without thinking into rapid acquisitive behavior. For this reason, it is the top prospect as the neural network recruited by the brain during intuitive prospection.

As suggested in Fig. 5.1, the human SEEKING system is set in motion by the ventral tegmental area (VTA), the green area in the midbrain, inside the pons, to the right, posterior, end, of the figure. When the VTA receives a representation of a rewarding stimulus from the eyes or nose, it immediately sends dopamine to the nucleus accumbens (also called the ventral striatum, of which it forms the largest part). It is the green area to the left, or anterior, end of the figure [60]. The VTA and nucleus accumbens are connected by the *mesolimbic dopamine pathway*, the topmost pathway in red. This pathway is contained within the subcortical basal ganglia of the medial forebrain [59] and is recruited for fast, "quick and dirty" processing. It accounts for desires without awareness. Electrical stimulation of this pathway causes feelings of pleasure, desire, and novelty seeking [61] whether or not one consciously seeks such feelings. Call it the subcortical road.[1]

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[1] Analogously, Joseph LeDoux identifies two pathways involved in fear processing [62] originating at the sensory thalamus. An unconscious pathway connected to the amygdala is recruited for fast and approximate processing. LeDoux says it sponsors fear without awareness. A conscious pathway connected to the cortex is recruited for slower, more precise processing. LeDoux says it sponsors conscious fear.

When a reward can be easily achieved, the subcortical road "coaxes" dopamine out of the nucleus accumbens and an immediate choice is made to pursue the pleasurable stimulus [63]. When a baby glimpses the smiling face of his mother, the subcortical road is activated and he moves toward his mom without thinking about it. When a rat is faced with a simple learning task, such as pressing a button to obtain a low reward (say, two food pellets), the subcortical road is activated [64]. The role of the mesolimbic dopamine pathway in desire is well-established. Amphetamines and cocaine cause fivefold increases in the level of dopamine along the subcortical road [65]. Heroin, nicotine, marijuana, and alcohol all stimulate dopamine production in the area. Since drug addiction is a behavior difficult to overcome, and since the subcortical road is a set of processes not under one's executive control, the mesolimbic path has become a key target for scientists researching new therapies for drug abuse [66–69].

The SEEKING system is also recruited during deliberative prospection which uses a second pathway, the *mesocortical dopamine pathway*. Running parallel to the mesolimbic pathway, it too originates at the VTA but, sidestepping the nucleus accumbens, heads directly for the orbitofrontal cortex [59]. It is activated when the pursuit of an unconscious desire is frustrated and we need more time and planning to achieve the goal. If one must assess one's options, negotiate obstacles, or find alternative means of reaching a goal, this cortical road leaps into action. By connecting the executive systems in the cortex with the subcortical limbic circuits, it is also capable of initiating top-down "stop" signals to extinguish initiatives in the limbic system.

In sum, the mesolimbic and mesocortical pathways handle different tasks and in different ways. When a simple cognitive task has an obvious low-cost solution, the subcortical road suffices and acts quickly. If you lesion the mesolimbic pathway of a rat, the animal gets slower at responding to rewarding stimuli [64]. If the task is more complex and demands cognitive effort and judgment, the mesocortical pathway takes over. If you lesion the mesocortical pathway of a rat, the animal becomes less likely to expend extra effort if it is required to achieve a high reward (say, four food pellets) [64]. These findings are consistent with the idea that when an animal no longer has access to its limbic system, it loses much of its ability to react quickly and grab rewards. And the findings are consistent with the idea that when an animal no longer has access to its cortex, it loses much of its ability to inhibit its impulses, accurately assess longer-term costs and benefits, and make prudent utility calculations.

The two pathways are dissociable [70]. While the subcortical road handles easy learning tasks, the cortical road handles more complex tasks. Put speculatively, if the mesolimbic pathway is recruited for unconscious seeking behavior, it is probably recruited for intuitive prospection. And if the mesocortical pathway is recruited for conscious seeking behavior, it is likely at play during deliberative prospection.

Having reviewed what is known about the neuroanatomy of human desire, what do we know about the cow?

## 5.10 Neural Correlates of Bovine Desire?

Does the cow recruit brain structures similar to ours when the cow exhibits desires about its future? We know little about the correlates of bovine desire; I am unaware of any fMRI studies of cow brains. The problem, as George M. Strain, Professor of Neuroscience at Louisiana State University, puts it, is that:

> Not many people are interested in bovine neuroanatomy or neurophysiology. . . .You won't have any luck finding neural correlates of 'desire' in cattle . . . because we don't recognize such as being present in animals, or at least have no way to identify it and measure it (personal correspondence, 19 June 2018).

Given the state of research, we cannot say definitively that cows have a SEEKING system similar to humans. However, given what we know about the mesolimbic pathways in humans, rats [54], rhesus monkeys [55], and other mammalian species [56], we can make some informed predictions about the cow brain. While we know that there are differences between the human and bovine brain—including their respective size, the structure of the frontal cortex, encephalization quotients, and number of A10 cells in the VTA [57]—whether such differences make a difference to whether a cow can look forward is still to be determined. However, given our shared evolutionary history, and extensive similarities between all mammalian brains, it is not unreasonable to hypothesize that we may eventually find in cows the bovine equivalents of the human neural SEEKING system. Figure 5.2 illustrates this prediction.

Is a cow's VTA connected to its nucleus accumbens by a subcortical mesolimbic dopamine pathway? If so, we should predict that cows recruit it during unconscious seeking behaviors. Should this hypothesis prove to be correct, we would have empirical support for the claim that cows have intuitive prospection. For, as the Russian biologist Dobzhansky observed, "nothing in biology makes sense except in the light of evolution" [72]. And it would make little evolutionary sense for an animal to expend energy developing and maintaining a complicated set of neural pathways and structures if they did not serve a key function. This is some reason to believe that the physical structures seen in Fig. 5.2 support prospective feelings in cows, if the structures exist in cows, just as similar structures support prospective feelings in us.

Perhaps, however, we are moving too quickly. Critics may point out that not all of an organism's traits are adaptive. For example, vestigial organs are useless historical accidents that continue to get passed from generation to generation (think human tailbones, male nipples, or wisdom teeth). It is possible that a cow's VTA, nucleus accumbens, or dopamine pathways are not adaptations and do not serve the functions in cows that they serve in humans. The evolutionary path leading to humans may have involved exapting the neural structures in question.[2] If our VTA, nucleus accumbens, and dopamine pathways were originally selected for purposes other

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[2] Thanks to Andrew Fenton for pointing this out.

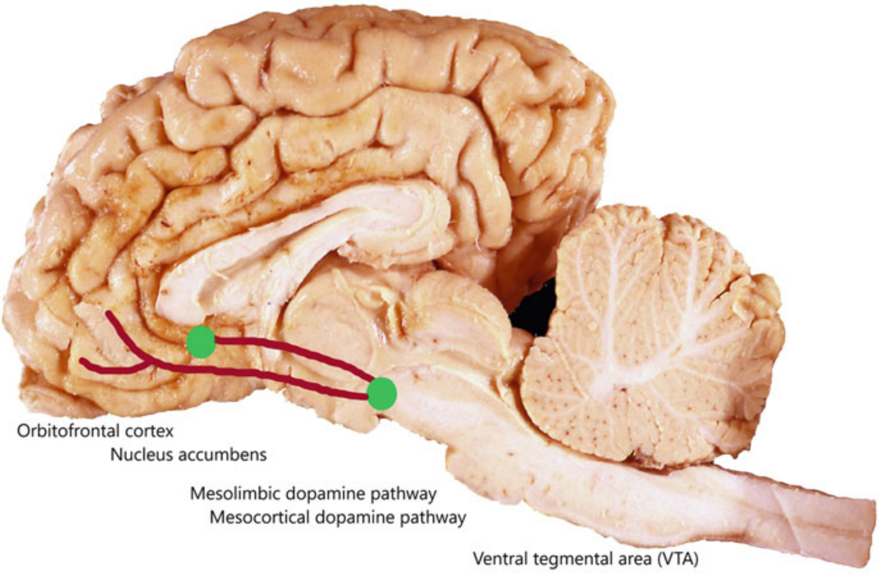

**Fig. 5.2** Prediction: bovine SEEKING system. Figure based on midsagittal view, "The brain of *Bos taurus*, version 3.0" [71], reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed and brain circumference outline removed

than the purposes they serve in humans today, then the fact that cows also have them will not suffice to show that they support the same functions or feelings in cows as they do in humans. A critic might object to my argument by pointing out that individual humans may have been selected over time because they possessed novel adaptive traits that co-opted the VTA and nucleus accumbens and put them to new uses. In that case, and according to this line of objection, then the argument from analogy between cow and human neural architectures fails to show that individuals of both species have similar feelings as well as structures because shared structures may support different functions.

In response to this objection, it is important to note that neural pathways and brain connectomes are not organs like wings, tailbones, or appendices. Unlike a vestigial trait that comes to be used for a function for which it was not originally selected (e.g., feathers originally selected for capacity to regulate temperature, not to fly), a complex network of neural connections must be strengthened through repeated use in order to support the original function for which it is selected. While such connections may be exapted over time and so enlisted for new uses, complex neural structures such as those under consideration are unlikely to be constructed in the first place unless they are being used repeatedly for some complex psychological purpose. Since neural architectures are far more complicated than limbs or organs, it is hard to see why these architectures would have been chosen had they not originally served in our last common ancestor with cows something like the functions the traits now serve in us.

It also seems that the structures in question are old and dedicated. That is, their presence in animals of different species is evolutionarily ancient and their functioning does not appear to require other, widely scattered, brain areas in the way that human language, for example, does [73]. If the VTA and nucleus accumbens are connected in cows, then the bovine pathway may sponsor in cows the tacit anticipatory feelings that the human pathway sponsors in humans. I do not take these claims to refute the objection. However, if my assumptions are correct, the objection is weaker than it initially appears. It is not implausible to conclude that the presence in cows of the human-like neural structures identified above would provide a reason, a powerful albeit defeasible reason, to believe that cows have something very like the mental states supported by these structures in humans.

In addition, we may ask whether cows have a cortical road connecting the VTA to the frontal cortex. If they do, this fact would provide reason to believe that cows can exercise executive control, inhibit urges, and consciously plan strategic interventions to achieve their goals. I admit, however, that this conclusion is far from established. Further research is needed, in any case, to determine whether cows have a mesocortical dopamine pathway.

Having completed a survey of how human and bovine brains may handle desire, what do we know about how they each handle belief? Unlike the SEEKING system, our beliefs appear to be impossible without the cortex. Begin again with the human case.

## 5.11 Neural Correlates of Human Belief

Which regions of the cortex are recruited to support which beliefs probably depends on the complexity of the belief. We know that more complex beliefs expressed in propositions and narratives take a longer time and a greater area to process than do simpler beliefs expressed in words.

At Uri Hasson's lab at Princeton, undergraduate experimental subjects listened to short stories while researchers mapped their cortical activations using fMRI [74]. As the task went from simple to complex, the time it took the brain to process the ideas took longer and longer and involved more and more regions. When the subjects first heard a short story, they heard gibberish because it was played in reverse. In trying to make sense of incoherent noises, the subjects recruited only a small part of their temporal lobes. Figure 5.3 shows these sections in red, the sections posterior (P) to the lateral sulcus (LS). When the sound played was an intelligible word, however, the yellow areas were also recruited, the posterior (P) regions of the superior temporal sulcus. If an entire sentence was played, the larger green areas were added, areas stretching toward the temporal-parietal junction (TPJ) plus regions anterior to (A) the central sulcus (CS). When subjects heard an entire paragraph, distant expansive blue regions of the brain were activated, including medial prefrontal cortex (mPFC) and intraparietal sulcus (IPS).

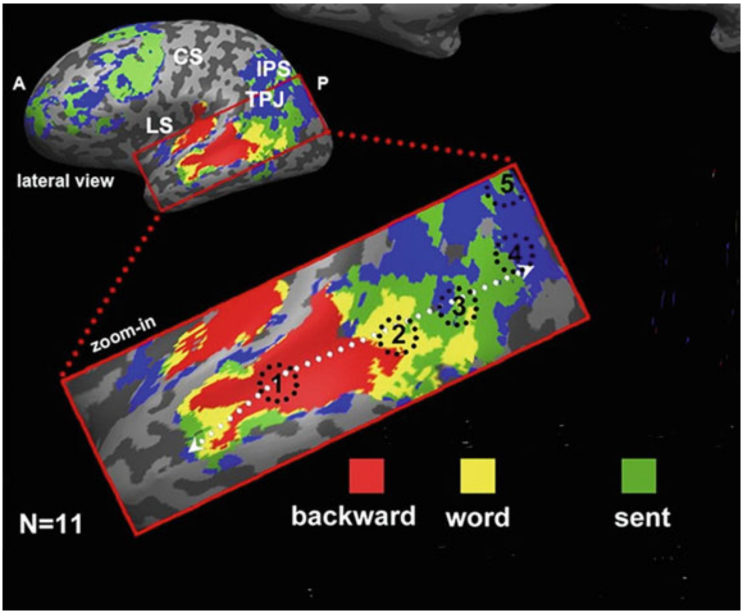

**Fig. 5.3** Hierarchical topography of temporal receptive windows in fMRI image. Reprinted with permission of *The Journal of Neuroscience* from [74]. Figure cropped and modified with permission of Uri Hasson

Lerner et al. call the length of time it takes for the brain to make meaning out of sounds a temporal receptive window. Generally speaking, we require at least a half second to process a word, 3 s for a sentence, and 17 s for a paragraph. As we move from comprehending a word to a sentence to a story, our temporal receptive window expands as does the area of the brain in play.

It is not implausible to think that the red, yellow, and green areas activate during deliberative prospection as we form narratives about the who, what, and where of the future. Nor is it a stretch to think that the blue "paragraph" areas must also be recruited when, during autobiographical prospection, we form stories about our future. Going forward, at least, I shall help myself to these assumptions.

## 5.12 Neural Correlates of Bovine Belief: What Do We Know?

We know almost nothing about how cows process beliefs. However, basing our hypotheses on what we know about humans and other mammalian species, we may again hazard a prediction. We may predict that differences in the complexity of bovine beliefs will be reflected in patterned differences in bovine brain activation. For example, should a cow hear an incoherent noise and try to make sense of it, part of her cortex may be activated, perhaps the red area near the lateral sulcus (LS) indicated in Fig. 5.4.

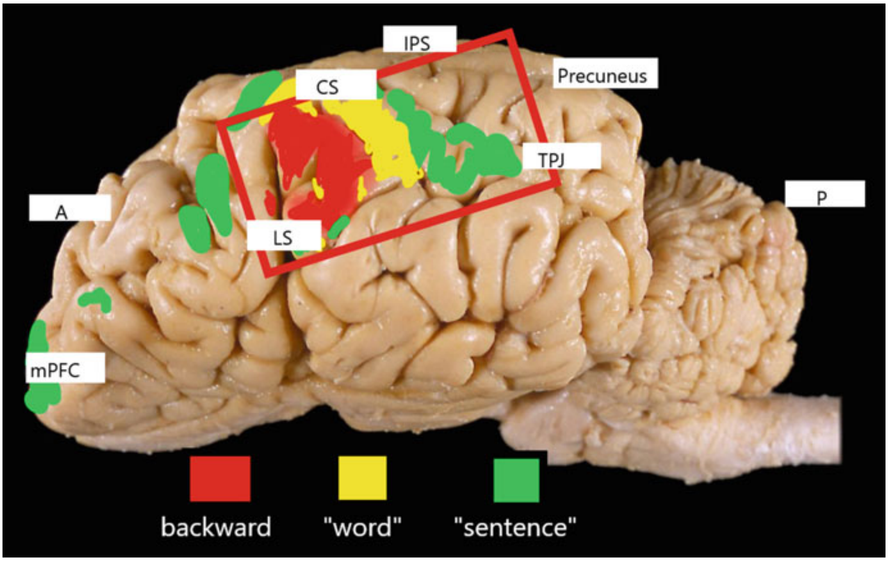

**Fig. 5.4** Prediction: bovine BELIEF system. Figure based on lateral view figure of "The brain of *Bos taurus*, version 3.0" [71], reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed

On the other hand, should the noise turn into a recognizable vocalization of one of the animal's familiars—such as a cow's low frequency call for her calf [75]—larger regions, I now hypothesize, become involved. Call the yellow areas plus the red area, somewhat tendentiously, the cow's WORD system, here proposed to involve areas posterior (P) to the central sulcus (CS). If cows can process even longer and even more complex vocalizations—such as higher frequency extended bellows intended to coordinate social interactions [61]—it may be that the larger green areas are needed. These may include regions, as in humans, anterior to the temporal-parietal junction (TPJ) and the medial prefrontal cortex (mPFC). Call this the cow's SENTENCE system. I understand beliefs and desires in terms of propositional attitudes. There are many propositions that can be represented in any one of the thousands of human languages spoken through time. Cows do not speak any of these languages, but they may nonetheless think using analogous representational formats. Imagine that cows use, say, images, maps, rhythms and melodies, or gestures to represent objects and ideas to themselves and others [52, 76]. In that case, cows have words, the cognitive tool needed to represent objects even if cows lack narrative, the cognitive tool needed to represent selves.

Few would predict that cows understand, or will come to understand, human assertions, much less narratives. However, I leave open the possibility that cows may have a capacity to process beliefs and desires expressed in bovine terms more complicated than the bovine WORD system can handle. Thus, Fig. 5.4 proposes green areas. However, since we have no reason to think cows have autobiographical capacity, Fig. 5.4 has no blue areas.

Let us sum up before moving ahead. We have behavioral evidence that cows form intermediate-length intuitive prospections, that is, prospections that look dozens of seconds into the future. We have neuroanatomical hints that their brains may have the structures necessary to support such intuitive, narratively structured, prospections. And we have testable hypotheses to determine whether these structures are recruited when cows ostensibly prospect. But now, again, comes the hard question. Is a cow's prospection *conscious*?

This is an impossible question to answer because it is not well formed. We mean too many different things by "conscious." In fact, the language used in this area quickly becomes confusing, as Panksepp's identification of "anoetic consciousness" and Carruther's category of "nonconscious experience" exemplify. The usual strategy of trying to address the issue is to define the characteristics of what we take consciousness to be in humans and then ask whether this or that animal has those characteristics. This strategy has not proven fruitful. I agree with Carruthers that we should stop asking whether animals are conscious "not because they aren't," but rather "because [there's] no fact of the matter [77]." Instead, we can ask a more tractable question.

## 5.13 Is a Cow's Prospection *Like Ours*?

To try to answer this question, we must first ask who we are. I assume "we" includes aphasic nonreporting humans who cannot tell us whether they are conscious prospectors. And I will assume that they are, in fact, conscious prospectors. By an aphasic nonreporting human, I mean an individual who congenitally lacks the autobiographical capacity to understand their life as a story.

## 5.14 Belief and Desire in Neotenic Complex Syndrome

An adult with neotenic complex syndrome may provide an example. Brooke Greenberg could not construct, follow, or understand her life as having a narrative arc because of profound delays in her mental development. When she died at age 20 she had never spoken, read, written, walked without support, fed herself, controlled her bladder, passed false-belief tests, or lived independently. She was capable of recognizing family members and enjoyed playing with her sisters and rocking in swings. She could "vocalize for attention and occasionally smile/laugh socially" [78]. She had, as one of her doctors put it, the "cognitive development" of "a child less than 1 year old" [78]. An MSNBC production, "A Child Frozen in Time," shows Ms. Greenberg at age 16 in her walker, looking ahead toward the homeroom of her special education school building [79]. She slowly scoots ahead, propelling herself down the hall. When she reaches the spot, she turns right, to the delight of everyone, including her mother, her teacher, and herself.

Let's go back to the first frame. At the beginning of the sequence, she is peering down the hallway preparing to launch herself toward her homeroom. As she begins to push herself forward, she intends to move ahead, her behavior is goal-directed, and she has a representation of where she wants to wind up. But is it correct to say that she travels mentally through time to envision the future moment at which she will have reached her goal? I think this is unlikely given the limits of her cognitive capacities. However, along her way down the hall she inhibits the urge to give up and collapse in her walker. We see an aide pulling her along at one point, but Brooke does not want assistance and she perseveres on her own. We can easily imagine her encountering a janitor's cart that blocks her path and her responding to the challenge by devising a way around it.

Three descriptions of Ms. Greenberg's mental state at the beginning of the hallway sequence are available.

(A) There's my Mom, my teacher, and Grandma in front of my homeroom. When I maneuver my way into the classroom, I hope they don't jump up and down in front of the students like they did yesterday. I know they want to cheer me on, but they embarrass me when they make a show.

(B) BELIEF [if target room is entered, smiles all around].
BELIEF [if target room is not entered, no smiles all around]
DESIRE [smiles all around]

(C) [*blank*]

Notice that in (C) Brooke has no beliefs or desires, no conscious states; she's not feeling anything. Defenders of this option might point out that Brooke lacks language and cannot form beliefs about the future. The first response is autobiographical prospection, the second response is intuitive prospection, and the third answer is stimulus-response. Which is correct? I'll argue for the second.

We have no grounds to adopt (A), the first, autobiographical, interpretation. To attribute such thoughts to Brooke we would have to assume that she is conscious of her own thoughts and body and has a theory about the intentions and thoughts of others, beliefs about what motivates them, ideas about how they perceive her, and a sense of what justice requires. We have no evidence to attribute such thoughts to her, no evidence that she has the capacity for moral agency or the mental facility either to construct narrative plots or attribute moods to characters. Absence of evidence is not evidence of absence, but neither is the promise of forthcoming evidence the bringing forth of evidence (for further discussion, see [80]).

Nor is there any reason to think (C), that her mind is blank. To the contrary, she has a unified perspective on the world which she vocalizes to express pain or happiness, frustration or accomplishment, discouragement or satisfaction. She can recognize friends and foes. She has basic emotions, beliefs and desires, and executive control over them. She can aim at goals, devise hypotheses for achieving them, and choose rationally among those hypotheses. She has a welfare and can be harmed or benefitted, and she can decide on strategies to overcome obstacles in her way.

## 5.15 Nonreporting Human Intuitive Prospection

A first-order biographical analysis of Brooke's mind would begin at $t_1$ by attributing three mental states to her:

(16) BELIEF [if target room is entered, smiles].
(17) BELIEF [if target room is not entered, no smiles]
(18) DESIRE [smiles]

(16)–(18) are unconscious states presumably processed by the mesolimbic pathway. They automatically produce leg-moving behavior at $t_1$ as Brooke propels herself forward without thinking. If (16)–(18) sufficed to move Brooke into her room, then she would not need to recruit the mesocortical pathway and we could do away with the reference to BELIEF because we could explain her behavior in subcortical, stimulus-response terms. In most instances, Brooke's movements in her walker are unreflected upon and unavailable for her to reflect upon. If this were a complete description of the episode, then the "Brooke's mind is blank" interpretation would be validated by the evidence. In that case, and contrary to the facts, her perception of the room would be the rewarding stimulus and her automatic movement into the room would be an unfelt response. We could always go on to interpret her behavior in terms of beliefs but there would be no need and doing so would violate Morgan's canon. In the imagined case, subthreshold neural interactions suffice to explain behavior. End of story.

However, as it happens, Brooke cannot reach the room directly. Interrupted in her attempt to satisfy her desire, she must now turn her attention to what she is doing. Here, at $t_2$, she finds herself with a genuine belief, one that surprises her and one that cannot be explained by the stripped-down stimulus-response apparatus:

(19) BELIEF [path is blocked]

(19) introduces a matter that Brooke's automatic systems cannot handle. *Additional effort required to reach the goal! How to proceed?* She pauses. Perhaps she feels some anxiety and wonders whether she is still committed to (18). I am not suggesting that Brooke is carrying on an internal monologue with herself conducted in the English sentences found here. But I am suggesting that she has some kind of tacit language of thought she uses to represent and interpret the world. If she finds that she still wants smiles, then she must inhibit her current urge to press again, only harder, against the janitor's cart. She needs a novel strategy. She calculates. Is the reward she seeks worth the effort? Yes, she decides. Now, at $t_{3,}$ still desiring to make others happy, she thinks:

(20) BELIEF [if path is blocked, room is not entered]
(21) BELIEF [if alternate path is found, room is entered]
(22) DESIRE [enter room]
(23) BELIEF [alternate path requires left turn]
(24) DESIRE [turn left].

(25) BELIEF [alternate path requires right turn].
(26) DESIRE [turn right].

Calculation begins. Combining (20)–(22) with (23)–(26) and making the relevant utility assessments, the cortex, as it were, determines that the goal is worth the effort. It promptly sends a signal down the mesocortical pathway that is strong enough to stop the mesolimbic system from continuing to urge renewed pushing against the janitor's cart. The prefrontal cortex commands a novel twisting motion and the motor cortex responds, engineering new leg thrusts to the left and then to the right.

At $t_3$, a few dozen seconds after $t_1$ and after clearing the janitor's cart, Brooke has two new beliefs:

(27) BELIEF [push straight ahead, enter room].
(28) BELIEF [do not push straight ahead, do not enter room].

The iterative updating process of narratively connecting mental state sets continues until Brooke, having combined (27) and (28) with (22), completes her plan. At $t_4$, she enters her room, to smiles all around.

We have good reason to deny that aphasic nonreporting humans like Brooke Greenberg have moral responsibility. If one does not have representations of oneself over time or a narrative understanding of how one's personal identity in the past is related to one's future, one cannot understand how one's actions are connected to their consequences [81]. Likewise, for individuals with depersonalization disorder or dissociative amnesia, moral accountability may be compromised or nonexistent. In conditions in which one cannot locate one's identity, one cannot be regarded as a morally autonomous agent. Nonetheless, such beings can be moral patients, and moral patients can be harmed. They are not by virtue of their psychological limitations open subjects for exploitation.

We have no reason to deny that aphasic nonreporting humans like Brooke Greenberg intuitively look forward to things in their future. It feels like something to be them looking forward. With a little imagination, the rest of us can come to understand much of how that feels, too.

## 5.16 Conclusion

Is all cow prospection nonconscious? The behavioral evidence suggests otherwise. Cows aim at goals, suppress urges to act instinctually, turn their attention to what they are doing, and negotiate obstacles in the way of their goals. They can look several dozen seconds, at least, into the future. We can tell stories about how they are dealing with twists and turns in the plots they, unbeknownst to them, are living out. If neuroanatomical research shows what is unlikely—that cows lack a mesocortical pathway—then we may have reason to doubt that cows can take an interest in their future. In the meantime, given the evidence of mesocortical pathways in other mammalian species, we have little justification to think cows lack a cortical road.

While I have not definitively shown that cows have intuitive prospection, I have accomplished two preliminary tasks. First, I have described a research program to test for bovine intuitive prospection. And, I have noted that the weight of evidence lies on the side of the assumption that cows seek, anticipate, and look forward.

How to get inside a cow's head? First, think about who *we* are: a varied lot, with a diverse range of cognitive capacities. Second, follow Temple Grandin's gesture that "[a]utism is a kind of way station on the road from animals to humans" [82]. Third, assume, as we must, that *we* includes aphasic nonreporting humans with severe cognitive limitations who look forward to their futures. Assume, further, that some autistic people think in alternative representational formats, such as pictures, and that cows think in these formats, too. If all of these claims are true, as I believe they are, cognition may not require propositional thought at all. Finally, ask: Are there any morally relevant differences between the intuitive prospection of some of us and the intuitive prospection of some cows? I don't see any.

How then should we treat cows? This is a question for another day. Note, however, that if cow neuroanatomy turns out to be as predicted, cows probably can take a morally relevant interest in what is to come. This much does not establish that feeder calves have a right to life that we violate when we slaughter them for beef. However, it makes a nonstarter out of the idea that those calves must lack a right to their future because they lack the capacity to take an interest in it.[3]

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[3] I am grateful for comments from Bill Bauer, Veljko Dubljevic, Robert C. Jones, and Eze Paez. I owe special debts of gratitude to the editors, L. Syd M Johnson and Andrew Fenton, for assistance in clarifying the argument; to Floris Wouterlood for providing the cow brain figures; and to Stevan Harnad for an invitation to discuss the ideas at the 2018 University of Québec at Montréal Summer School in Animal Cognition.

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# Speciesism and Human Supremacy in Animal Neuroscience

# 6

Robert C. Jones

> *Our anthropocentric way of looking at things must retreat further and further, and the standpoint of the animal must be the only decisive one.*
>
> Jacob von Uexküll (quoted in [1], p. 53)

**Abstract**

Since epistemic access to the mental lives of animals is limited even more than it is in our human conspecifics, caution about cognitive attributions to nonhumans may be prudent. However, too often skepticism regarding animal minds, cognition, and experience (e.g., reluctance to attribute thoughts, beliefs, phenomenal consciousness, and sentience to certain taxa) is justified by reference to physiological heterologies in neural structure/complexity between humans and the other animals. An example is the argument that fish cannot experience pain because they lack the requisite neocortical structures. In this chapter, I contend that these kinds of scientific and philosophical arguments reflect a kind of *anthropodenial* embedded in speciesism and, specifically, human supremacy and neurotypicalism. I further argue that there is good reason to believe that vertebrates such as fish—and even some invertebrates such as crustaceans and insects/arachnids—are experiencing beings, that there is a what-it's-like to be them, and that these conclusions have ethical implications.

**Keywords**

Speciesism · Sentience · Human supremacy · Animal cognition · Animal rights · Animal liberation

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_6

## 6.1 Introduction: Speciesism and Human Supremacy

Much of canonical Western philosophical theory (along with Western scientific and cultural thought) is anthropocentrically speciesist. As with other *isms*, anthropocentric speciesism (hereafter “speciesism”) can be interpreted in various ways. Singer sees speciesism as a state of ignorance, a mistaken belief about the moral superiority of all humans over all nonhumans [2]. Sanbonmatsu views speciesism as the central organizing principle of the human project, the basis of a kind of universal, civilizational form of bad faith, wherein speciesism operates as a powerful and pervasive social structure—a mode of self-deception—in which we suppress and deny that speciesism is a way of being that we freely choose and ignore our own conditions of possibility or transcendence [3]. Belcourt argues that speciesism—particularly in North America—is a vestige of the white supremacy manifest in the erasure of Indigenous bodies and the emptying of Indigenous lands for settler colonial expansion [4].

However one conceptualizes it, speciesism assumes that humans occupy a moral sphere separate from and superior to all the other animals by virtue of being human. Seen as a kind of human supremacy, speciesism is committed to the claims that humans are *unique* in their possession of some metaphysical entity (like a soul), divine relation (e.g., uniquely made in God’s image), trait (like species membership), or set of capacities within the physiological or cognitive domains and that the possession of such substances, relations, traits, or capacities makes all and only humans morally superior to beings (such as nonhuman animals) who lack such sundry properties (although this view is compatible with other animals having moral interests). Ignoring the metaphysical and religious aspects of it, the first claim is largely empirical, and the second normative [5]. These two claims constitute the two fronts on which those philosophers seeking to expand the moral status of nonhuman animals mount their attacks in an attempt to dismantle the foundations of human supremacy.

## 6.2 Sentience and Comparative Neuroscience

Central to the strategy employed by those philosophers who seek to undermine human supremacy and reenvision the moral status of animals has been an attack on its empirical aspects by presenting evidence from science, and increasingly neuroscience, that demonstrates the possession by some nonhuman animals of some set of morally relevant physiological or cognitive capacities. When successful, arguments of this kind undermine the first prong of the human exceptionalist thesis. Thus, one strategy for philosophers of animal ethics has been to question the existence of a clear distinction between all humans and all other animals with regard to the possession of what are seen as morally relevant capacities. The candidate capacities—sentience, self-awareness, memory, and theory of mind (also known as mindreading)—are not the only capacities that bear on the moral status of individuals, but often play a central role in debates regarding the moral status of nonhuman animals. Since the claim that humans are unique in their possession of some set of morally relevant cognitive capacities is an empirical one, it is quite useful—and, in some cases, indispensable—to see what neuroscience has to say about which animals possess which capacities, making the empirical data on this question central to the question of the moral status and treatment of nonhuman animals. For example, with regard to sentience, if no clear distinction can be empirically drawn between humans and animals, then the foundations of human supremacy may—at least in theory—be substantially reenvisioned.

It's important at this point to briefly clarify what I mean by *sentience*. Though in its broad sense the term *sentience* can refer to the capacity for *any* kind of conscious experience, the more narrow sense of the term as employed in the animal ethics literature (and throughout this essay) refers specifically to conscious experiences with an attractive or aversive quality. These capacities include experiences such as pain and pleasure, suffering, anxiety, and fear [6]. Though capacities implicating sentience are crucial in determining which beings are the proper objects of moral concern, some caution is in order. Since our epistemic access to the experiential lives of animals is arguably even more limited than access to the experiential lives of our conspecifics, it is prudent to be cautious about attributions based on comparative neuroscience, and selective about the kinds of evidence for such attributions we have at our disposal.

Rogers and Kaplan [7] warn that basing the moral status of animals on comparative cognition and other biological measures can be fraught. Take, for example, the well-known mirror self-recognition (MSR) test [8]. Self-awareness as measured in these kinds of tasks is limited to the visual modality, failing to take into account other modalities of self-representation (e.g., auditory, tactile, and olfactory) as well as certain salient anatomical differences [7]. For example, in a study that translates the MSR study for dogs (a species whose primary sensory modality is olfaction) into an "olfactory mirror" test, Horowitz has shown that dogs can recognize and distinguish an olfactory "image" of themselves [9]. Self-recognition is just one example. When it comes to other physiological and cognitive capacities, including things as basic as sentience, of the almost 6000 extant mammalian species, 10,000 avian species, tens of thousands of reptile and amphibian species, a still greater number of fish species, and millions in both the insect and arachnid classes, only a small fraction have been investigated for such capacities. There is nothing close to certainty when it comes to conclusions drawn from comparative physiological and psychological investigations.

Whatever evidentiary bar we commit to regarding the sentience of a particular animal species, we cannot require anything close to certainty before granting legal protections. A common challenge from skeptics of animal sentience involves questions of the form, "How can one ever really know that species X is sentient?" However, that's a very different sense of "know" from the one used in claims of animal sentience [10]. That's not what scientists who make such claims mean by "know" when they say, for example, that we now *know* that fish are sentient. When one asserts that research now supports the claim that teleosts are sentient [11–13], it's important to reiterate that this claim is provisional (as are all scientific claims), and justified through an inference to the best explanation, a point that Birch makes, and one worth reiterating [6].

Further and related to this worry is the narrow sense in which claims of folk psychology (and, indeed, folk psychology itself) are characterized. For example, the accepted methodological paradigm in animal cognition research characterizes folk psychology as necessarily involving conspecific belief attribution and seeks only evidence of the kinds of behaviors that confirm and conform to this model of psychology. However, Kristen Andrews argues forcefully that the standard account of folk psychology demands more than is necessary, since it assumes that correct prediction of a conspecific's behavior requires the ability to attribute beliefs, false beliefs, and beliefs differing from one's own. Andrews rejects belief attribution as a necessary condition for conspecific behavior prediction, urging researchers to integrate social psychology research on how normal adult humans actually predict behavior [14].

Despite these challenges, given the fact that investigations into nonhuman animal cognition can rarely rely on full-blown intersubjective communication (e.g., spoken language), comparative neuroanatomical methods remain the most reliable metric in our understanding of the mental lives of animals and those capacities that bear on questions of animal welfare.

The research on animal cognition and sentience has mushroomed in the last 20 years, and there are numerous studies on many aspects of animal cognition and sentience. In the remainder of this chapter I'll look only at the issue of animal *pain*, and the current research into animal sentience, with a particular focus on fish pain. The body of research on animal sentience provides an excellent case study for the debate over attributing phenomenal states to nonhumans.

## 6.3 Sentience: Pain and Suffering

The International Association for the Study of Pain (IASP) provides what seems at first blush to be a reasonable definition of pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [15]. The definition is followed by a footnote informing us that "pain is always subjective" and that the IASP definition intentionally "avoids tying pain to the stimulus." However, this definition of pain is both physiologically and philosophically problematic since it emphasizes subjective experience and self-report while supporting conflicting philosophical interpretations of pain (e.g., subjectivist and objectivist views of pain), and it remains silent on the question of the relationship of the physiological bases of pain to its phenomenal aspects [16].

Given that pain and suffering are likely very old phenomenal states, it would be strange if pain did not provide selective advantage, were not widespread across varied species, or did not serve a similar adaptive function in nonhuman animals as it does in humans. Understanding the basic mechanics of pain is imperative to understanding its role in animal sentience. Pain in humans is at least a two-step process. The first step involves the stimulation of special receptors called *nociceptors* that transmit injury detecting electrical impulses to the spinal cord, triggering an automatic reflex response. At this first stage, there are no conscious aspects of the experience. In the second stage, the signal moves from the spinal cord to the neocortex at which point the phenomenal aspects of pain kick in and we experience the unpleasant sensation associated with tissue damage. Though researchers are clear about the mechanisms involved in the first stage, it is the second stage of the process—which includes the affective aspect of pain—that remains somewhat mysterious.

When it comes to nonhuman animal pain we can ask which animals possess nociceptors (or exhibit a "nociceptive response") and whether and how they respond to noxious stimuli, analgesics, and anesthetics. We can further explore which organisms possess neural organs more complex than simple neural nets (e.g., organs such as ganglia, brain masses, or brains) and, of these, which possess nociceptor-to-brain pathways.

A solid methodological framework for an investigation into whether an animal is sentient includes investigating whether a particular organism possesses or exhibits:

- A central nervous system and other structures and psychoactive chemicals homologous to those known to control pain response in humans, e.g., neuroanatomical (opioid receptors, nociceptors) and neurochemical (opioids).
- Physiological or behavioral responses to noxious (or positive) stimuli, analgesics, and anesthetics. Noxious stimuli used in pain research on nonhumans include *mechanical* (such as pricking or probing), *thermal* (heating or freezing), *chemical* (exposure to acidic irritants), and *electrical* (shocking).

Though at first blush these capacities seem clear and well-founded, a little reflection reveals that things are not as straightforward as they seem.

Pain is a notoriously difficult phenomenon to understand, in humans and especially in nonhuman animals. The first challenge involves the fact that data on the high variability between the physiological mechanisms and the phenomenal aspects of pain are often confounding, raising puzzles about the connection between the two. For example, the very same kind of stimuli can elicit a pain response of widely varying intensity (or none) in different human individuals or even in the same individual at different times, making generalizations challenging—even more so when generalizing from humans to animals. Though we have a good idea of how the nervous system detects and responds to painful events in humans, exactly how the human brain processes the stimuli and generates the phenomenal aspects of pain induced by injury remains far less clear.

A second challenge arises from pain asymbolia, a type of dissociation in which human subjects report recognizing the sensation of pain (i.e., "feeling" the pain) while being not at all bothered by it. These reports suggest that pain has both a sensory and an affective component. Cases like these only complicate the issue of animal pain by widening the gap between identifying the mechanical aspects of pain in other species and inferences about the unpleasantness, and therefore the badness, of pain [17].

Despite these challenges, it is reasonable to take seriously the massive corpus of data on animal sentience [18] and not disregard inferences based on those data as worthless in the face of such epistemic challenges. To do so would be to place too high an epistemic warrant on just those inferences that fail to resolve the problem of other minds.

## 6.4 The Evidence for Pain in Nonhuman Animals

In this section, I want to canvass the neuroscience on vertebrate pain. Following this, I will look at the objections to the inferences that researchers have made from these data as excellent case studies concerning charges of anthropomorphism. I will look specifically at an argument against fish pain and elucidate the philosophical, conceptual, and empirical missteps supporting such arguments.

### 6.4.1 Consider Fishes

Despite a handful of skeptics, most researchers and philosophers writing on the subject believe that most typically developing/developed cephalized vertebrates are sentient. However, with regard to fish—specifically teleost, or ray-finned fish—skepticism about pain has persisted even among those ready to attribute pain sensation to other, “higher” vertebrates. Popular interest in the question of fish pain and welfare has abounded in recent years. The escalation of interest in the issue of fish sentience and welfare can be traced back to the publication of two papers.

The first, by Lynne Sneddon [19], made three important findings, namely, that fish possess nociceptors capable of detecting noxious stimuli, that nociceptor-to-fish-brain pathways process nociception signals in a quite similar way as those of the “higher” vertebrates (including humans), and that fish behavior is adversely affected by the administration of noxious stimuli. After confirming the existence of nociceptors and the electrophysiological pathways requisite for the transmission of pain signals, experimenters injected noxious chemical stimuli (bee venom and vinegar) into the lips of rainbow trout. The results demonstrated that the noxious chemicals affected both the physiology (increased breathing rate) and the behavior (decreased appetite) of the trout, responses consistent with pain reactions and behaviors in other vertebrates.

As a suggestive example of pain-related behavior, Sneddon et al. [20] also observed that noxiously stimulated rainbow trout do not display classic fear-response behavior when presented with a novel object (Lego blocks). Control trout spent most of their time moving away from the novel object, whereas noxiously stimulated trout spent most of their time in close proximity to the novel object and showed no additional increase in respiration rate to novel object presentation. The researchers concluded that the noxious treatment commanded the majority of the attention capacity in the fish subjects, evidence that the trout were experiencing some level of pain.

A second prominent paper on fish pain by Sneddon [21] found that the administration of morphine to the lips of rainbow trout injected with noxious stimuli significantly reduced pain-related physiological and behavioral responses. Sneddon concluded that if morphine acts as an analgesic in the rainbow trout, then such pain-related behaviors are not simply reflexes but are rather indicators of pain perception in fish. It's crucial to note that the kinds of inferences that Sneddon and others make here—namely, the inference from the fact that opioids can alter an organism's response to noxious stimuli to the conclusion that the organism feels pain—are subject to debate. The fact that opioids can influence *both* the peripheral and central nervous systems, while only the central nervous system appears to play a role in sentience, makes possible a reduction in pain *behaviors* independent of any phenomenal, affective aspects of the experience of pain. Yet, while Sneddon's inference may be debatable, what *is* true is that had the administration of opioids effected no change in pain behavior, then that observation would have counted as *some* bit of evidence against the hypothesis that the organism feels pain. Therefore, the causal connection between the administration of opioids and an observed decrease in pain behavior counts as *some* evidence to confirm the claim that the organism feels pain. If nothing else, such results are at least *consistent with* the suggestion that these organisms feel pain. Since the publication of those two papers, the research on fish pain has increased dramatically.

Based on research like this demonstrating the presence of pain-related neural structures and behavioral responses, one can infer by analogy that a wide range of vertebrate animals can respond to noxious stimuli with nociception or nociceptive-like responses. The evidence is more sparse for invertebrates. Given the complexity of the phenomenon of pain—that it requires not only nociception but neural complexity, perception, and some level of phenomenal consciousness—at present conclusions regarding non-cephalopod invertebrate pain would be premature. However, as Allen et al. point out, analogical arguments for animal pain that rely on similarities between humans and other nonhuman animals are impoverished in that, for all the physiological and behavioral similarities between humans and nonhuman animals, there are dissimilarities that can be used to deny the inference that nonhumans experience pain [22].

Given these difficulties, we may throw up our hands and conclude that animal pain cannot be studied empirically. Alternatively, we may conclude too quickly and without warrant that scientific investigation has already revealed that many other animal species feel pain. The challenge is to find a framework or program to help us decide when similarity and dissimilarity are relevant when taking on the task of assessing comparisons of anatomy, physiology, and behavior. To that end Allen et al. propose a framework in the form of an empirical research program, one that reasonably assumes a functionalist notion of pain and allows sophisticated comparisons to be drawn between the pain experiences of humans and those of other animals. Although the details of their program are beyond the scope of this essay, the takeaway for our purposes is that inferences from anatomical, physiological, or behavioral evidence to conclusions about animal pain need not be simplistic, overly skeptical, or lacking epistemic warrant.

### 6.4.2 Reconsidering Fishes

Critics of claims of fish sentience argue that fish lack the requisite brain structures for pain and that conclusions about fish sentience are nothing more than anthropomorphism. The work of Rose [23] and, more recently, Key [24] are emblematic of these kinds of responses. The basic argument denying sentience in teleosts (as well as invertebrates) turns on the claim that *human* neocortical structures are required for pain. These arguments share a similar structure and look like this:

P1. Conscious neural processing (M) requires a unique neural architecture (N).
P2. Thus, N is a necessary condition for M (i.e., no N entails no M).
P3. Species X (e.g., rainbow trout) lacks N.
C. Therefore, species X lacks M.

Looking closely and critically at this argument can be quite instructive, specifically with regard to views denying phenomenal consciousness to teleosts (and invertebrates) and more generally to charges of anthropomorphism.

First, these kinds of arguments are rooted in the "bioengineering principle" that structure determines function. However, this kind of reductive analysis of function is problematic. Although biologists commonly *correlate* structure with function, it is an error to argue that an understanding of the neuroanatomical structure of an organism reveals that structure's function. For example, the recent discovery of a heretofore unknown structure of the human cornea (e.g., Dua's layer) certainly did not ensure the identification of its function through only structural information. Furthermore, different structures—for example, teeth and gastric acids—often carry out the same function. Arguments like Key's rely on the assumption that pain is a functional result of one set—*and only one set*—of neuroanatomical structures that humans possess and fish lack. However, this type of structural-functional determinism overlooks the quite real possibility that phenomenal states like pain in fish are realizable by multiple, different means. Allen [25] notes, "[t]he possibility of convergent evolution at the behavioral and cognitive levels despite morphological and anatomical differences at the neurological level makes fish an enormously interesting testing ground for ideas about multiple realizability of cognition" [23].

Second, the central premise—that human neocortical structures are required for pain—begs the question. The claim that because neural structure N is required for mental state M in humans, N is a necessary condition for M in fish is problematic both empirically and philosophically. Biologically speaking, convergent evolution may implement similar functions in structures that are or are not homologous. For example, while it's true that the bone structure of the wings of bats is required for bats to fly, it does not follow that organisms lacking such structures, such as bees, cannot fly. Philosophically, to say that certain human structures are required for fish pain again begs the very question. For even if particular neocortical structures that fish lack but that humans possess are required for *human* pain experience, it does not follow that they are required for fish pain experience.

Third, critiques of this kind trade on a kind of *neurotypicalism*. The term emerged from autistic and neurodiversity communities and describes a species both of human supremacy and *ableism*, rooted in the view that characteristics or properties that are species-typical are therefore cognitively normative. Disability theorists like Sunaura Taylor [26] argue that ableism—a bias favoring abled human embodiment and neurotypical human intelligence—is intimately connected with human supremacy, speciesism, and systemic animal oppression. According to Taylor, ableism and, thus, neurotypicalism help "construct the systems that render the lives and experiences of both nonhuman animals and disabled humans as less valuable and as discardable, which leads to a variety of oppressions that manifest differently" (p. 59). Salomon [27] argues that neurotypicalism "privileges a form of cognitive processing characteristic of peoples who have a neurotypical (e.g., non-autistic) brain structure, while at least implicitly finding other forms of cognitive processing to be inferior, such as those natural to autists and nonhuman animals" (p. 47). Taylor argues persuasively that "ableism is intimately entangled with speciesism, and is deeply relevant to thinking through the ways nonhuman animals are judged, categorized, and exploited."

## 6.5 Domination and Oppression

That the most common and ubiquitous argument used to support the continued domination and oppression of nonhuman animals is that they lack any number of psychophysical or cognitive processes that are species-typical to human beings "shows the extent to which speciesism uses ableist logics to function" [26] (p. 58). Both the claim that a unique neural architecture is required for conscious neural processing in humans and the claim that the same neural architecture is a necessary condition for conscious pain in fish conceal the same neurotypicalist bias that has been used to justify the oppression of both animals and some humans. We need not look to the treatment of nonhuman animals to find the ethical dangers of such an assumption for both animals and humans. For example, in *Buck v. Bell*, [28] the United States Supreme Court approved the forced sterilization of the 18-year-old "feebleminded" Carrie Buck "for the protection and health of the state." In actuality, Carrie Buck was not cognitively disabled, but rather was a victim of pregnancy by rape, and was deemed "promiscuous." Such cases speak to how dangerously easy it is to go from the claim of neuro-atypicalness to a claim of reduced moral status both within and between species.

Domination and oppression are terms usually reserved exclusively for humans. I have written at length elsewhere on this topic [29], but let me just gesture towards what it means to say that animals are oppressed and dominated. *Domination* in the sense that I am using it here refers to a structural or systemic condition that prevents individuals from determining the conditions of their actions. Since humans can determine the conditions of animals' actions, some (or, it may be argued, *all*) nonhuman animals live within structures of domination. *Oppression* in the sense that I am using it here refers to a systematic institutional process that immobilizes or diminishes a particular group (which can include particular species) through the exercise of systemic violence and exploitation. Applying the concepts of domination and oppression to nonhuman animals may seem confused or even misguided, yet these concerns dissolve once we see animals as agents. Following Steward [30], I see the concept of agency as an outgrowth of the concept of animacy. The concept of animal agency involves the ability of the animal to move the whole or parts of their body, the possession of some form of subjectivity and rudimentary intentional states (e.g., trying, wanting, perceiving), and the animal as the "settler of matters" concerning certain of the movements of its own body. Ultimately, "[v]ariations among species should be embraced and cherished rather than used to justify human dominance" [31] (p. 27).

Though the domination and oppression of animals is manifest in practices such as sport hunting, medical and military experimentation, and industrial fur production, let me focus only of the role of animals in global food production. Worldwide, 300 million cows, 1.5 billion pigs, and 66 billion chickens are slaughtered for food annually [32]. Most of those animals are raised in high-density confinement for the production of meat, eggs, and dairy products. Cattle raised for beef are castrated, dehorned, and branded, all without anesthesia or analgesics. Sows live out most of their lives in cramped, individual gestation crates where they give birth to between four to eight litters. Male piglets have their testicles removed, their tails and ears docked, and their teeth clipped, all without anesthesia or analgesics. Laying hens live out their lives in small, restrictive battery cages. To prevent stress-induced behaviors caused by overcrowding, hens undergo debeaking without anesthesia or analgesics. Laying hens on concentrated animal feeding operations (CAFOs) are "spent" and unable to produce eggs after just 2 years, at which time they are slaughtered.

The figures on the number of fishes slaughtered for food annually are tougher to pinpoint since industry figures are provided in terms of mass not numbers of individuals. That said, reliable estimates put the numbers at about 0.97 to 2.7 trillion fishes caught from the wild annually [33]. Fishes undergo a number of standard industry procedures that inflict pain, including handling and transport which involves the removal of fishes from the water and air exposure, the causing of abrasions and the removal of scales (which removes a fish's protective mucous coat), and excessive weight loading on fish at the bottom of nets and brailles, as well as excessive crowding of fish by increased stock densities. Fish slaughter techniques include removal from water, asphyxiation in ice, asphyxiation in $CO_2$-saturated water, and gill cutting [34]. I trust these cases make clear some of the ways that nonhuman animal agents suffer systemic domination and oppression.

## 6.6 Anthropomorphisms and Anthropocentrism

Critics like Key [24] exhort us to overcome our "anthropomorphic tendencies that bias interpretations of behavioral observations" (p. 2) and warn against jumping to "unsupported anthropomorphic conclusions" (p. 3) that fish feel pain. Charges like these of anthropomorphism obscure and conflate numerous distinct and important senses of "anthropomorphism." Regarding attributions of mental states, critics charge that generalizations from linguistic humans to nonlinguistic animals are bad science; thus in order to do "good" science, anthropomorphism must be rejected and overcome. However, the role that anthropomorphism plays in science—especially comparative neuroscience—involves not only empirical arguments about specific experimental setups and inferences made from their results, but, more importantly, methodological and theoretical arguments that concern the proper methods of science, the scope of science, and the interpretation of data [35–37]. That is, the use of animal models already accepts and employs anthropomorphism, in that by definition researchers attribute human characteristics or biological homologies to other animals at the ground floor. Research on animal pain is sometimes research on a pain model, the assumption being that studying animal pain can tell us something useful about human pain. It's worth noting here how anthropomorphism is already "baked in the cake" in much of comparative psychology and neuroscience. For example, the reason that hippocampal activity in rats is perceived as evidence that rats deliberate during decision making relies on the fact that hippocampal activity is evident in human brains when humans deliberate [38].

Various senses of "anthropomorphism" can be lost in such debates, but even a cursory understanding of the different connotations can help clarify the fact that those engaged in these debates may sometimes be talking past each other. What critics of fish sentience mean by "anthropomorphism" is what I will call *unnecessary anthropomorphism*. Unnecessary anthropomorphism involves explaining behavior by attributing what are believed to be uniquely human traits and characteristics to beings or objects whose behavior can be better explained without such an attribution. For example, the explanation for my computer not booting up despite my having pressed the power button is not that my computer is angry with me (which would require *unnecessary anthropomorphism*), but rather that there is some malfunction with the powering-up mechanism.

By contrast, a number of alternate notions of anthropomorphism have been proposed, concepts that are useful (some say indispensable) to doing *good* science. Bekoff [39] argues for what he calls *biocentric anthropomorphism* which involves the indispensable use of human terms to explain animals' phenomenal states. According to Bekoff, "[a]nthropomorphism allows other animals' behavior and emotions to be accessible to us," and we can be "biocentrically anthropomorphic and do rigorous science" (p. 867). Burghardt [1] advocates for what he calls *critical anthropomorphism*. Critical anthropomorphism involves employing various sources of information when trying to understand the mental and phenomenal states of nonhuman animals, including "natural history, our perceptions, intuitions, feelings, careful behavioral descriptions, identifying with the animal, optimization models, previous studies and so forth in order to generate ideas that may prove useful in gaining understanding and the ability to predict outcomes of planned (experimental) and unplanned interventions" [1, p. 73]. de Waal [40] warns against exaggerating the uniqueness of *Homo sapiens*, a tendency he terms *anthropodenial*, a "blindness to the humanlike characteristics of other animals, or the animal-like characteristics of ourselves" (p. 2). Among its other vices of hubris and moral superiority, anthropodenial ignores the Darwinian notion of continuity across species. Andrews and Huss [41] caution against the bias denying a mental or phenomenal state to an animal who actually possesses that state, a bias they call *anthropectomy*. Arguments denying sentience can also trade on what Sheets-Johnstone calls “reverse anthropocentrism.” According to Sheets-Johnstone [42], reverse anthropocentrism occurs when “nonhuman creaturely life is interpreted in a way which exalts the measure of humanness: humans become special creations” (p. 346). Broader than anthropomorphism, reverse anthropocentrism assumes “humans as the center of the animate world such that, for example, any assessment of nonhuman mental powers must take as its standard of measurement a human mind” (p. 350).

As regards fish (and other nonhuman animal) sentience, by employing alternate senses of anthropomorphism, we can attribute pain states to fish based on reasonable interpretations of the overwhelming behavioral and neuroanatomical evidence. Epistemological worries about the mental states of nonhuman animals present unique challenges to claims of knowing their phenomenal states. To address the epistemological puzzle, it’s not necessary to solve the mind-body problem or the problem of other minds. What we need is the ability to aggregate and synthesize our best physiological and behavioral data on the question of nonhuman animal pain and, from that, make a reasonable inference regarding the experiences and phenomenal aspects of our fellow earthlings, like fish. Surely, though not uncontroversially, the corpus of such evidence currently weighs in favor of fish sentience.

## 6.7 The Precautionary Principle: Is It So Much Anthropomorphic Sentimentalism?

There is a growing body of physiological and behavioral evidence of fish sentience. Although the usual epistemological challenges arise whenever we encounter proclamations about the mental states of other beings (especially with creatures like reptiles, amphibians, and teleost fishes), the most sensible approach to issues of vertebrate pain and welfare is the precautionary principle. The precautionary principle states that where there is a reasonable potential for harm (such as causing a sentient creature to experience pain), precautions should be taken to prevent it. Advocates of the precautionary principle advise that given the lack of scientific consensus on the question of fish sentience, it is more prudent to assume that fish are indeed sentient and that this assumption should inform fish welfare policy and practice [6, 43]. Critics like Key [24] warn *against* applying the precautionary principle in questions of fish welfare for fear of “catastrophic effects” including “inappropriate approaches to fish welfare” and negative economic impacts for the fishing industry [32, p. 3]. However, as with any decision informed by the precautionary principle, the proportionality of the risk of harm must be weighed against the cost and feasibility of a proposed action. In the case of fish, the conclusion that we should abandon the principle is premature.

It’s important to note that when it comes to the attribution of sentience to nonhuman animals and a warranted application of the precautionary principle, there is a bit of burden shifting going on. Historically, many philosophers and scientists—from the Cartesians to the logical positivists—writing on and investigating nonhuman animal cognition have assumed an equally strong inverse precautionary principle (a kind of *decautionary* principle), advising that in cases where uncertainty exists about the sentience of a particular species, we should treat each member of that species as though they were *not* sentient, unless rigorously demonstrated otherwise. This decautionary principle is captured most pithily by that fundamental precept of parsimony in comparative psychology, Lloyd Morgan's Canon,[1] according to which, with regard to an animal's behavioral states, "in no case is an animal activity to be interpreted as the outcome of the exercise of a higher psychical faculty, if it can be fairly interpreted as the outcome of the exercise of one which stands lower in the psychological scale" [44] (p. 59). But this assumption is implausible and unreasonably strong, in addition to introducing scientific biases that could unduly influence the design of experiments and inhibit discovery and the acquisition of knowledge.

If history is any indication, no matter what evidentiary bar we choose short of full-blown first-person introspective, intersubjective verbal self-reports, skeptics will seek (and sometimes find) counterexamples that maintain human supremacy. To that end, it is important to make explicit the connection between the historical denial of cognitive and affective states (such as pain and suffering) in both animals and humans as reflecting abysmal, anti-scientific, and dangerous uses of science to support and further social and political ideologies. For example, in his study of the use of anesthesia in nineteenth century American hospitals, Pernick [45] found that the amount of anesthesia provided to white women during childbirth was decreased since it was believed that women would not bond with their child unless they felt pain. And black women, even when being used for painful experiments, received no anesthesia at all. Such attitudes are not mere relics, but persist today. A 2016 study by Hoffman et al. [46] found that *half* of a sample of white medical students and residents endorsed false beliefs about biological differences between blacks and whites (e.g., "Black people's skin is thicker than White people's skin"). As Rollin demonstrates, the history of science is rife with instances in which science is used to support a social or political ideology [47]. To claim that science is value-free is to ignore the history of institutional paradigms of scientific racism, ableism, and neurotypicalism as evidenced in practices such as craniology, eugenics, and the use of nonhuman animals in basic research.

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[1] Interestingly, Morgan—himself a *panpsychist*—would most certainly disagree with such a decautionary principle.

## 6.8 Conclusion: Ethical Ruminations

As I claimed at the opening of this chapter, canonical Western philosophy has been (and remains) rife with arguments denying reason, thought, and sentience to animals. Although Descartes's is the most notorious and perhaps extreme view in this regard—a view known as the *bête machine* wherein animals are nothing more than reflexive automata—many philosophers, ancient and contemporary, deny mentation [48] or even sentience [49] to animals.

In response to immoderate views like Descartes's, Hume boldly opens Book I, Section 16 of *A Treatise of Human Nature*, "Of the reason of animals," by attacking such views:

> Next to the ridicule of denying an evident truth, is that of taking much pains to defend it; and no truth appears to me more evident, than that beasts are endow'd with thought and reason as well as men. The arguments are in this case so obvious that they never escape the most stupid and ignorant [50].

What reasons have philosophers and scientists offered to deny such an "evident" truth? Sneddon et al. suggest that sentience is often denied because "sentience is at the heart of the decision about whether to provide animals with legislative protection" [51, p. 3]. This sentiment suggests that unwelcomed moral, social, and practical implications may motivate claims for sentience denial rather than objective empirical data employed in the pursuit of truth.

"Unacceptable" moral, practical, or economic consequences should not drive answers to empirical questions regarding animal sentience and, specifically in this case, fish sentience. This is bad faith, plain and simple [3].

Although I applaud the work of those researchers dedicated to the empirical demonstration of animal sentience, I think the question of animal sentience is actually a moral canard. Currently approximately 68 billion vertebrate land animals [52]—*whom we know, with as close to scientific certainty as is currently possible, are sentient*—live lives of abject misery and suffer and die in grisly, ghastly, ghoulish ways, all for human consumption. Our best neuroscientific understanding regarding the cognitive and sensitive properties of these beings makes unnecessary the implementation of a kind of precautionary principle regarding their abilities to experience pain and suffering. Better science, near-certainty regarding sentience, or increased welfare legislation alone will not end the suffering that is visited upon billions of animals under cover of speciesism and human exceptionalism. That task requires transcending our own bad faith by untelling the stories we tell ourselves about the meaning and necessity of animal pain and suffering. As Sanbonmatsu argues, "[b]y telling ourselves that we have no 'choice' but to kill and to consume animals, thereby refusing responsibility for our participation in terror, we undermine our claims to being the kind of being that alone can exercise autonomous judgment" [3] (p. 43).

What all this shows is that the question of animal sentience is less about the pursuit of truth and more about supporting a speciesist agenda—a moral conclusion in search of data, scientific findings, and legitimating arguments. In this sense, it is similar in kind to the eugenics research in vogue in the USA and Europe in the early twentieth century, which was motivated not by a search for truth, but rather to give a scientific imprimatur to classism, white supremacy, and an ableist sociopolitical agenda. Near-certainty regarding animal sentience will not end speciesism nor human supremacy. That enterprise does not require better neuroscience, research methodologies, or conceptual arguments. That enterprise requires transcendence of our moral bad faith and the hubris of unfounded human supremacy.

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# Part II

# Neuroethical Issues and Nonhuman Animals

# On Mitigating the Cruelty of Natural Selection Through Humane Genome Editing

# 7

Rey Edison and Kevin M. Esvelt

## Abstract

Natural selection cares nothing for animal suffering. However, it is artificial selection that governs the genetics of billions of domesticated animals and consequently their predisposition to well-being. Even without directed research, future insights into the genetics of mood will almost certainly enable us to substantially improve the lives of trillions of animals, posing a profound neuroethical challenge (Food and Agriculture Organization of the United Nations (FAO). Live animals. FAOSTAT statistical database, 2018). The sheer magnitude of the potential change in animal well-being demands great caution in evaluating whether, when, and how to develop and apply such technologies. A single mistake, whether rhetorically or technologically, could result in a great deal of animal suffering that might otherwise be avoided. Here we outline the moral responsibilities of those who choose to engage with the problem and those who decline. We discuss possible approaches for evaluating the efficacy of genetic methods and the concern that over-optimizing for indirect measures of well-being may reduce the extent to which we can be confident that those phenotypes are still meaningful indicators of what we are trying to measure. Lastly, we consider the extent to which we can expect animals used in agriculture to have been subject to selective pressures that result in their improved well-being in factory environments and the implications for the question of whether we should deliberately employ genetic methods to improve animal well-being.

**Keywords**

Animal well-being · Genetic methods · Factory farming · Natural selection · Evolution · Action/inaction distinction

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_7

## 7.1 Introduction

Natural selection improves animal well-being only insofar as those improvements increase the organism's chance of achieving reproductive success. The sum of all positive experiences dating back to the origin of life occurred because they were useful means to an end, not an end in and of themselves [1–3]. The relaxing ambience of a pleasant environment, the pleasure of consuming good food, the satisfaction of social camaraderie, the joy of youthful play, the comfort of parental care, and the ecstasy of mating all are evolutionary incentives to behave in ways that enhance the likelihood of surviving and reproducing [4–10].

The same is true of pain and suffering. Natural selection is no more cruel than it is benevolent; it simply is. It may seem harsh to paint the natural world as shaped entirely by indifferent and amoral forces. But those of us who care about well-being, for any ethical reason, should take heart, because it means that existing organisms are far from optimized for well-being [11–15]. It follows that selective breeding or genetic engineering could theoretically produce future animals with far more positive subjective experiences than their natural counterparts. Because monitoring and breeding can mitigate the effects of drift and selection in domestic populations, these positive traits could in principle be maintained by humans indefinitely [16–18].

Even if no directed research programs specifically examining the genetic bases for well-being are conducted, genotypes that greatly ameliorate suffering in a laboratory setting are still likely to be identified inadvertently during the course of other studies [19, 20]. Given that methods of genetically improving animal well-being may be discovered even if no one looks for them, it is important to carefully consider how our probable future understanding may inform decision-making about how animals are bred for human use.

In this chapter, we highlight three areas that could be addressed in a careful dialogue about using genetic methods to ameliorate animal suffering: (1) moral responsibilities for improving animal well-being, (2) how to evaluate the efficacy of genetic methods for improving well-being, and (3) factory farming (selective pressures and environmental context).

## 7.2 Moral Responsibilities for Improving Animal Well-Being

### 7.2.1 Countervailing Beliefs

All discussions of human moral responsibility for animal suffering that could have been prevented must acknowledge widespread reverence for a perceived "natural order" [19–21]. This belief, which is shared across many cultures, renders many people disinclined to accept the basic premise that animal well-being can be improved by human intervention—especially genetically. Laying the groundwork for thoughtful, responsive discussions of the legitimate concerns from all sides will be critical to finding an ethical path forward [22–24].

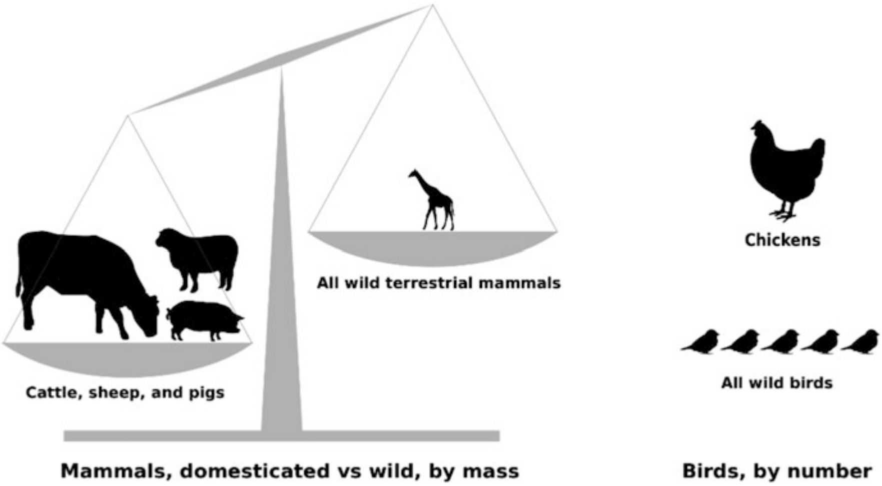

**Fig. 7.1** Domesticated livestock mammals outmass all wild terrestrial mammals combined by a factor of 14. Domesticated chickens outmass all wild birds by a factor of 3

### 7.2.2 The State of the World

Selective breeding has been a primary occupation of our species for tens of thousands of years and has now been extended to a planetary scale. Domesticated livestock now outmass all wild mammals combined by a factor of 14, while domesticated chickens—of which 56 billion are born every year—now outmass all wild birds by a factor of 3 (see Fig. 7.1) [25, 26]. For every five wild birds, there is one chicken. Of creatures thought potentially capable of complex cognition, only fish have not (yet) been substantially reshaped by humanity. If we have sinned, we have done so on a scale almost unimaginable. That is by no means an excuse, only an acknowledgment that we have already intervened in the natural order and will presumably continue to do so. This fact underscores the importance of our central question: what are our moral responsibilities for the well-being of future animals in light of our presumed future ability to apply genetics to improve their lives?

### 7.2.3 Action Versus Inaction

An illustrative example of the action-inaction distinction is the trolley problem, in which a bystander observes a runaway trolley on course to run over five people on the tracks. The bystander realizes that by pulling a lever, they can redirect the trolley onto another set of tracks, where the trolley will instead kill a single person. Clearly, pulling the lever will save lives, yet surveys show many people disagree on what the ethical choice is in the trolley problem and its many variants. Those who say pulling the lever is wrong may cite a belief that the bystander is more responsible for a death resulting from the action of pulling the lever than for deaths resulting from inaction.

Though the trolley problem is a hypothetical dilemma, similar themes are at play whenever inaction may constitute a missed opportunity to mitigate negative outcomes, and decisions regarding the use of technology are no exception.

Assuming that genetic methods of improving animal well-being are likely to become increasingly available as we learn more about genetics in diverse species, are we morally responsible for the consequences of choosing *not* to use them? It is common to intuitively distinguish between the consequences of an action and those resulting from doing nothing [27]. Philosophically, the justification for the action-inaction (or commission/omission) distinction is much less clear, especially outside the context of simplified dilemmas involving a finite number of choices and perfect information about the consequences of each [28–30]. With respect to most real-world scenarios, it's hard to envision how the brain could possibly evaluate the consequences of every possible inaction because there are so many possible actions that each individual could take [31]. Arguably, that means there is no plausible method by which humans could do anything other than distinguish between action and inaction. Here we prefer to err on the side of caution by assuming that we are to some extent morally responsible for *inaction*.

### 7.2.4 Individual Versus Collective Action and Inaction

Thinking carefully about the consequences of both action and inaction with respect to animal well-being is important because individual actions may lead to collective inaction. That is, various actions taken by individuals could lead to indefinite delays in the effective use of genetic methods for improving animal well-being. For instance, applying genetic methods at scale without visible caution and discussion, including inviting concerns and criticism, could result in the prolonged and unnecessary suffering of many animals. Additionally, any perception of recklessness could result in a public backlash that delays or prevents widespread use. Backlash could also result in unnecessary suffering as a result of statements that prematurely discredit or hype a proposed method for ameliorating suffering or enhancing well-being [32–35]. In these and other ways, our current actions may affect welfare outcomes for future animals even before any specific genetic methods for improving animal well-being are fully developed.

### 7.2.5 Philosophical Versus Empirical

There may be a strong tendency to dismiss evidence demonstrating improved welfare outcomes based on a lack of confidence in the capacity of scientific methods to address what may be seen as a philosophical rather than an empirical problem [36]. We should remember that many existing policies and practices are predicated on indirect evidence supporting claims about the relative levels of suffering experienced by species with very different behaviors and physiologies [37]. It may be more challenging to design experiments that compare very different species than it is to design experiments to distinguish levels of suffering experienced by two strains of lab mice that are almost genetically identical and have similar behavior and physiology [15, 38–40]. Before concluding that the epistemological challenges associated with assessing the effects of genetic interventions for animal welfare are too great, it is worth considering the ways in which we as individuals and as scientific communities already make decisions based on indirect evidence when we make choices that affect the suffering and well-being of animals we buy or breed [19, 24, 39, 41]. Great caution is warranted when making decisions that would affect massive numbers of animal lives, and great care should be taken when reviewing evidence regarding the efficacy of interventions meant to improve animal welfare.

### 7.2.6 Encouraging the Sharing of Mistakes

Regardless of the amount of care taken, there is always a risk that new information will indicate that past decisions caused animals to suffer more than was necessary. We may also realize that we might have made better choices given the information available at the time. The guilt or shame associated could potentially impair the ability to recognize when a mistake has been made [42–46]. Likewise, fear of external criticism or condemnation could lead individuals to keep secrets that might otherwise help prevent further unnecessary animal suffering caused by similar mistakes in the future [47]. Establishing a culture that is accepting of past mistakes is likely to prove critical for minimizing animal suffering in the long run [44, 48–50].

## 7.3 How to Evaluate the Efficacy of Genetic Methods for Improving Well-Being

We cannot directly measure the subjective mental states of others. To reduce the amount of suffering experienced by a given animal, we need ways of directly assessing animal well-being [51]. Many approaches use behavioral and physiological indicators that change in measurable ways when animals are experiencing circumstances believed to be distressing or unhealthy. From these patterns, we infer that by observing these indicators, we can assess well-being or monitor the suffering of similar animals in different conditions [52, 53]. While it is often accepted that certain disturbances of normal behaviors or baseline physiology indicate stress or discomfort, it can sometimes be less clear that the absence of such disturbances reliably confirms well-being [14, 54–56]. It is also important to remember that most aspects of animal behavior and physiology evolved under selective pressure for fitness in wild environments, not well-being in captivity, and so there is a limit to how much we can expect behavioral and physiological stress responses to reflect an animal's conscious subjective experience [13, 39, 41, 57, 58].

Another approach for evaluating the effects of genetic methods for ameliorating animal suffering could involve neuroscientific tools that monitor brain activity in behaving animals. Though we are unable to read minds, we may be able to visualize signaling in pathways believed relevant to creating positive or negative subjective experiences and to observe how patterns change when animals are in circumstances expected to be positive, negative, or relatively neutral [14, 59]. As more is understood about how different signaling pathways contribute to emotional valence, we may become better able to interpret changes in brain activity in ways that help us infer whether a certain approach reduces the extent of an animal's suffering [60, 61]. When possible, it may be useful to create inducible versions of genetic edits, such that the changes made are only expressed under certain circumstances. For instance, a change could be engineered so that it could be activated or deactivated as necessary by a small molecule drug required for transcription of a specific gene. One benefit of inducible edits is the ability to assess the efficacy of a genetic edit within a single animal, rather than simply between experimental and control groups [62]. It also suggests possible ways of allowing animals to choose whether the edit is expressed, just as one might test whether an animal chooses to spend more time in an enriched habitat versus a sparse one [55].

In addition to what type of experimental tests are used to evaluate a genetic edit's efficacy, it is also worth considering who performs the experiments and when they should be conducted. During the early stages, the developers of a genetic edit will likely both test whether their method is being carried out successfully (i.e., whether the specific changes made to the genome are being expressed as desired) and whether there are signs of improved well-being in the animals to which the method is being applied. Before the edit is used specifically for the purpose of alleviating suffering in unrelated experiments, its efficacy should also be tested and the data evaluated by third parties. As research into genomics and neuroscience provides new insight, we may uncover new ways of assessing animal well-being, and this may suggest new ways to test the efficacy of genetic edits. We are responsible for the outcome of decisions to use or not use genetic methods for mitigating animal suffering, and part of this responsibility involves actively acquiring and considering new evidence without drawing premature conclusions about the effectiveness of the available methods.

If we want to minimize the suffering of animals created for human use, we are compelled to gather evidence to inform our decisions, even though it is impossible to directly quantify the suffering they experience. A risk of testing genetic methods for improved animal well-being is that doing so involves navigating an evolutionary landscape with very high dimensionality with no absolute definition of what is optimal. Though resources limit how quickly different genotypes may be tested while developing genetic methods, we will not run out of combinations and refinements that could be considered because of the large number of potentially relevant genetic loci [63–66]. Furthermore, there is no consensus as to which observable metrics of well-being ought to guide welfare decisions, so one can imagine a temptation to keep combining genetic edits in order to demonstrate improved welfare by as many popular metrics as possible [67–69]. Because there is no clear stopping point, it is important to consider what might be lost as more and more changes are made to the genome to try and optimize indirect measures of well-being.

One risk is that indirect measures of well-being may become less meaningful when taken out of the context of the genetic background produced by natural selection. It is difficult to imagine pursuing genetic methods without starting from some version of the premise that the general function of suffering is largely conserved across animals: that is, the neurological activity corresponding to states of suffering has some intrinsically negative valence meant to guide seeking or avoidance behavior by virtue of being less preferable to neurological activity producing other subjective experiences [38, 70–73]. The more changes are involved in a given genetic method, the less certain we can be that the phenotypes we are measuring still correlate with subjective well-being [15, 40, 74–77]. We get what we select for, not necessarily what we want.

## 7.4 Intensive Animal Agriculture: Selective Pressures and Environmental Context

Intensive animal agriculture (commonly known as "factory farming") is a system of livestock farming in which animals are kept in confinement at high density. Several aspects of intensive animal agriculture can negatively affect animal well-being, including: crowding and the resulting pollution from concentrated animal waste; the stresses of confinement, including the inability to move freely; the separation of mothers and offspring; and the prevalence of infection, injury, and disease and the resulting use of antibiotics and other drugs. Most animal agriculture, and especially intensive animal agriculture, involves the selective breeding of animals, which raises two key questions. First, to what extent have animals already been selected for improved well-being in intensive animal agriculture environments? Second, if such selection has occurred, does this mean we have no moral responsibility to consider genetic methods for reducing the suffering of farm animals?

Selection occurs when farmers avoid breeding animals that are especially prone to aggression toward other animals or handlers. Likewise, animals who show signs of stress such as anorexia or poor hygiene may also be less likely to be bred due to low body mass or the appearance of poor health [78–80]. Additionally, certain traits may make animals more or less likely to die before their intended productive lifespan, a form of natural selection or at least inadvertent artificial selection [81, 82]. For instance, animals with aggressive tendencies when kept in close quarters may be more likely to be injured in fights, preventing them from breeding. Selection for less aggressive behavior or the appearance of good health could produce a population that shows fewer obvious signs of suffering.

However, we cannot be confident that such selection would produce a population that actually experiences less subjective suffering because selecting for appearance and behavior is not the same as selecting for well-being, and improved reproductive performance does not always correlate with improved health [41, 83–88]. An animal that does not fight may be less distressed by its surroundings, but could just as easily be more prone to learned helplessness. Because either outcome would be favored by selection, we cannot be certain of the cause.

Even supposing past selection has reduced the suffering of animals on factory farms in some cases, it has only improved well-being in ways that happened to correlate with production [82]. Because genetic methods specifically intended to improve well-being could reduce suffering further, the possibility that breeding has made animals less distressed does not preclude a moral responsibility to consider genetic methods for improving animal well-being in factory environments [69, 89, 90].

Should such a genetic method be developed, consumer opinion is a potential barrier to adoption. Even if there is scientifically convincing evidence to show that a genetic method could greatly reduce the suffering of numerous farm animals, widespread use is not feasible if consumers have their own moral objections to the use of such a method [20, 91]. As discussed above, widespread beliefs that what is perceived to be "natural" is necessarily good will presumably conflict with the rationale behind genetic methods of improving well-being [19, 21, 92].

With respect to perceived "naturalness," it is important to distinguish between an aversion to consuming part of an animal one believes to be unnatural in some physical way and an aversion to buying a product whose production necessitated the birth of an animal thought to be unnatural. An aversion to consuming an animal whose suffering was alleviated with genetic methods is similar to objections consumers may have more generally about food produced using genetic engineering. This is a topic beyond neuroethics, so we focus here on the latter aversion: the belief that there is something morally wrong about creating animals that have unnatural neurological attributes.

What might a person mean when they say an animal is unnatural in some aspect of its neurology? This could be interpreted to mean that the brain is unnatural or that the animal experiences an unnatural mental state. Since mental states are the product of electrical and chemical signaling, either interpretation suggests that there would be something unnatural about the anatomy or biochemistry of an animal's brain as the result of a genetic method. However, research on psychiatric conditions like depression and PTSD has shown that extreme distress, especially prolonged distress, can effect long-term or permanent changes in the brain, including changes in connectivity, epigenetic modifications, and size of different regions of the brain, as well as altered neurotransmitter and receptor production [93–99]. While such research is geared toward understanding human psychiatry, it also suggests that brain structure and functioning could be substantially altered by keeping animals in states of prolonged suffering [100, 101]. In short, unnatural environmental conditions, such as barns where animals are densely packed, lead to unnatural neurological states that may result in suffering.

Being kept alive in a factory farm is not a natural situation, so it is not apparent that changes made to animal brains due to the experiences of living in a factory farm are inherently natural [102–106]. While this does not mean that the cause of neurological changes is irrelevant to the moral outcome—because different means will create different functional changes to the brain—it is still worth bearing in mind that the types of neurological consequences of genetic methods are not *unique* to genetic methods [107–110].

The possibility remains that some consumers may have objections to changing a genome, but not to long-term changes in gene expression or epigenetic modifications in the animal brain that occur due to a lifetime of "unnatural" environmental conditions that lead to suffering [111]. Importantly, these objections may not extend to genetic methods such as selective breeding or even genome editing restricted to genes that already exist in the species, though such constraints may limit the extent to which a genetic method can reduce suffering [15, 81, 112, 113]. If the goal is to prevent the most unnecessary animal suffering, the question is whether it would be better to compromise a method's efficacy so it can reach more animals sooner, or to focus on developing the method that best improves well-being in each individual animal in the hopes that consumer attitudes will change. This question is obviously not easily answered.

## 7.5 Conclusion

Because improved well-being does not always result in increased evolutionary fitness, there is reason to believe the genotypes of existing animals are not locally optimized for well-being. This suggests that present-day animal genotypes and genotypes capable of alleviating suffering in a laboratory setting may be separated by relatively few genetic changes. That is, genotypes correlated with substantially reduced suffering in a laboratory setting may be in the sequence space explored during the course of other research and could be discovered even if no research programs are specifically implemented to look for them.

Discussions about the moral responsibilities of scientists are often limited to how they conduct or present their own research. However, for those who believe that we are at least partially culpable when our own lack of action results in increased suffering, there is also a moral responsibility to consider the implications of technologies that may be just a few steps ahead of our current knowledge and how our current actions may influence the likelihood that such technologies are developed, as well as the ways in which they are used.

This concern, like most others discussed in this chapter, is certainly not unique to genetic methods of reducing animal suffering. Still, this focus is an especially salient example of a largely unexplored potential technology that is very likely to be discovered regardless of whether it is explicitly sought out, if only because natural and artificial selective pressures have favored improved well-being only insofar as it was correlated with improved reproductive success, survival, or enhanced productivity, convenience, or value to humans. Additionally, very little has been done to investigate, let alone to mitigate, the negative effects of natural adaptations that are harmful to the animal's experience in a captive environment.

When it comes to reducing animal suffering, the largest challenge that may need to be overcome is the cognitive dissonance that can be produced by living in societies with industries whose production schemes do not prioritize animal well-being. Given that the number of animals impacted is so extraordinarily large and their lives are so different from those we might wish for our own pets, even acknowledging the extent of the present situation may cause many a great deal of distress [114–118]. Rejecting any substantial moral responsibility to reduce animal suffering is one way of reducing this cognitive dissonance [119–123]. Carefully considered genomic approaches to improve animal well-being, if offered as ways for good people to help animals overcome the unthinking cruelty of amoral evolution, could effectively reduce cognitive dissonance over complicity in factory farming [49, 91, 124–126] and promote an expanded circle of empathy.

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# In Defense of Neural Disenhancement to Promote Animal Welfare

# 8

Bob Fischer

**Abstract**

I argue that animal welfare advocates don't act wrongly if they promote research into ways of neurally disenhancing animals. More precisely, I contend that even if we conclude that it's wrong to disenhance animals because it's the wrong kind of solution to the situation that we've created, the considerations in its favor make it permissible for animal welfare advocates to support its development and use for the time being. This is because total suffering is likely to be substantially worse without such research; because disenhancement is not as bad, morally speaking, as it can initially seem to be; and because it's a promising way of mitigating the risks involved in not disenhancing animals.

**Keywords**

Disenhancement · Psychological disenhancement · Animal well-being · Animal agriculture · Welfarism · Genetic modification

## 8.1 Introduction

Nearly 40 years ago, Beilharz and Zeeb [1] wrote this:

> If we succeed in showing that animals are suffering under particular conditions of husbandry, what is to be done? There are two approaches. Either (1) we change the animals genetically and adapt them to the environment, or (2) we improve the environment.[1]

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[1] For a related observation, see Rollin [2, p. 75–76]: "Clearly, the rise of intensive as opposed to extensive agriculture has changed the agricultural playing field enormously. No longer are we constrained by the animals' evolved nature in our production practices. Industrialized, high

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_8

When animal welfare advocates lobby for welfare improvements, they encourage those in the animal agriculture industry to improve the animal's environment: to expand cages, provide superior bedding, improve sources of stimulation, and so on. But new technologies are making the first option increasingly realistic. This generates an important question for animal welfare advocates (i.e., welfarists). Let's assume that welfarists *shouldn't* be radical abolitionists, who insist that we should only promote the abolition of animal exploitation. These abolitionists contend that advancing welfare reforms is tantamount to arguing for further rights violations. If we reject such a position, then we can instead encourage the industry to improve the environments in which animals live. However, is it permissible to encourage the industry to create animals that are better suited to productivity-maximizing environments? To do so is to promote *disenhancement*: namely, creating animals with more limited capacities. And to promote *psychological* disenhancement, in particular, is to promote creating animals with limited perceptual and/or cognitive capacities.

Of course, this isn't the only way to use the term "disenhancement." Some suggest disenhancement is relative to the capacities an organism "ought" to have, where that notion could be cashed out in different ways (e.g., the "normal" capacities of members of a species). But we might instead think about it as being relative to well-being. In that case, an animal has been disenhanced only if she's been made worse off by an intervention. And depending on how we understand "well-being," these two definitions may lead to different judgments about cases. Suppose we understand well-being hedonistically, solely in terms of the organism's positively and negatively valenced affective states. Then, the two definitions certainly come apart: if the loss of capacities leads to improved well-being, then we'll have disenhancement in one sense and enhancement in the other. But if we understand well-being in a perfectionist sense, where part of well-being is functioning "properly" (where that's relative to the capacities that the organism is, in some sense, "supposed" to have), then the loss of certain capacities is indeed a loss of well-being. Of course, it might still be a net gain: functioning properly might not be all of well-being, and a loss of one kind might be offset by another. That is, on a perfectionist theory of well-being, disenhancement is only sometimes bad: it depends on both (a) how disenhancement affects the various dimensions of well-being and (b) the relative value of those dimensions. So even if it's bad for animals to lose certain capacities, they could still be better off on balance.

However, very little turns on how we decide to use "disenhancement," as we can express the central question regardless. The point at issue is whether welfarists may encourage the industry to create animals that are psychologically better suited to productivity-maximizing environments. If we think about disenhancement as

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technology agriculture has given us the ability to move beyond our implicit contract with the animal, to move beyond keeping square pegs in square holes. We can now put square pegs in round holes, round pegs in square holes, and still generate successful production and profit. Technological "sanders" help us fit animals into environments which are good for us without necessarily being good for them."

removing capacities that an organism ought to have (in some sense), then we're asking whether we may encourage the industry to disenhance animals in order to improve net well-being. If we understand disenhancement as relative to well-being, and we're hedonists, then we're asking whether we ought to remove certain capacities in hopes of enhancing animal well-being. I'm going to continue to talk in the former way, as I think it's more natural, but I don't think that anything substantive turns on this decision.

In any case, there's a strong case against promoting disenhancement. Some of the concerns are practical. Consider Sandøe et al.'s [3, 4] discussion of breeding blind hens for egg production. The hope [5] was that these animals would be better off overall than sighted chickens, largely due to their being less aggressive toward one another than sighted animals in the same circumstances.[2] (Blind hens can be produced via normal selective breeding techniques, but CRISPR and other germline genome editing technologies open up other possibilities.) However, it isn't clear that the hope is borne out. Sandøe et al. [4] summarize some later studies that motivate their doubts: it looks like blind chickens are less social, peck less, and have a harder time finding feed; as a result, they may have less rich lives and also have significantly higher 2-week mortality rates. So while a particular disenhancement might seem like a promising way to improve welfare, it may well have unintended side effects that reduce welfare overall.

Moreover, there is an important in-principle challenge. Marcus Schultz-Bergin [9, p. 854] argues that the main issue is that disenhancement represents the wrong response to a historical injustice:

> On my *Historical Injustices Approach*, sentient agricultural animals are an historically wronged group. They have been systematically wronged for generations, and we have all benefited from that wrongdoing. The intuition that diminishment is wrong, then, can be grounded not in the wrongness of creating diminished animals per se, but in identifying animal diminishment as the solution to our wrongdoing. Creating diminished animals fails to display remorse for the wrongdoing that we nevertheless recognize.

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[2] In response to the possibility of breeding blinded chickens, Sandøe et al. [3, p. 322] propose "utilitarianism with side-constraints." According to this view, the goal should indeed be to improve animal welfare, but not at the cost of changing their nature in "significant" ways. As Paul Thompson [6] points out, however, none of the standard approaches to animal ethics generate this particular result: Sandøe et al. have to gerrymander a view that accords with their anti-disenhancement intuition. Adam Henschke [7] follows up on a suggestion that Thompson makes at the end of his article, which is that it will be difficult to criticize disenhancement if we focus on action-centric frameworks. If, however, we focus on an agent-centric framework, such as virtue ethics, we may be able to do better. Henschke points out that one of the troubling aspects of disenhancement is the context in which it occurs, where the parties considering disenhancement are already invested in intensive animal agriculture and have as their main motivations "the increase of profits and/or the increase of meat production, whilst minimizing criticism." Since this is an objectionable goal within an objectionable system, we can condemn such attempts to modify animals. Marcus Schultz-Bergin [8] argues that isn't so easy to attribute such motivations to those who might genetically alter animals.

Schultz-Bergin doesn't identify the precise duty that we violate in creating disenhanced animals, but one possibility is that there's a duty of restitution or repair in the wake of an unjust relationship to a group. Rather than bearing the costs of wrongdoing, disenhancement is a strategy for dodging them, enjoying the benefits of animal agriculture without acknowledging the history of wrongdoing.[3]

Nevertheless, I think welfarists may indeed encourage the industry to do research—and, if the research is promising, breed—disenhanced animals. That is, I maintain that even if disenhancement sometimes fails to improve overall animal welfare, and even if it's the wrong kind of solution to the situation that we've created, the considerations in its favor make it permissible for welfarists to support its development and use for the time being. I'm not claiming that it's morally permissible to do this research, nor that it is permissible to breed disenhanced animals. Instead, I'm arguing that of the various objectionable trajectories for contemporary animal agriculture, the ones that include disenhanced animals are preferable to those that don't. And as long as animal agriculture is so deeply entrenched in contemporary society, that's reason enough to lobby for the creation of such beings.

I proceed as follows. I begin by presenting the main argument in favor of promoting disenhancement, which is based on the limits of current advocacy strategies and the potential promise of genetic interventions. Then, I consider a number of reasons why, though certainly problematic, disenhancement isn't as bad as it may seem to be. I conclude by considering the costs of not pursuing this strategy.

## 8.2 The Main Argument for Promoting Psychological Disenhancement

Intensive animal agriculture isn't going away. Global incomes are rising, and rising incomes are generally associated with increased demand for animal products [11]. Moreover, global population is still increasing, so there is likely to be more demand from even more people for meat, milk, and eggs. It is true that animal agriculture in its current form is environmentally unsustainable, and it may well dwindle as a result of that problem alone. But if so, that decline is many years away. The industry is responding to the environmental pressures it faces: it's experimenting with feed supplements and genetically modified feeds that reduce methane production; it's looking for ways to reduce waste and maximize productivity per animal; the USDA is promoting anaerobic digesters that convert manure into energy that can be used on the farm, thereby reducing overall carbon footprint.[4] In

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[3] If this is indeed the right interpretation, then the argument bears some affinity with the line in [10].

[4] On the first and third points, see https://www.agric.wa.gov.au/climate-change/carbon-farming-reducing-methane-emissions-cattle-using-feed-additives and https://www.americanbiogascouncil.org/pdf/Biogas-Roadmap.pdf.

such circumstances, it would be a mistake to focus exclusively on the question of how to end animal farming. Additionally, we need to consider how animal farming should proceed. That is, when advocates consider the many options open to those who design intensive systems, we should ask which are preferable in terms of animal welfare and then seek to influence the industry in favor of higher welfare possibilities.

Many welfarists agree and so promote various welfare reforms: larger cages for laying hens, slow growth breeds, etc. And some of these changes are implemented: consider the recent passing of Proposition 12 in California, which enacted minimum standards on the conditions in which farmed animals are confined. However, there are significant drawbacks to an exclusive focus on these conventional improvements. For instance, when we pursue such reforms politically, they are only feasible in relatively liberal states. In the USA alone, then, billions of animals don't benefit from them. This problem can be addressed by corporate campaigns, where advocates convince companies to promise to source their animal products from farms that meet certain welfare standards. However, whatever standards these companies want their suppliers to meet, the suppliers don't always come through, as revealed by recent investigations into farms that Whole Foods uses.[5] What's more, as intensive animal agriculture expands in South America, Asia, and Africa, US- and EU-based legal and corporate campaigns affect a smaller and smaller percentage of farmed animals.

What other strategies are available? The one that seems to be getting the most attention is "cultured meat" (or "clean meat" or "synthetic meat"), motivated by the thought that animal agriculture is most likely to be undone via direct competition.[6] If it turns out that we can grow meat without animals at massive scales, and the process is both less expensive and better for the environment than the *status quo*, perhaps the industry will end entirely—or, at least, shift in a dramatic way.

There are, however, some reasons to be skeptical. First, even if cultured meat takes off in developed countries, it will be a long time before it becomes standard in developing ones, which are unlikely to adopt high-tech programs of this kind in the short term. Second, we shouldn't underestimate the significant labeling and regulatory battle that is bound to occur in developed countries. There have already been some initial salvos, with industry groups arguing that "meat" should be defined more precisely.[7]

Third, there is absolutely no reason to think that the massive system devoted to animal agriculture is close to being dismantled or that once the process begins, it will be dismantled overnight. It's crucial to remember that the task is not simply to produce cultured animal protein. That's being done, though at great cost and on a small scale. The task is to produce cultured animal protein (a) that cooks and eats like conventional meat and (b) that is no more expensive—and ideally cheaper—than

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[5] https://theintercept.com/2017/09/15/whole-foods-free-range-chicken-animal-rights/

[6] See, e.g., the optimism that's obvious in [12].

[7] https://qz.com/1205165/the-us-department-of-agriculture-is-being-asked-to-differentiate-beef-from-clean-meat/

conventional meat. At present, no one knows how to make cultured meat that tastes like sirloin steak; at best, companies can imitate chicken nuggets and chorizo. And we are a very long way from price parity, much less the production of a cheaper product at enormous scales. What's more, after the technology improves, there will still be an extended period of consumer acclimation to a new product category. At the same time, there will be a predictable struggle during which traditional producers do their best to preserve the dominance of their industry, invoking all the legal, economic, and rhetorical tools available to them. (It's easy to imagine advertisements that involve vague appeals to America's heartland, rural values, and the perils of having Silicon Valley take over the food industry. Much of this will be hypocritical, but that won't make it any less persuasive to a large swath of the American public.) Of course, these aren't reasons to think that cultured meat will *never* achieve dominance, but they are reasons to think that such an outcome is at least a generation or two out. In the interim, there are trillions of animal to consider.

Animal welfare advocates might insist that there are all the same reasons to worry about disenhancing animals. But I doubt that this is true. Obviously, there will be consumer resistance to some modifications. However, there won't necessarily be consumer resistance everywhere. US consumers, and even Western consumers generally, shouldn't occupy all our attention. Instead, we should keep in mind Chinese and African consumers, as that's where intensive animal agriculture is growing the fastest [11, 13]. Moreover, blind chickens are sympathy inducing, but other modifications won't raise the same red flags. For instance, it may be possible to moderate corticotropin-releasing hormone (CRH) levels in pigs via genetic interventions. CRH affects cortisol production and behavioral displays of stress [14], increased CRH receptors are linked to abnormal sow behavior and higher piglet mortality [15], and high levels of CRH are linked to depression in mice and rats [16]. Reducing CRH levels is associated with more moderate stress responses, partially evinced by a willingness to feed again more quickly [17]. However, it's also a form of disenhancement, since reducing those levels reduces activity levels generally. Obviously, there's much more research that needs to be done on this front, but it's possible that this kind of modification may improve both welfare and productivity: the former, by directly reducing stress in pigs and by reducing the aggression caused by stress, and the latter, by increasing weight gain and decreasing premature death (relative, of course, to what's already a premature death). US consumers may not react very strongly to such genetic modifications. And, of course, the industry will deploy its powerful lobbying resources to block labeling requirements, promote images of intensive animal agriculture as humane, and enjoy major price advantages for the foreseeable future.

Admittedly, there are legitimate worries about disenhanced animals being patented. This occurred for the first time for any food animal in 2015, when the FDA granted a patent to AquaBounty Technologies for AquaAdvantage Salmon (US5545808A), a fish that's been genetically engineered to reach slaughter weight in half the time of conventional breeds. Will this limit the scope of disenhanced animals in the industry, since proprietary breeds will be limited to particular companies? That's certainly a possibility. However, given the way that the industry has been consolidated over the last 75 years, there are individual corporations that determine the fates of millions—if not billions—of animals per year. So, even if it's the case that a single corporation decides to use a particular kind of disenhanced animal, the difference in aggregate welfare could be quite significant. Moreover, it's worth remembering that quite a lot of research on new breeds isn't done by private corporations, but by the USDA itself—perhaps most notably at the US Meat Animal Research Center, which aims to develop "new technology to solve high priority problems for the US beef, sheep, and swine industries," with the more specific goal being "to increase efficiency of production while maintaining a lean, high quality, safe product."[8] Since this research is done with the aim of benefiting the US industry as a whole, some disenhancements will be available to domestic producers generally.

For all I've said so far, we still might doubt that there will be much interest in disenhancing animals and so doubt that this specific research will even happen. But disenhancement fits neatly with a major current trend in the industry: namely, the push toward "sustainable intensification."[9] There is significant debate about exactly what the phrase means, but the general thought is that, in response to growing population and environmental pressures, the goal should be to increase productivity while avoiding increases in land use, feed, water, and so on. Obviously, sustainable intensification is not about improving animal welfare: instead, it's about increasing efficiency, where the aim is maximizing the outputs relative to the inputs. But that also means that there's an economic incentive to adopt any disenhanced breed that helps achieve this goal.[10] It may not be politically feasible to ban the practices that ought to be banned, corporate promises can be broken, and cultured meat is a long way from market dominance. However, if new breeds are better for the bottom line, then industry support seems more likely.

This matters when we consider the various strategies that advocates have for improving the welfare of animals. The long-term goal, of course, is to prevent animals from being in intensive facilities in the first place. But moral deliberation isn't just about setting long-term goals: it should guide action in the short term as well, making implementability highly relevant to our all-things-considered judgments about what ought to be done. If there is potential interest from the industry, then that matters in assessing what ought to be done.

With all this in mind, consider the following. Suppose we know that, for all practical purposes, there is no way to avoid cages for layers for the foreseeable future. Suppose further that there are two equally productive breeds, one with high levels of cortisol when caged and one with low levels of cortisol when caged. It

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[8] See https://www.ars.usda.gov/plains-area/clay-center-ne/marc/. To be clear, I'm not claiming that the current research at USMARC improves animal welfare on net. I'm suggesting that USMARC is probably the kind of place where people would be willing to explore disenhancing animals and that given their aims, breeds with those disenhancements would likely become available to many US producers.

[9] For an overview, see [18].

[10] Plainly, economic incentives aren't *generally* aligned with animal welfare, and I'm not suggesting as much. I'm only saying that they *can* be so aligned, and this might be one of those cases.

seems obvious that in such circumstances, we would have a very good reason to encourage producers to raise the low-cortisol breed rather than the high-cortisol breed. This is true even if the low-cortisol chickens would probably never be selected for in the wild, and the resulting chickens will be further from the species-typical ideal as a result. Moreover, it's true even though breeding birds with low cortisol is, in some sense, the wrong response to the problem: producers ought to expand cages, but since they won't, we can encourage them to breed animals that are psychologically better suited to the cages that they're willing to provide.

The point is just this. There may well be ways of disenhancing animals that leave us with essentially this choice, and given that, it's clear what we ought to encourage producers to do. When it's all but certain that producers aren't going to rework chicken sheds and feedlots in ways that serve the interests of livestock, it's permissible to encourage them to find ways to engineer animals to fit agricultural environments, assuming that total welfare is higher as a result.

## 8.3 Getting Perspective on Disenhancement

The above parallel isn't exact, as no one needs to create the new breed in the original scenario. Moreover, as I said at the outset, I grant that creating disenhanced animals is the wrong way to respond to the harms that are part and parcel of intensive animal agriculture. But it's also easy to overestimate the badness of disenhancement. We can forget the significance of the non-identity problem, we can underestimate the quality of the lives available to disenhanced animals, we can overlook the way that disenhancing animals may result in less wrongdoing overall, and we can underestimate the costs of not having disenhanced animals.

### 8.3.1 The Non-identity "Problem"

First, Clare Palmer [19] observes that we shouldn't frame the issue as a trade-off between having (what would otherwise be) a valuable capacity, on the one hand, and improving welfare, on the other. Given the non-identity problem, we should frame things in terms of the ethics of bringing certain animals into existence. (So, the parallel in the last section is closer than it first appears to be.)

In short, the non-identity "problem" is that there are certain person-creating actions that are intuitively wrong and yet don't seem to harm anyone. Consider, for instance, a woman who is interested in getting pregnant. She's currently on a medication known to cause nontrivial birth defects. Her doctor tells her that if she switches to an equally good alternative medication and waits a month, the old drug will be gone from her system and she can conceive with no risk to the fetus. A month wouldn't make any difference to her plans, and her partner is willing to do whatever she prefers. But she decides to ignore the doctor's advice, stay on her current medication, and conceive. Many people judge that this is wrong: she should have waited. But had she waited, she wouldn't have spared the very same fetus from a birth defect, but instead would have conceived an entirely different child. The fetus she *actually* conceived simply wouldn't have existed if she'd waited; the only way for *him* to come into existence is for him to be conceived at a time that involves the relevant risk. If actions are only wrong if they make someone worse off, then she didn't act wrongly, as no one was made worse off.

There are deep disagreements about how to understand such cases. However, there needn't be a puzzle: we can simply accept that some of our intuitive judgments are mistaken, and what seems impermissible is, in fact, morally aboveboard [20]. I'm not recommending this as a general approach to the non-identity problem, but I am suggesting that it's worth considering for nonhuman animals. For instance, perhaps it matters that human beings have concepts like *my first child* and *future generations*, which inform the way that we relate to the beings to whom we apply those notions. These sorts of differences between human and nonhuman animals may explain why there are deontic or virtue-based constraints on how we treat one another that don't apply to our treatment of nonhuman beings.

At this point, of course, this is only speculation: it would take me too far afield to explore this hypothesis in any detail. However, if this is indeed a reasonable way to think about cases involving nonhuman animals, then we can observe that disenhanced animals simply won't exist if we don't create them: it isn't as though there are particular individuals who are going to come into existence either way, and the only question is whether they will have certain capacities or lack them.[11] Instead, we are making the choice between creating animals who are more or less well suited to the environment in which they're going to live, where coming into existence as a "disenhanced" animal doesn't actually involve making the animal worse off than she would otherwise be—as there is no other way for her to be.

Of course, we certainly aren't *benefiting* the animals we bring into existence: if it's indeed true that there is no other way for a particular animal to have been, then she isn't better off than she would've been. Moreover, she's likely to suffer at the hands of producers, and that's clearly bad. But I don't need the claim that disenhanced animals are better off than they otherwise would be or the claim that they won't suffer. I only need the claim that they will suffer less than conventional animals. With that claim available, then the difference in total suffering provides the reason to advocate for the creation of disenhanced animals.[12]

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[11] Note that we might be willing to go this route for animals, even if we aren't sure that it's the right story for human beings, for whatever reason.

[12] Now, Schultz-Bergin [9] suggests that the non-identity problem creates no trouble for his group-oriented account either—which, recall, is designed to provide a basis for criticizing disenhancement quite apart from any empirical concerns about its prospects. On his view, the idea is that disenhanced animals are members of a group that has suffered injustices, so it doesn't matter that they weren't individually harmed by various modifications. But notice that thinking in terms of group membership makes a great deal of sense when we are focused on human beings: we care deeply about our identities, and we form them in part by aligning ourselves with temporally extended groups. However, such groups are human artifacts, and it's deeply implausible that farmed

### 8.3.2 Perfectionism

Second, and relatedly, we might presume that even if total welfare would be higher in a population of disenhanced animals, they would be badly off by some perfectionist standard, as they would lack some capacity that, objectively, it's valuable to have. That alone would provide some reason to worry about advocating for disenhancement. However, even if we grant the relevant version of perfectionism, the worry isn't yet well motivated. Disability in one respect can be a net enhancement, insofar as it enables a form of life that's valuable in its own right and was otherwise unavailable. This is a point that disability rights advocates have been making for years: blindness or deafness needn't be construed as a deprivation, but rather as an enabling condition for other goods. Shriver and McConnachie [22, p. 171] put the point well:

> . . .it seems likely that armchair assumptions that the welfare of genetically engineered animals is "diminished" are likely to be vulnerable to similar mistakes as armchair assessments about the well-being of people under various conditions. Our intuitions in both cases can be seriously biased by our imagining how we would feel immediately after losing one of our own capacities. Just as we should take seriously the testimony of disability advocates that blind humans are capable of living as rich and emotionally rewarding lives as sighted humans, we should also recognize that there is no good reason to assume, prior to empirical evidence, that blind chickens, or dehorned cattle, or short-beaked chickens, will have lower wellbeing than other animals. The point here is not, of course, that genetic modifications that eliminate capacities cannot diminish animals' welfare, but only that we should not assume so in the absence of empirical evidence based on current best practices in the field of animal welfare.

For instance, it's important to recall that to experience the world without visual input can be to experience other aspects of it much more vividly, as other perceptual abilities and cognitive capacities become more prominent in the absence of sight. Likewise, experiencing others without visual input can create new relational

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animals care about them, not least because it's doubtful that they can form the relevant concepts. (If we were farming cetaceans or nonhuman primates, the story might be different.) So, it's hard to see why we should think of them as belonging to groups that could ground the conclusion that Schultz-Bergin wants. Someone might object that this will have objectionable results for populations of humans with significant cognitive disabilities: if it turns out that they also don't care about certain temporally extended groups, then we won't be able to appeal to them to ground certain duties of justice. But this seems like exactly the right consequence to me. Our duties—whether of justice or anything else—are sensitive to the interests of the relevant beings. If you are the kind of being who identifies with an historical group, then you have an interest in the degree to which others respect that identification. If you don't, then you have no such interest. (Of course, *others* might have that interest on your behalf: there might be some instrumental value to treating humans with significant cognitive disabilities as though they have an interest that they lack. But there are also risks associated with such moves, as they can make us insensitive to the interests of current individuals.) All that said, I think it's also worth noting that we should be very careful about denying that various human individuals have the capacity to identify with certain human groups. For discussion of this point, see Eva Kittay's contribution to [21], as well as the essays in Part IV of that book.

possibilities. Skin color becomes much less interesting than skin texture; facial symmetry might be less interesting than personal fragrance. Of course, chickens and pigs in agricultural contexts don't need to get over racism and unrealistic standards of beauty. But the point isn't that our hang-ups are also theirs. Rather, the point is that being "disenhanced" isn't necessarily a net loss: depending on the capacities that remain, as well as on contextual factors, it can be a net gain. With respect to animals in intensive agricultural environments, to experience the world with less stress probably means having gentler interactions between conspecifics. And in environments where animal sociality is generally undervalued, disenhancement in one respect can be enhancement in another, enabling connections between animals that can be sources of pleasure and comfort.

Of course, disenhancement in one respect can simply be disenhancement in two respects: aggression can be an important part of animal sociality (as, e.g., groups of chickens establish a pecking order or groups of pigs establish relative dominance relations), and eliminating it might relieve the animals of some pain only at the cost of isolating them from one another. This risk is real, but in the context of animal agriculture, it's difficult to assess its severity, as the environment is so hostile to sociality in the first place. So, although it's a genuine concern, I submit that it's one to be addressed by breeding and observing different groups of animals, rather than by trying to predict how their social lives may or may not be affected.

Seen from this perspective, we now face the hard question of whether some particular disenhancement—e.g., knocking pain out of livestock, as Shriver [12] discusses, or reducing CRH levels—would allow them to live lives that are as rich, or even richer on balance, than their unmodified counterparts. By and large, we don't have the empirical information required to answer this question. However, there are two things to keep in mind here.

For starters, and recalling the worries about blind chickens that Sandøe et al. [4] summarize, it's important to note that different disenhancements may require minor modifications to housing conditions. If blind chickens struggle to find feed, then we might conclude that we shouldn't create blind chickens. But that doesn't follow until we've checked to see whether there are minor ways of adjusting feed delivery systems to accommodate hens' limited abilities. If there aren't, then there aren't. However, if there are, and if blind chickens are more productive in these adjusted surroundings than are their sighted counterparts, producers will have reason to adopt the changes. The point isn't that it's easy to address these kinds of welfare problems; it probably won't be. Rather, the point is just that "engineering animals to fit environments" doesn't necessarily preclude making any changes at all to the environments.

Additionally, as Shriver and McConnachie [22, p. 176] observe, research on disenhancement is already happening, though generally not in agricultural contexts. Instead, this research is happening in biomedical contexts:

> John Wood at University College London has created a strain of mice that mimic humans who are born without the ability to feel pain.... [These] humans and mice have increased endogenous opioids that act as painkillers throughout their lives and for reasons that are not

> entirely understood they fail to develop a tolerance for the opioids. One problem with using Wood's mice as a model for research… is [that] in the absence of a suffering signal, the animals tend to cause serious self-harm. However, investigations are currently underway to see if gene editing could be used to produce mice that are not pain-free from birth, but who rather can be triggered to be pain free via the introduction of an inert bio-compound. It is thus easy to see how research on using gene editing to improve welfare could progress in the laboratory and later be translated to agricultural settings.

Similar neurological interventions are conceivable. Researchers use pigs as models for studying dementia, Alzheimer's, and other degenerative cognitive disorders. If it turns out that limiting the short-term memories of pigs actually makes them less stressed in conditions that are relevantly similar to those they would experience on a Concentrated Animal Feeding Operation (CAFO), then that is a reason to limit the short-term memories of pigs. To be clear, I am not claiming that this research is morally justified. However, if researchers are going to create animals with these sorts of conditions, then information about their welfare can be gleaned for agricultural purposes.

Plainly, none of this shows that any particular strategy for disenhancing animals will improve welfare. However, the goal is not to establish any such conclusion. Instead, the goal here is to undermine the intuition that it isn't worth advocating for research on disenhancement. The considerations sketched here help to shift the burden.

### 8.3.3 A Route to Permissible Use

Third, we should note that as long as we aren't opposed to animal use per se, we can view disenhancement as the attempt to create beings that we can use permissibly. Jeff McMahan [23, p. 73–74], for instance, imagines the following case:

> Suppose that we could create a breed of animals genetically programmed to die at a comparatively early age, when their meat would taste best. We can then have a practice of benign carnivorism that would involve causing such animals to exist, raising them for a certain period in conditions in which they would be content, and then simply collecting their bodies for human consumption once they died. Such a practice would not be bad for the animals and would arguably be good for them, since they would have lives worth living and would not have existed at all if not for the practice. And the practice would not involve doing anything to them that would be against their interests, such as killing them.

Of course, McMahan doesn't believe that animals have rights, but even those committed to animal rights can accept views of this kind, since not all conceptions of rights preclude all use. Alasdair Cochrane [24], for instance, develops an interest-based account of rights; on his view, although animals have an interest in not being harmed, and have rights protecting that interest, they don't have an intrinsic interest in not being used. As a result, as long as all their other interests are respected, he thinks that we may use animals in ways that benefit us, even to the point of farming them for their corpses—i.e., giving animals excellent lives and then only consuming their bodies after they die natural deaths. He doesn't explicitly address the possibility of genetically modifying animals for this purpose, he doesn't think that anyone is doing this right now, and he isn't suggesting that such a model would be economically viable. But the point here is just that you can probably develop the framework in a way that's consistent with McMahan's scenario being permissible.

Obviously, though, most disenhanced animals won't actually be used permissibly: there will still be significant conflicts between human and animal interests, and those will generally be resolved in favor of humans. (However, there may be fewer impermissible resolutions if disenhanced animals lack some of the properties in virtue of which conventional animals deserve greater moral consideration. If disenhanced animals are less morally important than their conventional alternatives, then it may be easier to justify their use in various contexts.) But there are plenty of cases where it's obvious, even from an animal-centric perspective, that we should prefer suboptimal-but-better-than-the-status-quo options: consider, for instance, bivalve consumption [25] and eating beef over chicken [26]. If producers are not going to do what they ought to do, then we ought to encourage them to do the next best thing. And in this case, the next best thing is disenhancing animals. That is, in the nonideal circumstances in which we live, how far can we get the industry to go toward respecting the interests or rights of animals while raising them for food? If we think about disenhancement in these terms, then it becomes the attempt to move the industry in the direction of farming species that aren't made worse off by our farming them. Of the aims that producers might have, that's more admirable than many of the realistic alternatives.

## 8.4 Avoiding Other Costs

Finally, it's important to note that there are very real costs of *not* creating disenhanced animals. Producers are going to continue to look for ways to improve productivity. In 2015, for instance, researchers at Seoul National University produced pigs with approximately double the muscle mass of ordinary pigs.[13] Their large muscles create complications during birth, less than half survived to 8 months, and of the ones that did, the researchers only considered one of them healthy. Because the researchers haven't published much information about the health and welfare of these animals, we can only guess at their medical issues. However, the mortality rate and health assessment suggests that they are worse off than their unmodified peers. And if it turns out that breeding such animals is ultimately more profitable, due to the amount of meat that each animal offers, it wouldn't be surprising if producers adopt this breed or a similar one.

Cases of this kind are important reminders that genetic modification is bound to be an important part of the industry. From the perspective of agribusiness, the question is not *whether* to modify animals, but *how* to modify them. If the industry

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[13] https://www.nature.com/news/super-muscly-pigs-created-by-small-genetic-tweak-1.17874

can find ways of disenhancing animals that improve welfare while simultaneously increasing productivity, then they may well be willing to adopt them and perhaps more willing if animal welfare advocates get behind those modifications. This doesn't mean, of course, that every successful modification is going to be adopted. Scientists at the University of Guelph created Enviropigs, which excreted waste containing 60% less phosphorus than conventional pigs [27]. However, Enviropigs aren't being bred for food anywhere today, and the University euthanized the last one in 2012. So, researchers may well figure out a way to "improve" animals along some dimension without any significant market response; there are certainly going to be cases where it would be politically unwise for industries to switch to the relevant breed. But this is just a reason for promoting research on genetic modifications that are more palatable to consumers and as a result more attractive to producers—not a reason to avoid doing such research in the first place.

Additionally, we should remember that there is going to be an ongoing tension between increasing the productivity of particular animals (getting more meat, milk, or eggs from an individual) and increasing the productivity of the barn (getting more meat, milk, or eggs overall, accomplished by increasing the number of individuals and tolerating a higher mortality rate). I take it that, from any animal-centric perspective, the goal should be to minimize the number of animals harmed in food production and maximize the welfare of those who are so used. Disenhancement can be a route to this goal. Less stressed animals are less likely to die prematurely (again, relative to their already premature deaths), partially because they are less vulnerable to disease, and any reduction in premature mortality is a productivity improvement at the barn level. They may also be more productive at the individual level, since stress and illness tend to reduce feeding rates.

Indeed, even if we ignore the welfare of farmed animals, we still have an animal-centric reason to hope that producers are indeed able to sustainably intensify animal agriculture—in the sense of increasing productivity while keeping input levels constant. After all, their failure doesn't mean the immediate end of animal farming, but rather increased inputs. And that, of course, simply means more land devoted to both feed production and/or grazing, both of which are bad for wild animals, as well as more greenhouse gas emissions. Those greenhouse gas emissions exacerbate the problem of climate change, of which wild animals are also victims. So although it's bad that so many animals are being harmed in the context of animal agriculture, it would be even worse if all those animals were being harmed and then wild animals were also to face unnecessary suffering.

## 8.5 Conclusion

It seems to me, therefore, that welfarists may indeed encourage research on disenhancing animals, even if no particular disenhancement is currently promising and even if Schultz-Bergin is right that disenhancement would be the wrong response to an historical injustice. Again, none of the above shows that disenhancing animals is permissible. But when choosing advocacy strategies in nonideal circumstances, questions about permissibility aren't particularly interesting, and we should ignore them. When we know that people won't do what they ought to do, the question is not what they *may* do. Instead, the question is what we can get them to do relative to their willingness to submit to morality. I've been arguing that animal welfare advocates may encourage those involved in animal agriculture to research—and, if successful, ultimately pursue—disenhancement.

In an essay that's generally supportive of animal sanctuaries, Karen Emmerman [28, p. 228] still describes them as "imperfect solutions to horrific problems." I'm not sure that I concur with that assessment of animal sanctuaries, but I appreciate her willingness to stand behind a solution that is, by her own lights, the best of a bad lot. It reflects a willingness to acknowledge that when the world is broken, moral decision-making is tragic. And in that spirit, I say both that it's wrong to create psychologically disenhanced animals and that we may encourage the industry to do it.

**Acknowledgment** Thanks to the editors for detailed and thoughtful comments on earlier drafts of this chapter.

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# The Four Cs of Modern (Neuro)ethology and Neuroethics: Cognition, Complexity, Conation, and Culture

# 9

Simon Gadbois

**Abstract**

Most of the modern arguments for or against the use of animals in research have a tendency to focus on animals' cognitive and metacognitive abilities or seem to make consciousness and self-awareness prerequisites for an argument for the ethical treatment of animals. In the age of animal well-being (as opposed to their mere welfare), a modern neuroethological and post-cognitivist perspective on the animal mind may be fruitful. Unfortunately, the popularization of science (a strong venture in animal behavior and neuroscience) often weakens potentially good arguments and disfigures the science, the data, and the facts, adding only confusion to the issues at hand and creating myths that stall the progress of the ethical matters being discussed. We will discuss four main points: (1) cognitive perspectives in animal behavior emerged in ethology and comparative psychology and may have sidetracked some of the most salient issues relevant to neuroethics; (2) complex behaviors can emerge from simple brains, bridging the "mind gap" between human and nonhuman animals; (3) a conative approach to the behavioral sciences and neurosciences (already historically well established) is relevant to animal well-being and welfare in defining what animals want; (4) social neuroscience, behavioral plasticity, and the emergence of an understanding of animal culture narrow the divide between what we always assumed was uniquely human (species-specific behavioral flexibility and diversity).

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This title is inspired by John Fentress' (1989) "Comparative Coordination (A Story of Three Little P'S in Behavior)". The paper discussed Process, Patterns and Phenotype as the fundamental constructs of behavior patterns in animals and influenced the rest of my thinking about animal behavior. [1]

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_9

**Keywords**
Conation · Cognition · Culture · Complexity · Affective neuroscience · Social neuroscience

## 9.1 Introduction: A General Historical Commentary and a Critique of Pop-Neuroscience

Neuroscience, the behavioral sciences, and the cognitive sciences share a relatively short yet tumultuous history. There are many books and textbooks covering the history of psychology, for psychologists are remarkably introspective and indulge in the history of their science more than neuroscientists or biologists. This précis of the history of the sciences mentioned above will be brief (and the reader is referred to [2] for more).

In 1879, "Experimental Psychology" began to individuate from philosophy, seeking to become a science in its own right. The first laboratory of Experimental Psychology was founded in Germany. At that time, much of psychology was also about neurophysiology. Indeed, the field of Physiological Psychology was fully integrated into "Experimental Psychology." Those early experimental psychologists were from the school of Structuralism. Soon after, Americans, influenced by William James, started the school of Functionalism (also highly influenced by Darwin). Gestalt psychologists were also influential, including Köhler (1887–1967), with his observations on insight in chimpanzees during problem-solving tasks. The most relevant (and persistent) schools of thought for our discussion are without a doubt Behaviorism and Cognitivism. Inspired by Pavlov's classical conditioning principles, Watson envisioned a science of psychology focused only on behavior or what can be observed directly without hypothetical constructs or intervening variables. Also inspired by Thorndike (a Functionalist), the law of effect, and the principles of trial and error learning, Behaviorism proposed a form of learning, instrumental or operant conditioning, based on reinforcement. The stimulus-response-consequence (S-R-C) formulation of behavior was proposed by Skinner, Hull, Spence, and others. Behaviorism flourished in the USA, but encountered some resistance in Europe, from Gestaltism, and North America, from Cognitivism.

Ethologists also disagreed with Behaviorists. Although both Behaviorists and ethologists agreed that the focus of their science was behavior, they had remarkably different takes on methodology and the nature of behavior. Animal psychologists of the early twentieth century (all Behaviorists at the time) were very much focused on laboratory studies, the use of the hypothetico-deductive method, a strong focus on nurture or acquired behaviors, and a propensity to support the "blank slate" argument. They were also more likely to be Cartesian dualists. Ethologists, being the early behavioral biologists—preceding by decades the behavioral ecologists that emanated from the sociobiological revolution of the 1960s and 1970s—were proponents of field research or studying animals in their natural environment. They used the inductive method to generalize from observations and had a strong focus on nature, or innate behaviors, developing sophisticated theories of instincts [3]. They were also more likely to be monists.

For decades the debates between ethologists and Behaviorist psychologists were numerous [4] and led to an interesting and fruitful synthesis [5, 6]. Then, according to some, as early as 1956 [7] Cognitivism emerged in the USA, influenced by Cybernetics and Information Theory. Cognitivism embraced a computer metaphor of the mind and adopted Systems Theory to solidify its scientific aspirations. Gestalt psychologists started the Cognitivist wave, as did Piaget (1896–1980) and Vygotsky (1896–1934) who had immense influence on cognitive psychology as a whole. Cognitivism commits a number of sins according to Behaviorists. First and foremost, cognitivists embrace mentalistic concepts and terms to explain behavior; they study, after all, intellectual processes (perception, attention, memory, problem solving, even language). Additionally, they are comfortable evoking mentalistic mechanisms, hypothetical constructs, and intervening variables, such as discussing "motivation" or "attention" and using "performance scores" to infer the existence of the underlying processes.

Cognitivism focuses on mental representations, making them a target of Behaviorists who insist that only observable or overt processes can be studied. Many Cognitivists claim that "covert processes," such as thoughts, are behavior. This has been a fundamental disagreement between the two groups, one that we can be sensed today between behavioral neuroscientists (who are not Behaviorists per se) and cognitive neuroscientists.

Some Behaviorists, in different waves, questioned their position. Tolman (1886–1959) and his "cognitive maps" in rats navigating mazes is one of the best known examples. Krechevsky (1909–1977) developed the concept of "hypotheses" in rats, to account for the fact that rats make complex decisions with quick readjustments when wrong. Although not a Behaviorist, but certainly a comparative psychologist, Yerkes (1876–1956) offered the construct of "ideations" in primates. This led to an explosion of cognitive theorists among animal learning specialists. The late 1960s and early 1970s were particularly remarkable for the adoption of cognitive principles in animal learning. Mackintosh introduced an attentional theory of learning [8], and Honig introduced mnemonic concepts (working memory) from human cognitive psychology into animal learning in two books that signaled the birth of animal cognition from a psychological perspective [9, 10].

Ethology was slower to take up the Cognitivist perspective. Like Behaviorists, they focused on observable behavior, albeit in the natural environment of the animal. But testing hypotheses in field conditions is not easy, and despite the fact that ethology allows for the study of covert processes, it was not until Griffin that there was a "cognitive ethology" worth mentioning. Griffin's perspective was criticized by philosophers and psychologists alike, as much of his writing tends to conflate cognitive processes and consciousness [11–13]. The fields of *cognitive ecology*, *neuroecology* (both within behavioral ecology), *behavioral economics*, *neuroeconomics*, and *zoosemiotics* have since flourished and have helped situate a cognitive and neurocognitive perspective within behavioral biology. In the remainder of this chapter, any mention of Behaviorism or Cognitivism refers to the perspectives mentioned above, entirely from the psychological perspective for Behaviorism and mostly from psychology for Cognitivism.

Not so long ago, the term “neuroscience” was quite marginal or unusual. It was not until the 1990s that the term was used systematically to define a science. It quickly defined multidisciplinary academic programs interested in the brain and slowly began to refer to a multidisciplinary science of the brain. The prefix “neuro” is already in use for neurobiology, neuroethology, and neurophysiology, and many neurosciences are historically broad in what they consider neuroscience. In psychology, for instance, “biological psychology” refers to a broadly biological take on psychology (from genetics to evolution and all aspects of the physiological underpinnings of behavior), while “physiological psychology” focuses on the neurophysiology, (neuro)endocrinology, metabolic physiology, and neuroimmunology of the brain-behavior system [14, 15]. Important historical distinctions exist, with related fields having their own perspectives on the brain-behavior issue. For example, neuropsychology is usually more clinical in its approach and studies neuropathologies or trauma to the brain. Psychophysiology focuses on the autonomic nervous system, electrophysiological measures (galvanic skin response, heart rate, blood pressure, etc.; essentially, elements of the polygraph or lie detector), and some central nervous system responses (EEG, evoked potentials, etc.) mostly in a noninvasive manner. A multitude of domains looking at sub-systems have flourished over the years, such as psychoneuroimmunology and (neuro)psychopharmacology. The prefixes “neuro” and “psycho” were often used together. Then something peculiar happened. “Neuroscience”—which is really a large number of neurosciences with a converging interest on the brain—became the million dollar word. It was not many sciences of the brain anymore; it was *the* science of the brain. It still includes diverse departments and disciplines, including neurotheology, neurophilosophy, neurosemiotics, neuroeconomics, neuroecology, neurolinguistics, and neuroethics, and more. But in the late 1990s and early 2000s, the term neuroscience became both unifying and, sometimes paradoxically, dividing.

In 1997, at the Society for Neuroscience in New Orleans, a presenter commented that over 50% of the membership was from Psychology departments. Although I have not been able to retrace the source, that number stuck with me, and a quick historical overview of the neurosciences suggests the massive influence of biological/physiological psychology. But the *Zeitgeist* of the 1990s eventually incited academic psychologists to adopt the “neuroscience” catchword and most of biological/physiological psychology became “behavioral neuroscience,” “cognitive neuroscience,” “social neuroscience,” “affective neuroscience,” etc., depending on the speciality and perspective of the researchers involved. This terminological change had a profound impact on the popular view of psychology and neuroscience. Let me offer an example. Donald Hebb (1904–1985) [16, 17], one of the most cited psychologists and neuroscientists ever owing to his contribution to the understanding of natural neural networks or the “cell assembly” in the 1940s and 1950s [18], is mysteriously labeled as a “mere psychologist” or “just a psychologist” in two popular bestsellers. In *The Mind and the Brain: Neuroplasticity and the Power of Mental Force* [19], it is said that "Hebb, after all, was a mere psychologist, not a neuroscientist" (p. 107). *Train Your Mind, Change Your Brain* [20] claims that "It took years for synaptic plasticity to catch-on. Partly because Hebb was 'just' a psychologist and not a neuroscientist, brain researchers were slow to take him seriously." Both quotes demonstrate the lack of understanding of what neuroscience actually is, as well as its origins and history. The same book refers to William James as "'only' a psychologist, not a neurologist" (p. 5) and describes psychologist Edward Taub as "an outsider of the elite field of neuroscience, a psychologist. . ." (p. 39). This vision has hurt neuroscience more than psychology. Neuroscience is a multidisciplinary discipline, or, better, a collection of disciplines, and could have benefited from emphasizing the plurality of the "neurosciences." After all, as far as behavior goes, Shepherd [21] summarizes the purpose and *raison d'être* of neuroscience: "Nothing in neurobiology makes sense except in the light of behavior" (p. 9). He continues, ". . . behavior is a product of nervous system organization and is also an agent in moulding that organization." There is no justification, in science or pop-science, for a disconnection between the behavioral sciences and the neurosciences, as they share a common history, thanks to psychology and ethology. Psychology and ethology, as behavioral sciences, are neurosciences. Similarly, the neurosciences should be considered behavioral sciences. Beyond "behavioral neuroscience," cognitive neuroscience, affective neuroscience, social neuroscience, and other areas of the neurosciences were historically and epistemologically associated with psychology or ethology.

## 9.2 Cognition

### 9.2.1 An Epistemological Commentary

Modern neuroscience is at a crossroads. Almost 30 years since the beginning of the "decade of the brain"[1] neuroscience is not the new kid on the block anymore. It has made its way deep into our understanding of the human condition, as well as our understanding of other animals, including the interpretation of their behavior in neuroethology and neuroecology. I present here a bottom-up perspective on behavior and the brain meant to highlight the similarities between humans and nonhumans and narrow or mitigate the perceived differences. The dangers of speciesism, both its anthropocentric and non-anthropocentric variety, and the idea of a human cognitive and moral hegemony, impact our use of animal models in neuroscience and the clinical sciences in general, but also our attitudes and beliefs surrounding pressing animal conservation issues all around the world.

Instead of emphasizing the exceptionality of humans, the relativist (nonpolarizing and hopefully nondogmatic) and synthetic/integrative perspective presented here

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[1] https://www.loc.gov/loc/brain/

points out the failures of a true dialectical synthesis. Despite having all the tools, data, and disciplines in place, we seem to keep on making the same points and emphasizing the same irrational arguments. The *scala naturae* is so ingrained in our perception and understanding of the nonhuman animal world that it is like walking on a moving sidewalk: We seem to quickly go somewhere with little legwork, but the essence of the problem stays the same—the achievement of a science-informed ethics is an illusion. As we make arguments to save the apes or the whales based on some exceptional socio-affective or cognitive feat, we undermine the rest of the animal kingdom. This attitude is institutionalized as well. For instance, in Canada (see the guidelines of the Canadian Council of Animal Care, CCAC[2]) and the EU [22] animal research ethics recognizes a fundamental qualitative and quantitative difference between vertebrates and invertebrates (with an intriguing exception for cephalopods).

The dialectical operation and epistemological development of the neurosciences (and behavioral sciences) seems to have resulted mostly in historical pendulum swings between false dichotomies (nature-nurture, innatism-behaviorism, behaviorism-cognitivism, monism-dualism, overt behavior-covert behavior, etc.) that created a relatively sterile landscape with little common ground or synthesis. This chapter will present what some would describe as a *post-Cognitivist* view (since Cognitivism is also seen as anthropocentric and anthropogenic [23]), integrating some not-so-new but emergent perspectives in the behavioral sciences and neurosciences. Although not necessarily mainstream, and not necessarily that new (so I hesitate to use the other common label of “neo-Cognitivism”), post-Cognitivist schools are mostly reactionary to classical Cognitivism and often aggregate elements of sub-movements within mainstream schools.

### 9.2.2 A Personal Reflection

Many of the reflections presented here are personal and represent my struggle to make sense of the mainstream theories of the past centuries, as well as their updated versions. Having harmonized the approaches from neuroscience, ethology, and experimental and comparative psychology, a clash of ideas was inevitable. My academic trajectory forced me to face the contradictions and paradoxes of the mainstream schools of thought in all three fields. The malaise became more salient in the context of animal ethics and particularly invasive neuroscience.

I vividly remember my first week at the Canadian Centre for Wolf Research (CCWR) in the early 1990s. It was a surreal time for me as I was coming late into a childhood dream of working with wolves. At 11, I read Konrad Lorenz (*Man Meets Dog*, translated from the French *Tous les chiens, tous les chats* [24]) and was immediately taken by ethology and the idea of observing animals in order to understand their behavior. Before I was a doctoral student, I was mostly exposed

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[2] https://www.ccac.ca

to lab rats (in behavioral pharmacology) and pigeons (in comparative cognition), as well as some research on human neurocognition. I had been mostly exposed to cognitive psychology and neuroscience, but also some neo-Behaviorism. I had always tried to integrate equal parts of experimental psychology, behavioral biology, and neuroscience in my interests in animal behavior. But beyond the disciplines, there was also a malaise surrounding the schools of thought that were dominant at the time. In 1992, after 6 years of undergraduate and master's work, as well as Skinner boxes and lab animals, I was up for a real challenge to some of my assumptions.

At the CCWR, I studied social and endocrinological factors in reproductive suppression of nonbreeders in wolf packs. The breeding season in wolves takes place during the winter, and the competition within sexes can be intense at times [25–27]. One morning, in the middle of an observation session, I declared out loud "it is all limbic!" It was a heartfelt epiphany from a former lab researcher hit by the reality of an animal in their natural environment, in their natural social system, doing their natural things, worrying about the basics of their existence and their core and basic motivations. Granted, the CCWR wolves were in an enclosure, but the 10 acres were heavily wooded, and not visited by humans other than the researchers, so they were left to self-regulate as much as possible (except for food we provided). I should not have been that surprised. If I read Lorenz, I ought to have known all the arguments for naturalistic and systematic observation of behavior and the harsh Lorenzian criticism of experimental comparative psychology. Yet, I was floored. For years, I had tried to reconceptualize the contradictions and paradoxes of my former training with the more trendy "cognitive" framework of the time. Behaviorism was never fond of neurophysiological explanations and constructs such as "emotions" and other mentalistic concepts. A wolf in its environment and a pigeon or rat in a Skinner box, stripped of the relevance of its innate behaviors, are two different universes.

### 9.2.3 The Battle of the Most Influential Theories of the Past Century

Of one thing I was sure, Behaviorism was not going to work for understanding lupine behavior. To this day, I am convinced that Behaviorism is viable as a pragmatic tool in training animals (especially pets) and as a formalist lab-based perspective on animal (and human) learning (e.g., visual discriminations with pigeons in a Skinner box). Beyond that, it (in its original version) falls short on a number of issues: the recognition of crucial hypothetical concepts and intervening variables to the study of behavior and, by extension, the "mind." Behavioral biology and much of comparative psychology have embraced Cognitivism over the years. More recognition that covert processes may be important to the understanding of behavior (emotions, motivations, and cognitions) have emerged, not to mention the rise of the neurosciences. Behaviorism struggled with two movements in the behavioral sciences: the classical ethology perspective of innate behaviors and how instincts can trump training (i.e., learning; see the classic by the Brelands on the

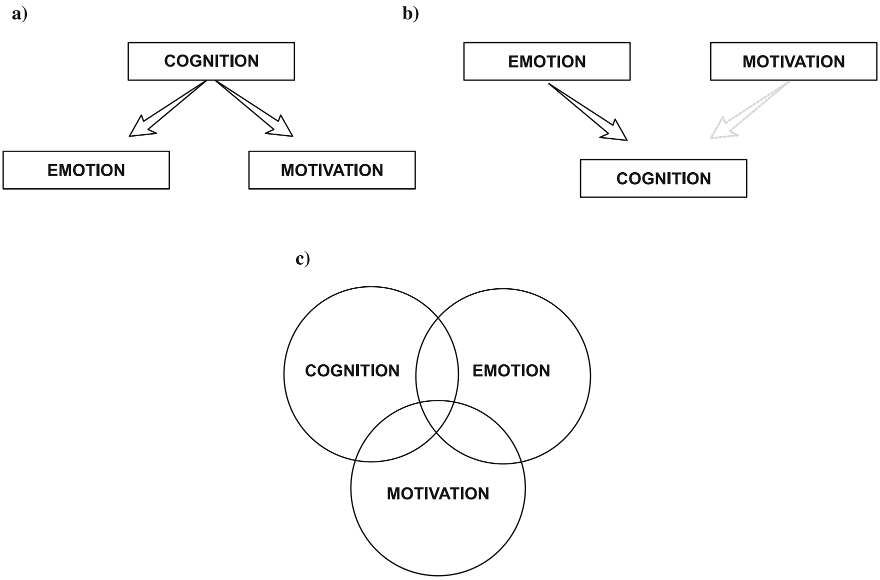

**Fig. 9.1** The perspectives of the cognitive sciences, affective neurosciences, and post-Cognitivism in regard to the three components of the mind/brain

interference of fixed action patterns on learning simple tasks [28]) and the Cognitivist perspective, demonstrating intelligent behaviors such as problem-solving abilities in isolation and within social cooperation [29].

It is not *all* limbic, but there is no doubt that social interactions are heavily modulated by the limbic system. Panksepp [30] makes the point that the limbic system is the most consistently conserved or phylogenetically preserved part of the telencephalon and integral to social behavior and self-preservation. He also highlights the fact that emotions, in "lower" organisms (invertebrates and "lower" vertebrates), are clearly the basic mechanism for survival, self-preservation, and conservation. Although Panksepp does not deny the ability of "higher" vertebrates to assess and evaluate basic stimuli, threats, and emotions cognitively, he resists the idea that cognitive processes are supreme or even necessary for basic survival. In other words, limbic processes may supersede cognitive processes. This is not a popular view among Cognitivists, who have no problem suggesting that the study of emotions (or motivation for that matter) is a part of cognitive psychology or neuroscience [31, 32]. Figure 9.1 illustrates the view from modern cognitive science (a), in contrast with the affective neuroscience view (b). The last representation is the post-Cognitivist view (c).

In the late 1990s, affective factors were well recognized in the study of social dynamics and social neuroscience [30, 33]. The consensus among behavioral neuroscientists is that emotions are a fundamental dimension of the mind, as the Ancient Greeks knew very well. Modern psychology and neuroscience are founded on the triad of the mind so dear to the Ancient Greeks [34]: the affective (emotional), the cognitive (intellectual), and the conative (motivational). Some modern research programs literally define the brain within the framework of those hypothetical constructs and elevate them to systemic entities. For example, Berridge, Robinson, and Aldridge [35] discuss the interaction among the "liking" system (affective component), the "wanting" system (motivational component), and the learning component. In other words, there is empirical, functional, and structural/systemic evidence for this kind of brain organization and these brain processes. Obviously they interact, and together they contribute to complex social behavior and social cognition, self-awareness, and, ultimately, consciousness.

Assuming that the cognitive capabilities of animals are not the only relevant factors in our ethical stance, the next three arguments may help bridge the gap between the current narratives in neuroethics when working with animals, either as animal models or as subjects of research themselves, and considering individuals themselves (including their motivations and wants), particularly in ethology and neuroethology. Cognition aside, and beyond affective factors, a post-cognitivist ethology and neuroethology can bridge the "mind gap" between human and nonhuman animals. Moreover, we underestimate the ability of the brain of any taxa to produce complex behaviors; spawn complex choices, preferences, and decisions; and coordinate complex social and cultural behaviors.

## 9.3 Complexity: Complex Behaviors Can Emerge from Simple Brains

A few years ago, a video[3] went viral on the Internet showing a dog "rescuing" a fish on land. The video showed a fish, still alive, on what appears to be a cement surface. There is a bit of water splashed around, a little puddle of water next to the fish, and a dog pushing water over the struggling animal. The popular reaction to the video was to interpret the action of the dog as empathic. There are two problems with this that I address in this section.

First, if this were a rescue, we would have to accept that dogs understand that fish need water to breathe. I am on the fence on the issue of theory of mind (e.g., allowing for perspective-taking) in canines, but this example would require a dog to understand that another species needs water in order to breathe. Second, the video actually shows a typical natural action sequence (a modern term to describe innate behavior patterns) in wild or domestic canids—covering or concealing a high value food item—triggered during foraging and/or when the canid is satiated and may come back to the item later.

Before I elaborate on the two points mentioned above, let me state first that "complex behaviors can emerge from simple brains." This can apply to the tremendously complex behaviors of many animals, including many with very rudimentary central nervous systems. Arthropods such as bees have been known

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[3] https://www.youtube.com/watch?v=LBiAlqygvms

to engage in sharing of directional information for food source (the well-known waggle dance), and many ant species engage in the tandem run, which some [36, 37] think is a form of teaching (at least as defined by Caro and Hauser [38]).

Louise Barrett [39], in a chapter appropriately entitled "Small brains, smart behavior," discusses other cases involving invertebrates and some vertebrates and makes an interesting point: "it becomes very hard to decide where 'perception' ends and 'cognition' starts" (p. 56). Barrett describes the behavior of *Portia*, a genus of jumping spiders that engages in surprisingly complex behaviors (e.g., deceptive and aggressive mimicry).[4] Barrett's comment about *perception* is key to my central cautionary note: Making arguments about ethics based on the cognitive or metacognitive abilities of animals can backfire, but it can also be conceptually weaponized if we open our minds to the idea that humans and other mammals and birds we tend to cognitively glorify (e.g., corvids, psittacids, social carnivores, primates, cetaceans, etc.) are not so remarkable or exceptional.

The field of animal behavior has a tendency to be framed (in a polarizing way, at least in North America) by the divisive arguments of the Behaviorist vs. Cognitivist perspectives. I see this as a renewed trend in the canine behavior and cognition world in the past decade, and more so in canine pop-science. The missing link seems to be in schools of thought that have been around for quite a while, but rarely seem to surface as mainstream (except perhaps in the context of motor control, sensorimotor integration, and neuroethology). I categorize them as post-Cognitivist or neo-Cognitivist perspectives (although, again, they are often pre- or not so neo-Cognitivist theoretical frameworks). They include the perception-action framework. Gibsonian and neo-Gibsonian theories are part of this niche.[5] In the Gibsonian and post-Cognitivist perspective, the mechanisms are not stimulus-response, but rather sensorimotor coordination and integration. They are also not overly mentalistic, and in fact, some post-Cognitivist schools are remarkably reductionistic (at least at some level, e.g., Connectionism, Neural Network Theory). Most of these frameworks reject the representationalism[6] of modern cognitive science and instead focus on a direct realism (direct perception) giving a voice to an interaction between environment and perception in the genesis, regulation, and modulation of behavior. In this realm of theories, there is also a strong rejection of Cartesian dualism and Computationalism[7] (as it was framed within cognitive psychology and its use of

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[4] Even the Wikipedia entry for *Portia* is telling: "*Portia* is a genus of jumping spider that feeds on other spiders. They are remarkable for their intelligent hunting behavior, which suggests that they are capable of learning and problem solving, traits normally attributed to much larger animals." (https://en.wikipedia.org/wiki/Portia_(spider))

[5] The schools of embodied, situated, distributed cognition, as well as enactivism, dynamical systems, etc.

[6] In other words, the use of mental representations of objects, subjects, events, spatial information (mental maps), chronological events (temporal maps), etc.

[7] In other words, the use of the computer metaphor in cognitive science, at both the software (coding, programming) and hardware (serial vs. parallel processing) level (e.g., artificial neural networks).

Information Theory and cybernetics). Tenets of these post-cognitivist theories will often present a version of the following principles:

1. As much as perception can influence behavior, behavior can influence perception.
2. The reference to *mental* representations is not necessary.
3. Hypothetical constructs and their accompanying intervening variables are often not necessary (that would be a rule in behaviorism and Gibsonian psychology),[8] but are tolerated *if* only used heuristically and supported by data: the concepts of attention, memory, affect/emotion, motivation,[9] etc.
4. When it comes to "information processing," e.g., perception, the "what" (stimulus, environment, context) supersedes the "how" (i.e., sensation or physiological mechanisms).

There is a rejection of the "poverty of the stimulus" standpoint (the idea that the stimulus is secondary in importance to its mental representation and the internal mechanisms at play to process it) from classical cognitive psychology, in favor of a "richness of the stimulus" position (e.g., a position held by semiotics, with a focus on the actual stimulus and the environment) and a focus on context and natural behaviors in natural environments. Basically, this is a classic ethological perspective (often labeled "ecological," as in ecological psychology).

I was mentored by influential scientists in the field of animal learning (Werner Honig, Marvin Krank, Vincent LoLordo, Bruce Moore, Ward O'Neill) and ethology (John Fentress, Fred Harrington, Peter McLeod), but not one of them had the same take on Behaviorism and Cognitivism. They all had their own version of some sort of compromise, if they cared at all about those labels. Long conversations with my PhD supervisor, John Fentress (ethologist and neuroethologist), initially frustrated me in the early years of my degree, especially when I was working on action sequences in *canids*. Being influenced by a rather strong cognitive mindset, I was puzzled that he did not care at all about any cognitive explanation or search for "cognitive control." As a classically trained zoologist and ethologist, early ethological theories had influenced him, and the idea that innate behaviors are common in animals (and humans) and, by definition, not under cognitive control, was deeply influential. I spent most of my PhD reframing everything from that classical perspective and its modern version. I am not sure of what Fentress would think of my current take on behavior and behavior patterns (he died in 2015), but much of our shared perspective is summarized in a number of articles and chapters [41–50].

Neuroethology and perception-action perspectives in psychology and neuroscience have always minimized the importance of cognitive control and cognitive processes and avoided reference to self-awareness. It may be that a recognition and appreciation of complex behaviors in organisms with small brains or simple

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[8] Note that J.J. Gibson was once referred to as the "Skinner of perception" [40].

[9] After all, many Behaviorists could not escape the concept of motivation or drive in their explanation of how reinforcement would work in instrumental conditioning.

nervous systems was the buffering factor, at least in neuroethology [45, 51]. In the next section, I examine two questions directly relevant to animal behavior and animal welfare, respectively: How are complex behaviors in complex situations generated? And how do motivational factors control behavior and what is their relevance to what animals may want?

## 9.4 Conation: It Is About What Animals Naturally Do (Innate Behavior) and What They Want

The proposal of a conative science encompassing ethology, psychology, and neuroscience would require the merger of two re-emerging trends in modern behavioral neuroscience (including neuroethology):

1. Updated theories of instincts, (mostly) innate behaviors, and behavior patterns, from "fixed action patterns" [52] to the modern "natural action sequences" [50]
2. Updated theories of motivation (from the drive theories of psychology and ethology), to the modern incentive theories overtaking the neuroscience of motivation [53]

Modern neuroethology recognizes the importance of both innate and learned behaviors. But despite the fact that there is a modern recognition of the full integration of nature (e.g., genes) and nurture (environment) for all behaviors (and other phenotypes), ethology and neuroethology have documented numerous behaviors that are strongly genetically predetermined, from rodent grooming patterns [54–56] to canid caching sequences [50, 57, 58]. Although not "fixed action patterns" (FAPs) per se (because of some degrees of freedom in the sequencing and expression of the behaviors [59]), there are still common patterns, with varying degrees of freedom (within and between sequences). In other words, between a fully deterministic sequence (close to the classic FAP) and full randomness, there are levels of stochasticity (probabilities of variation in time and space). To return to the dog/fish video, it illustrates an innate motor program.[10] Interestingly, it is reported by Lorenz [52] in his classic "The Foundation of Ethology":

> If, for example, a researcher is able to observe the way in which a wolf in the wild carries the remains of a kill to a covert place, digs a hole in the earth there, pushes the piece of plunder in with his nose, shovels the excavated earth back—still using his nose - and then levels the site through shoves with the nose, the teleonomic question concerning this behavior sequence is easy to answer, but the question concerning the causal origin of this behavior pattern remains completely unanswered. If, in contrast to this, the observer of captive animals sees the way in which a young wolf or dog carries a bone to behind the dining room drapes, lays it down

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[10] Other terms are often used in this literature as well. For example, the terms "motor syntax" or "motor grammar" refer to the serial or sequential organization of behavior in various levels of temporal and spatial resolution. The term "syntax" is also found in zoosemiotics [60] to describe the structure of behavior.

> there, scrapes violently for a while next to the bone, pushes the bone with his nose to the place where all the scraping was done and then, again with his nose and now squeaking along the surface of the parquetry flooring, shoves the nonexistent earth back into the hole that has not been dug and goes away satisfied, the observer knows quite a lot about the phylogenetic program of the behavior pattern. Lorenz 1982 [52, p. 48–49]

What looks at first glance like a deliberate, thoughtful, planned, and strategic behavior is no more than a motor program triggered by a specific stimulus (food) within a specific context (foraging) and state (satiety). The animal needs to be satiated or the caching does not take place (i.e., the motor sequence is not expressed). Although not a typical FAP (and arguably not a modal action pattern either,[11] see [50] for a comprehensive discussion of the terms), the flexibility in the sequencing, rhythm, melody, etc., of the behavior is deceptive. Long and complex sequences can be patterned. The prosody (the musicality of behavior [49]) refers to one dimension of degrees of freedom: The kinetic signature of behavior may change, such as rhythm and melody, but there is a recognizable overall pattern and, more importantly, the behavior is not learned. It is spontaneously produced by young animals and seems quite resistant to developmental modulations and motor fine-tuning. In other words, the behavior sequence is not random.

The relevant psychology, ethology, and neuroscience of such innate complex behaviors are part of what I argue is a *conative* psychology, ethology, and neuroscience. Conation refers to the motivational processes underlying behavior. As Berridge indicated [53], the study of conation has been central to the study of the brain and behavior. Integrated with a perception-action view of behavior, the conative perspective adds the acknowledgment that behavior is modulated by internal and external states. Woodworth, in 1897, thought that psychology could be reconceptualized as "motivology" [2], a science to be concerned with how to know what an organism will do in a given situation. A research program built around that construct defines the aims of the behavioral and brain sciences, but, note, without any assumptions about the cognitive dimension of behavior.

To be clear, I am not suggesting that nonhuman animals do not have cognitive abilities or that they should not be studied. I am not putting forward a Behaviorist manifesto either. But I am also critical of some aspects of the traditional theories of cognitive psychology and neuroscience: the representationalism bias, the poverty of the stimulus (which is not acceptable from a zoosemiotic perspective), and, from laboratory-based cognitive psychology and neuroscience, the "poverty of the environment."[12] The missing contextualism, ecological validity, and inclusion of the role

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[11] MAPs, or modal action patterns, were Barlow's version of FAPs with less rigidity and more flexibility or degrees of freedom. With MAPs the issue of stereotypy in a behavior pattern is for the first time defined in probabilistic terms [60].

[12] As an extension of the "poverty of the stimulus," the "poverty of the environment" as a whole—i.e., targeted or processed stimuli and beyond (what cognitive psychologists call the scene)—is crucial to information processing. This goes toward ecological validity.

of affordance(s)[13] [61, 62] limit the expansion of the neurocognitive sciences by limiting the choices to either a Behaviorist, Cognitivist, or Innatist view of behavior. It pits an anthropogenic/anthropomorphic view against a zoogenic/zoomorphic one. At the very least, the malaise of having to situate the apparent complex (if not "cognitive") behaviors of bees, ants, and spiders in relation to humans is difficult without the synthesis of the Behaviorist, Cognitivist, or Innatist perspectives. That is what some proponents of a post-Cognitivist, Conativist, perception-action view of the neurobehavioral sciences offer.

So how about a corollary conative proposal? As we focus on what animals feel and think, we forget a fundamental question: What do they *want*?

If they cannot tell us easily how they feel or what they think (or even less *how* they think), they may be able to tell us what they like or dislike. Psychophysiological measures and behavioral endocrinology have allowed us to infer their positive and negative emotions from the fundamental limbic activations of the brain. But perhaps the ultimate goal is to determine what they *want*. What an organism likes is not always what an organism wants—drug addicts may want their drug, but they may not like their drug. Nonetheless, modern behavioral neuroscience actually recognizes such a "liking" system and a "wanting" system [35]. Affective, conative, and cognitive sciences (ethology, psychology, and neuroscience) may converge elegantly to answer questions about what animals may want. Volitional decision-making and studies based on choices and preferences have made their way into animal welfare. Conative (neuro)ethology must not lose sight of the promising work started by Georgia Mason [63, 64] and Marian Stamp Dawkins [65, 66]. Influenced by behavioral ecology, behavioral economics, and neuroeconomics, this approach to conative processes brings strong functional and qualitative models to the assessment of wants, perceived needs, and motivational-behavioral priorities. A more ambitious and intriguing idea is proposed by Fenton [67, 68] in discussing animal dissent, specifically in the case of chimpanzee biomedical research. From the integrative framework presented so far, these ideas are appealing as they do not compel the scientist to address what the animal may be understanding (the cognitive) or feeling (the affective), but rather what the animal wants or does not want. Paradoxically, from this perspective, conative ethology and neuroscience may shed light on affective and cognitive processes. I have a sense that this is what the functionalist Woodworth would have seen as a fitting and worthy "animal motivology."

If complex sequences of behavior can be produced without complex cognitive means of control, and can address the motivational state, wants, and desires of animals, could it be, as I suggested earlier, that complex social behaviors are also exempt from underlying complex systems? Can a simple system produce and modulate complex social interactions and regulations? This is parsimoniously attractive, but is it realistic? What could be the mechanisms? In the next section I

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[13] In the Gibsonian ecological psychology, "affordances of the environment" are (in Gibson's own words): "what it offers the animal, what it provides or furnishes, either for good or ill." (p. 127) (1977, 1986).

suggest that the same type of brain processes and dynamic patterns [49, 69] that produce complex sequences of caching in canids, or grooming in rodents, could also be responsible for social behavior.

## 9.5 Culture: Social Neuroscience, Behavioral Plasticity, and the Emergence of an Understanding of Animal Culture

An emerging literature on animal culture is taking hold, mostly in studies of primates and cetaceans, although it is likely to extend to other species. As we contemplate complex social interactions, it is easy to slide into an unchecked Cognitivism, starting with suggesting that social cognition is essential to the social complexity of social birds and mammals (including humans). Such an approach is not necessary, and a reductionistic perspective can apply to (eu)social insects as well as big-brained birds and mammals, once again narrowing the perceived gap between humans and nonhumans and raising questions about human exceptionalism. I start, once more, with a general historical commentary. I will also discuss how scientific ideas can sometimes experience a negative transformative process during popularization: A critique of canine and lupine pop-ethology will illustrate how pop-science can derail debates about the ethical treatment of animals.

Modern (neuro)ethology has changed much since the idiographic, descriptive, qualitative style of its early protagonists. The modern study of animal behavior has become nomothetic, focusing on generalization and averaging of many cases and trying to understand behavior by looking at graphs or tables of means and standard deviations and inferential statistics. We have excised the narrative out of behavior. I often tell my students that behavior is change in time and space. The idea that we can describe or merely summarize behavior with numbers out of context, as standalone frequencies or durations, is disconcerting. Lorenz allegedly boasted about never publishing a single graph [4].

Some areas of modern ethology and neuroethology found ways to combine the quantitative *Zeitgeist* of the modern behavioral sciences and the narrative elegance of the descriptive ethology of the early ethologists. This can be seen, for example, with the sequential analysis of behavior and the search for (stochastic) patterns, an approach that can be traced back to Chomsky in linguistics [70][14] as it describes rule-based systems governing patterns of actions. Rule-based systems are not new to behavioral biology and are often evoked to explain the innateness, for example, of some communication systems in animals [75]. I think the human analogy (the reference to Chomsky and human language) is only an analogy. But the idea that rule-based systems are generating and modulating brain systems (neural networks), motor behavior (the Fentress references above), and even social behaviors [76–78] is common. The approach is fundamentally Structuralist in the sense that it recognizes

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[14] See also MacNeilage [71], or Morris in semiotics [72, 73], and more recently our work [49, 50, 74].

that biological systems are organized in a nonrandom fashion and that, from a behavioral perspective, these rules are inborn [49, 50]. The reason I distance myself from the Chomskyan perspective[15] is that the post-Cognitivist perspective has interpreted much of Chomskyan ideas as "*cognitive* rules," or rules for language and other complex "thought behaviors," or cognitions [80]. Instead, Fentress and I suggest simple rules and grammars (sometimes potentially complex grammars) to explain simple, innate behaviors (historically called instincts) as well as emerging complexity in sophisticated social behaviors. Coppinger [81, 82], for example, applies the principles from Fentress and McLeod initially [48] and Gadbois et al. later [49, 50] to explain the artificial selection of movement patterns in border collies. The border collie essentially uses the same action syntax as the wolf while hunting, except that the end of the sequence is truncated (the bite and the kill). It is suggested that via selective breeding, it was possible to isolate and eliminate the last two components of the hunting sequence to keep only the stalking segments.

Because it seeks to explain language and cognitive processes, the Chomskyan perspective is in some ways top-down, whereas my perspective [49, 50] is bottom-up. It follows the idea that basic behaviors (individual behaviors but also social behaviors) are innate, encoded in the genes, and expressed with various levels of degrees of freedom. This does not mean that some practice, fine-tuning, or even observational learning is not useful, especially in big-brained birds and mammals (as social deprivation experiments have shown with primates). In the context of social behavior, this translates into "social grammars" or rules of the what and how of social interactions and conventions [76–78, 83, 84]. The approach is bottom-up, reductionistic, and parsimonious because it suggests that simple systems can produce complex behaviors from those simpler mechanisms and even from simple brains.

But how can complexity emerge from simple systems and grammars? How can the structure (syntax) and meaning (semantics) of communication be expressed and account for the complexity of animal communication and social structure? Part of the answer is in the mathematical/computational underpinnings of life systems. Ian Stewart [85] explains why rules in rule-based systems are so powerful and yet simple. We can identify at least four principles: efficiency, consistency, adaptability, and locality. First, rules are efficient, by the nature of their simplicity. As Stewart points out "Rules are simpler than the behavior they generate" (p. 197). Second, rules are consistent. In other words, rules guarantee a consistent response or action in the appropriate context. Third, rules are adaptable. A rule-based system can evolve, first, by inserting exceptions, then, if necessary, by making the exception the rule. If rules are encoded in the genes, they are subject to natural selection, sexual selection, etc. Fourth, rules are local. Rules apply to the individual, in its immediate

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[15] Chomsky is often seen as one of the fathers of cognitive science (as a linguist). Yet, his concept of Universal Grammar has inspired both ethologists (e.g., Fentress) and psychologists (e.g., Pinker) in describing a predisposed structure to language. For Fentress, this was linked to innate motor programs (the motor system is known to be hierarchically organized), and, for Pinker [79], it gave an innate blueprint ("language instinct") for the language structure described by Chomsky.

environment and situation, in the here and now. As Stewart puts it, rules "involve only what an individual can reasonably be expected to perceive." Rules can explain behaviors that seem magnificently complex (such as schools of fish [86] or the murmuration of birds [87]) with extraordinary simplicity: e.g., keep your eyes on the individual(s) next to you and avoid contact while in motion. Indeed, complex behaviors can emerge from simple systems, simple rules, simple brains, and also complex ones. In other words, they level the playing field once again between simpler organisms and humans.

This idea can be illustrated with a question about dominance, which has been popularized in the now massive pop-ethology of canines and other canids. In the past 20 years, within the canine behavior world (with dog trainers, breeders, veterinarians, and scientists) there has been a serious debate over the question of dominance in dogs, the usefulness of the concept of dominance in training, and even the relevance of the construct of dominance hierarchies in wolves. I am an advocate of the position that dominance-based training has no place in modern training. Force-free training is ethical (as in stress-free, fear-free, pain-free) and scientifically sound. But the dominance debate started on the wrong foot and is often mixed with other complex issues, such as the origin of dogs.[16] For example, wolves may not be the direct ancestors of modern dogs. Molecular genetics has challenged this a number of times, and this point is brought forward by Coppinger in order to distance dogs from wolves and to question the necessity of evoking dominance and dominance hierarchies in dogs, including in their training. More problematic, Coppinger has claimed that wolves (and by extension, dogs) may not have the cognitive ability to have dominance hierarchies to start with. That assertion strikes me as singular considering that dominance hierarchies have been identified in invertebrates (crustaceans) and "lower vertebrates" such as fish and reptiles and obviously multiple species of birds and mammals. Advanced cognitive abilities or complex social cognitions are not obligatory at any level of complexity in animal social behavior for the reasons explained above (e.g., murmurations in starlings, schooling in fish). The other assertion from Coppinger (and others) is that dominance hierarchies are simply not present in dogs. This has been challenged and debated quite a few times in recent years [88, 89]. The apex of this debate came when Mech [90] wrote about the wolves of Ellesmere Island. Although at no time does the paper claim that wolves have no dominance hierarchies, the paper describes a specific population and challenges the concept of "alphas" by moving from a rank-based theory to a role-based theory of social organization while using the concept of leadership instead of "alpha."[17]

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[16] There is a lot of background to this story that would take too much space and time, but is covered in blog I wrote for dog trainers and other dog enthusiasts in 2015 (http://doyoubelieveindog.blogspot.com/2015/04/51-shades-of-grey-misuse.html). Other ethologists such as Marc Bekoff and Roger Abrantes also contributed similar discussions to clarify the issue of dominance in wolves.

[17] Furthermore, following the 1999 paper, Mech [91] wrote "Leadership in wolf, Canis lupus, packs" and with co-authors a paper entitled "Leadership behavior in relation to dominance and reproductive status in gray wolves, Canis lupus" [92]. The word "alpha" is not used anymore, but the concepts of leader and leadership appear. The term dominance is still used.

It is unclear to me why the debate spilled over to dogs, as it is clear that through selective breeding over thousands of years of domestication, humans have done quite a good job of eliminating in dogs the behaviors associated with dominance, such as aggression. But Mech's paper was immediately hijacked by the force-free community as a flagship study debunking the myth of dominance in wolves and, by extension, in dogs. This illustrates the necessity of caution about the popularization of science. Many nuances are missing, and much seems to be taken out of context, or misunderstood, or simply manipulated to fulfill a specific agenda. Dominance and dominance hierarchies are complex constructs in social mammals. Although pop-ethology tries to depict dominance as an evil, the biological and socioecological reality is that dominance hierarchies are there in order to prevent conflict, not to encourage or generate it. And even if there is a belief that dominance, aggression, and stress are higher in captive wolves than wolves in their natural environment, there is in fact very little evidence for that assertion [25, 42, 93].

But let's start with the basics. Where is the confusion coming from? What are the facts about wolves and dominance? And why bring up this topic here? You will have to be patient for my third point, but it is the one that closes the loop: Wolves are not all the same. Wolf populations vary based on factors that are still unknown.

To start, we need to understand the socioecology of wolves. Much of the information below is summarized from Gadbois, Mech, and Packard [25, 42, 94]. Wolves are monogamous or, at the very least, socially monogamous (in other words, in principle, by convention, only one breeding pair is found in a pack, the alpha male and the alpha female). Wolves are also potential cooperative breeders, meaning that, when the group is based on an extended (multigenerational) family unit, nonbreeders are helpers. Indeed, large packs are hierarchically composed of the parents, alloparents (all the other adults of the pack as, typically, they are all engaged in pup care), and pups. I say "potential" because sometimes the immediate or nuclear family system is adopted (as in coyotes and jackals). In this case, you find the parents and the pups of the year: no aunts, uncles, cousins, or sisters and brothers of a previous litter, etc. This matters for a few reasons. It may determine if a dominance hierarchy needs to be in place. It is important to note that dominance hierarchies are often described as being important for access to resources, mostly food and mates. We have argued [25, 42, 95] that dominance hierarchies in wolves are mostly regulating the privilege to breed. There is indeed evidence that wolves determine the breeders of the pack within their own sex; in other words, females and males, respectively, figure out their own dominance hierarchies. By default, the female and the male that emerge at the top of each hierarchy will breed [25, 42, 93, 96]. But even if that was not the case, and that somehow the negotiations were strictly among males, the principle stays the same: Most of the time, only one female will breed with only one male.

Dominance hierarchies can be a means to establish or maintain reproductive suppression or inhibition in subordinates, a known mechanism in avian and mammalian cooperative breeders [25–27], highlighting that it is about more than competition for food. It also complicates the main point that I am seeking to make here: Dominance hierarchies are not merely about conflict or conflict regulation.

Pop-ethology has lost sight of the primary purpose of dominance hierarchies. In wolves, they are mostly about breeding privileges, and the tensions around food sources (mostly during the breeding season)[18] are only side effects of the hierarchical structure. Contrary to some popular beliefs, dominance hierarchies are meant to *prevent* conflict, not instill it. In fact, they may even procure the structure and mechanisms for conflict resolution [25].

With context about what dominance is for, we can re-examine Mech 1999 [90]. It is worth noting that a dilution of a dominance effect or fuzzy boundaries in a dominance hierarchy are hardly surprising. Pack size is a major factor in the emergence of a dominance hierarchy. The difference between nuclear or immediate family units and extended or multigenerational family units is not insignificant. One more piece of socioecological information surfaces with regard to those two types of family units: It is well documented (references above, also Mech's seminal book, *The Wolf* [97]) that young wolves do not attain sexual maturation until the age of 1–2 years old. Consequently, they do not join the dominance hierarchy until they are ready to be a contender to an existing breeding male (i.e., the alpha male). But some ecologies also force the dispersion of yearlings. In other words, a nuclear family unit may never grow into a multigenerational family unit. The limited resources and carrying capacity of the environment force the young to leave the pack to form their own. This means that in some populations, in some environments, and in some ecologies, wolves may never exhibit a dominance hierarchy.

In pop-ethology, the strange attempt to get rid of the concept of dominance hierarchies had a simple goal: Among the so-called ethical or force-free dog trainers, it was to eliminate any reference to "dominance-based training." While a noble idea, it could have been achieved by recognizing that several thousand years of deliberate, planned selection (or selective breeding) was enough to prune out undesirable behaviors in early dogs such that the dominance hierarchy concept had simply become irrelevant. It seems that we threw the baby out with the bathwater. Dominance hierarchies, after all, are about reducing conflict, not creating conflicts, and their ultimate purpose (as with other cooperative breeders) is to establish breeding privileges. Domesticated dogs are outside of any ecologies that could justify that social system.

But there is more to all of this: Not all wolf packs seem to have the same social ethogram or sociogram. Now we are faced with another reality: lupine cultures. Mech and Boitani [94] and Packard [93] describe the complexities of the lupine socioecology and population biology. The topics of behavioral plasticity, acculturation, or boldly, "culture" in mammals is an emerging area of inquiry in ethology. It started in the field of primatology [78, 98, 99] and spread to cetology (whales, dolphins [100–102]), but has not yet reached social carnivores. Because canids have

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[18] January to mid-March in North America.

some of the most sophisticated social structures and dynamics of social carnivores,[19] it is surprising that the concept has not been found in the considerable literature on wolves. Wolves are also sophisticated communicators [105] with vocalizations possessing enough structural complexity to be suggestive of dialectal differences [106], not to mention individual signatures [107]. It is surprising that studies like the ones undertaken with cetaceans have not emerged in the lupine literature. Vocalizations aside, the importance and significance of pack or group-level and population-level profiles and idiosyncrasies is hard to overestimate.[20]

It is strange that, in a fundamentally cognitive science of animal behavior (cognitive ethology, cognitive ecology, cognitive comparative psychology, etc.), the concept of animal culture has not been more pervasive. Social neuroscience, for one, could expand on its strong foundations [33, 108, 109] and its emergent interest in epigenetics to tackle the fundamental bases of culture. This neuroecological bottom-up approach would be a great complement to the top-down approach of the ecological anthropologists [110, 111] and human behavioral ecologists [112]. Perhaps in the future, young graduate students will sit excitedly in the snow with binoculars in hand and exclaim after a few hours of careful, systematic observations “It is all cultural!” Because, after all, cultures are not all the same. Perhaps the neurocultural movement is just around the corner.

## 9.6 Conclusions for the Neurosciences and Neuroethics

I am not anti-Cognitivist, and I am certainly not refuting affective factors, as I studied them in wolves (i.e., stress). Affective processes are fundamental to social behavior. But neither am I a classical Cognitivist or Behaviorist. I would not obviously discuss brain processes, affective processes, or any mentalistic constructs if I were. Although I do see the value and parsimony of innate mechanisms, I acknowledge the relevance of cognitive control, regulation, and processing in complex brains, at the very least in social reptiles [113], birds, and mammals. But they are not a prerequisite for the ethical treatment of animals (“do no harm”), their well-being, or welfare and tend to derail the issues into an anthropomorphic *scala naturae* of intellectual prowess. Clearly emotional regulation, at least as self-preservation, is relevant to welfare, but again, the issues surrounding the sophistication of emotions and the tendency to link them to self-awareness and even cognitive capacities obscure the importance of the *conative* dimension of animal minds.

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[19] Especially wolves, African wild dogs (*Lycaon pictus*), likely bush dogs (*Speothos venaticus*), and even more so dholes or Indian wild dogs (*Cuon alpinus*) as they form clans of packs, a structural layer seen only in primates [25, 103, 104].

[20] Discussing wolves, captive or wild, with colleagues from around the world has made me sorely regret not taking detailed notes. It is fascinating how our discussions about behaviors are (or were, at least initially) about “you are wrong, we are right” and not “you saw that, we see this,” where the latter embraces the possibility of diversity and variability in the behavioral phenotype of social carnivores.

Natural behaviors and natural motivations may be all we need to address ethical and welfare issues in animals. Environments that allow for a free expression of natural behavior patterns and experimental constraints and housing conditions that take into consideration what animals *want* (i.e., what they can or would choose) are important to ensure animal well-being, welfare, and good science. There is no need to infer what animals *think* and *feel*: We don't know, and we may never know. But we can establish what they *want* if we let them tell us. Finally, in continuity with my post-cognitive take on animal behavior, I do not believe that social cognition holds the key to the understanding of social behavior. Socio-affective and socio-conative processes with a rule-based framework can invoke cognitive control when necessary, but nature had to situate social behaviors in much simpler organisms than whales or primates, including eusocial insects.

In an integrative mindset, here is how I summarize behavior:

$$B(f) = \mathrm{M\ E\ I\ A}$$

where B = behavior, M = motivations, E = emotions, I = information, and A = affordances. This formula acknowledges the importance of what one could define as the affective, conative, and cognitive dimensions of behavior while adding affordances. Although I do not have the space to expand on the interactions between all the components, the term "information" is used in a classical Gibsonian and ethological sense: Animals are seekers of information (olfactory, visual, auditory, etc.) and that information defines their behavior. Modern perception-action theories would amend and consider how those behaviors may modulate the information (or its perception, at the very least).

The information sought is environmental, from the internal or external environment, in nature. Gibson was clear that perception is based on *information*, not on *sensation*. Affordances can be perceptual (in the true Gibsonian sense), affective, conative, and social. They also define the niche of the situated organism, as Gibson notes: "a niche refers more to how an animal lives than to where it lives. I suggest that a niche is a set of affordances" and "The niche implies a kind of animal, and the animal implies a kind of niche" (p. 128 in [62]). An ethical neuroscience, animal welfare science, and neuroethics will let captive animals build their niche, as they naturally do in their natural environment, or allow them to choose between the most suitable artificial niches. Motivation (M) and affordance (A) meet, and what is between, how they feel (E) and how they think (I), follows, not the other way around. As Freeman [114] stated, *meaning* is what matters to the brain: Information (I) and affordance (A) define what is meaningful, as information alone is nothing to the brain if not meaningful, and that meaningfulness is often in relation to the motivational state of the animal.

The remarkable diversity, variability, and flexibility of animal social systems are nothing less than humbling. We now must wake up to the fact that the *one mold fits all* model does not work. Lack of convergence in observational data of social behavior is easily explained by, once again, its tremendous degrees of freedom.

Maybe, one day, neuroethics in animal research and animal husbandry can be more about animals' own degrees of freedom.

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# Large Brains in Small Tanks: Intelligence and Social Complexity as an Ethical Issue for Captive Dolphins and Whales

## 10

Lori Marino

**Abstract**

Dolphins and whales are highly complex, large-brained social mammals. To date, thousands are kept in concrete tanks in marine parks and aquariums around the world. In these environments, they endure lack of control, lack of stimulation, and loss of the ability to engage in activities necessary for them to thrive. The fact that they are such complex, self-aware, intelligent beings makes it more difficult for them to cope in artificial environments, not less, as might be expected. This is because their needs cannot be met outside of their natural habitat. The only ethical response to this situation is to phase out the keeping of dolphins and whales for entertainment and to move those in commercial facilities to sanctuaries that prioritize their needs.

**Keywords**

Cetacean · Captivity · Well-being · Health · Stress · Sanctuary

## 10.1 Introduction

An impressive body of scientific evidence shows that dolphin and whale brains are highly complex and elaborated and that, consistent with these neuroscientific findings, they are extremely intelligent, self-aware, and socially sophisticated beings who are adapted to an equally complex natural environment. Concrete tanks in marine parks and aquariums are an anathema to their well-being, and, despite all efforts, they cannot thrive in these artificial conditions. Thus, they suffer from psychological abnormalities which reflect the fact that their brains did not evolve to handle the stresses of confinement and loss of autonomy. Their intelligence and

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_10

their behavioral flexibility do not, as some would suggest, provide a buffer against the deprivations of living in display tanks. Instead, the opposite is true. Their complex intelligence exacerbates their vulnerability to the stresses of living artificially. The only ethical response to this situation, if release to the open ocean is out of the question, is to move them to sanctuaries, which provide them with an environment as close as possible to their natural, free-ranging environment and where their well-being is a priority.

## 10.2 Who Are Dolphins and Whales?

A species' evolutionary and adaptive history shapes its modern nature, that is, those characteristics that need to be expressed in order for members of that species to flourish or thrive. Evolutionary adaptation to a set of specific selective pressures, modified over tens of millions of years, has made dolphins and whales who they are today—streamlined predators with large complex brains who inhabit a diversity of aquatic environments from the coasts to open ocean to rivers. Their diets are equally varied and range from preying upon other marine mammals to specializing on specific species of fish and even certain body parts of their prey. They are travelers and divers living in a three-dimensional spatial world. And they are long-lived (members of some species can live to 50 or 60 and, in the case of orcas, can live over 90 years) with prolonged juvenile periods spanning many years. In these ways, their life history is very similar to that of humans and other great apes. They also have strong family bonds and live in complex social networks with cultural traditions underwritten by learning, communication, and a formidable mind [1].

### 10.2.1 Evolution

The cetacean order of mammals contains two modern suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales, dolphins and porpoises); the latter will be the focus of this chapter. There are six families within Odontoceti comprising about 78 species. The families include the delphinids (the large family of "true" dolphins, including orcas), the monodontids (belugas and narwhals), the phocoenids (porpoises), platanistids (river and freshwater dolphins), physeterids (sperm whales), and the lesser-known family of ziphids (beaked whales, etc.) [2].

Modern cetaceans evolved from the Archaeoceti, terrestrial ancestors of even-toed ungulates, 50–55 million years ago [3, 4]. Between 30 and 35 million years ago, the archaeocetes were replaced by early forms of modern dolphins and whales, known as Neoceti ("new whales") [5]. And with the Neoceti, came the earliest detectable changes in odontocete brain size and structure [6, 7].

Archaeocetes possessed brains of average to below average size relative to their bodies [6, 7]. That is, their brain mass was predictable (average) or less than predicted (below average) relative to their body mass compared with other mammals. But 30–35 million years ago, in response to shifts in ocean temperatures and prey availability, early odontocete bodies became much smaller and their brains became much larger, increasing their encephalization (a measure of relative brain size) to unprecedented levels [6, 7]. These changes were accompanied by major shifts in social ecology (i.e., how these early dolphins used their environment to eat, travel, and defend against dangers). Around this same time, there were changes in the inner ear bones of odontocetes that eventually led to the capacity for echolocation, which gradually became an integral part of their psychology [2]. With these changes, the cetacean brain was modified considerably, representing, arguably, the most dramatic example of neurological evolutionary change. Today, modern odontocetes have above-average Encephalization Quotients (EQ; a measure of relative brain size) ranging up to 5.0, that is, brains five times the expected size (compared with a value of 7.0 for modern humans) and a complex, highly convoluted neocortex with characteristics that underlie complex cognition [6–9].

### 10.2.2 Brain Size and Structure

Modern odontocetes have achieved EQ levels second only to modern humans; along with an increase in mass, their brains underwent significant changes in organization and structure at many levels [6]. These structural adaptations inform our understanding of what parts of the mind are especially well developed in dolphins and whales.

The neocortex is a sheetlike structure in the mammalian forebrain which serves as the substrate for some of the most complex cognitive capacities, such as self-awareness, communication skills, sensory–perceptual integration, problem-solving, and innovation. Expansion of the neocortex occurs through folds on the surface (known as convolutions) and, thus, is indexed by surface area. The modern cetacean neocortex is among the most highly convoluted of all mammals [10, 11]. Orcas have the most convoluted neocortex on the planet, surpassing modern humans in terms of neocortical surface area and, potentially, processing units [10–12]. Therefore, dolphin and whale brains have a highly elaborated neocortex, a part of the brain intimately connected with cognitive capacities most closely associated with the term “intelligence.”

In addition to neocortical surface area, there are a number of other aspects of dolphin and whale brains that serve as strong evidence for complex cognitive, emotional, and social abilities. The anterior cingulate and insular cortices, the temporal operculum, and paralimbic regions (all situated deeper within the forebrain) are extremely well developed [12], and the expansion of these areas is related to high-level sociocognitive functions such as attention, prediction, social awareness, and empathy [12]. Moreover, recent studies show that the anterior cingulate and insular cortices in larger cetaceans contains a type of projection neuron, known as a spindle cell or von Economo neuron [13, 14], considered by some to be involved in social cognition, at least in larger brains [13]. Increasingly, these specialized neurons are found in primates with smaller brains, and they may be more ubiquitous in smaller brains across a range of taxa [15].

In summary, dolphin and whale brains are massive and complex and evince several features known to form the basis of complex psychology. To put it succinctly, the present evidence for complexity and large size in cetacean brains is entirely consistent with the evidence for behavioral and social complexity in cetaceans [9].

### 10.2.3 Behavioral Ecology

Cetaceans (with few exceptions) are adapted to traveling long distances and diving to deep depths. Importantly, they live in all three spatial dimensions of their environment. Traveling and diving are an integral part of their ability to catch prey, socialize, and simply explore their world. Bottlenose dolphins (*Tursiops truncatus*) off southeast Florida, for example, often dive to the ocean bottom where they reach depths of 7–13 m and engage in "crater feeding" (i.e., burrowing into the sediment to catch fish hiding there) [16]. Many bottlenose dolphin groups utilize the full water column when foraging, typically feeding at depths of 20–30 m (but sometimes more) and often diving from the surface to the sea bed and back again [17]. Many of the foraging habits of dolphin groups, such as sponge-carrying (a learned behavior, passed down from one generation to the next, in which some individuals carry conical marine sponges on their rostrum), in Shark Bay, Australia, have become enriching cultural behaviors for them [18] and provide a way to exercise behavioral and social choice. Belugas in open water can cover thousands of kilometers over a few months and can swim at a rate of up to 6 km/h and to depths of 600–1000 m [19, 20]. Orcas often swim in a consistent direction at a rapid pace when they are not foraging or hunting and often engage in synchronized dives [18], suggesting an important social purpose for traveling independent of procuring food. Resident orcas have been measured traveling at a rate of over 20 km/h [21] and off New Zealand dive to the ocean bottom (~12 m) to feed on stingrays [22]. There is, obviously, a wide range of ways different species, populations, and groups of cetaceans utilize their three-dimensional environment. However, it is evident from all of the literature on free-ranging cetacean foraging, traveling, socializing, and cultural behaviors that they engage their environment in a way not physically possible in captivity.

### 10.2.4 Cognitive Abilities

Cetaceans are among the most cognitively sophisticated animals on the planet, demonstrating prodigious problem-solving, communication, inferential capacities, and a high degree of self-awareness. Most of the evidence for these abilities comes from a handful of species frequently kept in captivity (e.g., bottlenose dolphins, orcas, beluga whales, and a few other smaller species). Thus, for the remainder of this chapter, I will focus on bottlenose dolphins, beluga whales, and orcas. However, it is important to keep in mind that other dolphin and whale species, including

Mysticetes, have shown sophisticated cognitive and behavioral capabilities of their own.

Captive bottlenose dolphins have demonstrated a wide range of complex capacities. These include mirror self-recognition [23], the comprehension of gestures as symbolic referents to their own body parts [24], metacognition (i.e., the ability to report on one's certainty about the proper response to a task) [25], foreplanning [26], vocal imitation [27, 28] as well as imitation of arbitrary behaviors [29], and behavioral innovation [30]. They understand human pointing [31], are sensitive to human visual gaze and attentional stance [32, 33], and employ referential pointing themselves using their body position and rostrum [34]. Bottlenose dolphins are also well known for their prodigious comprehension of an artificial symbolic language with syntax [35].

Beluga whales show exceptional communicative and mental representational abilities. They are able to comprehend and produce symbolic lexigrams and sounds (modulated computer-generated whistles), demonstrating an understanding of the bidirectional relationship between symbols and the objects they represent [36]. They also can imitate other beluga whales [37]. And, a captive beluga whale named NOC demonstrated spontaneous imitation of human speech (i.e., voicing and creation of comprehensible words [38]), adding to the body of evidence for sound mimicry in belugas [38, 39].

Orcas in captivity have also demonstrated the sophisticated ability to imitate the novel actions of conspecifics [40], and, like many other cetaceans, orcas are vocal learners [41]. In studies of their responses to mirrors, orcas show contingency checking behavior—a correlate of self-directed responses exhibited by most individuals who demonstrate mirror self-recognition, and one orca showed behavior highly suggestive of self-recognition [42].

This nonexhaustive and brief review of the extraordinary cognitive abilities evinced by bottlenose dolphins, belugas, and orcas in captivity should be taken in the context of the fact that they are demonstrated in highly artificial and restrictive settings. These capacities are reflections of a complex psychology that evolved over tens of millions of years in the open ocean. And one of the ways to understand why dolphins and whales are so intelligent is to observe how these cognitive capacities may be manifested in the social complexity of free-ranging cetaceans.

### 10.2.5 Dolphin and Whale Cultures

The most critical factor in understanding who dolphins and whales are is their level of sociality. Although not all cetaceans are highly social, those species kept in captivity, ironically, tend to be among the most socially complex. Bottlenose dolphins, beluga whales, and orcas develop slowly, with very long juvenile periods in which they learn the social and material skills needed in adulthood, underwriting the capacity for learned cultural traditions [43]. These cultural traditions, in turn, are based on strong emotional ties within the group and often involve mothers teaching their young about specific hunting techniques or learning dialects that dictate group identity [44].

Bottlenose dolphins live in fission–fusion societies with strong mother–child bonds in which they learn foraging strategies and social rules [45]. Social network analysis demonstrates that groups of dolphins form a social infrastructure with different social roles which vary in importance to the integrity of the group [46]. Arguably, the most complex nonhuman social relationships described to date are among bottlenose dolphins in Shark Bay, Western Australia. Males in this population form two and possibly three levels of nested alliances within a social network numbering in the hundreds. Males cooperate in groups of 2–3 to form consortships and also hold membership in larger groups of 4–14 individuals who cooperate in competition with other groups over estrus females [47, 48]. Such "alliances of alliances" are rare outside of our own species, even among great apes [49]. There is also evidence that individual role-taking has emerged in dolphin societies to facilitate cooperative relationships [50] and decision-making processes [51].

There are numerous reports of bottlenose dolphins engaging in epimeletic (helping) behavior toward injured or sick members of their social group by providing physical support as well as food sharing and defense of juveniles [52–55]. Additionally, there are accounts of grieving behavior manifested by carrying dead infants for a prolonged period [53] and alloparenting ("babysitting") and adoption in this species [56].

Beluga whales live in small groups that join, from time to time, with larger aggregations of hundreds or thousands of individuals. Adult females are strongly bonded with their newborns as well as an older child. These triads stay together and join with others to form large nursery groups. Generally, group composition is fluid and underwritten by complex vocalizations, facial expressions, and a variety of other characteristics [57]. Recently, robust learned cultural traditions have been identified in beluga whales in the North Pacific as they pass on information about migration routes from one generation to the other [58]. Allonursing and epimeletic behavior as well as grieving behavior have been reported for belugas [59–61].

Free-ranging orcas live in highly complex societies with long juvenile periods and differentiated relationships embedded in complex social networks relying heavily upon learning and memory [62, 63]. Orca social networks are weakened by the loss of key individuals, as in the common practice of transferring individuals from one captive facility to the next [63]. Orcas are a cosmopolitan species possessing some of the most varied and complex social traditions known. Resident orcas in the North American Pacific Northwest live in matrilineal social units, which are themselves parts of pods, which, in turn, are members of clans, with one to three clans forming a community [64]. These nested levels of social units are distinguished by dialects and other behavioral traditions formed by social learning. In some orca communities, adult males stay with their mothers their entire lives, and their survival is jeopardized if their mother dies. Moreover, epimeletic behavior and pronounced grieving are well known among orcas [65]. In one well-publicized recent case, J-35 Talequah, a young orca mother off the coast of Washington State carried her dead calf for 17 days (until the body decomposed) while her family took turns carrying the calf and sharing food with her [66]. These cases speak to the depth of emotions of which dolphins and whales are capable.

## 10.3 Large Brains in Small Tanks: The Unworkable Formula

This brief review of who cetaceans are provides an answer to the question: "What do cetaceans need in order to flourish?" Cetaceans need to move. They need to travel and to experience variety in their physical environment. As highly intelligent beings, they need to be challenged by their physical and social environment. Cetaceans are autonomous beings. That is, they have desires, intentions, and a sense of self [67, 68]. And, as autonomous beings, cetaceans need to exercise control over their lives (i.e., they have an inherent right to bodily liberty and bodily integrity) [67, 68]. They need to be able to raise their children through a very long childhood and navigate a complex social environment that involves social roles and alliances. Cetaceans need social opportunities to bond, to relate, to interact, to reproduce, and to learn from each other. They also need a social infrastructure, that is, an intact social network, family ties, and even social competition. And, far from their sheltered life in captivity, they need to be challenged and expend effort solving problems and escaping dangers.

The public labors under the misconception that intelligence provides a buffer for dolphins and whales and that they are able to learn to adapt to life in small tanks. Yet the opposite is true. Intelligence and social complexity are actually a risk factor for psychological trauma and ill health in cetaceans kept in concrete tanks. Their lives in tanks are, in many ways, analogous to solitary confinement for human prisoners. The reality is that cetaceans are so complex that life in the barren tanks is just too far a cry from anything that could come close to meeting their needs. The more complex the needs of any animal, the more difficult it is to accommodate them in tanks and cages. It is unworkable.

The captivity industry, which includes aquaria and commercial marine parks like SeaWorld, claims that it protects cetaceans from the rigors of the natural environment and, because of this, they lead a better life in tanks than in the ocean [69]. If this were the case, then we should see evidence of health and well-being in captive dolphins and whales. But instead there is an abundance of evidence for shorter lifespans (particularly in orcas and belugas), higher mortality rates, rampant illness, and behavioral abnormalities—all related to chronic stress. Chronic stress leads to immunosuppression and susceptibility to physical diseases that impacts mortality rates [70–72]. The United States Marine Mammal Inventory Report published by the National Marine Fisheries Service lists numerous stress-related disorders, such as ulcerative gastritis, perforating ulcer, cardiogenic shock, and psychogenic shock as causes of death along with immunodeficiency-based infections such as pneumonia [73]. Orcas, belugas, and bottlenose dolphins live shorter lives in concrete tanks than in the wild [74–76]. In addition, captive dolphins and whales display a variety of behavioral abnormalities that are common indicators of chronic stress, such as excessive chewing on parts of the tank [77] and repetitive swimming patterns [78]. Some of these behavioral abnormalities also contribute to systemic disease and death.

### 10.3.1 Chronic Stress, Abnormal Behavior, Infection, and Mortality: The Vicious Cycle

One of the more common behavioral abnormalities found in captive animals is stereotypy. These highly repetitive behaviors with no clear function are often self-stimulatory. There have been numerous reports of oral stereotypies in captive orcas, including biting, chewing, and jaw-popping on hard tank surfaces and the steel gates used to separate the whales [77]. These behaviors are more than manifestations of psychological stress, as they lead to extensive and chronic dental pathologies [77, 79, 80]. Poor dental health is a known cause of systemic illness [81] because the openings in the damaged teeth provide a pathway for pathogens to enter the bloodstream and impact organs.

While dental wear is found in free-ranging orcas, it is typically isolated to those populations who have very specific feeding habits that wear on the teeth (e.g., certain prey items with abrasive skin that require mechanical manipulation before consumption) [77]. Extensive tooth deterioration is rare in general [77]. In marine parks, however, orcas are fed exclusively a diet of dead fish and squid, and gelatin (to minimize dehydration), all placed at the back of the oral cavity and swallowed, requiring little to no contact with the teeth. Yet, the majority of captive orcas have tooth wear and dental pathology. Over 60% of captive orcas in the United States have fractures of their mandibular teeth, and 24% exhibit “major” to “extreme” mandibular coronal tooth wear down to the gumline [77]. In order to treat abscesses and drain debris and pus, the majority of captive orcas undergo a modified pulpotomy procedure that involves drilling into the tooth pulp and requires daily flushing [77, 79]. These efforts are only partially successful in stemming the development of chronic systemic bacteria which are treated, in turn, by long-term antibiotic dosing that contributes to antibiotic resistance [77, 79]. Therefore, oral stereotypies by captive orcas (and other cetaceans) result in a vicious cycle of ongoing dental damage and pathology with serious health consequences that extend well beyond problems with their teeth [77, 81]. These systemic problems are directly linked to the fact that an intelligent, socially complex being cannot thrive in the barren concrete tanks of marine parks and are, therefore, vulnerable to a deadly cycle of health events that are caused by putting large-brained animals in small tanks.

Cetaceans evolved to cope with the rigors of the wild and, therefore, flourish with the challenges of living a natural life. They have no such adaptive history with captivity. What humans may think is a “stress-free” life in marine parks is actually the most stressful experience a dolphin and whale can have. Thus, the claim that captivity is better for cetaceans than the rigors of the wild is contradicted by the poor welfare record of captive dolphins and whales. As Rose, Parsons, and Farinoto (2009) point out:

> To use the rigors of the wild as a justification for the conditions of captivity is misleading and disingenuous. This argument implies that the natural state is an evil to be avoided and that the captive environment is the preferred state. The suggestion is that animals must be protected from the very surroundings that sustain them. This misrepresentation of the natural environment as threatening to the health of these animals will certainly not encourage people to protect, respect, or understand the animals' natural habitat. [82, p. 19]

The quote above takes aim at the anthropocentric and hubristic view that humans know the best way for other animals to live. But the overwhelming evidence for poor health and psychological damage are not data which can be ignored. And they call for an ethical response to the worldwide keeping of dolphins and whales in concrete tanks.

## 10.4 Sanctuary: The Ethical Solution to the Tanks

As demonstrated above, there is a fundamental incompatibility between who dolphins and whales are and the life they are forced to lead in concrete tanks. An ethical response to this situation has no practical solution within the walls of entertainment parks and research facilities—places that objectify and commoditize these animals for profit of one kind or another. The solution, in order to be effective, has to come in the form of a paradigm shift: concrete actions that represent a permanent and pervasive change in the way we relate to cetaceans and other animals.

The fundamental core of this paradigm shift is recognition of what our species has done to undermine the inherent rights of captive cetaceans to bodily liberty and integrity and to restore to them what was taken from them. In other words, we must enact reparation. As commonly understood, reparation is the return of something stolen to its rightful owner, recompense for injury or loss, and restoration to a natural state. The concept of restitution is one that is often used in relation to human affairs but is arguably just as germane to human–nonhuman relations.

In the case of keeping cetaceans in tanks for our gain, the paradigm shift comes in a form of restitution already established for many other species—sanctuary. A sanctuary is typically thought of as a place of refuge and protection, and indeed it is. But in the case of sanctuaries for other animals, there is also the need to restore the individual to an appropriate environment akin to their natural one, that can provide the right kinds of habitat, physical and intellectual activities, and social opportunities. As the Performing Animal Welfare Society defines it:

> A wildlife sanctuary is a place of refuge where abused, injured and abandoned captive wildlife may live in peace and dignity for the remainder of their lives. True wildlife sanctuaries do not breed or exploit for commercial purposes. A true sanctuary respects the integrity of individual animals, providing safe, healthy and secure refuge in enclosures specifically designed for the unique animal which it supports. [83]

Sanctuaries are still captivity and do not allow for a complete restoration of a natural life (e.g., no breeding), but the signature characteristics of an authentic sanctuary are as follows: (a) the individuality of each animal is respected and promoted, (b) there is no exploitation, and (c) the goal is to provide a life that is as close as possible to one in which the individual can thrive. Successful, authentic sanctuaries are places where traumatized individuals can heal and enjoy their lives and, for captive-born animals, perhaps for the first time. Cetaceans should never be placed in captivity in the first place, but for those in captivity now, their best alternative for a flourishing life is to be placed in a sanctuary. Seaside sanctuaries are the way forward into a more ethical future relationship with the other large-brained complex beings on our planet—the cetaceans.

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# Animal Rights and Captivity in a Non-Ideal World

# 11

Robert Garner

**Abstract**
This chapter explores what animal ethics has to say about the issue of captivity. The best-known version of animal rights morally prohibits all use of animals, including confinement. One obvious response is to reject animal rights in favor of a traditional animal welfare ethic. It is argued in this chapter, however, that there are two ways it is possible to justify animal captivity from an animal rights perspective. The first involves the adoption of a more nuanced, interest-based, rights theory. This allows us to claim that animals do not have a strong enough interest in liberty to be accorded a right not to be kept in captivity. The second involves the adoption of a non-ideal theory of animal rights. This allows us to bracket liberty, and therefore the issue of captivity, as a component of an ideal theory and therefore not of immediate ethical concern.

**Keywords**
Animal rights · Captivity · Confinement · Cognitive capacities · Animal welfare

## 11.1 Introduction

This chapter explores what ethics has to say about the issue of animal captivity and confinement. As a preliminary exercise, the role that cognitive capacities have played in the animal ethics debate is outlined. It is shown, in particular, that the best-known version of animal rights, associated, above all, with Tom Regan [1], adopts a particular approach to rights discourse and is dependent upon the claim that at least some animals have considerable cognitive capacities. Of particular importance, for this chapter at least, is the point that, for the conventional animal rights

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_11

position, all human uses of animals are morally prohibited, irrespective of what is being done to them whilst they are being used. In other words, all things being equal, keeping animals confined and captive is inherently wrong and does not, for instance, depend on the degree to which they suffer as a consequence.

Accepting an animal rights ethic, as described above, would seem, then, to be very exacting. It means that a whole variety of established, and possibly even benign, practices involving the confinement of animals become illegitimate. Circuses and zoos are obvious examples, but so is the ownership of pets or companion animals which usually involves confinement. It would mean, too, that the confinement of animals in the laboratory becomes morally illegitimate, even if the animals do not suffer and are not killed. Similarly, even if a way was found to raise animals for, say, the production of wool and milk, which did not cause suffering (which, it should be pointed out, is a long way from the current reality), this would be morally objectionable from the conventional animal rights perspective. To avoid the conclusion—that it is inherently wrong to confine animals—one obvious alternative position to adopt is an animal welfare ethic. Here, confining animals does not, by itself, raise any ethical issues, and, even when such confinement obviously causes the animal to suffer and results in death, it can still be justified if that suffering is deemed to be necessary.

It is argued in this chapter, however, that there are two ways it is possible to justify animal captivity from an animal rights perspective. The first involves the adoption of a more nuanced, interest-based, rights theory. This allows us to claim that animals do not have a strong enough interest in liberty to be accorded a right not to be kept in captivity, but do, at the very least, have an interest, and therefore a right, not to have suffering inflicted on them by humans. The second involves the adoption of a non-ideal theory of animal rights. This allows us to bracket liberty, and therefore the issue of captivity, as a component of an ideal theory and therefore not of immediate ethical concern.

## 11.2 Does Ethics Need to Be Based on Cognitive Capacities?

Central to the bulk of the work in animal ethics has been an evaluation of the moral significance of the cognitive capacities of nonhuman animals (hereinafter animals) and, indeed, humans too. In this *capacity-oriented* approach [2], moral worth is granted on the basis of the possession of some capacity or other, whether it be mere sentience or greater cognitive capability. Not all ethical theories, to be sure, are based on a capacity-oriented approach, and two alternatives, which have appeared recently in the animal ethics literature, should be noted at this point. These are based, respectively, on relations and virtue.

In the relational ethic, in its pure sense at least, the moral worth of an individual is based not upon her capacities or interests but upon the relationships she has with others. The relational approach has its roots in the feminist care ethic tradition which suggests that we should value emotion and sentiment over reason. One version of this tradition holds that our moral obligations should derive from the (positive) relationships we develop and not as a result of impartial rules. Applied to animals, then, our duties to them are based not on the grounds of impartial and abstract principles but from our duty to care about those animals we forge (positive) relationships with (see [3]).

This relational ethic has also been utilised by some animal ethicists to account for the intuitively popular assumption that we should treat domesticated animals differently from wild animals [2]. That is, it is commonly thought that it is permissible to leave wild animals to their fate, whereas we have positive duties to the domesticated animals we are responsible for. Note that the cognitive capacities possessed by these groups of animals are irrelevant morally. Donaldson and Kymlicka [4] utilise the relational approach in their application of citizenship theory to animals. Domesticated animals, those who are part of our societies, are equivalent to co-citizens and have certain particular rights because of their relational status with humans. By contrast, genuinely wild animals are equivalent to separate sovereign communities which ought to be regulated by norms of international justice.

One major problem with the relational position, or at least a "pure" version, is that if we adopt a theory which grounds moral duties in the (positive) relationships we forge, it is difficult to see how these duties can be applied to those with whom we do not forge such a relationship. For example, if we have no positive relationships with wild animals, then, strictly speaking, the relational ethic accords no moral worth to them and justifies exploiting them rather than a prescription of non-interference. As a result, it would seem morally arbitrary to deny moral entitlements to animals (and indeed humans) with whom we do not have a relationship, irrespective of their cognitive capacities. To avoid this conclusion, Donaldson and Kymlicka's account [4] combines relational and capacity-oriented strands. Indeed, their starting point is the acceptance, as a baseline, of an animal rights agenda based on a capacity-oriented ethic. That is, they accept that all animals (domesticated and wild) have a right to life and liberty which prohibits humans from killing or confining them.

The second approach which denies the moral importance of cognitive capacities is virtue ethics. This long-standing approach, dating back to Aristotle, which has had something of a revival in the last three decades or so, links morally right actions in terms of, not capacities and rules, but the character of the actor. According to the virtue ethics approach, then, what is wrong, say, with killing is "not so much that it is unjust. . .but that it is callous and contrary to the virtue of charity" (p. 6 in [5]). A virtue, then, is a "good, or admirable, or praiseworthy character trait" (p. 147 in [6]). Insofar as virtuous behavior is to be commended because it benefits the human behaving in such a way, as part of a flourishing human life (this was Aristotle's original intention), it has the advantage of providing a reason (enlightened self-interest) for treating animals well [7].

However, there are a number of problems with virtue ethics which raise doubts as to its claim to be a viable alternative to a capacity-oriented position in animal ethics. In general terms, there is the long-standing debate over whether it is beneficial to the agent to behave morally or virtuously and, if so, in what ways [8, 9]. Applied specifically to animals, it is also the case that virtue ethics, like care ethics, does not always provide a clear guide to action or moral judgement [10]. This is particularly the case where virtues conflict. An illustration of this is the debate between Hursthouse [6] and Roger Scruton [11] on blood sports. Both invoke virtue ethics in the case of blood sports, the former arguing that it is illegitimate because those engaging in it are behaving callously, the latter arguing that those participating in it are behaving courageously. Here we have, then, a conflict between the vice of callousness and the virtue of courage. If we choose to hunt, are we behaving courageously, in which case our lives flourish, or are we behaving callously, in which case they do not? Similarly, take the virtue of mercy. Imagine a situation—often presented by those defending scientific research on animals—whereby we are faced with a choice between being merciful towards the animals that are assigned to be used in scientific research and being merciful towards the sick children who might benefit from such research.

Of course, it might be contended that a rights-based ethic also suffers from potential conflicts. Virtue ethics, though, can also be subjected to a further criticism. This is that to attach labels such as charity, kindness, compassion and so on to our treatment of animals assumes, if it is to make any sense, that animals have some capacities which it is regarded as important to protect. That is, to describe our treatment of animals as cruel assumes that they are sentient beings who can be hurt. We would not, by contrast, seek to claim that it is possible to behave compassionately towards, say, a work of art or a historical monument. Virtuous behavior as regards animals, therefore, is predicated on the duties we owe to them directly as a result of their capacity to be harmed [12]. It seems to be the case, therefore, that "a conception of moral virtues can never provide a complete account of morality, since it presupposes further normative standards that cannot be reduced to virtues" [13].

## 11.3 Cognitive Capacities and Animal Ethics

The relational and virtue ethics approaches have remained on the periphery of animal ethics. By contrast, the centrality of cognitive capacities to the way in which animals have been discussed in moral theory has been marked. Thus, prior to the late eighteenth century, it was common, in theory and practice, to accord animals no moral standing (in the sense that, like inanimate objects, they have no moral worth whatsoever) on the grounds either that they were deemed not to be sentient or that sentience was not deemed to be sufficient for moral standing. The nineteenth century, by contrast, was marked by a growing recognition that animals are sentient, having the capacity to experience pain and pleasure, and that sentience was important morally. This recognition was reflected in the popularity of the Utilitarian position developed above all by Jeremy Bentham. For Bentham, sentience was the benchmark of moral standing. As he wrote, *the* question of moral status is not "Can they reason? Nor, Can they talk? But, Can they suffer?" (p. 311 in [14]).

The Utilitarian position, that sentience provides the benchmark for moral standing, has had a considerable influence on debates about the moral worth of animals leading to the acceptability, in theory and practice, of the dominant animal welfare ethic (see below). In addition, a contemporary Utilitarian, Peter Singer, invokes the sentience criteria to go beyond the animal welfare ethic [15, 16]. Animals' lack of moral agency (and, in general terms, their lack of a collection of capacities usually described in shorthand as personhood) is still, for Singer, philosophically important. However, he denies that all species of nonhuman animals lack the capacities of personhood and further maintains that even those species that do not possess the capacities of personhood are still morally considerable. In short, there is now a consensus that the sentience of animals means that we have some moral obligations to them.

What is most notable about the debate in animal ethics since the 1970s has been the emergence of an animal rights position which goes beyond both the animal welfare ethic and the utilitarian approach associated with Singer. The key advocate of animal rights was the American moral philosopher Tom Regan [1]. In many ways, his starting point was a rejection of Utilitarianism. This was very much in line with much moral and political philosophy at the time. A similar rejection of Utilitarianism, for instance, was a central part of John Rawls' landmark account of justice in *A Theory of Justice*, first published, in book form, in the early 1970s [17]. In terms of the animal ethics debate, Regan's target was Singer. While agreeing with the latter's objectives—an end to the use of animals for food and as experimental subjects—Regan argued that a Utilitarian ethic, dependent upon an aggregative counting of consequences, simply could not justify such absolute moral conclusions (their debate can be found in [18, 19]).

Regan's preference, therefore, is for a rights-based ethic. In his earlier writings, Regan [20] sought to justify this ethic merely on the grounds that animals are sentient, as does Gary Francione, a well-known contemporary animal rights scholar [21]. By the time of his book-length study, however, Regan had developed a more complex theory. Regan seeks to show that at least some animals are what he calls "subjects-of-a-life", possessing enough mental complexity to be morally considerable. Because at least some animals have these capabilities, Regan argues that they have a welfare which is capable of being harmed by not only inflictions of pain and deprivation but also death, since it forecloses all possibilities of finding satisfaction in life. The key point, then, is that rights are not granted to animals by virtue of their sentience but because they are "subjects-of-a-life", beings with considerable cognitive capabilities including having beliefs and desires, emotions, memories, and a psychophysical identity over time.

I describe Regan's position as a species-egalitarian version of animal rights, on the grounds that, to all intents and purposes, it advocates moral equality between humans and at least some animals. That is, humans and at least some animals share an equal right to life and liberty. A corollary of this is that—for most animal rights philosophers, animal rights activists and, indeed, their opponents too—animal rights and abolitionism are synonymous. Abolitionism seeks, on the grounds that animals have a right to life and liberty, a prohibition on the use of animals by humans *irrespective of the ways in which they are treated*. Thus, for Regan, the animal rights movement "is abolitionist in its aspirations. It seeks not to reform how animals are exploited. . .but to abolish their exploitation. To end it. Completely" (p. 127 in [22]).

## 11.4 Animal Welfare and the Personhood Position

Accepting the conventional animal rights position, as exemplified by Regan's work, requires the rejection of all uses of animals, including their confinement (where confinement is not specifically in their interests) irrespective of what is done to them while they are being confined. To some extent, the effects of this can be exaggerated in the sense that not all animals, according to Regan [1], are "subjects-of-a-life". At the very least, though, in Regan's view, it applies to all mature mammals, and, given that many of the animals that fall into this category are used by humans for a variety of purposes, accepting an animal rights position does significantly constrain what humans are morally entitled to do.

It might be thought that such an abolitionist conclusion is unacceptable morally since it significantly overstates the moral status that animals possess. The obvious response is to reject an animal rights position in favor of an animal welfare position that might be regarded as the moral orthodoxy. The central feature of the dominant animal welfare ethic is an insistence that humans are morally superior to animals, but that—since animals are sentient—they have some moral worth. As a result, we are not entitled to inflict suffering on them if the human benefit thereby resulting is not necessary. The principle of *unnecessary suffering*, therefore, can be invoked if the level of suffering inflicted on an animal outweighs the benefits likely to be gained by humans. The political philosopher Robert Nozick (p. 35–42 in [23]) provides a concise but admirably effective definition of animal welfare when he writes that it constitutes "utilitarianism for animals, Kantianism for people". Sacrificing the interests of animals for the aggregative welfare, then, is permissible providing that the benefit is significant enough, but treating humans in the same way is prohibited whatever the benefits that might accrue from so doing.

The animal welfare ethic still remains the dominant ideology behind state approaches to the treatment of animals, of course, and would allow for the confinement of animals *and*, if necessary, inflicting suffering and even killing them. Of course, what is deemed to be *necessary* suffering is vague enough to allow the capture of changes in public opinion over time. Now, for instance, many practices involving animals—the wearing of fur, the toxicity testing of cosmetics, and the worst excesses of factory farming, to name but a few—are no longer regarded as *necessary* in the way that they once were.

The problem with the animal welfare ethic, however, is that it is, ethically, not on very firm ground. The case for human moral superiority is reliant upon being able to show convincingly that we have morally significant characteristics not possessed by nonhuman animals. As Bonnie Steinbock, in one of the surprisingly few published philosophical retorts to philosophers such as Singer and Regan, states: "We do not subject animals to different moral treatment simply because they have fur and feathers, but because they are in fact different from human beings in ways that could be morally relevant" (p. 247 in [24]). Humans, it is typically said, are rational, self-conscious, autonomous persons, able to communicate in a sophisticated way and to act as moral agents. This is often converted into a shorthand claim that humans are persons whilst animals are not (i.e. the personhood position). From empirical evidence, it is argued, can be derived a justification for regarding humans as morally superior to nonhumans, and therefore providing a defence of the moral orthodoxy (see also Cohen's contribution in [22, 25, 26]).

At one level, the defenders of human cognitive superiority surely have a point. It is true that Regan and others are correct to claim that at least some animals do possess more than mere sentience. They can have desires and preferences and have the ability to act so as to satisfy them. However, it is still difficult to establish that the cognitive characteristics possessed by most animals are anything remotely approaching those possessed by most humans. Humans, as Frey [27] points out, have a much higher quality of life involving a rational assessment of desires and a willingness to shed or moderate some, particularly first-order, desires—eating and drinking for example—if they are not consistent with an individual's conception of the good life. At most, then, animals are only capable of dealing with a very basic set of first-order desires.

So, whilst it may be accepted that animals do have an interest in continued life—they are not merely beings that live entirely in the present without psychological connections with the past and the future [28]—it is transparently the case that the value of human lives is higher than that of animal lives. What is more, most animal ethicists, even those who reject some of the components of the moral orthodoxy, would accept this. Thus, the argument that the duty not to kill animals is as strong as the duty not to kill humans is, in David DeGrazia's words, "very hard to believe" (p. 233 in [29]). Similarly, it might also be argued that keeping animals in captivity does not present the same problems for animals as it does for humans. Of course, if that confinement causes suffering—a lack of space, insufficient food, and so on—it can be deemed a moral problem. But confinement in itself would not seem to be a problem for animals in the same way it is for humans, who are thereby prevented from pursuing their life plans.

So, given these defences of the personhood position, why ought we to have some concerns about it? Three main points can be made here. In the first place, it is clear that some animals—the Great Apes being a primary example—are, or are close to being, persons. In other words, the distinction between human personhood and animal non-personhood does not always hold. However, important though it may be to acknowledge that more needs to be done to protect the interests of the "higher" nonhuman animals, all this recognition does is to create a new moral boundary, above which are most humans and those nonhuman species who possess at least some of the characteristics of personhood and below which are the vast majority of other nonhuman animals. It does not, in other words, provide a justification for the kind of broad application of rights to animals that is usually regarded as the aim of animal rights advocacy.

The second challenge to the personhood position is the claim that not all humans are persons. That is, some humans—infants, anencephalic babies (a condition where a baby's brain is seriously underdeveloped), the permanently comatose, the severely cognitively disabled, those who have suffered severe mental impairment through strokes, those with advanced dementia and so on—cannot be accurately described as persons, at least in the way we have defined it here. In the so-called "argument from marginal cases," it is argued that if we persist in treating these "marginal humans" as though they are full persons (so that we regard it as morally objectionable, say, to eat them or experiment on them), then consistency demands that animals, with similar cognitive capacities, are treated in the same way [30].

The use of the argument from marginal cases is ubiquitous in the animal ethics literature. It would be wrong to suggest that it has not been, sometimes quite effectively, challenged (see [25, 28, 31]), although it is, in my judgement, difficult to argue against its logical consistency. What I would suggest, though, is that it is not the most effective critique of the personhood position. For this, we have to consider, again, the claims being made by the personhood position which are played out in the conclusions of the animal welfare ethic.

What the personhood position wants to claim is that the identification of some characteristic that humans possess and animals do not—rationality, autonomy, language, and so forth—is sufficient for the claim that *all* human interests are morally superior to *all* animal interests. This is the basis for saying that, because humans are persons and animals are not, we are entitled to sacrifice the most fundamental interests of animals if, by so doing, a significant human benefit accrues. But surely this blanket inegalitarianism cannot hold. That is, we can accept that animals do not possess as great an interest in liberty and continued life as humans, but this does not mean that animals do not possess a considerable interest in other things. In particular, if humans and animals are capable of suffering (in the sense of experiencing pain and other negative states) in an equivalent manner (and, all things being equal, there is no reason to think many cannot), then why is this capacity of animals downgraded on the grounds that humans also possess the characteristics of personhood? In other words, what has personhood got to do with suffering?

What I am arguing here, then, is that accepting it as fact that humans are persons and animals are not cannot justify the whole range of differences between our treatment of humans and animals that the personhood position wants it to do. To put it simply, torturing an animal is wrong because it hurts. Here, the fact that the animal does not have the characteristics of personhood would seem to be irrelevant. As Rachels (p. 167 in [32]) points out: "Autonomy and self-consciousness are not ethical superqualities that entitle the bearer to every possible kind of favorable treatment".

## 11.5 Captivity and an Interest-Based Theory of Animal Rights

If the personhood position is flawed, as I suggest it is, is there an opportunity to rescue animal rights as a preferable ethic? I would suggest that this is possible but only if we dispense with, or adapt, the conventional animal rights position as exemplified by Regan. There are, I would argue, two ways in which this can be done. The first, covered in this section, involves the adoption of a different version of animal rights, one based on interests. The second, dealt with in the next section, focuses on non-ideal theory.

First, here, we need to pay more attention to what, intuitively, seems to be the problem with the conventional animal rights position as exemplified by Regan. In this conventional version, animal rights is synonymous with the abolition of all uses of animals, and this abolitionist assumption derives from Regan's claim that to use animals, irrespective of how they are treated whilst being used, is to infringe their right to respect which, in turn, derives from what Regan sees as their inherent value. It is a species-egalitarian version of animal rights centered on the granting of equal rights based on equal moral value. The implication of this is that to use animals, irrespective of what is done to them whilst they are being used, is illegitimate. Thus, just as slavery is unjust for humans because it infringes their right to liberty, the confinement of animals, whether or not such confinement causes them suffering, is unjust because it fails to treat animals with the respect they deserve. It is for this reason that animal rights advocates often draw a "dreaded comparison" between human slavery and the use of animals [33].

I suggested above that the personhood position is flawed morally because it does not take into account the fact that, like humans, animals have important interests (such as avoiding suffering) that are not dependent upon possessing the characteristics (rationality, autonomy, language and so forth) of personhood. Likewise, the species-egalitarian version of animal rights is similarly guilty, but rather than failing to take into account the importance of non-personhood interests, it fails to take into account the moral significance of those interests associated with persons. In other words, the species-egalitarian strand of animal rights is flawed because it is difficult to argue against the claim that the differences between "typical" adult humans and adult animals *are* substantial and *are* morally significant. In short, the level of complexity of an individual affects what can be a harm for it. In particular, the fact that most animals lack the characteristics of personhood challenges the claim that they have levels of interest in life and liberty equivalent to "typical" humans.

Before we dispense with animal rights, though, it should be noted that there is an alternative theory of animal rights which does address the problems inherent in the conventional version. The conventional account depends upon the employment of a particular Kantian approach to rights which holds that the function of rights is to establish arenas within which individuals can exercise choices [34, 35]. There is, however, an alternative theory of rights based on interests. The interest theory of rights holds that the function of rights is to uphold individual well-being. The possession of an interest therefore leads to a duty on others to ensure that the right, the existence of which follows directly from the existence of an interest, is upheld. Advocates of an interest-based theory of rights are not suggesting that all interests can be translated into rights, only that rights derive from interests. It may be that we decide that some, relatively trivial, interests are not strong enough to be translated into rights whereas others clearly are, or that some interests ought not to be promoted because they harm others.

Adopting an interest-based theory allows for a much more nuanced, and arguably more convincing, theory of animal rights, and indeed rights in general. This alternative theory of rights has been present for a long time in the animal ethics literature, in the work, for example, of philosophers such as James Rachels [36] and Joel Feinberg

[37], but it has been overshadowed by the dominance of the Regan position. The first theorist to put forward a comprehensive interest-based theory of animal rights is Alasdair Cochrane [38]. His central argument, in line with defenders of the moral orthodoxy, is that animals do not possess an intrinsic interest in liberty, because, unlike humans, they are not autonomous agents.

At this point, one could invoke the argument from marginal cases and suggest that, because we would not want to deprive non-autonomous humans of a right to liberty, consistency demands that we ought not to deprive nonhuman animals of such a right either. Interestingly, though, Cochrane rejects this position on the grounds that, in practice, marginal humans are treated as if they do not have the same interest in liberty as non-marginal humans. This commits Cochrane to the position that it is justified to deprive marginal humans of their liberty not only when it is in their interest to do so (where it may often be the case) but also when it is not. Thus, he writes that "humans such as babies and the severely mentally disabled have no interest in not being used in experimentation that is painless and which does not result in death" (p. 316 in [39]). This latter claim is, of course, controversial and does not meet with accepted practice. In his defence, Cochrane [39] then suggests that the use of marginal humans in experiments is rarely morally permissible, either because it causes suffering or because such a move will be unacceptable to carers or parents.

According to Cochrane, then, because nonhuman animals do not possess an *intrinsic* interest in liberty, they do not have an automatic right to liberty. Adopting an interest-based theory of animal rights, however, means that Cochrane does not have to conclude that animals possess no rights because of their lack of autonomy. For example, animals, for him, *do* have an interest in avoiding suffering (and therefore a *right* not to have suffering inflicted on them) and so in cases where the use of animals does infringe this right, it ought to be prohibited. The effect of this analysis, then, is to "decouple animal rights from animal liberation" (p. 19 in [38]). An interest-based theory of animal rights, then, would allow us to say that, whilst most nonhuman animals may not possess an interest in liberty and continued life—or at least have less of an interest than humans—this does not mean that animals do not possess a considerable interest in other things and, not least, an interest in avoiding suffering. If this interest translates into a right, it clearly places limits on what might be done to animals in pursuit of human benefits and certainly does not justify the blanket exploitation of animals allowed by the moral orthodoxy.

## 11.6 Captivity and Nonideal Theory

What if I am wrong to deny the claims of the conventional animal rights position? I could be. Are animal rights advocates then always committed to the position that the confinement of animals is always wrong? I would argue that this conclusion does not necessarily follow if we invoke non-ideal theory. Theorising about the distinction between ideal and non-ideal theory has become increasingly popular within political philosophy. This can be accounted for by the increasing frustration felt by many at the discrepancy perceived between the abstract normative work of political philosophers, in which ideal political and moral principles are advocated, and the difficulty of applying such principles in the non-ideal real world.

Non-ideal theory recognises that an ideal theory may not be achievable, at least in the short term. For some philosophers, many instances of ideal theory are so far removed from reality that ideal theories of justice ought to be given a much-reduced status, if not dispensed with entirely. Farrelly, for instance, argues that taking into account the political, social and economic realities within which ideal theory has to operate, "will mean that there is less room for armchair theorizing and that the primary focus will not be on winning a philosophical debate among first-order theories of justice" (p. 860 in [40]) (see also [41]). Those who advocate this strong version of non-ideal theory are not then claiming simply that political pragmatism should prevail over normative political philosophy, but rather that any political or moral philosophy which does not take account of the non-ideal world it is attempting to influence and address is *normatively* deficient [41–45].

Clearly, the species-egalitarian version of animal rights falls into the category of a barely realistic ideal theory. Thus, even if the ethical principles are sound, in the sense that they prescribe accurately what morality demands of it, there is a case for rejecting abolitionism because it demands too much of human beings. As Nagel notes: "An ideal, however attractive it may be to contemplate, is utopian if real individuals cannot be motivated to live by it" (p. 904 in [46]). Abolitionism is confronted by some hard facts about the world. No country in the world has prohibited the use of animals as sources of food or has introduced a blanket ban on the use of animals as experimental subjects on the grounds that it is unacceptable morally to do so. Countries differ significantly in the degree to which the use of animals is regulated, but nowhere have these fundamental uses of animals been abolished or challenged to any great extent. It is true that, in some political jurisdictions, the use of some species, such as the Great Apes, in scientific procedures has been prohibited. However, this has come about not because the dominant personhood position has been rejected but because it is increasingly recognised that some species of nonhuman animals exhibit cognitive characteristics that are equated with personhood.

Even more importantly, in the context of this chapter, the species-egalitarian strand of animal rights might also be regarded as counterintuitive because it eschews the idea of beneficial relationships between humans and animals which involve the latter's confinement. That is, there is a tendency within animal rights abolitionism to regard animals and humans as operating in different realms so that it is our moral obligation to leave them alone. This leads to the expectation that once the exploitation of domesticated animals is abolished, the very notion of domesticating animals—of, in other words, humans having close relationships with animals—ends too.

A non-ideal theory of animal rights, then, must seek to bracket some of the more unrealistic elements of the conventional animal rights model. There is insufficient space here to outline this non-ideal account in detail, but I will briefly sketch out a model, the "sentience position", which I have developed elsewhere (see [47]). The sentience position seeks to bracket the notion that animals have a right to life and liberty. It morally prohibits the infliction of suffering on animals for human benefits, but at the same time accepts that humans can still, under certain circumstances, use them and, by extension, confine them.

The sentience position is far from being a defence of the *status quo*. Indeed, it is very demanding on human beings, because, as a rights-based ethic, it rules out the infliction of suffering on animals for our benefit. A contrast with the animal welfare ethic is instructive here. According to that position, it is permissible morally to inflict suffering on an animal provided that the benefits to be gained from so doing are perceived to be sufficiently large. The sentience position, on the other hand, rules out such a cost–benefit approach. *Whatever* the benefit that might accrue to humans, or other animals for that matter, practices that inflict suffering on animals are prohibited.

On the other hand, the sentience position is more realistic than the species-egalitarian version of animal rights which seeks to deny the ethical validity of using animals as, for example, sources of food and as experimental subjects irrespective of what is done to them whilst they are being used. It is possible to conceive of instances where animals are confined for some human purpose, but where the animal does not, or could be made not to, suffer. From this perspective, keeping some species in zoos, for example, does not raise ethical objections from the perspective of the sentience position, and neither does the use of animals for experimental procedures providing, again, that they do not suffer in the process.

Of course, determining the ethical permissibility of confining animals depends on how we define suffering. It is beyond the scope of this chapter to go into much detail about this. What can be said is that sentience, defined as the capacity to experience pleasure and pain, is narrower than suffering if the latter is defined to include a variety of negative states including pain, anxiety, boredom, frustration and so on. DeGrazia, for instance, describes suffering as “a highly unpleasant emotional state associated with more than minimal pain or distress” (p. 262 in [29]). One can therefore experience pain—in the sense of momentary pain for my own good—without suffering, and one can suffer without experiencing pain. It is credible to claim that all mammals are capable of suffering as so defined (see the evidence in p. 15–18 in [2]). Having said this, it is credible to claim that some forms of suffering—such as disgust, embarrassment, grief, and shame—can only be experienced by self-conscious beings, which probably excludes most animals.

Clearly, if we define suffering in a wide sense, as suggested, the confinement of animals becomes much harder to justify. For instance, although some common factory farming practices may not cause physical pain, there is significant evidence from animal welfare scientists that animals suffer as a result, and the same applies to some practices involved in the confinement of animals in zoos. What constitutes suffering will, of course, vary according to the nature of the circumstances accompanying confinement and the particular species involved. The key point here, though, is that, if the confinement of animals is to be prohibited in any particular case, it is justified, according to the sentience position, by its propensity to cause suffering and not just because of confinement itself.

## 11.7 Conclusion

This chapter has emphasised that, with one or two notable exceptions, much of the debate in animal ethics has focused on drawing ethical conclusions from the existence of cognitive capacities. Of course, both the normative and empirical elements are disputed. From the perspective of the conventional animal rights position, associated with Regan, at least some animals are rights holders as a result of their considerable cognitive capacities. As a result, it is illegitimate morally to use animals, and certainly to confine them, irrespective of what is done to them whilst being used and confined.

This chapter considers whether, if one thinks that the prohibition on confining animals is ethically mistaken—because it is too exacting—then we must dispense with an animal rights ethic. The obvious alternative is to adopt an animal welfare ethic. The grounds for thinking this is a sound move are based on the probably correct conclusion that the personhood position does account for some differences between at least most humans and animals that are morally significant. The rest of the chapter argues that the rejection of an animal rights ethic, and the adoption of an animal welfare alternative, should be resisted. This conclusion is based partly on the blanket inegalitarianism of the latter, which is obviously mistaken. More importantly, it is argued that animal rights can be rescued if a more nuanced, interest-based version is adopted and/or if we take account of the need to distinguish between ideal and nonideal theory.

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# Nonhuman, All Too Human: Toward Developing Policies for Ethical Chimera Research

# 12

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**Abstract**

In this chapter, we address the ethical challenges raised by chimera research policy, using as a case study the National Institutes of Health (NIH) 2016 proposal to change its policy governing the funding of human–nonhuman animal chimera research. In this case, we find a troubling shift from a focus on nonhuman animal welfare to poorly thought-out concerns with humanization. Despite the restrictions on modifying early-stage nonhuman primates, the proposed changes make it possible to modify animals in ways that may significantly impact neurological functions and behavioral capacities with serious implications for the welfare of research subjects. The NIH's restrictions target the development of humanized brains—particularly in nonhuman primates—reflecting, we suspect, a concern to avoid creating chimeras that are in some sense "too human." While we endorse robust restrictions on chimera research, particularly in the face of a growing globalization of research in varied and inconsistent regulatory environments, we maintain that policies should not be based on beliefs about inherent human uniqueness but should (minimally) instead conform to the widely accepted 3Rs framework for research involving nonhuman animals, and our best welfare science.

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_12

**Keywords**
3Rs framework · Animal ethics · Animal welfare · Chimeras · Humanization · NIH

## 12.1 Introduction

Concerns about chimeras are not new. Fear about the ethical horrors of scientists creating tormented chimeric beings is a well-worn trope in science fiction, dating back at least to Mary Shelley's *Frankenstein* [1]. In the public imagination, reports of pigs (e.g., [2]) or monkeys (e.g., [3]) genetically modified to grow human cells or organs conjure up images of monstrous births, reminiscent of Sigourney Weaver's Ripley walking through a laboratory populated by her alien chimeric sisters in various states of suffering [4]. Although fictional depictions of such creatures are motivated by real-world concerns about the ethics of scientific research, they are often also motivated by a kind of hyperbolic alarm and anxiety that forms a poor basis for sound research regulation.[1] Policies addressing human–nonhuman animal chimeras require careful engagement with the best current science and close analysis of accepted ethical principles governing the use of nonhuman animals in research.

In recent years, attention to chimera research has increased in response to technical innovations that make possible increasingly precise genetic and embryonic manipulations (such as CRISPR-Cas9). Although some national regulatory agencies have made efforts to develop policies restricting research for ethical reasons (e.g., in the USA), other nations appear to be taking a significantly more permissive approach. In China, for instance, researchers are developing human–nonhuman primate chimeras to study various psychiatric conditions [6] and Japan's Brain/MINDS (Brain Mapping by Integrated Neurotechnologies for Disease Studies) is developing human–marmoset chimeras as a model for both basic and translational research [7]. Shi et al.'s recent study of macaques modified with the human MCPH1 gene in an effort to provide insights into human evolution exemplifies the kind of controversial research that can be pursued in this permissive environment. While researchers in the USA are also engaged in the production of certain types of human–nonhuman chimeras—such as the genetic modification of pigs [2] and sheep [8] to grow human organs—the regulations of the US National Institutes of Health (NIH) on chimera research restrict what can be done.

The US policy, however, is by no means fixed, and, in observing its growing pains, one can see how various values, norms, and concerns shape the ethical

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[1] That chimeras represent some kind of violation of nature might be compelling for some, but it is by no means a universal sentiment. Other cultural representations of chimeras that do not reflect fears of animal–animal or human–animal admixtures include the seraphim from the Hebrew scriptures (the *Tanakh*), the beings surrounding the throne in the Christian *New Testament* book of *Revelation*, as well as Garuda and Lord Ganesha in what we now know as Hinduism. In these contexts, chimeras are associated with the Holy. For a brief overview of mythological and contemporary representations of chimeras, see [5].

discourse more generally. For example, in August 2016, the NIH released a proposal to amend its funding eligibility guidelines concerning biomedical research involving the use of human–nonhuman animal chimeras, thereby promising to overturn a moratorium they had instituted the year before [9]. While presented to the public as an effort to "increase restrictions" on chimera research [10], the proposed changes actually tighten some restrictions (e.g., on modifying early stage nonhuman primates) while loosening others (e.g., on modifying other early-stage animals or any, primates included, post-gastrulation). In fact, relative to the *status quo*, the recommended policy changes promised to increase the number of eligible research projects involving chimeras.

In this chapter, we interrogate the proposed changes from the NIH. We believe this offers a fascinating case study that provides general lessons about some of the motivations behind policy interventions, as well as the basic ethical considerations that should constrain this research. We argue that in these suggested policy changes, the NIH appears to be concerned to avoid creating chimeras that are "substantively humanized."[2] The concern is not with humanization *simpliciter*, since the NIH and the research community have long embraced various humanized rodent models [12]. However, a chimeric organism becomes "substantively humanized" when the addition and functional integration of human cells renders it in some sense "too human." Though other jurisdictions have introduced rules to restrict the development of chimeras with humanized faces and hands [13], the NIH's restrictions target the development of humanized brains, particularly in nonhuman primates.[3]

The next section of this chapter outlines our case study. The following sections situate this research relative to the dominant framework for addressing the ethics of research on nonhuman animals—William Russell and Rex Burch's 3Rs [15]—and identify the importance of looking beyond concerns about humanization to attend to more substantive concerns about welfare. Finally, we question the cogency of the NIH's apparent concern about creating substantively humanized chimeras, which generalizes to all policies grounded on this concern. We argue that any scruples about the possibility of endowing chimeras with human capacities that confer

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[2] The term "humanization" is used ubiquitously in debates about human–nonhuman chimera research in the sciences. There is, however, a broader political context in which the language of humanization and, more frequently, its opposite, dehumanization is employed. Critical discourse addressing inequality on the basis of gender, ability status, race, class, etc., often identifies dehumanizing attitudes and practices as a central feature of discrimination. At first glance, it appears that these meanings are quite distinct because in political contexts these concepts are moral ones, whereas in scientific context, humanization marks a purely biological description. However, because there are often folk biological beliefs underlying discriminatory attitudes against particular groups of humans, we wonder if a strict distinction can ultimately be maintained. The situation is yet more fraught when biological humanization threatens to influence moral status. Taking a page from Claire Kim's work [11], we acknowledge the difficulty of negotiating this space, though we do not have a solution to these difficulties. It is a happy result of our view that we discourage evaluations of moral status on the basis of measurements against some human ideal, thus moving away from the kinds of hierarchical thinking that often grounds discriminatory attitudes.

[3] This focus is present in the ISSCR Guidelines concerning hESC research [14].

human-like moral status must first seriously contemplate the possibility that members of the parent species already possess these capacities.

## 12.2 Case Study

In September 2015, the NIH released a statement on its website announcing a funding moratorium on stem cell research specifically involving human–nonhuman animal chimeras. “The National Institutes of Health (NIH),” the announcement read:

> is informing the research community that it will not fund research in which human pluripotent cells are introduced into non-human vertebrate animal pre-gastrulation stage embryos while the Agency considers a possible policy revision in this area. [16]

The language of the moratorium identifies three matters requiring evaluation before making chimera research of this sort eligible for NIH funding: “the state of the science in this area, the ethical issues that should be considered, and the relevant animal welfare concerns associated with these types of studies” [16]. Less than 2 months after the institution of the moratorium, the NIH convened a workshop to discuss them. The consensus at this workshop was that stem cell research involving the creation of chimeric beings is scientifically valuable, that the preponderance of the evidence speaks in favor of lifting the moratorium, and that funding should be reintroduced to support stem cell chimera research once more [17]. The August 2016 proposal marked the next step in this process (the completion of which remains unclear, though this is not relevant to our analysis).

There are two substantive changes in the NIH’s proposal. Although the proposed changes are relatively difficult to interpret, the NIH aims to expand the scope of stem cell research eligible for NIH funding so as to *include* the following: (1) research in which “human pluripotent cells are introduced into non-human [non-primate] vertebrate embryos, up through the end of the gastrulation stage” and (2) research in which “human cells are introduced into post-gastrulation non-human mammals [. . .], such that there could be either a substantial contribution or a substantial functional modification to the animal brain by the human cells” [17]. While the language of the proposed changes suggests expanding existing restrictions on stem cell research using nonhuman primates, the ultimate aim of the proposal is more research involving nonhuman animals, not less. The material effect of this change would be to curtail pre-gastrulation human stem cell research in nonhuman primate embryos. Section IV-B of the proposed guidelines preserves the ineligibility of research “involving the breeding of animals where the introduction of human cells may contribute to the germ line” (though “human cells” replaces “hESCs” and “human induced pluripotent stem cells” in the 2009 Guidelines [18]). Importantly, the proposed changes do not provide much specificity about this restriction. On a charitable reading, this means that the NIH could fund research projects that produce chimeric animals that carry human gametes (such as a pig with human sperm) as long as the animals are not intentionally bred by researchers. The language of

Sections IV-C and IV-D does not significantly alter the existing 2009 Guidelines, leaving intact the ineligibility of research projects that contravene the Dickey–Wicker Amendment or use hESCs derived from "somatic cell nuclear transfer, parthenogenesis, and/or IVF embryos created for research purposes."[4]

In the next three sections, we explore three concerns about chimera research that are exemplified by the NIH's 2016 proposed changes.[5] We worry that they evince a fundamental shift in how questions concerning the ethical conduct of human stem cell research involving animal chimeras are framed and interpreted. Nowhere is this shift more evident than in the evolution of the NIH's own discourse between 2015 and 2016. When the NIH first instituted the funding moratorium in 2015, they did so on the grounds that animal welfare concerns need to be taken seriously by researchers and funding agencies. This worry, however, seems to fall into the background of the NIH's discourse by 2016 when the changes to the 2009 Guidelines and the revocation of the moratorium are proposed. There, what seems to motivate the NIH is not so much a concern for the welfare of chimeric beings but a worry that some kinds of research may violate the human/animal divide by humanizing animals to a morally intolerable degree. This shift is problematic for three reasons: first, it threatens to undermine a substantive commitment to the 3Rs; second, the proposed changes do not sufficiently engage the welfare sciences and thus cannot ensure that chimeric beings are treated, managed, or cared for in ways that meet minimal ethical standards; and third, the concept of "substantive humanization" that appears to inform the changes is incoherent and an outgrowth of Great Chain of Being ideology.

## 12.3 The 3Rs Framework

Concerns for the welfare of animals used in research are most readily associated with the 3Rs framework of Replacement, Reduction, and Refinement, which is widely recognized as an international standard for ethical research using nonhuman animals. Put simply, Replacement concerns the use of "less sentient" or non-sentient models where it is methodologically permissible to do so. Reduction concerns using the minimal number of animals needed to reach a reliable scientific conclusion in any given experiment or study. Refinement concerns minimizing scientifically unnecessary distress, pain, or suffering. The use of in vitro models, computer simulations, some fish, or even arthropods instead of, say, mice or rats exemplifies Replacement [22], which takes pride of place as the first and arguably most important of the Rs.

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[4] The Dickey–Wicker amendment prohibits the use of appropriated funds "for: (1) the creation of a human embryo or embryos for research purposes; or (2) research in which a human embryo or embryos are destroyed, discarded, or knowingly subjected to risk of injury or death greater than that allowed for research under applicable Federal regulations" [19].

[5] For two defenses of the NIH's proposed changes, see [20, 21].

Drawn from Russell and Burch's influential 1959 text, *The Principles of Humane Experimental Technique*, the 3Rs are often presented as capturing the ethical aspirations of every conscientious animal researcher [23]. They direct the researcher's gaze to the costs of research in terms of animal distress or pain and introduce, as an ethical duty, the minimization of these costs wherever it is scientifically and methodologically possible. This, proponents argue, achieves a balance between the benefits of advancing science and the morally acceptable costs to research subjects [24]. The spirit of the 3Rs framework, evident when considering the principles of Replacement and Reduction together, is the eventual elimination of harmful research on nonhuman animals [25].

It is reasonably straightforward to motivate this framework. Where you can achieve your morally acceptable ends[6] through means that cause differing degrees of distress, pain, or suffering (reasonably understood as differing degrees of harm), you should choose those that cause the least harm. Of course, if one of your options will result in no harm to the relevant research subjects, then you should choose that one. This commitment to doing the least harm is pervasive in moral thought [26].

Two implications of using this framework to constrain animal research are immediately noteworthy in this context. First, there is a tacit acknowledgement that causing distress or pain to animals matters morally. Second, a substantive commitment to implementing the 3Rs permits judging certain scientific studies as unethical without having to take a definitive stance on the pressing, but difficult, question of animal moral equality. Under the 3Rs framework, research that could have used "less sentient" animals, non-sentient animals, tissue cultures, or simulations, *or* that uses more animals than is required to secure reliable findings, *or* that causes more stress and distress than is necessary is ethically unacceptable [27]. This holds true even if we *deny* that other animals enjoy similar moral status to our own and even if the research is epistemically sound or scientifically and socially significant. In other words, from these ethically conservative starting points, we can motivate ethical constraints on research that offset appeals to human benefits or moral judgments that challenge the permissibility of some harmful animal research.

The 3Rs also permit increasingly significant constraints on the continued use of animals in science. Replicating studies is an important self-correcting mechanism in the sciences, and this, we can concede for the sake of this point, is no less true of harmful animal research. Duplicating studies, including harmful animal studies, however, does not *advance* science. Such harmful animal studies do not provide benefits that offset costs to the animals used. They are not, then, the sort of morally acceptable end that motivates the use of the 3Rs to balance the costs and benefits of research. Once harmful research on animals has demonstrated something to be true, it is ethically unconscionable to re-demonstrate it on more sentient animals.[7] We

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[6] We assume, but only for the sake of this argument, that the use of animals in harmful research that is not in their interests can be morally acceptable.

[7] Using animals in teaching, particularly where they are harmed, complicates this claim. Though teaching prepares the next generation of scientists, and so indirectly contributes to the advancement

should not, say, allow scientists to conduct experiments that re-demonstrate the effects of maternal separation in nonhuman primates evident in the work of Harry Harlow (e.g., [29]).[8]

We can go further. The use of animals in research contexts where alternatives—such as "less sentient" animals or non-sentient models—are available should stop. We have seen this constraint emerge in recent discussions of the use of chimpanzees in government-funded research in the USA. An influential 2011 Institute of Medicine (IOM) report entitled "Chimpanzees in Biomedical and Behavioral Research: Assessing the Necessity," concluded that most research using chimpanzees in NIH-funded studies was unnecessary [31]. This generated a NIH Council of Councils Report that accepted most of the recommendations of the IOM report, and the NIH moved to end most NIH-funded chimpanzee research. The US Fish and Wildlife Service then reclassified captive chimpanzees as endangered, effectively limiting future use of chimpanzees to research that benefits wild populations or the species as a whole. As a result of these changes, the NIH quickly declared its intention to retire the agency's research chimpanzees to sanctuary [32].

### 12.3.1 Some Implications of the 3Rs for Human–Nonhuman Chimera Research

Several concerns arising out of our discussion of the 3Rs, especially the importance of animal welfare, apply to human–animal chimera research. Refinement considerations should remain sensitive to modifications that cause differing degrees of pain, distress, or suffering. Chimeric experiments with the brains of mice have already yielded subjects that perform better than controls in memory and learning tests [33]. However, changes that increase an animal's associative capacities and memory of past events may also increase their distress when presented with certain stressors in laboratories. Should this happen, it could in turn increase the traumatic effects of certain laboratory procedures or create such effects under circumstances where unmodified conspecifics had not previously experienced them.

Where the benefits of research can be secured with modified animals that experience less pain, distress, or suffering, then research should favor those animals. Shriver [34] has suggested that there are already knockout rodent strains that exhibit an awareness of pain but may not experience its unpleasantness (reflecting two prominent components of pain experience). An imperative to favor "less sentient" modified animals takes on particular force when the psychological capacities of animal research subjects are not relevant to their use as models (e.g., in some toxicity

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of science, it is recognized that this use of animals sits uneasily with a 3Rs commitment [28]. At best, the harmful use of nonhuman animals requires that this training is limited to those individuals who are likely to enter the relevant fields (e.g., graduate students rather than undergraduate or high school students).

[8] A personal and comprehensive assessment of the moral problems with this type of research can be found in a recent memoir by John Gluck [30].

testing). There could even be psychological studies that also do not require a fully sentient research subject. Presumably, invasive neuroscientific studies of visual or auditory capacities qualify as examples [34]. Creating "less sentient" research subjects out of concern for their welfare arguably falls out of a genuine commitment to the 3Rs, but is absent in the documents posted by the NIH regarding the changing funding guidelines.

If unmodified animals remain adequate models when compared with human–animal chimeras that experience more distress, pain, or suffering, then the unmodified animals should be favored over pursuing the creation of the relevant human–animal chimeras. This, again, falls out of a genuine commitment to the 3Rs. Inverting this last point, if human–animal chimeras are better models when compared with unmodified animals, a 3Rs commitment will favor the modified animals. In such circumstances, to continue to use unmodified animals as models would be morally unacceptable.

## 12.4 Lack of Attention to Animal Behavioral Sciences

Although concerns about animal welfare motivated the NIH's original moratorium, welfare does not appear to garner much attention in their proposed revisions. A shift away from welfare concerns is especially troubling given that the animal welfare challenges posed by chimera research are likely to be particularly acute.

We have already noted issues with chimera research that intersect with a general concern for animal welfare. The 3Rs framework rests on the premise that nonhuman animal welfare matters morally and that scientific necessity constrains their use in harmful research. Indeed, arguably the 3Rs are aspirationally abolitionist because the best possible world would be one in which all research not in the interests of the animal research subjects but harmful to them would be done without using any sentient nonhuman animals. We have also noted that the question of how to weigh nonhuman animal interests becomes more troubled if we consider those animals with whom humans share morally relevant capacities. As with welfare issues in general, these are not questions that can be answered by first principles but require careful, species-specific assessment of the best current research in the behavioral sciences and a serious engagement with ethical theory.

Of course, scientific evidence should ground all ethical assessments of research protocols and practices—after all, one can hardly hope to assess welfare, let alone determine ethically acceptable refinements, without a comprehensive understanding of the relevant animals' species-typical needs, capacities, and behaviors. However, chimera research promises to make such assessments particularly challenging precisely because chimeras are what Palacios-Gonzalez [35] calls "patchworks" of cells from different species. As individual chimeras or chimera models increasingly diverge from their nonhuman parent species type, the insights gained from the behavioral and welfare research appropriate for their parent species may become more difficult to apply. The most obvious cases are those where a trait or capacity that is directly relevant to the welfare of the animal is the target of the research; for instance, standard enrichment protocols for pigs might be inadequate for cognitively modified pig–human chimeras [36].

More troubling, however, are the challenges raised by the possibility of off-target effects. Organisms—especially complex, multicellular animals—are highly integrated systems, and while some organs and developmental processes are quite modular and self-contained, others are not. Anticipating the welfare needs of chimeras, particularly when chimera models are still under development, will often be challenging given the inevitability of some off-target effects [36].

Moreover, as social behaviors are increasingly recognized as crucial aspects of the welfare of social animals, attention cannot be limited to gross morphological, physiological, or behavioral traits or capacities at the level of the individual. Bayne and Würbel have noted:

> The evidence is clear across the multitude of species used in research that single housing can have a negative effect on social species and that social housing, managed properly, has numerous positive effects on the animals. Primary among these is the reduction or elimination of abnormal behaviour and the opportunity to express species-typical social behaviours. [37, p. 274]

Genetic or developmental interventions that affect the social capacities of chimeras by subverting their ability to appropriately interact with others in their social milieu must also be assessed. Consider, for instance, a social behavior that is prompted or mediated by scent and a chimerized organism who no longer produces the appropriate odor or is incapable of smelling the scent of others. When these social bonds, particularly between parent and offspring, are disrupted, the long-term welfare effects may be severe.

Finally, it is worth remembering that welfare issues are not simply of ethical concern, but they are also often crucial to scientific validity, depending on the research project in question [38]. Clearly, research that fails to meet basic standards of scientific validity can never outweigh the costs to animal research subjects. The animal welfare and behavioral sciences are also quickly developing fields, and any efforts to seriously address the thorny ethical issues arising from human–nonhuman chimera research must also monitor them.

## 12.5 "Substantive Humanization" Is an Incoherent Concept

To return to our case study, in their proposal, the NIH is particularly concerned that in some chimeric research, especially primate research, "human cells might contribute to the central nervous system and affect the cognition of the animal" [17]. It is difficult to discern what exactly the target is here, but we suggest it reflects a general anxiety about what we call "substantive humanization."[9] The concern seems to be that introducing human cells or the relevant genes into the central nervous system of another animal will produce "humanized brains," which, given the relation of brains and minds, could lead in some organisms to "humanized minds."[10] The new restrictions appear to be concerned not to cross a line beyond which humanized minds might be considered "too human" and thus deserving of an ethical status typically reserved for humans—an ethical status that the conditions of their existence may already have violated.

This concern motivates a number of critics of human–nonhuman chimera research [39, 40]. It, and indeed the entire ethical landscape that grounds it, is not only confused but also premised on a series of problematic theoretical assumptions about the Animal Kingdom. In particular, this line of reasoning seems to presuppose a kind of moral–biological hierarchy reminiscent of the Great Chain of Being [41]. On this view, humans stand at the top of the Animal Kingdom because they have been endowed with a specific set of morphological, neurological, and physiological (and, ultimately, genetic) traits that confer full moral status. The rest of the animals are scattered below human beings, possessing the latter's morally relevant traits only in a derivative or diminished form—or not at all. Every nonhuman animal, on this view, is a morally imperfect or underdeveloped creature, a mere shadow of the ape at the apex.

The NIH fails to explain why they focus on this specific kind of humanization, why they worry about it relative to only some animals but not others, and where the line between acceptable and unacceptable levels of humanization should be drawn. If the integration of human brain cells in another animal's central nervous system tracks potentially morally significant modifications, it is imperative that we clarify exactly what kinds of modifications are likely to trigger this effect and why. Certainly, many scientists and philosophers view the central nervous system as the basis of the cognitive, affective, and social capacities that justify the moral status accorded humans. But not all of the cognitive, affective, and social capacities human beings possess are morally relevant, which is to say, relevant for the determination of moral status. Consider, for example, our ability to see blue light, our ability to feel disgust upon smelling food that has previously nauseated us, or our capacity to live in large social groups. A number of species other than human beings have these capacities. Others do not. Yet, these capacities do not seem to be relevant to deciding whether the interests of animals should be given consideration by human beings or

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[9] Hyun's [20] concept of "moral humanization" is similar to our concept of "substantive humanization." Ours, however, has the advantage of permitting distinct discussions of humanized minds and modified animals deserving higher moral status than their unmodified kin.

[10] There are ongoing debates in fields ranging from neuroscience and cognitive psychology to the philosophy of mind about the relationship between brains and minds. Most scholars hold that brain states and mental states are intimately related, but no one holds that all brain states have a related mental state. Since our objective here is merely to highlight one of the concerns motivating the NIH's proposed changes (which has to do with the humanization of nonhuman beings), we do not enter into these more technical debates.

whether the interest of some animals should enjoy greater weight than others [42, 43]. Our point here is that unless one properly distinguishes between these forms of humanization—that is to say, between those that matter from a moral standpoint and those that do not—policies aiming to curb problematic humanization of chimeras will remain abstruse, if not outright incoherent.

These matters are further complicated by a proper appreciation of the diversity within our own species as well as the similarities across taxa. Human brains can be remarkably diverse morphologically and functionally, as are nervous systems more generally, owing to biological evolution. Of course, the same is true of humans' cognitive, affective, and behavioral capacities. There is no singular human kind or type. There are only variations on a theme [44].[11]

Moreover, this entire discussion about the ethical implications of humanizing nonhuman animals presupposes that animals are not already sufficiently similar to human beings in ways that matter morally. One can concede that some genetic or cellular modifications might culminate in "substantive humanization" of nonhuman animals if the modifications give the animals in question certain morally relevant capacities (whatever those may be). Even so, it could be that the concerns about humanization remain misguided and misplaced. They appear to assume that the capacities that are morally relevant are currently uniquely human, in spite of the fact that humans are both diverse and share many genetic, neurological, developmental, and physiological traits with other animals.

Attempts to identify capacities that are morally relevant tend to single out those that, upon reflection, turn out to be primate (or even mammalian), rather than solely human. The growing evidence from the animal welfare and behavioral sciences of the shared cognitive, affective, and social capacities of both human and nonhuman primates, varied though they may be, is just what an evolutionary framework predicts. In light of these considerations, *any* assumption that human moral status surpasses all other animals looks ill-conceived.[12] Indeed, it seems to reflect a kind of ideological anthropocentrism that smacks more of theology than rationally based policy or careful scientific study.

The previous considerations place invasive research on nonhuman primate–human chimeras in particular in an extremely troubling light. If the cognitive, affective, and social traits that are typical of humans make it unethical to perform this research on us, then there is a strong *prima facie* reason to believe that these same traits in nonhuman primates also make it unethical to perform the said research on them. This is the kind of experimentalist's dilemma highlighted by philosophers such as Bernard Rollin [50]. Indeed, some of the latest insights from the life sciences suggest that it is not only primates that may share cognitive, affective, and social capacities that should confer significant moral status. Other animals—including

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[11] Species essentialism and talk of "human nature" have long been critiqued by philosophers of biology. For some useful critiques, see [45–47].

[12] For some differences in neural structures and sociality among cetaceans that might challenge this assumption, see [48, 49].

some avians [51], cetaceans [52], and pachyderms [53]—have remarkable capacities that problematize the notion that there is a clear, single-line marking moral status, with all humans on one side and all other animals on the other. The question of which animals share morally relevant capacities is an open question that must be settled empirically. Yet, the best available evidence suggests that they are not uniquely human.

## 12.6 Conclusion

In sum, the ethical challenges posed by human–nonhuman chimera research are profound. In order to develop ethically adequate and scientifically robust policies, policy-makers must start by articulating their basic commitments. Welfare considerations must be given a central role. Concerns about "substantively humanizing" chimeras distract from the more pressing task of determining whether some chimeras or chimera parent species already possess morally relevant capacities that render their use in research problematic. This is especially urgent given the broad range of possible harms likely to befall chimeras, which will be difficult to predict and might be particularly severe. Furthermore, those developing the policies governing chimera research need to clarify how their policy incorporates the best evidence from the animal welfare sciences and meets the requirements of the 3Rs framework.

Given the promise of chimera research to modify model species in ways that may significantly diminish their suffering and the requirement to use the most reliable models available, there is a potential for a radical shift in research. If policy-makers are distracted by focusing on monitoring the boundary between the nonhuman and the all-too-human, they will fail to appreciate the ethical costs of chimera research.

**Acknowledgement** The authors thank Sona Ghosh, Andrew Lopez, MacGregor Malloy, and Caroline Vardigans for their assistance, as well as an audience at the 2016 meeting of the Animal Bioethics Affinity Group of the American Society for Bioethics and Humanities. We also acknowledge the support of the Social Sciences and Humanities Research Council and the Canada Research Chairs Program.

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# The Role of Neuroscience in Precise, Precautionary, and Probabilistic Accounts of Sentience

## 13

Adam J. Shriver

**Abstract**

Given that there is currently no consensus as to exactly which animals are sentient, how should we make moral decisions when we are uncertain as to which of the animals influenced by that decision are sentient? And how relevant is evidence from the neurosciences for making these decisions? In this chapter, I outline three different approaches toward incorporating uncertainty about sentience into moral decision-making: what I call precise, precautionary, and probabilistic approaches to sentience. I suggest that neuroscientific evidence has different relevance for each of these accounts. Precautionary approaches should be adopted to provide basic protections for animals even when we are uncertain about their sentience, but probabilistic accounts are more relevant for decisions where we need to carefully weigh positive and negative consequences of different possible decisions. Precise accounts can be useful for providing guidance but are not directly relevant for making decisions or guiding policy.

**Keywords**

Sentience · Consciousness · Arguments by analogy · Precautionary principle

**The Fire**: You have a choice. A fire has ignited at one of the local university's agricultural research facilities. The humans have all been evacuated but some of the animals remain behind for what is, without intervention, certain death. You are leading a team of volunteer firefighters driving a truck to the affected area and only have limited time. You can either save a barn full of ten cows, another barn full of fifteen chickens, two aquariums full of fifty fish, or a terrarium that contains seventy ants. All of the animals would, if saved, live exactly two more months of a relatively comfortable, though mostly bland, existence. Those who are left behind will die via asphyxiation (even the fish). As luck would have it, one of your colleagues

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_13

> brought along the most recent edition of *Principles of Neural Science* and suggested that you quickly scan the pages to see what can be found out about the comparative neuroanatomy of the different species. What should you do? And should the info from the book, assuming that you'll have time to read it on the way, be relevant to how you make your decision?

This scenario offers a stark choice that seems at first glance to depend on how we value the lives of different types of animals. Though it clearly is not a very realistic scenario, it resembles other types of value judgments made daily that have consequences in the real world. For example, in invasive animal research, researchers often interpret the "replace" principle in the 3Rs guidelines (replace, reduce, refine) as suggesting that it is better to run an experiment on larger numbers of mice than it is to run a similar experiment on equal or even smaller numbers of monkeys. In food ethics, some have argued that we should shift to a diet of insects to avoid the welfare problems associated with modern industrial farming of birds and mammals [1]. Others have argued that animal activists should focus on improvements to fish welfare compared with that of large mammals and even chickens due to the huge numbers of fish killed every year [2]. Each of these recommendations would seem to depend upon some method for comparing the lives and welfare of different species.

But though it might seem as though these different perspectives all require different evaluations of what types of capacities ground moral standing in animals, this need not be the case. All of the above positions can be reached from a starting point that assumes that all conscious experiences of positive and negative feelings are morally significant. Though two welfare promoters may agree that sentience matters for moral standing, they may nevertheless disagree about how to weigh potential evidence for sentience. Specifically, they may attach different significance to the extent to which different species have neural similarities with humans or other species they take to be clearly conscious, which in turn may determine at least in part how the potential interests of different species are weighed against one another.

In what follows, I examine the question of how we should treat neurological similarity under three different ways of thinking about sentience: what I call precise, precautionary, and probabilistic accounts of sentience. I argue that evidence from the neurosciences has very different importance for these three different types of accounts, to the point that evidence may not be required at all with regards to certain policy decisions. I suggest that each of the different accounts of sentience is appropriate for some contexts but not others. But prior to getting to these three accounts, I first need to say more about why assessing sentience and other mental capacities is such a challenge.

## 13.1 The Problem of Other Minds

In his *Meditations on First Philosophy*, Rene Descartes employed what some have called the Method of Doubt [3] in an attempt to find indubitable truths. He found that, when putting himself in a skeptical frame of mind, he could question almost everything he had previously taken for granted, including his knowledge of the existence an external world. However, due to his direct acquaintance with his own experience, he believed there was one thing he could not seriously doubt, which led to the famous *cogito*: "I think, therefore I am." Some have later questioned whether one could truly infer the existence of a continuing "self" that perseveres throughout our experiences [4], but nevertheless Descartes' observation that there is something special about our direct acquaintance with our own mental experiences, and his attempts to build upon that observation, has remained a powerful example of philosophical thought.

Unfortunately, however, this methodology does not reveal much about the minds of others (or, arguably, even our own). We do not have direct, immediate access to anyone else's mind. When trying to assess whether other humans are also conscious, the best we can do is to make inferences based either on how similar they are to us or other observations we suspect would be associated with conscious experience. This leads to the so-called Problem of Other Minds [5] or the problem of knowing that other humans are conscious.

This "problem" has been discussed extensively in the philosophical literature, but even philosophers who discuss it in great detail do not act in everyday life as if other people are insentient. And the very discussion can be enough to make some people roll their eyes at a certain style of philosophical methodology . . . surely no one could really take such concerns seriously! Similarly, many think that we should have an equally dismissive attitude to this type of skepticism when it is aimed at sentience in certain nonhuman animals. Can we really seriously doubt that companion cats and dogs are sentient even as they routinely exhibit clever ways of communicating their beliefs and desires? And if we think this about cats and dogs, it is hard to coherently think otherwise about many other kinds of animals with very similar behavior and neuroanatomy.

The problem, however, is that for some animals, the differences both in behavior and brain function are too dramatic to ignore. What should we think about animals that do not have anything resembling a brain or central nervous system and that do not respond to noxious stimulation or threats in the way we would expect? Many people draw the line once a certain limit is reached with respect to differences from humans, whether the line is drawn at fish, insects, or some other taxa or species. However, even when a line is drawn, given the extensive variation observed among biological organisms, can we come up with a principled explanation for justifying the differential treatment between those species on either side of the line?

Some have tried to sidestep this challenge by endorsing panpsychism, the view that phenomenal consciousness is a property that exists in all physical matter. However, the move from this position to specific moral recommendations is often unjustified. Even if we think that consciousness is ubiquitous, we know from our own experiences that not all conscious experience is morally significant. Some experiences are neutral and do not seem to have any positive or negative valence [6]. In fact, in rare circumstances, there appear to even be cases of pain that lack the unpleasantness that typically accompanies them [7]. So even if we were told definitively that, say, a hydrogen molecule has the property of consciousness to some degree, we would have no way of assessing whether that conscious experience was positive, negative, or entirely neutral. So, endorsing panpsychism just changes the challenging question from "how do we know which entities are conscious?" to "how do we know which entities have morally significant consciousness?" Endorsing panpsychism takes us no closer to knowing which animals should be taken into consideration in our moral judgments.

So, we are left to confront a situation where, although there are various theories of consciousness, any honest assessment would have to conclude that we do not yet know what physical processes are most central to the experience of morally relevant feelings (or other psychological states). And it is not just that we do not know what physical processes are relevant; we do not even know what exactly it would look like to have sufficient evidence to know that certain physical processes are central.

But we do not have the luxury of throwing up our hands and embracing agnosticism. Humans have impacted and continue to impact potentially sentient organisms at a scale that is almost impossible to exaggerate. In fact, we have the capacity to end all sentient life on earth, but sadly the jury is still out as to whether we have the ability to organize and guide societies in a manner that would ensure that this does not happen. Meanwhile, everyday activities such as modern industrial agriculture are likely causing suffering to tens of billions of animals every year [8]. The stakes are high. We need some principled methodology for assessing sentience that can be of use in attempting to formulate ethical and legal restrictions on our treatment of nonhuman animals. I now turn to several different strategies that have been used to do this, and in particular will examine the relevance of neuroscience for making final decisions on these frameworks.

## 13.2 Precise Accounts of Sentience

Until recently, most philosophical attempts at using sentience to guide policy attempted to set fairly clear lines that could be of use for ethical guidelines. That is, criteria were provided that could be used to say, for any given species, whether that species should be treated as sentient or not. There was, and currently is, no consensus on the exact criteria, so the designation "precise" should not be thought of as indicating the *success* of the endeavors so much as the fact that they, in contrast to the other two groups of theories I will be considering, *aspire* to provide precise criteria that can be used to make the relevant determinations. For these theories, we can say that, *if* they are true, then they set decision criteria that can be used to determine which beings are sentient.

Gary Varner [9, 10] has suggested that most standard arguments about sentience in animals can be usefully interpreted as arguments by analogy. An exchange between Varner and Colin Allen about such arguments nevertheless nicely illustrates some general challenges facing precise accounts of sentience.

To begin, we can follow Varner in suggesting the following general format for an argument by analogy for animal sentience:

P1. Things like X are known to have qualities a, b, c, . . . and m as well as n.
P2. Things like Y are known to have qualities a, b, c, . . . and m.
C. So, things like Y probably also have quality n. [9, p. 108]

Though most authors Varner is discussing do not explicitly formulate their arguments in these terms, they nevertheless can easily be represented in this way. Varner himself initially summarized four different meta-reviews of animal sentience to come up with a list of evidentiary conditions that may indicate sentience. This list includes both neural and nonneural criteria. The former include the presence of nociceptors, the presence of brains, the fact that nociceptors are connected to brains, and the fact that the organism has endogenous opioids. Among the latter criteria are behavioral responses to pain that resemble those of humans and behavioral responses to known analgesics. Taxa that ticked all of the boxes were regarded as good candidates for sentience. Based on these criteria, Varner initially concluded that most vertebrates were likely to be sentient, and invertebrates (with the exception of cephalopods) likely insentient.

However, as Allen [11] has pointed out, there are two serious weaknesses with using these arguments to make determinations about sentience. First, such assessments have to be based on the most current research, and the general trend has moved in the direction of discovering that in certain species capacities are present that were previously assumed not to exist. For example, in the 2 years between the time of Varner's initial argument and Allen's critique, nociceptors were discovered in several new species.

This concern can perhaps be addressed with what Varner describes as "going to war with the army you've got" [10, p. 115]. Surely all can agree that in the absence of conclusive evidence, we nevertheless have to make decisions based on what evidence we do have. However, as we will see, the type of line-drawing recommended by Varner can be problematic in ways that do not apply to other approaches I will consider.

Allen's second criticism reveals a deeper challenge. As he notes, just as there will be some biological similarities between humans and other animals, there will also always be some biological differences and in particular some neurological differences related to the capacity to feel pain and/or pleasure and/or other valenced states. So, sentience skeptics can point to these dissimilarities to argue against the claim that any given nonhuman animal is sentient. How, then, can we sort through the various similarities and dissimilarities to come up with the right criteria for comparison? Allen argues that we need a *guiding theory* that explains *why* we should expect certain features to be required for conscious experience that can guide the comparisons to firmer footing.

It is hard to argue against the suggestion that having such a theory would be ideal for any proposed account, and many authors have attempted to provide one, including Varner [10] in his response to Allen. Guiding theories for precise accounts of sentience might rely heavily on neuroscientific details or may eschew them entirely. But all guiding theories, as suggested by Allen, need to tell some story about why particular features give rise to conscious experience.

The problem, of course, is that there is intense disagreement about which theories should be preferred, and there is nothing coming close to compelling evidence to suggest that any particular theory is the right one. Meeting Allen's challenge with not just *a* guiding theory but rather *the correct* guiding theory requires nothing less than discovering the neural correlates of sentience. In the absence of such a theory, we could be skeptical that humans are sentient, too. But, as stated above, there are many ethical and political decisions to be made, and waiting (perhaps indefinitely) for the correct guiding theory to make these decisions is likely to result in the suffering of numerous sentient beings.

So, it seems that we are left with Varner's "going to war with the army we have" concession. But if we adopt this approach, despite tenuous knowledge and disagreement about what the relevant traits truly are, what happens if we draw the line at the wrong place? If a precise account of sentience tells us we should draw the line at vertebrates, and our regulations are correspondingly formulated such that only vertebrates are protected (as is currently the case in the USA), what are the ethically significant consequences if we are mistaken? Consider, for example, invertebrate species such as lobsters that are routinely boiled alive for human food. If they are in fact capable of feeling pain, then treating them otherwise would be causing vast amounts of morally relevant suffering. As such, using a firm line to determine our ethical obligations seems likely to result in seriously bad consequences. But other approaches for dealing with evidence for sentience have been developed that can avoid this problem.

## 13.3 Precautionary Accounts of Sentience

Whereas precise accounts of sentience can be thought of as drawing lines based on what could be characterized as the *best* account of the relevant evidence for sentience, a precautionary approach to sentience might be loosely described as drawing lines, in certain conditions, based on a *sufficiently reasonable* account of relevant evidence for sentience. The precautionary principle, which in its original form stated "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" [12, p. 3], was developed specifically to prevent serious harms from occurring in circumstances where scientific certainty is lacking. In particular, as Steele [13] notes, such a principle is needed to ensure that policy is not "susceptible to paralysis by scientific uncertainty" (p. 213). The principle is relevant for many challenges at the intersection of science and public policy, and perhaps most urgently with regard to climate change, where a number of interesting scientific questions remain despite it having been known for many years that action is warranted and, in fact, urgently needed.

The precautionary principle has been applied to nonhuman animals in the past, and a recent paper by Birch [14] provides a valuably detailed framework for applying it to policies that affect nonhuman animals. Birch begins by adapting the original policy-related precautionary principle so that it can be formulated to apply to nonhuman animals. The original precautionary principle references environmental degradation as the relevant harm, but if we think that other types of harms can be treated similarly, we can accept Birch's formulation of the Animal Sentience Precautionary Principle as: "Where there are threats of serious, negative animal welfare outcomes, lack of full scientific certainty as to the sentience of the animals in question shall not be used as a reason for postponing cost-effective measures to prevent those outcomes" (p. 3).

Birch, following Stephen John, bisects the precautionary principle into two components: what he calls an epistemic rule and a decision rule. The epistemic rule can be formulated as follows:

> For the purposes of formulating animal protection legislation, there is sufficient evidence that animals of a particular order are sentient if there is statistically significant evidence, obtained by experiments that meet normal scientific standards, of the presence of at least one credible indicator of sentience in at least one species of that order. (p. 5)

The decision rule is formulated as follows:

> We should aim to include within the scope of animal protection legislation all animals for which the evidence of sentience is sufficient, according to the standard of sufficiency outlined in [the epistemic rule]. (p. 5)

Birch provides a great deal of argumentation and clarification to motivate his position, but this outline is clear enough to make some general remarks about the value and unique attributes of the approach. First, as should be obvious, the precautionary approach avoids the most serious pitfalls of precise accounts of sentience since line-drawing occurs not at the point at which we think we have the *best* evidence, but rather at a point where we have *sufficiently reasonable* evidence. So, for example, Birch cites the research program by Robert Elwood that provides evidence that decapod crustaceans engage in motivational tradeoffs involving noxious stimulation. Thus, according to the decision rule provided, "decapods should therefore be brought within the scope of animal protection legislation" (p. 8). Presumably, this would mean, at a minimum, that restrictions be placed on how decapods are killed for food, and methods such as boiling lobsters alive would be prohibited.

The precautionary approach to sentience still has some risk of leaving out sentient animals, in cases where current credible methods for assessing sentience for some reason fail to detect it. But this risk is clearly far lower than that of precise accounts. As such, the chances of causing large amounts of suffering based on a mistaken assessment of sentience are greatly reduced when using precautionary approaches toward policy-making directed at animal protection laws and regulations, as well as determining morally permissible behavior. On the other hand, the risk of mistakenly treating some animals as sentient when they are not increases. Some particular industries, such as fishing, could claim that these economic harms are also serious. But in general, the asymmetry of harms—the potential harm in treating sentient animals as insentient versus the harm of treating insentient animals as sentient—is such that the first type of error carries far more moral risk.

Evidence from the neurosciences has an interesting role to play in precautionary approaches to sentience. It certainly seems conceptually possible that some comparative neuroanatomy evidence, against a background of other scientific knowledge, could count as "statistically significant evidence ... of the presence of at least one credible indicator of sentience" [14, p. 5]. As such, neuroscience evidence, in conjunction with behavioral evidence, could likely be sufficient to meet the epistemic condition. But purely neuroscientific evidence by itself probably would not tell us much, since without some understanding of how neural processing leads to behavior, it is difficult to connect this type of evidence to those mental states constitutive of sentience. However, it also seems clear that in some cases the epistemic condition for the precautionary principle could be met without any reference whatsoever to evidence from the neurosciences. Take the "motivational tradeoffs" criteria referenced above in relation to decapods. As it happens, Elwood also has neurological evidence regarding behavior, but one could certainly imagine a set of behaviors sophisticated enough that, even in the absence of any comparative neuroscience, it is sufficient to meet the epistemic criteria. An organism such as a lobster, for example, that typically withdraws from noxious stimulation, but is willing to undergo such stimulation in exchange for particular rewards, and whose tradeoff behavior is altered in the expected ways by the administration of analgesics, would seem to be a good candidate. Thus, though neuroscience evidence can be relevant for precautionary approaches to sentience, it is not strictly speaking required.

Though I think the above suggests that the precautionary principle has an important role to play in determining policy and ethics guidelines, it is also clearly limited in its application to certain types of decisions. For example, in the scenario described at the beginning of the article, we might imagine that the precautionary principle determines that the ants, fish, chickens, and cows all meet our epistemic criteria for sentience. Would it then follow that we should save the ants, even if the evidence for sentience was far stronger in the case of the other animals? It would be unfair to say the precautionary approach as stated above gets the wrong answer in such a case; more accurately, the decision rule above is simply not designed to answer this type of question. The principle is relevant for specific knowledge asymmetries where erring in one direction involves the risk of serious harms. It is not, however, useful for making decisions in situations that require carefully balancing harms and benefits between different options, such as the example at the beginning of this chapter. For that, I turn to a third type of approach to sentience: probabilistic accounts.

## 13.4 Probabilistic Approaches to Sentience

Returning to the original scenario, the earlier accounts of sentience do not provide plausible guides for decision-making. Relying on a version of a precise account, let us say one's preferred "guiding theory" of consciousness suggested that a certain type of corticothalamic feedback loop was required for consciousness, thus implying that cows and chickens meet the criteria, but fish and ants do not. This account presumably would suggest that we ought to save the chickens (assuming that cows do not suffer more or enjoy more, though this is not necessarily entailed by the fact that both are sentient). But this approach carries the risk of allowing 35 additional animals to die who could have been saved if your guiding theory was mistaken in excluding fish. If you think that this is an acceptable risk, what if the choice were between 500 fish and 15 chickens, or between 5000 fish and 15 chickens? Presumably at some point most of us would think the numbers should matter in our decision, but precise accounts that say policy should be determined solely by line-drawing based on the preferred theories would not be sensitive to such concerns.

Similarly, let us say we adapted the precautionary principle such that it suggests that once the epistemic criteria are met, our new decision rule specifies that "all should count for one, and none for more than one" and thus that all sentient lives should be treated equally. But imagine that there were 10 different, plausible evidentiary criteria for sentience and that mammals like cows met all 10, while the chickens only met one. Would we still have an overriding reason to save the 15 chickens over the 10 cows? Again, we can play with the numbers to generate more clearly uncomfortable results. If the choice was between 99 cows and 100 chickens, and we had *dramatically more evidence* that cows are sentient, surely the evidence should be enough to tip the scales at this point. So while the precise accounts are insensitive to numbers of animals, the modified precautionary account is insensitive to strength of evidence, once that evidence has crossed a certain threshold.

As such, we need a different approach. Imagine that we had good reason to think that there is a 95% chance that cows are sentient, an 80% chance that chickens are sentient, a 60% chance that fish are sentient, and a 10% chance that ants are sentient. On one relatively straightforward approach of multiplying the purported value of a particular outcome by the probability of it occurring, we can use those probabilities to assign weightings to different possible choices. Assuming for simplicity that there is no relevant differences in intensity or duration of possible experiences between the animals, and our goal is to maximize the number of sentient lives saved, we could multiply 0.95 by 10 to get an expected difference in the case of cows to 9.5, and multiply the 0.10 by 70 to get an expected difference of 7 for saving the ants. Thus, this approach would favor saving the cows over the ants. However, 15 times 0.8 would get an expected difference of 12 for saving the chickens, and 0.6 multiplied by 50 would get an expected difference of 30 for saving the fish. Thus, this account would recommend saving the fish (on this highly artificial setup) as the approach most likely to save the highest number of sentient animals. Of course, a full ethical accounting would need to take into consideration many other variables, such as how long the animals would live, whether there might be different intensities in emotions, etc., but hopefully the idea of how uncertainty about mental states could theoretically be built into the assessment is clear.

The probabilistic approach to sentience is prominent in certain animal advocacy communities and particularly in what is called the Effective Altruism community. This community is dedicated to doing the *most good*, and as such using probabilities to weight-expected outcomes is a straightforward way of maximizing the expected value of particular actions or policies. Starting from this perspective, it has been argued that it would be better to focus on improving the welfare of chickens over the welfare of cows, since 7 billion broiler chickens are slaughtered for food every year in the USA as opposed to 34 million cows. Though most of these advocates would agree that it is probably slightly more likely that cows are sentient, this slight difference is not enough to make up for the fact that 205 times more chickens are killed. Similar arguments have been put forward to argue in favor of prioritizing the welfare of fish over chickens and mammals, since their numbers (especially when bycatch is included) dwarf even those of chickens. And, perhaps even more surprisingly, similar numbers-based arguments have been used to suggest that insects should be prioritized over vertebrates even if we think there is a relatively low likelihood of them being sentient.

Of course, such accounts are only as plausible as the idea that we can reliably assign probabilities to the different possibilities. Since we do not truly have access to objective probabilities, the term "credence" is often used to quantify the subjective estimates of probability assigned to particular outcomes. If a new study comes out that says that, say, termites have nociceptors, this presumably should increase the credence we assign to the likelihood that termites are sentient. *How much* it should do so is of course a question that can be answered only in the vaguest terms. Though it is hard to have much confidence in the precise amounts of credence people assign to various bits of evidence, there are presumably some cases, say comparing the welfare of one cow to that of 10,000 chickens, where the differences in numbers are so large as to dwarf the differences that would come from subjective assessments of the likelihood of sentience.

Probabilistic accounts have an important role to play in ethical decision-making. In conjunction with the precautionary accounts, some version of the probabilistic accounts should guide our ethical decision-making in most cases. However, at least as practiced, the application of this framework also has flaws. In particular, it arguably assigns weight to *too many things*. The accounts are sensitive to evidence from any account of sentience that has not been definitively ruled out, which of course includes many mutually exclusive accounts, and thus it stands to reason that some ultimately irrelevant evidence will be playing a role in guiding decisions. Moreover, the approach in practice can (though need not) lead us to adopt an uncritical stance toward different evidence. It can be easy to simply say "person X says fish are insentient therefore I will adjust my credence appropriately" rather than thoroughly and skeptically evaluating the evidence, and it may turn out that faulty reasoning is missed as a result.

## 13.5 Guiding Ethics and Policy

In light of the above considerations, how ought we go about formulating our ethical and political commitments in light of evidence for sentience in different species? And how relevant are findings from the neurosciences?

In my view, the precautionary and probabilistic accounts are useful for directly guiding these decisions in certain situations, whereas precise accounts are never directly relevant for decision-making, but nevertheless provide important background considerations and guidance. For the sake of ensuring basic protections across nonhuman taxa, precautionary accounts of sentience are needed to prevent the risk of serious harms occurring. Thus, many laws and policies should be formulated that treat animals as sentient provided that there is statistically significant evidence, obtained by experiments that meet normal scientific standards, of the presence of at least one credible indicator of sentience in at least one species of that order. And the precautionary principle is similarly useful in situations where there is great risk of harm from treating sentient animals as insentient, and relatively little risk of harm from treating insentient animals as sentient.

However, other types of situations involve trade-offs between harms that are more proportionately aligned. In these cases, probabilistic accounts that take into account some rough estimate of the likelihood of sentience, the numbers of animals involved, and an assessment of the magnitude of harms and benefits are more relevant for decision-making. These may not be the only relevant moral criteria in such cases, since concerns about rights, autonomy, and such might be relevant, but it should at least be included as a component in the decision-making process.

However, as noted above, precise accounts must also play an important though indirect role. In particular, without an ongoing search for precise accounts of sentience, we will almost certainly be making incorrect judgments about sentience, and these mistakes have real costs (particularly in cases where we are relying on probabilistic accounts), costs that can include the suffering of sentient organisms and the misappropriation of scare resources. In searching for precise accounts of sentience, we will often discover that some criteria for sentience are flawed, and this in turn will have implications for how precautionary and probabilistic theories are applied. For example, one commonly suggested criterion for sentience is that an opioid has some effect on behavior in response to a noxious stimulus, with the implication being that if an animal changes their behavior as a result of a painkiller being administered, the original behavior must have been the result of a pain experience. However, we know from neuroscience that there are receptors sensitive to opioids in the peripheral nervous system, and thus reflexive responses to noxious stimulation can be influenced without any changes taking place in the brain. As such, just any behavioral response to opioid analgesics should not, by itself, be regarded as sufficient evidence for sentience, even on a precautionary account. Of course, the principle could possibly be modified such that it does necessarily involve opioids influencing brain systems, and perhaps this modified principle could be used instead. But the upshot is nevertheless that the earlier, more simple rule cannot be justified.

## 13.6 Conclusion

It is important that the search for precise accounts of sentience continues, and this will certainly involve neuroscience research for the foreseeable future. As connections are made between behavior, self-report, and neural function, criteria for sentience will continue to be refined. This in turn will help to improve precautionary and probabilistic accounts of sentience that are needed to guide policy. Though I think the precautionary principle should help guide the formulation of basic protections, and that evidence from the neurosciences is not *required* in some cases to conclude that particular species deserve protections, an ongoing search for the neural correlates of sentience must be pursued in order to avoid harms that occur from mistaken accounts.[1]

**Acknowledgement** Thanks to the Alternatives Research Development Foundation (ARDF) and the University of Pennsylvania School of Arts and Sciences for funding the "Animal Research Neuroethics" workshop, which has helped shape my views on these topics, as well as my contribution to the book project more generally. A grant from the Centre for Effective Altruism UK also contributed to the development of the ideas here. The writing of this chapter was supported by Wellcome Trust grant (203132/Z/16/Z). Thanks to the Oxford Uehrio Centre for Practical Ethics, and the Wellcome Centre for Ethics and Humanities for supporting my current work.

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[1] While this paper was in production, I came across a similar article comparing the precautionary principle and the expected utility function by Jeff Sebo. Though the papers have different methodologies and different aims, I highly recommend also taking a look at his insightful paper [15].

# Part III

# Neuroethics and Nonhuman Animal Research Ethics

# A Threshold Standard for Regulating Invasive Nonhuman Primate Research in the Age of the Major Brain Projects

# 14

Tom Buller

**Abstract**

On account of their phylogenetic similarity to humans, nonhuman primates (NHPs) play an indispensable role in both basic and translational neuroscience research. The recent establishment of a number of brain projects to map the brain and to discover new therapies for brain disease and disorders has focused attention on the use of NHPs, particularly since some of these projects have led to an increase in the use of NHPs in research (Australian Brain Alliance, Blue Brain Project (Switzerland), BRAIN Initiative (USA), Brain/MINDS (Japan) Canada Brain Research Fund, China Brain Project, Cuban Human Brain Mapping Project, Israel Brain Technologies, Korean Brain Initiative, Latin American Brain Mapping Network). At present, there is considerable variety in the national and international regulations governing NHP use. In order for the projects to gain broad public support and to provide adequate protection for NHPs, it is important that the regulations are harmonized.

The goal of regulations and guidelines governing NHP research is to set an appropriate balance between providing adequate protection to the animals and encouraging scientific investigation and progress. At present, the regulations governing NHP research in the USA, the EU, and China permit highly invasive research, and, consequently, it has been argued that the regulations are inadequate. This chapter provides an overview of the regulations governing NHP research in the USA, the EU, and China, considers a number of different approaches to tightening the regulations, and argues that the most satisfactory approach is to adopt a threshold standard of invasiveness.

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_14

**Keywords**
Nonhuman primate research · Neuroscience · International research guidelines · Animal welfare

## 14.1 Introduction

One of the questions that the American and Soviet space programs needed to answer before sending a human into space was whether a living creature could make this journey and return alive and unharmed. To answer this question, both programs sent animals, including nonhuman primates, into space to test the survivability of a prolonged period of weightlessness. In 1961, the first chimpanzee in space, Ham, successfully completed a mission in which he reached an altitude of 157 miles, a speed of 5587 mph, and experienced 6.6 min of weightlessness [1]. The success of Ham's mission enabled Alan Shephard Jr. to be the first human astronaut the same year. Eight years later, the first humans landed on the moon—the "giant leap" for humankind.

In 2013, American President Obama announced the launch of the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, a multi-billion-dollar program to map the human brain and to discover new therapies for brain diseases and disorders. The challenge to map the brain has been compared to the Apollo space program in terms of its potential contribution to human knowledge and the significance of its achievement. It has been described as a "great journey into the unknown"—a journey to map the brain's functions and structures, to discover "the interior of thinking, feeling, perceiving, learning, deciding and action to achieve our goals..." (p. 9 in [2]). Over the past few years, nearly a dozen other major national and international brain projects have been launched to advance our understanding of the brain and its disorders. The concurrent establishment of these projects reflects their international and integrated nature, as well as the shared perception of the importance of the goals.

A number of the brain projects that have recently been established involve a significant degree of NHP research. The use of NHPs is usually justified in terms of the overall balance of benefits and harms, the higher moral status of humans, and because the phylogenetic similarity between humans and NHPs makes their inclusion uniquely important. In opposition to this position, however, it can be argued that the similarity between humans and NHPs in terms of cognitive ability, intelligence, and social behavior should accord NHPs a similar moral status to that of humans, or that their difference in moral status is not sufficient to conclude that the interests of humans should always take precedence. Furthermore, it can be objected that the contribution of NHPs to neuroscience research is not as significant as claimed [3]. Few would contest that it would be a remarkable achievement if we succeeded in "mapping the brain," nor challenge the value of the discovery of new therapies for brain diseases and disorders. But questions remain as to whether NHP research contributes to these goals, and if it does, whether the existing regulations and practices provide adequate protections for NHPs.

The goal of this chapter is to attempt to answer the latter question. The first half of the chapter provides a brief overview of three of the brain projects, the US BRAIN Initiative, the EU Human Brain Project, and the China Brain Project, and compares their current regulations governing NHP research. The second half of the chapter discusses two proposals whose stated aims are to significantly reduce the scope of permissible NHP research and presents a number of objections to these proposals. An alternative proposal is presented, one that attempts to balance the value of scientific research with the welfare of NHPs by imposing a threshold standard on the level of permissible invasiveness.

## 14.2 The Major Brain Projects and Nonhuman Primate Research

In broad terms, the use of animals in scientific research is defended on the grounds that it leads to significant benefit and progress. In the *International Guiding Principles for Biomedical Research Involving Animals*, the Council for International Organizations of Medical Sciences (CIOMS) puts the matter the following way:

> The use of animals in research, education and testing is an essential component of the advancement of our understanding about human and animal function. This knowledge is important for advancing human and animal health and welfare through disease prevention and cures, new treatments, and drug and device development. The scientific community, understanding that using animals is a privilege entrusted by society, remains committed to ensuring the health and welfare of animals as an integral consideration when animals are used for these purposes. [4, pr. 2]

A similar sentiment is expressed in a joint statement by a number of scientific organizations:

> Research with nonhuman primates (NHPs)—monkeys for the most part—has led to critical health advances that have saved or improved millions of human lives. While **NHPs account for just one-half of one percent** of animals in current medical research, it is no exaggeration to say they are essential to our ability to find cures for **cancer, AIDS, Alzheimer's, Parkinson's, obesity/diabetes** and dozens of other diseases that cause human suffering and death. (p. 354 in [5])

The essential contribution that NHP research has made in relation to spinal cord injury, neurodegenerative diseases, NeuroAIDS, and other mental disorders has been described in a number of publications [6–10].

The moral sentiment that is evoked by the use of the term "privilege" in the CIOMS statement recognizes our fundamental responsibility to care for the welfare of the animals used in research. This responsibility is described more fully by the 3Rs principles that seek to minimize the welfare costs to animals [11]. The principles promote the *replacement* of sentient animals with other models, the *reduction* in the number of sentient animals used or experiments performed, and the *refinement* of procedures so as to minimize pain and suffering. These principles have been adopted by many organizations engaged in animal research, as well as national and international regulations and legislation [12]. It has been argued, however, that adherence to the 3Rs principles—particularly in the case of NHP research—is not sufficient. In particular, the contribution of NHPs to the diseases and disorders mentioned above (and neuroscientific research more broadly) is not as significant as is claimed [3] and that successful animal studies often fail to translate to clinical practice [13]. Furthermore, it has been claimed that the moral status of NHPs should accord them greater protection than the current regulations allow [14–18].

In very broad terms, "basic" (or "fundamental") neuroscience research can be distinguished from "applied" neuroscience research in that the former seeks to understand the brain's structure and functions, rather than to apply this understanding to the potential treatment of diseases and disorders. As the quotations above suggest, neuroscience research involving NHPs has been justified on the grounds that it can lead to "critical health advances." Since, by definition, basic neuroscience does not seek such advances, it is difficult to justify this type of research in these terms. This is not to question the value of basic neuroscience nor to challenge the claim that it has provided "decisive insights" into a number of areas in cognitive neuroscience, including perception and perceptual organization, decision-making, and motor control [6]. Rather, the problem is that although many would see the increased understanding of brain function to be very valuable, the lack of specific and direct benefit means that it is difficult to weigh that benefit against the hardship caused to the animals [19].

Although a variety of animals are used in neuroscience research, the inclusion of NHPs is thought to be necessary because of their phylogenetic similarity to humans [20].

> We expect the BRAIN Initiative to include nonhuman primates such as rhesus macaques, because they are evolutionarily the closest animal model for humans, and this will be reflected in their behavioral and cognitive abilities, genetics, anatomy, and physiology. (p. 50 in [2])

In comparison to other (nonhuman) animals, the NHP brain most closely resembles the human brain in terms of encephalization, the number and density of cortical neurons, and the large prefrontal cortex [21]. Furthermore, on account of their phylogenetic similarity to humans, NHPs can learn to perform specific and complex cognitive and behavioral tasks, for example, the control of a robotic limb through a brain–machine interface [22].

According to the most recent data, in 2016 there were 71,188 NHPs held in research facilities in the USA [23]. A considerable proportion of this number are held in the seven national primate research centers. Experiments on NHPs represented 0.28% of all laboratory animals used in research [21]. In 2014, 8898 procedures were performed on NHPs in the EU. Approximately 6000 NHPs were used in experiments in 2011 (0.05% of animal experiments) compared to 10,000 in 2008 [20]. In comparison to the USA and the EU, in China there are 290,000 NHPs held in research facilities and 40 breeding colonies [24, 25]. China supplies more than 70% of the research NHPs to US laboratories [26]. As evidence of China's investment in NHP research, the Chinese Institute for Brain Research has recently been established, new research facilities are being built at a number of institutions, and a National Primate Resource Center is being developed. The center will be the largest NHP research facility in China [25]. It is proposed that the China Brain Project, Brain/MINDS (Japan), and the Korean Brain Initiative will form a consortium, the "Asia Brain Initiative," to help foster collaboration among the three projects [27].

As the following descriptions attest, the various national and international brain projects have common goals.

> The Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative is aimed at revolutionizing our understanding of the human brain. By accelerating the development and application of innovative technologies, researchers will be able to produce a revolutionary new dynamic picture of the brain that, for the first time, shows how individual cells and complex neural circuits interact in both time and space. Long desired by researchers seeking new ways to treat, cure, and even prevent brain disorders, this picture will fill major gaps in our current knowledge and provide unprecedented opportunities for exploring exactly how the brain enables the human body to record, process, utilize, store, and retrieve vast quantities of information, all at the speed of thought. [28]

> The Human Brain Project aims to put in place a cutting-edge research infrastructure that will allow scientific and industrial researchers to advance our knowledge in the fields of neuroscience, computing, and brain-related medicine. [29]

> The China Brain Project covers both basic research on neural mechanisms underlying cognition and translational research for the diagnosis and intervention of brain diseases as well as for brain-inspired intelligence technology. [25]

> Studying the neural networks controlling higher brain functions in the common marmoset, to gain new insights into information processing and diseases of the human brain (sic). [30]

The concurrent establishment of a number of individual projects reflects the shared perception of the importance of the goal of mapping the brain and that the pursuit of this goal is a collaborative project in which resources, data, and technologies will be shared. The perceived importance of these projects is reflected in the significant funding that they have received. For example (in US dollars): BRAIN Initiative, 4.5–6 billion; Human Brain Project, 1.4 billion; Brain/MINDS Japan, $350 million. The China Brain Project is also expected to receive significant funding. China's brain research funding is currently 2.1% of GDP, and the goal is to increase this to 2.5%, or the equivalent of $110 billion.

Although a number of the brain projects include NHP research, the China Brain Project and Brain/MINDS have a particular emphasis on this type of research.

> In our opinion, given the rich resources of NHPs in China, the China Brain Project should include a substantial NHP component on the mesoscopic circuit analysis of the macaque brain, in parallel with other programs that focus on non-primate animal models. . . In line with the main focus of Japan's Brain/MIND project on marmosets, the China Brain Project could make a significant contribution in studying cognition in macaque monkeys. (p. 592 in [25])

The planned expansion of NHP research in Asia and the development of an "Asia Brain Initiative" is in contrast to the declining amount of NHP research in the USA and EU. This decline is due, in part, to the tightening of regulations governing NHP research in the USA and EU.

## 14.3 Regulations Concerning Animal Welfare and the Use of NHPs

At the federal level, animal research in the USA is regulated by the Animal Welfare Act, known as the "Blue Book" [31], and the Public Health Safety (PHS) Act [32]. The AWA sets "general standards for the humane care and treatment" of animals that are bought and sold, transported, exhibited, or used in research. The AWA requires that a research facility that has an animal program appoint an Institutional Animal Care and Use Committee (IACUC) to assess the animal program and its facilities, procedures, and personnel training [31]. In regard to what qualifies as appropriate care and treatment, the AWA requires the following: research activities do not duplicate prior studies and are scientifically valid; procedures will avoid or minimize pain, distress, and discomfort to the animals and. . . less painful measures are not available; appropriate sedatives and analgesics will be used unless their withholding is justified for scientific reasons; a veterinarian will be involved in the activities planning; animals that experience severe chronic pain or distress that cannot be relieved will be painlessly euthanized; the living conditions will be appropriate for their species; and that the housing, feeding, and nonmedical care of the animals will be directed by personnel trained and experienced in the proper care and handling of the species being studied [31]. In addition, paragraph 3.81 of Subpart D requires that

> Dealers, exhibitors, and research facilities must develop, document, and follow an appropriate plan for environment enhancement adequate to promote the psychological well-being of nonhuman primates. (p. 175 in [31])

In 2016, the National Institutes of Health (NIH) convened a workshop on "Ensuring the Continued Oversight of Research with Nonhuman Primates." The stated goal of the workshop was to determine whether the NIH "continues to have robust policies and practices for supporting both cutting edge science and the highest ethical standards of animal care and use" [9, p. 2]. The workshop's summary conclusion stated that, "The NIH remains confident that the oversight framework for the use of nonhuman primates in research is robust and has provided sufficient protections to date" [9, p. 4]. The NIH has effectively retired the remaining chimpanzees they had maintained for biomedical research. This decision followed a recommendation by an expert panel convened by the Institute of Medicine that concluded that "most current use of chimpanzees for biomedical research is unnecessary" (pp. 66–67 in [33]).

Animal research in the EU is governed by the directive "On the Protection of Animals Used for Scientific Purposes" [34]. In regard to NHPs, the directive states

> [T]he use of nonhuman primates should be permitted only in those biomedical areas essential for the benefit of human beings, for which no other alternative replacement methods are yet available. Their use should be permitted only for basic research, the preservation of the respective nonhuman primate species or when the work, including xenotransplantation, is carried out in relation to potentially life-threatening conditions in humans or in relation to cases having a substantial impact on a person's day-to-day functioning, i.e. debilitating conditions. (par. 17 in [34])

The use of great apes is further restricted by the directive to research aimed at the preservation of those species or related to life-threatening conditions affecting humans and where no alternative method or animal is available (par. 18 in [34]). According to the latest data, there are currently no great apes used in biomedical research in the EU (p. 31 in [20]). Directive 2010/63/EU also requires EU member states to have regulations and policies regarding the housing and care of animals, research facilities, and the training of personnel.

In China, animal research is governed by a number of regulations at national and local levels. At the national level, the most important regulations are the *Regulations for Administration of Affairs Concerning Experimental Animals* [35] and the *Guidelines on the Humane Treatment of Laboratory Animals* [36]. The *Guidelines* promote the 3Rs principles and require each institution to establish a committee to oversee animal care and use [37]. In addition, two upcoming pieces of legislation, the *Prevention of Cruelty to Animals Law* and *Animal Protection Law*, have been drafted [38], and the first set of national guidelines on laboratory animal welfare in China is currently in its final draft.

> The National Standard will regulate the welfare and ethical review and administration, with respect to the production, transportation as well as the utilization of the laboratory animals, including the technical requirements for the ethics review body, the principles of ethical review, personnel qualification, facilities, responsibilities of the veterinarians, resources, technical procedures, animal care and use, occupational health and safety, transportation, recommended ethical review processes and criteria, and records and documentation. (p. 304 in [37])

Chapter IV, Section IV Article 30 of the draft version of the *Prevention of Cruelty to Animals Law* applies to "Animal Experimentation and the Replacement of Laboratory Animals."

> The State shall adopt measures to ensure that every unit engaged in experimentation shares international and domestic experimental data, in order to gradually promote replacement [alternative] methods and to reduce the number of unnecessary animal experiments.
>
> In carrying out scientific or other research, different experimental methods should be prepared and preferential selection should be made of the experimental method which uses the smallest number of animals and which causes animals minimal pain, suffering, distress or lasting harm, but which may still provide a valid result. [39]

China's goal to bring its guidelines and regulations in line with international standards has meant, to some degree, a revision in current ethical thinking. The concepts of animal welfare, the 3Rs principles, animal rights, and anti-cruelty are relatively new in China [38], and the debate about welfare and animal rights is a new phenomenon [26]. In their article, Lu and colleagues recommend that, in addition to new policies and guidelines, education on animal welfare should be provided to the general public and that there should be greater participation among those engaged in research in animal welfare science.

As the new regulations and guidelines being developed in China come into effect, it is hoped that there will be consistency such that there is a specific and uniform set of guidelines and regulations that clearly describe the conditions according to which NHP research can be ethically justified. In the absence of such uniformity, there is concern that NHP research may increasingly occur in those countries whose regulations are less strict.

> It is recognised that tightening of the existing strict EU regulations for NHP use may lead NHP research to transfer to other countries to the detriment of animal welfare. This can be avoided by international cooperation that engages as many stakeholders and organisations as possible to promote the international development of high standards for research and animal welfare and animal use. (p. 7 in [20])

A core component of the notion of "responsible research" is that social values as well as the perspectives of a variety of stakeholders should be addressed at all stages of a research program [40]. Furthermore, scientists who are involved in animal research have a "duty to engage" with the public and policy makers, "to explain their research and its importance and by addressing moral concerns and objections" (p. 653 in [41]). In one sense, the "internationalization" of NHP research makes this obligation more difficult for it is likely that there will be a more diverse range of social values and stakeholder perspectives. However, it is of paramount importance for the success of the brain projects that not only do scientists fulfill their "duty to engage" but also convince the public that animal research oversight is sufficiently rigorous (p. 950 in [42]).

## 14.4 The Justification of Nonhuman Primate Research

Although invasive chimpanzee research in the USA has largely been discontinued, the use of other NHPs in research continues. Furthermore, although the EU has considered a total ban on NHP research, the SCHEER report concluded that NHP research was justified and should continue "in those biomedical areas essential for the benefit of human beings for which no other alternative replacement methods are available" (p. 7 in [20]). As mentioned previously, a broad distinction can be drawn between "basic" (or "fundamental") research that seeks to understand the brain's structure and functions and "applied" research that is directed toward the potential treatment of diseases and disorders. If we apply the conclusion from the SCHEER report stated above, in order to justify basic neuroscience research with NHPs, we would need to defend the view that this type of research is "essential for the benefit of human beings."

According to a broadly accepted moral framework, research that causes harm to a research subject (human or animal) is justified only if the harm is outweighed by the potential benefit. This condition applies across the spectrum encompassing both minimal risk and greater than minimal risk research. It is important to note, however, that the benefit can be an increase in knowledge and understanding, rather than any direct or indirect welfare benefit. For example, consider the US regulations governing research with children [43]. These regulations state that research with children involving greater than minimal risk may be justified only if it presents the prospect of direct benefit to the subjects. Research with no prospect of direct benefit for the subject must involve no more than a minor increase over minimal risk (§46.406) and must be likely to yield generalizable knowledge about the subject's condition. Research that does not meet these conditions may still sometimes be approved if it presents an opportunity to understand, prevent, or alleviate a serious problem affecting the health and welfare of children (p. 407 in [43]). Accordingly, a research study involving greater than minimal risk that sought (merely) to *understand* the causes of childhood leukemia, but provided no direct benefit to the subjects or other children suffering from the disease, would be justified (other things being equal) if it provided generalizable knowledge about the subjects' condition or increased our understanding of leukemia.

If the above analysis is correct, then this suggests that non-beneficial, greater than minimal risk research can be justified if it leads to increased knowledge and understanding about the subjects' condition or their health and welfare more generally. This justification has two elements: first, the research must "relate" to the subject class, and second, the research must pertain to health and welfare. Accordingly, a study that proposed to conduct research on children for a condition that only affected adults would be judged to be morally unacceptable, as would a greater than minimal risk study on children that investigated their music preferences. The first of these elements is relevant to the validity of the research, for to say that the research must relate to the subject group is to say that the subject group may be included in a study only if their use is required by the nature of the research and the hypothesis to be tested. The second of these elements limits the focus of the research to a serious health matter affecting members of the subject class.

According to the SCHEER conclusion above, NHP research is justified if "no other alternative replacement methods are available." In one sense, the availability of alternative methods is the very point of contention between supporters and opponents of NHP research. For example, consider the use of NHPs in the development of brain-computer interface (BCI) technology. If one grants that (a) the similarities between human and NHP brain function and anatomy make NHPs appropriate subjects, (b) the cognitive capacities of NHPs and their ability to learn complex tasks make them uniquely qualified to be research subjects (apart from human subjects), and (c) it is unethical to use human subjects, then we are faced with the choice of either substantially revising or not conducting the research, or using NHPs as subjects. If one holds the view, broadly speaking, that NHP research is unethical, then the only choice available is not to conduct the research. In contrast, if one supports NHP research, then, given no available alternative, using NHPs is permissible.

For the sake of argument, let us grant that NHPs are scientifically appropriate subjects for BCI research due to the similarities between human and NHP brain anatomy and function. In other words, the research appropriately relates to the subject class—the first of the two elements mentioned above. The second of these elements limits the research to a serious health condition affecting members of the subject class. According to a prior conclusion, a research study involving greater than minimal risk that sought to understand the causes of childhood leukemia would be justified if it provided generalizable knowledge, even if the study provided no direct benefit to children. The argument is that the research is justified because it is *scientifically valid* and the benefits, although indirect, outweigh the harms. If this is correct, then we should draw a similar conclusion in the BCI case: in both cases, we have invasive research that offers the subjects no direct benefit but is justified on the grounds that it provides generalizable knowledge about a serious health condition.

It might be objected that there is an important difference between the cases, for whereas in the BCI case, NHPs are appropriate research subjects only because it is unethical to use human subjects, no such parallel constraint exists in the leukemia case. To put the point differently, we might say that whereas the involvement of children appeals to the notion of *scientific* necessity, the involvement of NHPs appeals, at least in part, to the notion of *moral* necessity. Since the very point of dispute is whether NHP research is morally necessary, this notion cannot be taken for granted. We must ask, then, whether it would be ethical to conduct invasive research involving NHPs if this research appropriately relates to NHPs and provides generalizable knowledge regarding a serious health condition that affects *both* NHPs and humans. On the basis of the above, we can answer that the research is morally defensible if it is scientifically valid and benefits the class to which the subjects belong—the same conclusion that we drew in the leukemia case. If this is correct, then it is not the case that we can justify NHP research only by appealing to the notion of moral necessity. The above conclusion prompts important questions, of course, regarding the comparative moral status of NHPs and humans and, in particular, whether greater justification is required for research involving one rather than the other. As the SCHEER statement and other international regulations attest, NHPs are thought to be appropriate research subjects precisely because of their purported inferior *moral* status to humans. That is to say, implicit in these regulations is the appeal to moral necessity. The conclusion drawn in this paragraph is that within this framework, classifying NHPs as vulnerable subjects does not mean that invasive research is impermissible.

On the basis of the above, non-beneficial research with NHPs that involves greater than minimal risk would be justified if the research is valid and increases knowledge and understanding about a serious health condition that affects both NHPs and humans. On this basis, research involving NHPs that increases knowledge and understanding about a serious health condition affecting *only* humans would be impermissible, for in this context, it can be argued that the research does not relate to the subject class. It is also important to point out that if the research produced an intervention that could benefit the subject class, then all members of the class should, in principle, be beneficiaries.

An important question to ask is whether basic neuroscience research would meet these conditions. The answer to this question would be a matter of considerable discussion and debate as to how we should interpret the notions of "about" and "generalizable knowledge." If we take the view that research should offer direct benefit to subjects, then it would seem clear that basic neuroscience research would be impermissible; if the leukemia case above is an appropriate example, however, then we have reason to claim that current regulations adopt a more permissive line that requires direct or indirect benefit. If it can plausibly be claimed that an increased understanding of brain function is likely to provide greater understanding and generalizable knowledge about a condition that affects both humans and NHPs, then such research involving NHPs would be morally permissible, even if the research was invasive.

The argument has been made that the conditions for ethically justifiable NHP research should parallel the regulations governing research involving children [14, 44, 45]. A core component of this argument is the claim that, like children, NHPs should be regarded as "vulnerable" research subjects and hence accorded special protections. This claim is based on the strong neurological and behavioral evidence that NHPs are intelligent and social animals, that they can experience physical pain, and that restrictive confinement and isolation causes significant distress. Moreover, a conservative (i.e., stricter set of conditions) is recommended on account of the fact that the harm is intentionally caused, the difficulties in balancing harms and benefits, and the uncertainty regarding the moral status of NHPs. This conservative position endorses the view that all research that is greater than minimal risk should be prohibited [14].

As the regulations above reveal, research with children that involves greater than minimal risk is justified under certain conditions. If we adopt a policy according to which invasive research with NHPs is never morally permissible, the policy pertaining to NHPs is, therefore, stricter than the policy pertaining to invasive research with children (assuming that some types of research that involve greater than minimal risk are invasive). It could be objected that research with children has to relate to a serious condition affecting the health and welfare of children, and so the research has to have the prospect of benefiting children; however, as we see above, although the research must relate to a serious health condition and be valid, the benefit can be understood in terms of increased knowledge and understanding. Accordingly, if policies regarding children and NHPs are to be consistent, invasive research with NHPs is sometimes justified.

One argument that could be presented for adopting different policies regarding NHPs and children pertains to proxy consent. In the case of research with children, decisions can be made on the children's behalf and in their best interests by a competent adult serving as a proxy decision-maker. Challenges in determining the preferences and interests of NHPs make this strategy more problematic in regard to NHPs [14]. However, it has been argued that these challenges can be overcome and that we should adopt a similar policy with NHPs [46]. In any case, unless we believe that it would never be justified for a proxy to consent to research involving children that is greater than minimal risk, the presence (or absence) of a proxy is not determinative of the level of invasiveness permitted (even if we grant the value of the proxy's gate-keeping role). Hence, the absence of a proxy in the case of NHP research does not adequately explain why the conservative position should be adopted.

A somewhat more moderate position has been recently defended that proposes "several necessary conditions for morally responsible—that is, morally justified or permissible—animal research" (p. 420 in [17]). The three conditions proposed are as follows: the assertion (or expectation) of sufficient net benefit, the worthwhile-life condition, and the no-unnecessary-harm condition [17]. The first of these conditions requires that there be good evidence from previous studies and potential future research to suggest that the present study will provide important net benefit to humans. The second condition asserts that the lives of animals used in research must be "worth living." In order for a life to be worth living, the harms imposed "are never so great as to reduce their quality of life to a point at which it would be a kindness to kill them humanely; if it would be a kindness to kill them humanely at any point, that would entail that the lives were at that point not worth continuing" (p. 423 in [17]). The third condition requires that any harm that is caused to an animal must be necessary, that is to say, is strictly required to carry out the study in a scientifically valid way [17].

The authors claim that if the conditions are accepted as necessary, there will be surprising implications for animal research. For it is claimed that the conditions are "demanding" and impose a higher standard of justification than is currently required. In particular, the conditions require that researchers should not deprive animals of their "basic needs"—food, water and shelter, competent veterinary care, access to conspecifics, and freedom from conditions that cause serious harm, avoidable harm, and premature death [17].

Unfortunately, it is not clear that the proposed conditions do impose a stricter set of conditions than currently exist. For example, consider a hypothetical memory study in which lesions are made to the macaque hippocampus. Furthermore, for the sake of argument, let us suppose that the regulations in place require that there be evidence that the research will provide important net benefits, that any harms caused must be necessary (as determined by scientific validity), and that the care and welfare of the animal is appropriately protected. The supposed demandingness of the proposed conditions is based on the requirement that researchers should ensure that the animals are provided with food, water and shelter, competent veterinary care, access to conspecifics, and freedom from conditions that cause serious harm, avoidable harm, and premature death [17]. However, the researchers grant that “we can easily imagine cases in which certain harms, including the deprivation of basic needs, *are* essential to the scientific rationale of the experiment—and therefore are necessary in the relevant sense” [17, p. 426]. The problem here is that if the necessity of harm is defined in terms of scientific validity, and there may be scientifically valid reasons to deprive the animal of basic needs, then it is not clear that the proposed necessary conditions impose greater restrictions on NHP research than are currently required.

In order to resolve this problem and provide more demanding protections to NHPs, we need to move away from justifying harms in terms of scientific validity. Current regulations permit substantial hardship to be imposed on an animal if it is required by the nature of the research, and there are no alternative models, and appropriate steps have been taken to minimize the hardship. The challenge we face is that research which by its nature and design is highly invasive, and which cannot be undertaken using an alternative model due to the particular aspect of brain function being studied, will meet the relevant conditions as long as the appropriate steps to minimize harm are taken. The hypothetical memory study in which lesions are made to the macaque hippocampus mentioned above would, in principle, be ethically justified, therefore, if it meets the conditions of scientific validity. If our goal is to protect the welfare of NHPs to a significant degree, defining “necessary harm” in terms of scientific validity will likely fail to achieve this goal, for it may be necessary by the nature and design of the experiment to cause significant hardship to the animal and to deprive it of its basic needs.

## 14.5 A Threshold Standard for NHP Research

We have previously considered the view that NHPs should be viewed as vulnerable subjects and accorded special protections, and, therefore, only research that is equal to or less than minimal risk is permissible. This view was criticized on the grounds that it would accord greater protection to NHPs than to children. A variation of this position is to view NHPs as vulnerable subjects and to apply the same conditions as are applied to research involving children: invasive research on NHPs is justified if it relates to a serious health condition that affects both NHPs and humans.

For the sake of argument, let us grant that basic NHP neuroscience research meets the above condition in some cases. If we return to the current US regulations pertaining to research with children, these regulations do not specifically describe the “maximal” degree of risk that is permitted; nevertheless, it is clear that an upper threshold implicitly applies. We can assume, for example, that a well-designed study that sought to prevent a serious health condition affecting children, but which imposed a substantial risk of permanent and severe harm to subjects, would not be approved. This suggests that there is a limit to the degree of invasiveness permitted, no matter how potentially beneficial or valid the research. If we adopted a similar approach with NHP research, this would mean that research that involves greater than minimal risk and is invasive is justified only if (a) the level of harm and deprivation that the NHP endures as a direct result of participation in the study does not exceed a certain threshold and (b) the other conditions for the responsible conduct of research are met.

This conclusion obviously prompts the question as to where to set the threshold. If the threshold is set at the level of severe and permanent harm, then it seems likely that the adoption of a threshold standard would have a significant impact on NHP research and the brain projects. For example, if the threshold is set at a level that prohibits severe and permanent harm, then lesion studies, or studies that have euthanasia as the endpoint, would be prohibited. Alternatively, if a lower standard is adopted that permits invasive research only if the interventions are temporary, appropriate measures have been taken to reduce pain and suffering, and the longer-term welfare of the animal is a matter of primary concern, then BCI research which implanted temporary devices into NHP brains could be justified.

There are a number of merits to the threshold approach. First, this approach is more consistent with the approach adopted toward children. In this regard, NHPs can be regarded as vulnerable subjects and accorded special protections. This means that invasive research is permitted only if the research relates to the subject class, concerns a serious health matter, and produces direct or indirect benefit. Second, and perhaps most importantly, a core component of the sentiment and argument against the use of NHPs—and other animals—in research is that the research is frequently harmful to the animal. On a broadly held moral view, pain and suffering are intrinsically harmful, and we are morally obliged, as best we can, to avoid causing harm. Unlike the more traditional harm–benefit viewpoint, a threshold approach makes harm the most important factor in determining whether research is morally justified. In simple terms, a threshold approach prohibits research above the threshold, regardless of its potential benefit. Third, this approach does not differentiate between basic and applied research. Basic neuroscience research with NHPs would be justified if it is valid, it meets the other conditions for ethical research, and any harm and distress caused to the NHP falls below the threshold. Fourth, this approach encourages the development of research interventions that are less invasive while also supporting the goals of the brain projects.

There are also a number of objections. First, it can be objected on epistemic grounds that we do not have a good way of determining the nature and quality of another's experiences, particularly when this "other" is a different type of animal. Accordingly, we do not have a clear idea of the degree of pain and distress that is being caused to the animal. In response, it can be argued that there is reliable neurological and behavioral evidence for us to conclude that NHPs experience pain in similar ways to humans [47–49]. This is not to deny that there are important epistemic challenges in determining the psychological states of NHPs, but from this, it does not follow that such states are necessarily opaque.

Second, it can be objected that the threshold approach is essentially no different from the view of DeGrazia and Sebo discussed previously which proposed a set of three necessary conditions. To recall, one of these conditions is that the "basic needs" of the animal should be respected. If the "basic needs" are understood in terms of freedom from severe and permanent harm, then in respecting the basic needs of the animal, we would thereby be meeting the threshold standard. However, although both views could, in principle, end up dividing permissible and impermissible research along the same lines, there is an important difference between the two approaches. One of the conditions in the earlier view is that any harm caused must be *necessary*, and a sufficient condition for a harm being necessary is that it is required for reasons of scientific validity. The threshold approach rejects this sufficiency condition: research that imposes upon the animal hardship greater than the threshold is impermissible, even if the harm is required and thereby justified for reasons of scientific validity.

## 14.6 Conclusion

This chapter has proposed a threshold standard as a way to balance the need to protect animal welfare while encouraging scientific research. On a very simple analysis, we protect an individual (animal or human) from harm if we limit the amount of harm to which the individual can be subjected. If our goal is to protect the welfare of NHPs while also encouraging the goals of the major brain projects, then a threshold standard may be the most straightforward approach to take.

The establishment of the major brain projects with their substantial funding heralds an exciting period for neuroscience research. By the end of the projects' lifetimes, we may have a much clearer idea of the neural processes that underlie cognition and consciousness, and we may have discovered effective therapies for Alzheimer's disease and spinal cord injury, for example. It is plausible to claim that the use of sentient animals in scientific research is one of the most controversial aspects of scientific practice, even if we believe that this practice is both justified and necessary. As described above, a number of the major brain projects include a significant amount of NHP research, in particular, the China Brain Project and Brain/MINDS Japan. In order for the projects to gain broad public and international support and to succeed as part of a "global brain initiative," it is important that national and international regulations provide a common level of protection for the NHPs used in research and a level of protection for NHPs that adequately protects their welfare.

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# The Right to Bodily Sovereignty and Its Importance to Mental and Physical Well-Being

# 15

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**Abstract**

Within the field of human research, respect for bodily liberty and integrity (summarily, bodily sovereignty) has arguably driven the creation and enforcement of relevant rules and regulations. These concepts are reflected in documents such as the Belmont Report, which emphasizes respect for autonomy and specific protections for individuals with compromised autonomous decision-making capacities. However, little to no attention is given to respect for the bodily sovereignty of nonhuman animals in research or other areas of society, despite its importance in determining health and well-being.

Today, scientific advancements support a nuanced view of autonomy and vulnerability in human and nonhuman animals. Both groups contain individuals with varying gradations of independent decision-making skills. However, regardless of the kind and degree of intelligence, neurological and other studies show that freedom from bodily trespasses and freedom of choice are critical to health and well-being in people and other animals. Rules and regulations governing the protection of nonhuman animals should be updated to reflect these scientific developments.

**Keywords**

Animal research · Autonomy · Vulnerability · Bodily liberty · Bodily integrity · Sovereignty

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_15

## 15.1 Introduction

The treatment of nonhuman animals in society is morally problematic. Ethical problems with the use of animals in research, food and clothing production, entertainment, and other areas of society have been well described in ancient and modern texts.[1] As some philosophers, ethicists, advocates, and practitioners have argued, since human research is guided by clear ethical principles, comparing animal experimentation with human research offers a particular opportunity to explore the ethics of how humans treat other animals [6–8]. Ethical principles that guide human research revolve around key concepts including respect for autonomy and special protections for vulnerable populations, as underscored in the Belmont Report (1978), Declaration of Helsinki (1964), and the Nuremberg Code (1947) [9–11]. Underlying these concepts and their applications are two related principles that are also reflected throughout human rights law: respect for bodily liberty and respect for bodily integrity (summarily, respect for bodily sovereignty). Though it is rarely articulated as such, respect for bodily sovereignty has influenced the creation and enforcement of principles such as respect for autonomy, special protections for those with diminished autonomy, and related rules and regulations within human research.

Here, I describe a broad conceptual understanding of bodily sovereignty and some of its philosophical, legal, and practical applications within society. Then, I discuss how human research guidelines and corresponding policies reflect respect for bodily sovereignty, whereas animal research guidelines are inattentive to bodily sovereignty. Finally, I conclude with a discussion of why respect for bodily sovereignty should guide decisions about the treatment of animals, whether those decisions relate to research or other areas of society.

## 15.2 Bodily Sovereignty as a Philosophical, Legal, and Practical Construct

The meaning of sovereignty has varied little throughout history. Fundamentally, it indicates *supreme* and *absolute* authority within a territory [12].[2] As a political and practical construct, sovereignty has frequently been understood through the development of sovereign nation states. In relatively recent history, international legal doctrines have also incorporated the notion of sovereignty to protect and promote human rights [13].

Just as a nation state is demarcated spatially, so is the body. And just as a state must be shielded from invasion, so should the body. According to international law,

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[1] See, for example, [1–4], among many others. For a brief overview of ancient arguments related to the use of animals in experimentation, see [5].

[2] Authority indicates the right to command and be obeyed, not necessarily power. See, for example, [12].

one has an inviolable right to be protected from harmful contact on one's body without consent or adequate justification [13].

There are ethical and legal tensions between concepts such as national sovereignty[3] and bodily sovereignty, and they are not morally or legally equivalent concepts. Even when there are risks to the sovereignty of the state, the body is typically protected from violations such as torture [14]. As with national sovereignty, bodily sovereignty also generally implies that one is free to do with their body as they wish, without infringing on another's bodily sovereignty. Sovereignty over one's own body therefore comprises two main ideas: the right to bodily integrity and the right to bodily liberty. Together, these concepts indicate self-ownership and the right to be the sole controller of one's body or life. Bodily integrity represents the integration of the body; that is, the right to keep one's body whole and intact without interference, manipulation, or touching, absent consent. Bodily liberty signifies freedom of movement and the freedom to make choices about one's body, in accordance with one's capacities, if one's choices also generally respect the sovereignty of others. Of these two ideas, bodily integrity is perhaps the most guarded. Even when infringements on bodily liberty are justified through the legal system (e.g., in cases of legal incarceration), rarely is unwanted touch (e.g., medical or surgical intervention or a similar incursion) permitted within societies that uphold principles such as basic liberties. Though sometimes referred to as bodily autonomy, the right to bodily sovereignty depends less on mental characteristics, compared with traditional notions of autonomy. Bodily sovereignty implies that the brain, or mind,[4] is an integral part of the body's territory, rather than distinct from, or superior to, the remainder of the body.

As a civil principle, bodily sovereignty has been conceptualized in terms of negative and positive rights [15, 16]. Among activists, bodily sovereignty is often invoked as a "negative right" against sexual violence, unlawful imprisonment, cruel or degrading punishment, or torture, or in promotion of reproductive rights. More recently, activists and scholars have employed the "positive right" to bodily sovereignty to promote universal access to healthcare, safe housing, clean air and water, and other social determinants of health [17, 18].

Within the law, bodily sovereignty is encompassed by the legal concept habeas corpus, from the Latin meaning "you shall have the body." Historically, it has been used as a way to test the lawfulness of imprisonment and to end the legality of exploitations such as human slavery and child abuse [19, 20].[5] More recently, lawyers, activists, and philosophers have argued that some nonhuman animals

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[3] National sovereignty typically includes safety from invasion or attack.

[4] The brain and mind are related concepts. Distinctions between the brain and mind are perhaps less important in discussions about bodily sovereignty, compared with discussions about autonomy. Nonetheless, both are self-limited concepts related to the liberty and integrity of the body.

[5] For example, in *Somerset v. Stewart* (1772), the Lord Chief Justice of England and Wales granted the writ of habeas corpus to an enslaved human [20]. In 1874, Elbridge Gerry successfully argued that a child named Mary Ellen had a right to habeas corpus and protection from confinement and abuse [19].

should also be granted a writ of habeas corpus, according to common law [21].[6] Internationally, the Universal Declaration of Human Rights, which was ratified by the United Nations in 1948 following the Nuremberg Trial and the Tokyo War Crimes Trials, also upholds the right to bodily sovereignty [13]. The ideas encompassed in the Universal Declaration of Human Rights have since been codified and incorporated into international and national laws in many countries, and they now form the basis of human rights policies across nations. Additionally, other global frameworks such as the International Covenant on Economic, Social, and Cultural Rights and The Convention on the Rights of the Child[7] expand upon the importance of "positive rights" related to bodily sovereignty, such as access to social determinants of health, in addition to "negative rights," such as protections from torture, enslavement, and confinement [22].

The right to bodily sovereignty is revered in different parts of the globe. For example, the concept is reflected in so-called "Western" literature [12], "Eastern" literature [23], and writings by authors who identify as Indigenous persons [24–26].[8] However, unlike mainstream modern European and American contexts, "Eastern" and Indigenous frameworks for bodily sovereignty are less likely to stress total independence or separation from others. Within "non-Western" contexts, connection, unity, harmony, and the notion of the cohesive individual influence bodily sovereignty. Subjective experiences are generally viewed as integrative proficiencies that influence the health, well-being, and nature of the whole [23–26]. Nonetheless, within these frameworks, interconnectedness does not equate with disrespect for bodily sovereignty. In other words, bodily sovereignty and integration with the objective world can coexist.

Arguably, respect for bodily sovereignty is a timeless, ubiquitous notion distinguishable from community-specific norms or cultural or religious ideas—likely because it represents a biological imperative that is critical to health and well-being. When viewed as a biological need, it is perhaps unsurprising that respect for bodily sovereignty has influenced the creation of guidelines governing the treatment of human beings in society, including in disciplines such as research.

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[6] Currently, legal arguments toward granting a writ of habeas corpus to nonhuman animals are focused on the members of species for whom there is robust scientific evidence of self-awareness and autonomy, though these qualities may not be necessary for granting a writ of habeas corpus. See, for example, [21].

[7] Notably, neither of these conventions has yet been ratified by the United States.

[8] Within Indigenous communities, the notion of sovereignty has emerged as a critical concept during decolonization. Nonetheless, it was initially difficult for Indigenous peoples to assert this right because of their communities' legal designations until perhaps the United Nations Declaration on Indigenous Peoples came into force [24–26].

## 15.3 Respect for Bodily Sovereignty as Reflected in Human Research Guidelines

Today, respect for bodily liberty and integrity is reflected throughout the US federal and international frameworks governing human research. These ideas are evident in documents like the Belmont Report.

Soon after the middle of the twentieth century, concerns about human research practices in the United States led to significant developments, including the Belmont Report, authored by the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (1978) [9]. These guidelines and subsequent regulations were chiefly formed in response to efforts to deceive, manipulate, or force human beings to participate in research that threatened or violated their bodily sovereignty, health, and well-being [9, 27, 28]. Prior to the 1970s, there was a relatively weak basis for a commitment to principles in the practice of biomedical ethics, but, soon after, established principles such as respect for autonomy, nonmaleficence, beneficence, and justice began to appear in biomedical ethics applications [9, 29]. These principles now serve as a basis for applications such as informed consent and distinct considerations for those who cannot provide informed consent.

Together, principles like respect for autonomy and duties to nonmaleficence, as well as protections for vulnerable individuals and populations, reflect a sincere reverence for bodily sovereignty. Respect for autonomy acknowledges the importance of choice or bodily liberty. Similarly, obligations to nonmaleficence, as well as specific protections for those who may not be able to protect themselves from bodily harm, emphasize the fundamental right to bodily integrity. Nevertheless, in the practice of human research, respect for bodily sovereignty has been diminished. A weakened respect for bodily sovereignty is particularly notable in the practical codification and applications of principles like respect for autonomy.

It is generally acknowledged that respect for autonomy is one of the most essential principles in medical ethics [30]. The modern notion of autonomy stems from various conceptions of rationalism and empiricism.[9] Like bodily sovereignty, autonomy implies self-rule. Autonomy can refer to the capacity to govern oneself, the actual condition of self-government, an "*ideal of character* derived from that conception," or the sovereign and absolute authority to govern oneself [34, p. 447].

The idea of autonomy is also tied to ideas about personhood, in that, with autonomy, one should have the opportunity to realize one's potential, or one's *telos* [30].[10] In order to exercise autonomy, one must be truly free of external influences, though what may constitute an external influence remains a matter of

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[9] Many different accounts of autonomy have been offered. Notably, these include accounts based on rationalism (e.g., Immanuel Kant's arguments) and empiricism (e.g., John Stuart Mill's arguments). Also see [31–33].

[10] In the case of a human or animal being, the word *telos* is typically defined as their purpose, goal, or final end. One's *telos* can only be fulfilled if they have access to the needs required not only to survive but also to thrive or flourish. See, for example, [35–37].

dispute [30]. Who qualifies as an autonomous individual has also been subject to debate. Such determinations often depend on the known presence of qualitative capacities such as rationality as well as somewhat arbitrary quantitative thresholds such as age. Discomfort with the notion of autonomy could explain why the Belmont Report lists *respect for persons* as a key tenet, alongside special protections for those who are deemed vulnerable to manipulation.[11] Arguably, given the many problems with notions of autonomy and personhood,[12] respect for bodily sovereignty, which encompasses a respect for choice as well as the intactness of the body, might have been a more appropriate principle to articulate the intent of the National Commission.

Within human research, the ambiguous nature of autonomy plays out in questions about who can or cannot provide informed consent, assent, or dissent [33, 41–44]. Regulatory answers to these questions remain problematic. US federal and international human research guidelines attempt to prevent severe violations of bodily sovereignty through designated protections for vulnerable populations, the Common Rule,[13] and other regulatory hurdles. However, these guidelines continue to reflect a paternalistic view that can in some instances be harmful to the individual [46]. For example, some adults can make decisions for children or other adults with compromised decision-making capacities in ways that violate their bodily liberty and integrity in the "negative"[14] and "positive"[15] sense.

## 15.4 Disregard for Bodily Sovereignty Within Animal Research Guidelines

Although the human research environment has its flaws, human participants are nonetheless generally protected from significant violations of bodily sovereignty. That is, an authorized person must make an informed choice before a medical or surgical procedure, or even a behavioral intervention, is undertaken. Requirements for risk–benefit analyses and higher risk thresholds for research involving vulnerable populations also guard against egregious violations of bodily integrity. In contrast, there is little to no regard for bodily sovereignty within the current enterprise of animal experimentation. Consistent with how they are treated in other areas of

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[11] Tom Beauchamp, who drafted the Belmont Report for the National Commission, has speculated that the Commission selected "respect for persons" as its first principle to indicate a level of moral status associated with personhood [38].

[12] There is still no agreed upon list of capacities for personhood favored by modern philosophers. See [39, 40] for further discussion.

[13] Many US federal agencies and private and public institutions have adopted a uniform set of regulations known as the "Common Rule," which offers specific protections for children, incarcerated individuals, and pregnant women and their fetuses. See [45].

[14] For example, invasive medical procedures.

[15] For example, prohibition from participation in research that might benefit the child or less autonomous adult in one way or another.

society, animals are commonly treated as instrumental objects within the field of research.

In the United States, the Laboratory Animal Welfare Act of 1966 (P.L. 89-544) and its subsequent amendments and the Health Research Extension Act of 1985 (P.L. 99-158) are the principal laws that regulate the use of animals in laboratory research and testing [47].[16] Although the Animal Welfare Act only applies to some species of animals, it is often supplemented by the Guide for the Care and Use of Laboratory Animals, which covers all nonhuman vertebrates [48].

Like the Animal Welfare Act and the Guide, policies published by the United States Public Health Service and other federal and international institutions provide relevant regulatory guidance but have generally avoided the establishment of principles recognized within biomedical ethics.[17] The majority of international and national standards operate on conjecture that animal research should proceed based on possible, perceived benefits to humans [50, 51]. For example, *International Guiding Principles for Biomedical Research Involving Animals*, first published in 1985 and updated in 2012 by the Council for International Organizations of Medical Sciences and the International Council for Laboratory Animal Science, assert that animals play a "vital," though involuntary, "role" in scientific activities which could lead to developments in knowledge that affect the health of some humans and animals [52].[18] Like other guidelines, the International Guiding Principles emphasize the "Three Rs." These standards, initially published in *The Principles of Humane Experimental Technique* by William Russell and Rex Burch in 1959, ask researchers and oversight bodies to replace the use of some animals with non-animal alternatives or animals from a species considered less sentient, quantitatively reduce the number of animals used in experiments, and attempt to refine experiments to limit the pain and distress to which animals will be exposed [54].[19] While the "Three Rs" may reduce some suffering and the number of animals used in research,[20] this framework does not address fundamental moral issues, including respect for bodily

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[16] Since 2002, the Animal Welfare Act has firmly excluded birds, rats, and mice used in research, as well as farmed animals [47].

[17] Perhaps the closest attempt to generate an ethical foundation for animal research is the Sundowner Report, which delineates principles to guide the use of animals by the National Aeronautics and Space Administration [49]. This brief report outlines three principles: respect for life, societal benefit, and nonmaleficence. While the report captures noteworthy ethical principles, it focuses primarily on stewardship and perceived advancements within the scientific community and human society. Like other guidelines, the report does not address the interests of individual animals, including their bodily liberty or integrity.

[18] Many scholars have questioned the merits of animal research for predicting human health outcomes. See, for example, [53]. Typically, the animal involved in the research does not benefit from the research protocol.

[19] The designation of one species as necessarily more or less sentient than another is a seemingly impossible task that depends on assumptions within and across species, independent of the individual and their capacities.

[20] Though the "Three Rs" represent clear goals, they do not necessarily result in reductions in suffering or the numbers of animals used in research. See, for example, [55–57].

liberty and integrity or justifications for violating bodily sovereignty—whether during the course of research or before or after research is conducted. On the contrary, it presumes animals will be used as tools to forward science. As a result, animals are regularly forced to breed and reproduce in ways that are unnatural to them, taken away from their parents and peers, confined, manipulated for research protocols, and, most commonly, killed at the end of experiments. Additionally, many animals are bred and immediately killed when their bodily characteristics do not fit the established criteria for a test or experiment.

Within existing animal research guidelines, there is some attention to concepts related to bodily sovereignty, such as welfare and care. However, in practice, "welfare" and "care" are commonly interpreted to comprise the technical aspects of research procedures and husbandry exercises. These practices include the use of tranquilizers, analgesics, anesthetics, paralytics, and euthanasia, presurgical and postsurgical veterinary medical and nursing care, and engineering standards for cages and other methods of restraint or confinement—violations of bodily sovereignty.[21]

Recently, there have been some notable changes in animal research policy. In the United States, these developments include an Institute of Medicine (IOM) Committee Report on the Use of Chimpanzees in Biomedical and Behavioral Research and subsequent Working Group reports created to interpret the original report's findings into practical recommendations [58–60]. The National Institutes of Health (NIH) commissioned these reports. In the original IOM report, the Committee determined that any assessment of the necessity of chimpanzee research should include ethical considerations, even raising issues such as whether chimpanzees could acquiesce to research [58, 61]. However, the report does not explicitly address matters such as autonomy or bodily sovereignty. Although the IOM Committee concluded that chimpanzees are largely unnecessary for biomedical research,[22] the report and the NIH mandate that preceded it continually refer to chimpanzees in terms of their utility rather than their right to protect their bodies or to make free choices about their bodies.

Recently, some scholars have suggested that human research principles such as respect for autonomy and special protections for vulnerable populations be extended to decisions about the use of animals in research [6, 7, 62]. Today, scientific advancements support a nuanced view of autonomy and vulnerability in human and nonhuman animals. Humans and nonhumans display varying gradations of independent decision-making skills, suggesting that some humans may not qualify as autonomous subjects, whereas some animals may.[23] Additionally, like some

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[21] As bodily sovereignty is articulated here, these practices violate bodily sovereignty. A separate issue is whether these or other violations of bodily sovereignty can be justified when weighed with other interests, including other determinants of health and well-being.

[22] The Committee also recommended a set of restrictive guiding principles and criteria for the assessment of current and future uses of chimpanzees in biomedical and behavioral research.

[23] There are many open questions about the degree to which humans and other animals display autonomy or autonomous action. In humans and animals, the capacity for self-determination can

human individuals and populations, some nonhuman animals may qualify as vulnerable subjects and require greater protections within research.[24] Though these arguments approximate attention to bodily sovereignty, as with human research, they could fall short of guaranteeing bodily liberty and integrity. Furthermore, regardless of kind and degree of intelligence, neurological and other studies show that bodily sovereignty itself, as a key vulnerability, is critical to health and well-being in humans *and* many other animals.

## 15.5 The Right to Bodily Sovereignty and Its Connection with Health and Well-Being

In recent years, attention has increasingly focused on the connections between health, rights, welfare, and well-being. Within medicine, there is an established relationship between health and human rights [69, 70]. For example, the concepts elucidated in human rights frameworks are viewed as rights rather than privileges precisely because they reflect many of the biological needs necessary to promote health and well-being. Similarly, philosophers, healthcare providers, and advocates have highlighted the connections between the rights, welfare, and well-being of nonhuman animals [71–73]. From a health perspective, these concepts are fundamentally inseparable.

Bodily sovereignty reflects a most basic need—that is, the need to protect one's body from physical, psychological, or other forms of harm.[25] As a principle, respect for bodily sovereignty extends beyond respect for autonomy or unique protections for those deemed especially vulnerable to harm or exploitation. Bodily sovereignty cannot be reduced to the principle of autonomy,[26] since the right to bodily integrity is not lost when autonomy is lost [74]. Similarly, respect for bodily sovereignty does not require that one be part of a designated class to qualify for protections from harms associated with violations of bodily liberty or integrity. Sovereignty of the body is not nearly as ambiguous a concept as autonomy or even some concepts of vulnerability. The body has clear borders that are easily understood and recognized, even if its dimensions change over the course of a lifetime. No subjective or qualitative determination is necessary. States of well-being, nociception, pain,

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change acutely or chronically over the course of a lifetime as a result of neurological, psychological, and emotional maturation or degeneration, or other changes in aptitude. For more on the subject of autonomy (self-determination) in humans and nonhumans, see, for example, [29, 33, 63–66].

[24] Animals are both intrinsically and extrinsically vulnerable. Currently, there is negligible attention on how nonhuman animals' vulnerabilities could influence decisions about their use in research. Though animals lack the capacity to provide informed consent, as it is currently understood in research settings, and they are at increased risk for coercion, exploitation, and harm, they are commonly used despite their vulnerabilities. For a fuller account of how animals may be considered vulnerable subjects, see, for example, [62, 67, 68].

[25] Harm is defined here as a setback of interests. It is in the interest of each body to remain intact, physically and psychologically healthy, and well, and to live up to their *telos*.

[26] See [74] for a more extended discussion of this issue.

pleasure, flourishing, and integration occur within the body itself [74]. Regardless of decision-making capacities, one's body is the "site, location, or focal point of their subjectivity (however understood and constituted)" [74, p., 580]. Everything the body does or receives becomes part of it in one way or another, as lived experiences and often as conscious or unconscious memories. The body often interprets these experiences as physical or mental effects that inhibit or foster growth—in other words, one's ability to live up to their *telos*. The power to control what happens to one's self also influences the subjective interpretation of various experiences.[27]

Violations of bodily sovereignty can lead to compromises in health and well-being and can often result in physical or mental illness, in both people and animals. No longer are animals seen as mere machines free of thought, consciousness, or significant feeling, as René Descartes suggested in the seventeenth century. For example, in 2012, a prominent international group of cognitive neuroscientists, neuropharmacologists, neurophysiologists, neuroanatomists, and computational neuroscientists gathered at The University of Cambridge to reassess the neurobiological substrates of conscious experience and related behaviors in human and nonhuman animals. They determined that "convergent evidence indicates that non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviors," and that "humans are not unique in possessing the neurological substrates that generate consciousness" (see [75]). Studies from multiple disciplines provide objective evidence of nonhuman animals' abilities to experience pain and distress, although expressions of their experiences are often unrecognized by humans [73, 76]. Many animals can experience acute or chronic pain, such as the pain of inflammation, visceral pain, or neuropathic pain. Like humans, other animals can also experience "sickness behavior" as a result of disease, which can result in lethargy, depression, anorexia, sleep disturbances, or enhanced sensitivity to pain [77]. Although the nociceptive pathways of pain are fairly well described, the molecular mechanisms involved in pain perception and the neurological responses to tissue and neuronal injury are not as well understood in humans or other animals [78, 79]. Nonetheless, these changes occur in the body in response to the objective world; they are part and parcel to the body's lived experiences. There is also evidence that animals (vertebrates and at least some invertebrates) remember adverse events like pain, learn avoidance patterns, and subsequently avoid painful or other aversive stimuli [73, 76, 80–83].

Many nonhuman animals can also experience fearful, avoidant, and hypervigilant psychological behaviors similar to those expressed by humans. In anxiety and depressive disorders, stressors can overwhelm normal physiological responses and cause structural and mechanistic changes in the body, including in neurological structures. For example, many vertebrates share a large number of brain regions

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[27] Interactions, touches, and exchanges gain positive value and meaning when they are chosen and preferred by the individual, compared with when they are not chosen. See, for example, [74] for a more extended discussion of this issue.

associated with emotional affect, including the amygdala, hippocampus, and hypothalamus, among other areas [73, 76, 81]. As a result, there are homologies among species in attachment disorders, depression, complex anxiety disorders, posttraumatic disorders, and other persistent disorders of social behavior [84–87].

The relationship between bodily liberty, which can take the form of freedom of choice, and health and well-being is well established. Experimental psychologists first studied the health influence of choice in dogs [88, 89]. When the dogs used in these experiments discovered they could not control electric shocks that violated their bodily integrity, they developed a series of behaviors described as learned helplessness. Soon, other scientists replicated these experiments in other animals, and some of the animals in these experiments also became physically ill and died. Similar behavioral patterns and physical and psychological illnesses are also seen in humans in whom bodily sovereignty has been violated.[28] Causality has also been established through other observational and experimental studies that show learned helplessness and associated physical and psychological illnesses, such as depression and posttraumatic stress disorder, can be reversed through the restoration of respect for bodily sovereignty. Neurotransmitters in the brain involved in learned helplessness and related mental disorders are not static. A sense of control may actually change the amount and strength of nerve connections in the brain and foster neuroplasticity.[29]

These findings illustrate that though it is important to acknowledge specific capacities like autonomy, and their relationship to health and well-being, bodily liberty and integrity are also critically important to physical and mental health—in people and animals of varying types and levels of intelligence.[30]

## 15.6 Conclusions

As a basic interest, bodily sovereignty must be weighed with other interests, including protections from harms unrelated to violations of bodily sovereignty. Nonetheless, bodily sovereignty should be counted as an independent interest in questions about the treatment of other people and animals. Other principles such as respect for autonomy and special protections for those with diminished autonomy

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[28] For example, in 2002, findings from Seligman and Maier's experiments with dogs were used to craft enhanced interrogation techniques like waterboarding. Two psychologists contracted by the CIA drew upon the foundational experiments to inform the architecture of its torture program and induce learned helplessness in human prisoners [90, 91]. Learned helplessness has also been widely described in victims of intimate partner violence and child abuse.

[29] See, for example, [92–94].

[30] Different forms and degrees of intelligence represent capacities and needs. When the ability to exercise one's intelligence is limited by external factors, one's needs may not be met and one can suffer as a result. However, when individuals lack neurological flexibility and have more limited coping mechanisms, they can also suffer more than they would otherwise when their specific needs are not met. See, for example, [72] or [95] for a fuller discussion of this subject.

will undoubtedly figure into these equations. However, these principles alone, lacking objective respect for bodily sovereignty, do not sufficiently address the needs of individual beings. Similarly, they do not account for the cumulative or synergistic effects of violations of bodily sovereignty that may occur over the course of a lifetime. Increasingly, health constructs such as trauma-informed care recognize the complex nature of various forms of repeated trauma, including violations of bodily sovereignty, and their complex impact on well-being [73, 96].

The right to bodily sovereignty is reflected throughout legal and regulatory frameworks that recognize the rights and biological needs of human beings, including in research settings. Respect for bodily sovereignty is not however generally extended to nonhuman animals, despite its established connection to the health, welfare, and well-being of many animals. Welfare is a concept that is articulated throughout documents governing the treatment of animals in research and other areas of society [47, 48, 52]. It is also a notion that is indistinguishable from the rights and needs of animals and our obligations to them [71, 72]. Any endeavor toward internal consistency requires that needs and principles such as bodily sovereignty be reliably respected, except perhaps in cases where there are clear justifications to the contrary [97]. Currently, there is no strong, broad moral justification for treating the liberty and integrity of one body, independent of capacities such as rationality, differently than another. Differences in treatment require specific justification absent bias, including prejudices related to species classifications.

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# The Trouble with Animal Models in Brain Research

## 16

L. Syd M Johnson

**Abstract**

This chapter focuses on two problems, or "troubles," with animal models used in neuroscientific research: the failure of many animal models to yield useful and beneficial information and the ethical dilemma built into claims about the similarity-based usefulness of an animal model, which is especially acute in the context of brain-related research. There are well-documented problems with validity and reproducibility, resulting in the failure of animal research to translate to humans. This chapter will focus in particular on the well-known and well-studied failure of animal models in stroke research. The essentially Utilitarian cost/benefit claim that human benefits justify harms to animals in research is threatened if those benefits consistently fail to materialize and, indeed, if there is the potential for significant harm to humans, including opportunity costs, wasted resources, and risks to human research subjects. An honest reckoning of the costs, harms, and benefits of animal research is unlikely to support the *status quo* because very little research will be useful or needed, and thus very little will be ethically justifiable.

**Keywords**

Animal models · Animal research · Research ethics · Neuroscience · Stroke · Dogs

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_16

## 16.1 Introduction

This chapter will focus on two interlaced problems, or “troubles,” with animal models used in brain research: (a) the failure of many animal models to predict results in humans, that is, to yield useful and beneficial information, and (b) the ethical dilemma built into scientific claims about the similarity-based usefulness of an animal model, which is especially acute in the context of brain-related research. Together, these weaken the typical ethical justifications for animal research.

Regarding (a), there are well-documented problems with validity and reproducibility, resulting in the failure of animal research to translate to humans. The essentially Utilitarian cost/benefit claim that human benefits justify harms to nonhuman animals (henceforth “animals”) in research is threatened if those benefits consistently fail to materialize and, moreover, if those failures result in significant harms to humans. There are a number of explanations for the failure of animal models, as will be discussed below. But if the scientific need to use animals is questionable, then so is the moral calculus. An honest reckoning of the costs, harms, and benefits of animal research is unlikely to support the *status quo* because very little research will be useful or needed, and thus very little will be ethically justifiable. Indeed, the failure of 90% of *all drugs* brought to clinical trials is sufficiently high to call into question the value of much preclinical research using animal models, and the claims of scientific need and human benefit that are the foundational ethical justification for harmful biomedical research with animals break down.[1]

Regarding (b), the ethical problem faced by brain research is that scientifically justifying the use of an animal model ideally requires demonstrating and emphasizing similarities between the animal and humans, but the more similar the animals are in terms of human-like sentience, cognition, mental states, behaviors, and capabilities, the harder it is to morally justify the use of those animals. This results in what Ferdowsian and Gluck have called a “justificatory dilemma” [1]. This dilemma is especially acute in brain-related research, including neuroscientific and psychological research, where many of the relevant similarities implicate features commonly thought to confer special moral status on humans. These include consciousness, rationality, sociality, emotionality, and intelligence, among others. If all or most of these features are present in animals, they would seemingly mean those animals matter morally. If we are to treat like cases as *scientifically* alike, consistency demands that we treat like cases as *morally* alike as well. Thus, emphasizing the similarities between nonhuman animals and humans cuts both ways: it undergirds

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[1] Consider an analogy. Five-day weather forecasts are accurate 90% of the time (https://scijinks.gov/forecast-reliability/). But imagine the opposite were true, and they were wrong 90% of the time. That would give us good reason to distrust the reliability of weather forecasts, and it would give the field of meteorology good scientific reasons to reconsider or justify its methodologies. Most of the time, inaccurate weather forecasts do not endanger lives. The 90% failure of animal research to translate to humans does endanger human life and safety and results in nonbeneficial harms to animals, both of which threaten the scientific and ethical justification for continuing to use animal models.

the scientific justification for an animal model, but undermines the ethical justification.

The scientific evidence *against* using animal models is compelling enough that the burden of proof must be on those who claim scientific need, and the benefits of animal research, as its justification. Is the comparatively small success rate—which might still mean thousands or millions of human lives saved or improved—adequate justification? Perhaps, instead, the accumulation of knowledge about the brain in research that does not bear fruit has other positive effects and furthers other research agenda. Many of the most significant developments in medicine have *involved* animal experiments, although the fact that this is true does not mean that the inferential value of those experiments was significant or that those discoveries *depended* on the use of animals [2]. As Matthews points out, the oft-repeated statement defending animal experimentation—"Virtually every medical achievement of the last century has depended directly or indirectly on research animals" (p. 95 in [2])—seemingly has no source, has never been formally validated, and appears to rest on little more than anecdotal examples.

## 16.2 What Is an Animal Model, and How Is It Predictive?

An animal model of a disease X exists when a nonhuman animal instantiates disease X or, in some cases, mimics symptoms of disease X. For example, Ebola virus is transmitted by bats, but they are not sickened by it and are not a model. Mice are used in large numbers for Ebola research, but the preferred models are macaques, because of their similarities with humans in disease pathogenesis, clinical presentation, laboratory findings, and causes of fatality.

Animal models do not exist for all known diseases, pathogens, and conditions. In some cases, animals are genetically modified to mimic symptoms or disease processes. Knockout and knockin mice are examples of animals genetically engineered in large numbers to mimic a variety of human diseases and conditions that do not naturally occur in that species. Genetically modified rhesus macaques have been created that exhibit symptoms and stereotypical behaviors that mimic those seen in autistic individuals [3]. Macaques are a nonhuman primate (NHP) commonly used in biomedical research, and the modified macaques are a putative model for autism, bridging mouse models and humans [4].

An animal model can also be a species that recapitulates human biological processes. For example, nonhuman mammals (along with animals from other taxa) have a cardiovascular system similar to that found in humans and can serve as phenotypic surrogates or models for the human cardiovascular system. The brains of some animals are structurally and anatomically similar to human brains. But even in animals with structurally/anatomically dissimilar brains, relevantly similar behaviors and capacities can be found.

A mistaken assumption about animal models is that they are themselves *predictive* of human responses. That is, if administering Y to rats relieves symptoms of disease X, it will do the same in humans with disease X. Shanks, Greek, and Greek identify this notion of the *reliable predictability of animal models* as the "overarching hypothesis" in the animal model research community. They claim it mistakenly treats animals as surrogate humans [5] and treats *Y relieves symptoms of X* as if it is affirmed by animal studies, rather than as a *hypothesis* that must be tested and confirmed in humans. If and only if the prediction is verified, that is, Y relieves symptoms of X in humans, can it be said that the animal model was predictive. There are numerous reasons why animal models are *not* predictive. In animals with similar phenotypes and genotypes, differences in complex biological processes can thwart prediction. Differences in metabolism, the bioavailability or ability to absorb compounds, and the toxicity of compounds are just a few examples of roadblocks in the translation of animal model research to human patients. There is variability both between and within species, including variability based on the age or sex of animals. The predictive failure of animal models is one reason for the high rate of *attrition,* or the failure, in human clinical trials of seemingly promising treatments that appeared safe and efficacious in animal models. Attrition occurs with some 90% of all drugs that make it to clinical trials [6].

Several explanations for the translational failure of animal models have been discussed in the scientific literature, including problems with methodological quality and statistical analysis; publication bias; the selection of models and the lack of congruence between humans and other animals; the effects of confounds like captivity, housing, and stress, and inattention to animal welfare; failure to replicate in humans the experimental conditions under which a treatment worked in animals; and a lack of standardized "best practices" in animal research (see, e.g., [2, 6–19]). The scientific community recognizes that there is a significant failure of animal research to yield expected benefits for humans. Even allowing for the inherent uncertainty of scientific experiments, where expected benefits for humans justifies the use of animal models, the sustained failure to produce benefits must call into question whether the experiments are in fact adequately justified by scientific need.

## 16.3 Brain Research with Animals: Trials and Errors

Animal models are used in brain research on many types of human disorders, including pain [20], traumatic brain injuries [21], seizure disorders, neurodevelopmental and neurodegenerative disorders [22], addiction [17, 22–24], and psychiatric and behavioral disorders [6, 25]. Numerous animal models have been developed for brain and central nervous system research, including dogs, cats, ferrets, mice, rats, rabbits, gerbils, pigs, sheep, birds, fish, and several NHP species. As is typical in biomedical research, transgenic mice make up the majority of the animals used. Across these different areas of research, it is recognized that "No perfect animal model exists for any aspect of any [central nervous system] disorder," (p. 75 in [18]) and that the value of animal models is open to question as they frequently fail to produce results that can be translated to humans. There have been numerous empirical studies aimed at discerning the reasons for the high rate of failure, and a vast scientific literature exists on the challenges faced by animal model brain science, the attrition crisis, and how the problems might be solved. One fundamental question concerns the inherent limitations of animal models and whether it is possible to replicate "disorders that often seem uniquely human" [25], like psychiatric disorders and addiction. In modeling neuropsychiatric disorders in animals, for example, Nestler and Hyman note that "Many of the symptoms used to establish psychiatric diagnoses in humans (for example, hallucinations, delusions, sadness and guilt) cannot be convincingly ascertained in animals. When there are reasonable correlates in animals (for example, abnormal social behavior, motivation, working memory, emotion and executive function), the correspondence may only be approximate" (p. 1161 in [25]). As a result, "animal models are unlikely to mirror the full extent of a given human neuropsychiatric disorder" (p. 1161 in [25]). Similarly, in addiction research, mimicking addictive behaviors is limited and potentially confounded by the conditions of captivity for the animal used in the research: "Although drug self-administration by rodents has provided important information, it is difficult to argue that it truly models compulsion, when the alternative to self-administration is solitude in a shoebox cage" (p. 702 in [24]).

The remainder of this section will focus on research with animal models for stroke, where there has been a well-documented and well-studied failure of animal models to predict human responses to neuroprotective drugs, as well as substantive efforts to solve the problem. In §16.4 I will consider stroke research in canine models.

### 16.3.1 Stroke Models

> A common perception of neuroprotection research is that everything works in animals but nothing works in people. This perception has been reinforced again and again by reports of unsuccessful or mixed outcomes in trials of candidate neuroprotectants in acute stroke patients. If animal experiments are indeed unable to inform clinical decision making, then serious doubts are raised about the utility of animal models of stroke and about the ethics of continuing current animal experimentation practices [16].

Stroke is the third leading cause of death among adults in industrialized countries. At present, there is one thrombolytic ("clot-busting") drug approved for use in acute ischemic stroke. Tissue-plasminogen activator (t-PA) must be administered within the first 3 to 4.5 h of stroke [26], limiting its clinical utility [27, 28].[2] Because stroke causes a great deal of human suffering through death and disability, experimental stroke treatments are a prime candidate for the kinds of harmful animal research that could potentially be adequately justified by the possible human benefits.

Moreover, the mechanisms and pathology of stroke are well understood, making it a seemingly ideal condition to replicate in animal models. About 85% of strokes

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[2] t-PA was developed using a rabbit model of thromboembolic stroke [27]. The drug was FDA-approved in 1996.

are ischemic, caused by a blockage of blood flow in a major cerebral artery. Ischemic injuries can be global (involving major blood vessels and resulting in widespread injury across several regions of the brain) or focal (involving the blockage of specific vessels and localized injury). In humans, the middle cerebral artery (MCA) is the site of the majority of ischemic strokes. The remaining strokes are hemorrhagic, caused by a burst blood vessel in the brain [27]. Animals used as models for stroke include mice, rats, gerbils, rabbits, cats, dogs, pigs, sheep, and monkeys [29]. Methods for inducing stroke-like ischemic and hemorrhagic brain injuries in these animals include clipping blood vessels, or cuffing and cauterizing arteries, introducing chemical or mechanical "clots" to induce embolisms, inducing cardiac arrest and ventricular fibrillation, and inducing asphyxia using neck cuffs and tourniquets, potassium cyanide, nitrogen, and carbon dioxide [16, 29]. Inducing stroke-like brain injuries sometimes involves surgery, including craniotomy (opening the skull), or accessing blood vessels transorbitally (through the eye). The latter method requires removing the eye, which can limit post-"stroke" behavioral assessment; the former method results in exposing the brain and leaves a potentially painful incision. As is true across animal research, the majority of the animals used are rodents.

Replicating stroke in an animal model has proven difficult. Notably, many of the experimentally induced "strokes" do not actually replicate strokes but rather cause cardiac arrest with anoxia/hypoxia [29]. While cardiac arrests and anoxic/hypoxic brain injuries are also common in humans, they are not strokes. In humans, strokes afflict persons of both sexes, and especially the elderly, individuals with chronic hypertension, and smokers, and commonly individuals who take multiple medications for preexisting conditions. Animals used in research are generally young, healthy, and male. Replicating human stroke in an animal model would ideally involve reproducing the preexisting conditions of stroke, a task just as formidable as reproducing stroke, its pathology, and outcomes.

Since 1960, more than 1000 drugs and therapies for stroke have been tested, in thousands of experiments on animals [16]. Of these, 37 drugs have been tested in humans in 114 clinical trials. The translational failure of all of these experimental treatments has been widely studied and discussed in the scientific literature, making them an ideal case study of the failure of animal models to predict human outcomes. For example, one class of drugs, NMDA channel blockers, caused side effects including nausea, hallucinations, hypotension, and respiratory arrest when administered to humans [7]. The animal models did not predict these human responses. The failure of animal models to produce results in stroke research led to the adoption of a set of guidelines, the Stroke Therapy Academic Industry Roundtable (STAIR) recommendations, published in 1999 and updated in 2009 [15]. The guidelines were intended to standardize protocols, improve the methodological quality of preclinical animal research, and thereby improve the applicability of animal stroke experiments to humans.[3] The experimental drug disodium

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[3] The STAIR guidelines for testing drugs require (1) that the drug should have been tested in both transient and permanent occlusion models, (2) reproducibility, with efficacy demonstrable in at least

2,4-disulphophenyl-N-tert-butylnitrone (NXY-059) was the poster child for these new standards, and its failure in human clinical trials was a blow both to the search for effective neuroprotective agents and to the presumed efficacy of the STAIR guidelines [30]. To date, the STAIR recommendations have not been "closely followed nor rigorously validated" (p. 2244 in [15]), have failed to lead to an effective neuroprotective treatment in humans [28], and they have yet to have "recognizable impact in clinical translation" (p. 409 in [14]).

Numerous explanations for the failure of neuroprotective drug research have been considered in the scientific literature. At the most basic level, despite evolutionary continuity between many species, there are confounding anatomical and physiological differences. For example, most of the small animal models used in stroke research are lissencephalic—their brains are smooth and lack the convoluted fissures of gyrencephalic animals like humans and some of the larger NHPs. Gyrencephalic species generally possess brains that exhibit cortical organization, white/gray matter ratios, and vasculature that resemble human brains more closely than the brains of lissencephalic animals (among other things, the fissures increase the total surface area of the cortex). The human brain has a higher proportion of white matter relative to the rodent brain, so it is thought to be "unlikely that a treatment that targets only neurons and that does not also salvage white matter tracts would have widespread clinical relevance" [15]. NXY-059 was studied in lissencephalic species—mice, rats, rabbits, and marmosets[4]—and it is speculated that this might have been one factor in the drug's ultimate failure in humans [28, 31]. The STAIR guidelines recommend testing for efficacy in gyrencephalic species, specifically cats or gyrencephalic NHPs, but acknowledge that the advantages, including the predictive value of using gyrencephalic NHP models, are unproven [15]. Indeed, while NHP models are often proposed as a solution to the problem of attrition in neuroprotective drug research, "Research to date has not resolved which primate model of stroke most closely models the human condition, nor whether studies of neuroprotectants in NHPs suffice to predict the results of a human trial" [28]. In other words, NHP models are endorsed as a solution without sufficient empirical evidence that they would be better models.

An entirely different problem, however, is that experimental conditions used in animal studies, such as dosage and timing of drug administration, are not and often cannot be replicated in human clinical trials. One reason for this is that drug toxicities vary between species, and many of the experimental compounds brought to clinical trials produced adverse and sometimes dangerous side effects in humans when given at dosages that were neuroprotective in animal models [27]. Moreover,

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2 independent laboratories, (3) evidence for efficacy based both on histological and behavioral outcome measures, (4) characterization of a therapeutic time window relative to the time of onset of the ischemic injury during which the drug is effective, and (5) evidence for efficacy in at least 2 species, 1 of which is a cat or primate [10].

[4] As reported by Bath et al. [31], the animals used were 9 mice, 544 rats, 32 marmosets, and 89 rabbits, totaling 674 animals. Published results for animal studies in rats and marmosets were positive.

experimentally induced strokes and stroke-like injuries occur in a setting in which drugs can be administered according to a controllable timetable, while the timing of diagnosis and treatment for human stroke patients are subject to uncontrollable variables.

Regarding the methodological quality of animal stroke studies, a systematic study of experiments on neuroprotective agents by Savitz "found them to be almost uniformly wanting" and concluded that "animal studies have been of insufficient methodological quality with the result that limited conclusions can be drawn from the data" (p. 578 in [10]). Issues with methodological quality include "high risk of bias and the failure to adequately control for physiological variables" (p. 577 in [10]). Sena et al. found that publication bias is prevalent in animal stroke studies, "such that data from as many as one in seven experiments remain unpublished. The result of this bias is that systematic reviews of the published results of interventions in animal models of stroke overstate their efficacy by around one third" (p. 2 in [11]). Publication bias occurs when neutral or negative results from animal studies remain unpublished, while apparently positive results are published, leading to erroneous conclusions about efficacy. The NXY-059 studies are a case in point: half of the *unpublished* animal experiments on NXY-059 were neutral, showing no neuroprotective effect [11, 31]. Bath et al. found several flaws in the animal studies, including "the presence of several potential sources of bias in the preclinical work, especially performance, attrition and publication bias" (p. 1169 in [31]). Publication bias raises a number of ethical concerns in addition to scientific concerns. When study data are unpublished, the animals sacrificed do not contribute to knowledge. Those animals suffered and died in vain. Additionally, human participants in clinical trials may be placed at unjustifiable and unnecessary risk because a drug's efficacy and safety in animals has been overstated.

To date, no successful neuroprotective drug has emerged from thousands of animal experiments. It is not necessary for research to be a complete failure, however, for it to warrant both scientific and ethical concern. Where flawed scientific practices are at least partly responsible for the failure of experimental therapies to translate to humans, the lack of rigor in preclinical studies implies that the burdens and sacrifices of animals matters so little that they are essentially disposable. That is, using inappropriate models, in poorly designed and implemented experiments, or disregarding unfavorable data, implies that the experiences and deaths of animals are not even worth the trouble of doing the science well. We need care no more about the suffering of an animal in, for example, stroke research, than we care about gloves and test tubes. But suppose, for the sake of argument, that it is true that animals are disposable and fungible, mere things to be used as humans wish, and we need have no moral qualms about using them. The lack of scientific rigor in animal studies also has important negative consequences and costs for *humans* when animal models fail to be predictive. There are opportunity costs when resources and time are wasted pursuing flawed treatments or when promising treatments are abandoned after failed animal studies. And human subjects may suffer from unforeseen and avoidable risks in clinical research when unsafe or ineffective therapies are tested. Treating animals as disposable in research results in treating human lives in much the same way.

## 16.4 Brain Research and the Justificatory Dilemma

> For many years, academics have tended to avoid the question of the subjective experience of a nonhuman animal, because it has generally been thought to be unanswerable. This has allowed scientists to sidestep the moral question of whether it is okay to use animals in medical research. When we see similar brain processes occurring in these animals, it becomes harder to ignore. And it isn't just dogs: Every week, I read about discoveries on the sophisticated cognitive abilities of other animals. Certainly they aren't automatons, like Descartes thought. (Neuroeconomist Gregory Berns quoted in [32])

Thus far, we have discussed how animals are *not* like humans in ways that may undermine the value and utility of using animal models in biomedical research and, specifically, brain research. Humans are not just big rats, and rats are not just tiny humans. If harmful research with animals is ethically justified by important benefits like reducing human suffering or saving human lives, and if those benefits are not and perhaps cannot be achieved by animal research, then the ethical justification for using animals in harmful scientific research fails [33]. However, if there is a sufficient difference in the moral status of humans and animals (or at least some animals), such that humans, and human needs and interests matter significantly more, it might still be possible to justify some harmful research, even if the human interests in doing so are rather remote, farfetched, or trivial. In this section, I will turn to the question of what moral differences exist between humans and other animals that make humans morally exceptional or that confer special moral status on humans, such that they matter morally and other animals either matter less or matter not at all.

One justification for human moral exceptionalism (i.e., moral difference) is that humans are simply humans, members of the species *Homo sapiens*. This justification fails because it is question-begging (or circular). Humans are *H. sapiens* so if the question is *Why are humans morally exceptional?* then it can be rephrased as *Why is* H. sapiens *morally exceptional*? without changing its meaning and without actually answering it. This justification is especially problematic for anyone who also wants to provide a *similarity-based scientific need* justification for animal research grounded in the similarities between other species and *H. sapiens*, as that claim would seem to be at odds with the exceptionalism (i.e., difference) claim. A more sophisticated response is to claim *biological similarity with moral difference*, which would require identifying the specific features of *H. sapiens* that account for its moral exceptionalism. Indeed, this is what Kant attempted when he claimed that humans and only humans are rational moral agents and eligible for membership in the moral community [34].

There are two pitfalls for this approach to justifying human moral exceptionalism. First, one would be hard-pressed to find any characteristics, traits, abilities, or capacities that are found exclusively in *H. sapiens*. Virtually any of the traits and capacities that arguably make humans special, such as intelligence, rationality, autonomy, consciousness, self-awareness, learning, sociality, emotionality, language or intentional communication, tool use, problem solving, future-oriented planning, decision making, culture, grief, mourning and death rituals, altruism, curiosity, playfulness and humor, sexuality, reciprocity, political activity, even economic activity that appears to follow the same economic laws that govern human behavior, and moral agency [35–40], have been observed in other species, from fish and octopuses to birds, cetaceans, and apes, depending on the properties in question. Second, it is not obviously true that any of these traits or capacities have any relevance to moral status. But let us suppose that possessing some subset or quantity of these traits and abilities is enough to make a human, or an animal (or other entity) matter morally, at least to some extent.[5] It is undeniably true that some humans exhibit none of these traits or capacities, some humans possess some or all, and many animals, including those used in research, exhibit at least some, if not many of them. It is not necessary to completely resolve the question of which animals matter morally or to what degree different animals matter. It will be sufficient for my purposes to show that when considering the traits and capacities generally thought to confer some degree of moral status (even if it is less than human status), many animals—and certainly the vertebrates used in research—matter morally.

Research from many fields, including zoology, biology, psychology, ethology, primatology, veterinary medicine, agricultural science, and economics, has contributed to our knowledge about animal minds and behaviors both through field observation of wild animals and in studies of captive animals (see, e.g., Boesch, Marino, Comstock, and Sneddon & Brown in this volume). Neuroscientific studies of animal brains and minds have likewise contributed to our knowledge of the differences and similarities between humans and other species. This includes research on the neuroanatomical, cognitive, and psychological features, knowledge about the impact of neurodevelopmental insults (e.g., maternal deprivation in infant monkeys), and knowledge about psychological disorders. The upshot is that centuries of research, including invasive and noninvasive neuroscientific research, demonstrates that there are animals who are more like humans than not in possessing many of the features thought to make humans exceptional.

### 16.4.1 Canine Minds and Models

One species that has been extensively studied is dogs (*Canis familiaris*). Dogs and humans have lived and worked together and have coevolved for several millennia, so it is no surprise that dogs have neuroanatomical structures and well-developed abilities that make them unusually attuned to human emotions and facial expressions [41], and they have the capacity to understand some human language, including processing both lexical and intonational information in human speech [42]. Indeed, dogs are unusually skilled at reading human social and communicative behavior and superior to our nearest primate relatives at this. They can use human communicative behavior like pointing or gazing to find hidden food, a task human toddlers can

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[5] If possessing some subset or quantity of these traits or abilities is enough to matter morally, then it must be possible that nonhumans, whether animal or nonanimal (e.g., extraterrestrials, robots, or AIs), qualify.

master at around 14 months. Chimpanzees, our closest genetic relatives, show little skill in this task, despite their intelligence and problem-solving skills [43] (although the lengthy history of dog domestication and cohabitation with humans—and the captivity of laboratory chimpanzees—may explain the difference).

fMRI studies by Berns [44], involving trained, unrestrained, awake dogs, found that many of the same things that activate the human caudate nucleus, and which are associated with positive emotions, also activate the dog caudate (in what is known as a functional homology) providing evidence of canine emotions.[6] "Dogs, and probably many other animals (especially our closest primate relatives), seem to have emotions just like us" (pSR5 in [45]). Dogs think, they feel, they have preferences and desires, and they solve problems. Dogs, like other social creatures, exhibit prosocial behaviors in play and, along with other species, exhibit the characteristics of being moral creatures [46–50]. The scientific evidence that dogs possess many of the traits and abilities sufficient to matter morally is substantial.

Canine models of ischemic stroke have been developed as a cheaper gyrencephalic alternative to using NHPs [51, 52]. There is an assumption that NHPs are superior as stroke models because they are more similar to humans, but practical and ethical considerations make it easier and less expensive to use dogs and rodents. The expense and the ethical barriers to using NHPs have been cited by some researchers as a reason to prefer dogs even though "canines are considered 'man's best friend', and society expresses concerns about the usage of canines when compared to other animals, such as rodents" (p. 135 in [52]). Ischemic strokes are induced in dogs by blocking arteries surgically, although features of the circulatory system in dogs complicate efforts to induce human-like strokes through MCA occlusion alone. The dogs who survive occlusion are assessed behaviorally for neurological deficits including level of consciousness, vocalization, gait, behavior, motor function, and sensory function [52] and then killed after assessment so their brains can be examined [51]. In dog models, it is not possible to assess the kinds of cognitive deficits that can occur chronically in human stroke patients, such as language impairments (aphasia), problems with thinking and memory (e.g., anosognosia and apraxia), and psychiatric disturbances such as anxiety, irritability, and suicidal ideation. Canine models of stroke are an example of how the choice of animal models is not always driven by scientific criteria, which undermines claims of similarity-based scientific need.

### 16.4.2 The Justificatory Dilemma

The differences between canine and the human brains, as well as differences in relevant capacities, reduce the value of canine models for stroke. At the same time,

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[6] Berns' research with dogs is not invasive or harmful. The dogs are trained through positive reinforcement to enter the fMRI machine and to remain still during scanning, but they are never restrained or sedated and are free to get up and leave if they do not want to participate [42].

neuroscientific research on dogs has provided new insights into the canine mind and canine cognitive capacities—that is, the ways in which dogs are similar to humans—that generates the justificatory dilemma in brain research with dogs. Ferdowsian and Gluck sum up the justificatory dilemma as it arises in psychiatric experiments with animals:

> The more researchers emphasize *similarities* between animals and humans, the more they threaten the prospects for ethically justifying the experiment in question; the more researchers emphasize *differences* between animals and humans, the more they threaten the prospects for scientifically justifying the experiment [1].

In other words, the *similarity-based scientific need* justification for the research undermines *human moral exceptionalism* as an ethical justification. Psychiatric and brain research in particular face this dilemma because the research implies the existence of the very mental and cognitive characteristics that seemingly make an animal matter morally, such as intelligence, emotionality, sociality, rationality, and mind. Indeed, that similarity is partly what makes the animal a relevant model to the extent that it is. Neuroscientific and other research on dogs, and their moral agency and intelligence (to name just two of their "human-like" qualities), undermines the ethical justification for using them in harmful, invasive research. In the case of using dogs as a stroke model, the acknowledged *inferiority of the species as a model* undermines the scientific justification, which also weakens the ethical justification. Of course, it is not just dogs: the accumulated knowledge about animal brains and minds from neuroscience and other fields reveals that many animals are "human-like" in ways that make them matter morally if the same characteristics make humans matter morally.

## 16.5 Conclusion

Brain research programs, like those described above, in which the sought-after benefits have not materialized after thousands of experiments, and in which the animal models are not selected on the basis of scientific criteria, are both ethically and scientifically questionable. The failure of the animal models, and the acknowledged inferiority of the chosen models, demonstrates that the use of animal models is not clearly *scientifically* justified. The lack of scientific justification undermines the ethical justification—there can be no moral imperative to pursue harmful research that inflicts suffering on sentient creatures when that research cannot reap benefits for humans.

Based on what we have learned from neuroscience and other fields about animal minds and brains, the degree to which the value of animal lives, their interests, and their suffering are currently discounted in comparison to the value of human lives, interests, and suffering is both scientifically and morally unsupported. That is, animals matter morally much more than is currently accounted for when the harms (to animals) and benefits (to humans) of animal research are weighed in a moral calculus. If animals matter morally, then our reasons for inflicting harm on them must be *significantly stronger* than they currently are. Just as harming other humans cannot be justified by mere appeal to the benefits to other humans, the harming of animals cannot be justified by mere appeal to the benefits to humans [53]. Moreover, an honest accounting of harms and benefits must include the *harms to humans* caused by reliance on animal research. Those harms, as noted above, include opportunity costs, wasted resources, and risks to human research subjects.

It is not my view that a Utilitarian-type calculation of costs and benefits is the only, or best way to assess the ethical permissibility of brain research with animals (nor biomedical research generally). However, it is the dominant paradigm, one endorsed by animal welfare regulations and guidelines, and by researchers and research review committees [54–56]. My aim is to show that, working within this widely accepted paradigm, an *honest and complete* accounting of both the harms and benefits will not support the *status quo* and will not result in a blanket justification of harms to animals based on benefits to humans. Nor is it compatible with inflicting certain and predictable harms for what have so far been unreasonably speculative and frequently nonexistent benefits.

Together, the predictive failure of animal models and the justificatory dilemma generated by brain research with animals call for radical reconsideration of the use of animal models in a wide range of brain research. Consistent failure of a model is a reason to reconsider the appropriateness and scientific value of that model and perhaps reject it. Consistent failure of multiple models, as in some brain research, is a reason to consider better alternatives to doing research that is so vitally important. As a practical matter, it is likely that the use of animal models in neuroscientific research will continue, at least in the near future. It is possible that raising animal research to the demanding *scientific* and *ethical* standards used in human research would make that research more scientifically useful and beneficial. These would not be trivial changes, and they would have to include rigorously justifying the choice of animal models and considering how the genetic modification of animals and their captivity affect well-being in a way that diminishes their value as models of free-ranging, diverse human populations. Such changes would recognize the suffering endured and the sacrifice of the animals involved, and take more seriously the mandate to reduce the harms and burdens of research and increase the benefits across all species. If animals have any moral status at all, they cannot be used carelessly and treated as if they are mere tools.

**Acknowledgement** Many thanks to Pandora Pound for her helpful and generous comments on an earlier draft of this chapter.

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# Animal Models and the Search for Drug Treatments for Traumatic Brain Injury

## 17

Pandora Pound

**Abstract**

This chapter focuses on the use of animals in research into traumatic brain injury. It begins with a brief consideration of the epidemiology of human brain injury, before examining the various ways in which animals are used to "model" human brain injuries. The bulk of the chapter explores the impact of preclinical animal research on the treatment of human traumatic brain injury. Bearing in mind this impact, the ethics of animal research into traumatic brain injury are discussed, as is the adequacy of current regulatory frameworks. Before concluding, advances in human-relevant (non-animal) approaches to investigating human traumatic brain injury are briefly considered.

**Keywords**

Traumatic brain injury · Evidence · Clinical impact · Ethics · Human-relevant

## 17.1 Introduction

One of the many ways in which animals are used in biomedical research is as "models" of human conditions. In other words, because some kinds of experimental research are not supposed to be performed on humans for ethical reasons, animals are used instead as proxies. The assumption is that the knowledge gained as a result of experimenting on animals will be generalisable to humans. Animal models are used in all areas of biomedical research; for example, there are animal models of Alzheimer's disease, autism, hypothyroidism, stroke, depression, cancer, blindness, heart failure and bone fractures, amongst many others. This chapter will consider the use of animals as models of traumatic brain injury (TBI).

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L. S. M. Johnson et al. (eds.), *Neuroethics and Nonhuman Animals*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-31011-0_17

TBI is defined as an injury to the head by either blunt force or penetration from an external force, which damages the brain to the extent that the patient suffers a change in brain function or pathology [1]. This chapter begins with an overview of brain injury in humans, before considering the ways in which animals are used in brain injury research. The scientific evidence is then explored to determine the value of animal studies of TBI for the treatment of human brain injury. There follows a discussion of the ethics of this body of research, as well as a consideration of advances in human-relevant (non-animal) research methods for investigating human traumatic brain injury. The chapter concludes with a reflection on the adequacy of current ethical and regulatory frameworks.

## 17.2 Epidemiology of Human Brain Injury

The causes of brain injury amongst humans include sports accidents, road traffic accidents, falls and violence (e.g. fights, shaken baby syndrome, military combat). The most common causes are estimated to be traffic accidents and falls [1], with the latter being the most common cause of TBI amongst older adults [2]. Amongst children, the causes of injury vary by age, with infants suffering inflicted injuries and toddlers suffering fall-related injuries, whilst older children's injuries tend to be sports-related or due to road traffic accidents [2]. Men are at a higher risk of TBI than women [2], possibly due to a greater propensity amongst men for certain types of risk-taking [3].

In Europe, crude incidence rates range from 47 to 694 per 100,000 population per year, whilst crude mortality rates range from 9 to 28.10 per 100,000 population per year [1]. Internationally, the incidence rate is estimated at 295 per 100,000 persons [3]. The causes of TBI vary geographically; the most common cause of TBI in developing countries is road traffic accidents, whereas in developed countries it is falls [2]. Europe has the highest percentage of fall- and work-related TBIs, whilst North America has the highest percentage of sports-related TBIs. In high-income countries, individuals with TBI are generally automobile occupants, whereas in middle-income and low-income countries, they are often vulnerable pedestrians, cyclists, and motorcyclists [2].

As these studies indicate, the incidence and causes of TBI vary by gender, age and socioeconomic context. Most epidemiological studies conclude that better prevention programs, improved regulation and robust public health policies and initiatives are necessary. These might include, for example, traffic regulations, road safety education, fall prevention programs, the use of safety equipment such as airbags and child car seats, regulations such as those relating to seat belts and helmets, and health and safety improvements in homes, schools, institutions and sports centers. In Taiwan, for example, the implementation of a motorcycle helmet law was associated with a 33% decrease in the incidence of motorcycle-related TBI [2], whilst legislation concerning sports-related TBI and improved traffic and safety regulations are credited with contributing to a decline in TBI in high-income countries [3]. Clearly then, much TBI is preventable.

## 17.3 Medical Management of Human TBI

Acute care in the case of severe TBI consists of ensuring that the patient has sufficient oxygen and blood supply, minimizing secondary damage due to inflammation or bleeding, maintaining blood pressure, and preventing further injuries to the head or neck. Diuretics, anti-seizure or coma-inducing drugs may be given, or surgery may be performed to minimize additional damage to the brain (e.g. to remove blood clots, stop bleeding or repair skull fractures). However, there is currently no approved medication for halting or reversing the pathological consequences, or sequelae, of brain injury, despite nearly 70 years of animal research dedicated to finding one.

## 17.4 Overview of Brain Injury Research in Animals

Although some TBI animal research aims to investigate basic mechanisms, the aim of most animal models of TBI is to understand the pathology of the primary injury and its sequelae in order to identify and test pharmacological treatments that might benefit humans with TBI. In pursuit of this goal, animals are subjected to a brain injury, given an experimental drug, monitored and then killed, if they do not first die of their injuries. Mice, rats, rabbits, ferrets, cats, dogs, sheep, pigs and nonhuman primates have all been used in TBI experiments. Since the 1950s, numerous methods and devices have been developed for inflicting brain damage on laboratory animals. Most involve some sort of impact to the brain, but others may involve rapid rotation, penetration of the brain or explosive blasts. After being brain-injured, animals are usually subjected to tests in order to monitor the effect of the drugs on their behavior. For example, tests for rodents typically include being forced to walk along an elevated narrow beam, to balance on an elevated, horizontal rotating rod and to swim in a glass cylinder from which there is no escape.

The various animal models of TBI are designed to produce controlled, homogenous types of injury [4]. According to O’Connor et al. [5], the current, most commonly used methods include the following: (1) dropping weights on animals’ heads, either onto the skull or through a hole in the skull (weight drop model); (2) dropping weights onto a steel plate glued to the animal’s exposed skull (impact acceleration model); (3) driving a pneumatic impactor onto the exposed brain through a hole in the skull (controlled cortical impact model); and (4) generating pressure on the brain via the impact of a rapid fluid bolus which is forced through a hole in the skull (fluid percussion injury).

Additional models include “non-impact acceleration injury models”, which are designed to mimic situations in which humans in road traffic accidents sustain brain injuries associated with rotational forces rather than direct impact to the head [5]. Gennarelli [6] developed a model in which nonhuman primates were fixed in a seated position to a chair that was rapidly rotated in a controlled manner along different planes (more on Gennarelli’s research later). A recent variant is designed to combine components of cervical whiplash and acceleration head injury; it uses a pneumatically driven piston to produce traumatic flexion of the animal's cervical spine and rotational acceleration of its head. It has been noted that this model produces protracted periods of inactivity, motor dysfunction, and temporary cessation of breathing in some animals [7].

The penetrating injury model aims to mimic missile wound injury to the brain and involves either firing a bullet into the brain of a restrained animal or using a captive bolt device to damage the brain [8], causing extensive intracerebral hemorrhage [4]. Blast TBI models attempt to simulate blast conditions by placing animals in the open air at specific distances from an explosive device which is then detonated [9]. For laboratory-based blast TBI research, animals are placed in "shock tubes" which are separated by a diaphragm from a device which generates high pressure and which, upon reaching a critical level, ruptures the diaphragm and creates a shock wave.

Other methods employed to inflict brain injury on animals include the use of lead-tipped darts, bolts, pendulum devices, padded darts fired from pistols, vacuum pressure [5] and metal probes [8]. In some research, animals are subjected to repeated brain injuries (e.g. by dropping weights, detonating blasts) in order to mimic the clinical consequences of repeated mild brain injury [4].

## 17.5 The Impact of TBI Animal Research on Treatments for Humans

As noted above, despite almost 70 years of animal studies into potential TBI treatments, not one has translated into an approved medication for humans [4, 10]. The type of drug that researchers are most interested in are "neuroprotectives", which limit secondary tissue loss after the primary injury. However, more than 40 neuroprotective drugs have proceeded to clinical trials over the past 30 years, and all have failed [11, 12]. So what is going wrong? Why has animal research into TBI failed to result in even one medication for clinical use? One of the reasons is that animal studies of TBI pay insufficient attention to factors that can undermine scientific validity. These issues will now be explored.

## 17.6 Poor Internal Validity

In common with the vast majority of animal research [13–24], animal studies of TBI suffer from weaknesses in experimental design and scientific rigor. Internal validity refers to the scientific robustness of a study's design, conduct, analysis and reporting. For example, animal studies of TBI frequently fail to take standard measures to prevent bias, such as randomizing animals to treatment groups and conducting masked outcome assessments [25–27]. In addition, they commonly fail to take account of the potential effects of confounding variables, such as anesthesia [28], or to conduct adequate physiological monitoring before and after brain injury is inflicted [29]. Furthermore, calculations that are necessary to determine the optimum sample size are frequently not performed, with the sample size instead being determined arbitrarily or, worse, the numbers of animals being increased until statistical significance is achieved [11]. Unfortunately, findings from studies that suffer from such weaknesses in experimental design cannot be relied upon, nor can they be reliably applied to other settings or populations [30]. The poor quality of TBI animal research therefore provides a potential explanation for the lack of clinical translation in this field.

## 17.7 Poor External Validity

External validity is the extent to which research findings derived in one setting, population or species can be reliably applied to other settings, populations and species [31]. External validity is a key criterion for assessing the credibility of scientific research and is of obvious relevance in animal research where the aim is to extrapolate animal study findings to human populations. Within the field of experimental TBI, there appears to be more attention to issues of external validity than to issues of internal validity, and four key concerns are identifiable within the animal model literature: the inability of animal models of TBI to mimic human pathophysiology, the failure of animal models of TBI to recapitulate the clinical context of TBI, the inability of animal samples to represent the human TBI population, and differences in neuroanatomy between animals and humans. All of these are potential explanations for the lack of translation from animals to humans in the field of TBI.

### 17.7.1 Animal Models Do Not Recapitulate Human Pathophysiology

Human brain injury is an unpredictable event with a range of pathophysiological mechanisms, neurological sequelae (e.g. seizures, reduced consciousness, coma) and “secondary insults” (e.g. hypotension, hypoxia). Consequently, no single animal model is able to reproduce the pathological mechanisms and changes that are observed after human TBI, particularly since there is considerable heterogeneity in the human response to TBI [5, 29, 32–34]. No two human brain injuries are identical; each will vary regarding cause, location and severity, and furthermore, humans experience a range of emotional and higher cognitive deficits (e.g. language problems) that cannot be recapitulated in animal models [29]. It has also been observed that most animal models mimic either focal or diffuse brain injury, whereas humans have various combinations of focal and diffuse patterns of tissue damage which can be complicated by their age, gender and preexisting conditions [32]. Yet in contrast to the pathophysiological heterogeneity observed in humans with TBI, animal models of TBI produce homogenous injuries [4]; the vast majority are impact models resulting in cerebral contusion in rodents, which, as Johnson et al. [9] suggest, may not even capture the most basic biomechanical mechanisms of human TBI. Furthermore, it is unlikely that a single agent could ever prevent the array of injury processes involved in human TBI [10].

### 17.7.2 Animal Models Do Not Recapitulate the Clinical Context

In animal TBI models, drugs have traditionally been administered either early after the inflicted brain injury or before it. Neither of these are relevant to the clinical context; in humans it is challenging to administer a drug early after TBI, and it is obviously not possible to administer a drug before the injury. Only compounds that can be administered late after onset of TBI are likely to have clinical relevance [4].

### 17.7.3 Animal Samples Are Not Representative of the Human TBI Population

Although some rodent models are described as producing severe TBI, the injured animals are able to move about, eat, and groom within hours of brain injury, which is very different from the situation in humans with severe TBI [9]. Consequently, these animals do not represent the human population very well. Furthermore, age and gender have a significant impact on the outcome of human TBI; for example, female sex hormones may have a neuroprotective effect after TBI [4], yet most rodent studies have traditionally been performed in male rats within a very narrow age range [29]. Age and sex differences are, however, increasingly incorporated into experimental TBI models [29, 32].

### 17.7.4 Species Differences

Most recent TBI studies have been performed in rats and mice [29], yet the human brain is much more complex structurally and functionally than the brain of rodents [32]. The neuroanatomy of rodents and humans is vastly different; rodents have lissencephalic (smooth) brains, and humans have gyrencephalic brains (with folds and convolutions). Gyrencephalic brains have a higher proportion of white-to-grey matter compared with lissencephalic brains. Because the incidence of human TBI involving white matter regions is high, it does not make sense to use animals that have a different distribution of white-to-grey matter. Indeed, a plethora of neuroprotective agents has successfully reduced grey matter damage in rodents, only to fail in clinical trials [12]. Additionally, after an inflicted injury, the lissencephalic brain will experience far less brain damage than the gyrencephalic brain [8, 12], suggesting that animals with lissencephalic brains are not good models for human TBI. Indeed, the differences between humans and rodents in terms of brain structure and function, craniospinal angle and white-to-grey matter ratio [4] means that humans and animals may have substantially different responses to traumas of comparable severity. Consequently, it has been suggested that the use of rodent models in TBI has had a negative impact on the ability to translate experimental findings to humans [12, 35].

## 17.8 Researchers' Responses to the Failure of TBI Animal Models to Translate into Human Treatments

Animal model researchers have responded to the lack of clinical translation by suggesting that they will modify their research methods. Some suggestions are to improve the scientific rigor of animal studies by using established methods for minimizing bias (e.g. randomization, masked assessment of outcomes). Others, however, have significant ethical implications. Some researchers, for example, argue that animals with larger, gyrencephalic brains and a high proportion of white-to-grey matter should be used in preference to rodents [12]. These would be animals such as pigs, dogs, cats, sheep and some nonhuman primates. It is argued that large animals' brains are also similar to human brains with respect to developmental patterns, degree of myelination, cerebrovascular anatomy and physiology [35]. Others note that the longer lifespan of larger animals enables researchers to study the long-term effects of their injuries; that their larger brains enable more clinically relevant monitoring; and that variables such as intracranial pressure, brain tissue oxygen content, and cerebral blood flow can be monitored using the same instruments as are used in humans [8, 12].

Others suggest that animal models of TBI should be made more complex. Xiong et al. [4] suggest that because TBI in the clinical setting is heterogeneous, with a combination of hematomas, contusion, diffuse axonal injury, subarachnoid hemorrhage, hypoxia, and ischemia, some of these factors need to be integrated into animal models of TBI in order to more closely approximate the clinical situation. Xiong et al. [4] also recommend that animal models of TBI incorporate multiple injuries because these can result in a complex pathophysiological and immunological response; they note, for example, that a model of TBI combined with a tibial fracture initiated a robust systemic inflammatory response in rats. Morganti-Kossmann et al. [32] also note that current research in neurotrauma is focusing on combining TBI with additional physiological insults.

Finally, because anesthesia can confound the results of experiments, it has been suggested that some animal model protocols should be revised to include components without anesthesia [7]. Clearly all the above suggestions for improving the validity of TBI animal models have significant ethical implications as they involve using an extended range of animals and increasing the range and severity of harms experienced by these animals. Before coming to ethical issues, however, it is important to consider whether the suggested modifications are likely to increase the possibility of clinical translation.

## 17.9 Will Modifications to Animal Studies Improve Clinical Translation?

If researchers using animal models of TBI increased the scientific rigor of their studies by minimizing the risk of bias and improving experimental design, then the internal validity of their research would be improved, increasing the likelihood that the results would be robust and trustworthy. Suppose, for the sake of argument then, that after much effort all the problems of internal validity were resolved. This would leave researchers with the problems of external validity. Leaving aside the ethical arguments for a moment, suppose researchers addressed the issue of external validity by using animal models that more accurately represent the human TBI population, by developing more complex animal models and experimental scenarios that more closely mimic the clinical context and by using larger animals with gyrencephalic brains. What then? It would take decades to make such changes and millions of animals would be used, but would animal models of TBI finally result in drugs that would benefit humans with TBI?

This would be highly unlikely, because the problem of animal–human species differences would remain. Species differences will always make the translation from animals to humans unreliable – even in animals whose neuroanatomy appears very similar to that of humans (except perhaps for those processes that arose early in evolution and that humans share with other species) [36]. The sort of thinking, where animal–human species differences are dealt with by using animals that appear “closer” to humans, is problematic because it focuses on superficial similarities between animals and humans and fails to adequately acknowledge important differences. The crude assumption that if two systems *appear* similar then they are likely to function similarly is incorrect. Over millennia, human and nonhuman species have adapted to very different environments, toxins, and pathogens, which in turn have resulted in very different microbiomes and immune systems [36]. Even very minor differences can result in substantial variations in biological processes and outcomes. These variations matter when it comes to developing safe and effective drugs for humans. Therefore, whilst internal validity and some aspects of external validity can in theory be improved, the problem of species differences cannot be overcome. Species differences will always undermine the extent to which findings from animal studies can be reliably applied to humans, meaning that animal models will never be fully scientifically valid, no matter how many “improvements” and modifications are attempted [30].

## 17.10 Ethics of Animal Research into TBI

In 1984, a research laboratory at the University of Pennsylvania run by Thomas Gennarelli was the subject of an undercover expose by the Animal Liberation Front (ALF). The ALF raided the laboratory, stole videotapes that researchers had made of their experiments and passed the tapes on to People for the Ethical Treatment of Animals (PeTA). PeTA produced a film that showed researchers laughing, smoking and behaving disrespectfully whilst a hydraulic device was used to inflict head injuries on baboons [37]. As a result, the university was fined and Gennarelli's funding was suspended. Because of ethical concerns regarding the use of nonhuman primates, the model was applied to pigs in the 1990s and later to rabbits [8]. Since then, however, there appears to have been little discussion about the ethics of TBI research.

This is bizarre because the harms that animals in TBI research suffer are particularly severe. As noted earlier, animals in TBI studies are restrained and have their brains deliberately damaged by a variety of means, including crushing, shooting, blasting, penetrating, probing, acceleration, rotation and spinal flexion. Many have surgical procedures performed in preparation for brain injury, and as noted above, many are followed up for varying periods and subjected to tests after being injured. Because of inadequate reporting, a phenomenon not specific to TBI animal research [16, 38], the extent to which animals receive anesthesia and pain relief is often unclear. It is also frequently unclear whether predetermined humane endpoints are established (i.e. points at which animals should be killed to end their suffering). Furthermore, as noted above, harms and their severity currently appear to be multiplying; suggestions for "improving" TBI animal models include making them more complex by adding in associated conditions or by increasing the injuries that each animal will be subjected to [4, 32]. Such modifications raise very loud alarm bells in ethical terms since, as noted above, these models are still bound to fail due to animal–human species differences [30].

Perhaps the current dearth of ethical discussion is due to ignorance about the type and extent of harms that animals experience as a result of TBI research. Little has been documented on these harms, but a retrospective analysis of 17 TBI research studies produced sobering results [39]. The studies were conducted between 1975 and 2005 in the USA, Israel, Turkey, Sweden, Germany, Mexico, South Korea and Taiwan. These TBI studies aimed to investigate whether corticosteroids could reduce intracranial pressure after brain injury. Between them the studies used at least 2296 animals (an accurate estimation of numbers was difficult due to poor reporting), including 1163 mice, 863 rats, 210 guinea pigs, 31 monkeys and 29 cats. For these studies, brain injuries were inflicted on animals, and the effect of corticosteroids on recovery was tested. The most common way of inducing brain injury (14 studies) was through the use of devices designed to drop weights or protruding rods onto restrained animals' heads. In one study, monkeys were attached to a sled that crashed at speed. In three studies, animals were not anesthetised, and in two studies, animals were only lightly anesthetised. No studies reported using painkillers, but one study that used only light anesthesia and inflicted injury by dropping weights on animals' exposed skulls reported that animals "did not seem to need any analgesics" (p. 396 in [40]). Animals were reported to die upon impact in eight studies, accounting for an estimated 10%–18% of animals in these studies. One study reported post-operative wound infections in two animals.

The animals were observed for varying lengths of time post injury, and some were tested for neurological status and grip. They were followed up for periods ranging from 2 h to 30 days. Nine studies reported that some animals died before the experiments had ended, indicating a severe level of suffering. In one study, animals were left to die of their injuries rather than being killed at the end of the experiment. Only one study mentioned post-operative care. The majority of the studies (76%) made no ethical statement (i.e. it was unclear whether the study received ethical approval, underwent ethical review, or followed any ethical guidelines). The harms experienced by animals in these studies were scored by a panel of experts according to the EU's severity classification (Annex VIII), which is similar to the American system in that both classify pain, suffering and distress into categories of mild, moderate or severe. Most of the panel scored the harms experienced by animals in these studies as "severe".

Since this investigation was a reanalysis of research conducted by Perel et al. [25], who explored the quality and clinical relevance of the same animal studies, it was possible to ascertain that the scientific quality of the 17 TBI studies was poor and that they did not result in any benefits for humans [25]. In fact, when corticosteroids for TBI were taken to clinical trials, they were associated with increased human mortality [25]. All in all, then, these 17 studies involved severe harms to animals, were of poor scientific quality, did not result in benefits for humans, and were associated with human harms, including death.

In the European Union, research projects using animals have to be independently evaluated by a competent authority as part of the approval or licensing process. This prospective evaluation involves a harm benefit analysis (HBA) to assess "whether the harm to the animals in terms of suffering, pain and distress is justified by the expected outcome" and whether the research "may ultimately benefit human beings, animals or the environment" [41]. As such, animal research is situated within a Utilitarian [42], instrumentalist, goals-based or consequentialist [43] ethical framework, where the end is deemed to justify the means. The ethical context of this framework is one in which humans are seen to count more in moral terms than animals; consequently, it is considered acceptable to allow animals to be harmed if the outcome is beneficial to humans. In the 17 studies discussed above, however, the harms to animals were clearly not outweighed by any benefits to humans. According to HBA criteria then, they should not have been approved.

The HBA is one of two ethical frameworks intended to safeguard research animals and has been a legal requirement in the UK since the Animals (Scientific Procedures) Act 1986 and in the European Union since 2013 [41]. In the USA, there is no legal requirement to perform a HBA, but in the USA the Institutional Animal Care and Use Committee is obliged to weigh the objectives of each study against its potential harms to animals [44].

The second ethical framework governing research animals is the 3Rs (i.e. the replacement, reduction and refinement of the use of animals in research) [45]. The reduction component encourages the use of fewer animals but has so far been unsuccessful. The refinement component (i.e. the use of methods and techniques that minimize harms to animals) currently gains the most attention from scientists working on animal models, possibly because it does not question the ongoing use of animals in research. With the increasing development of new, non-animal technologies and approaches, however [46], the concept of replacement is beginning to present a fundamental challenge to the animal model paradigm.

## 17.11 Advances in Human-Relevant (Non-animal) Research Methods for Investigating Human TBI

A variety of in vitro methods is being developed for investigating TBI. Single or mixed cell cultures and whole brain sections can be used to investigate the role of a single cell type in the pathophysiology of TBI. Cultured cells or tissues can be damaged by various means, including compression, load and acceleration, or by deforming the elastic substrate on which cells are cultured [32]. In vitro TBI models attempt to accurately reproduce each distinct mechanical component of TBI without systemic confounding factors such as inflammation, hypoxia and ischaemia [28], thus permitting tighter control of experimental variables and therefore greater experimental fidelity. Tissue models can be useful for understanding how tissue deformation (which, for example, can happen as a result of deceleration forces in car crashes) leads to brain damage [47]. The brain-on-a-chip system consists of 3D cell cultures that attempt to model the physiological responses of brain tissue in a microfluidic environment. These systems are currently used for high-throughput screening of chemicals to investigate whether any have a positive physiological effect on a micromodel of a neurological disease [28]. However, brain-on a-chip models also offer the potential of studying disease processes, although currently the ability to accurately model TBI on a chip is limited because of its complexity and incompletely understood pathophysiology [28]. Although study of the pathological sequelae of brain injury is more complex than study of the acute injury (involving as it does several processes such as inflammation and hypoxia), in vitro research is active in this area [28]. In vitro studies of TBI are clearly more ethical than animal studies, but it is argued that they are also more cost-effective [28, 48], allowing more data to be obtained in a shorter time frame, especially if a high-throughput format is used. Nevertheless, whilst in vitro studies appear to have enormous potential, there is clearly more work to be done in this developing field.

## 17.12 Conclusions

This chapter has shown that the traditional Utilitarianism argument in favor of TBI animal models (and animal research in general) appears to be gravely undermined by the evidence, namely that animal models of TBI lack scientific validity and have failed to lead to human benefit. Furthermore, the poor quality of animal TBI research renders that research invalid, meaning that the severe suffering endured by animals loses its moral justification because the animals' use cannot possibly contribute towards clinical benefit. Given that the Utilitarianism approach, which governs animal research regulation, appears to be no longer fit for purpose, a new ethics of animal research is required. It is vital that an updated ethical approach takes account of the burgeoning evidence regarding the poor quality of much animal research [16, 20, 22, 23, 38, 49–54] and its lack of translation to clinical medicine [21, 25, 55–60].

Animal models of TBI appear to be deeply unethical, not only for the animals involved but also for humans with TBI who continue to lack any effective treatments. Nevertheless, animal studies of TBI continue to be approved by ethical review boards and licensing bodies, indicating that current regulatory systems are failing to safeguard animals and humans and failing to ensure that only beneficial, scientifically rigorous research is approved. At present, responsibility for the authorization of animal studies in the UK is shared amongst researchers, ethical review boards, peer reviewers of funding applications and licensing bodies such as the UK's Home Office [61]. Consequently, crucial checks relating to the scientific rigor of studies, their likelihood of benefit, the availability of non-animal technologies and the assessment and minimization of animal harms are conducted in an inconsistent and disparate manner, with no guarantee that all the bodies involved hold the appropriate expertise. As a result, key checks for safeguarding animals may fall between the cracks. There ought to be much greater scientific and ethical scrutiny of project applications involving animals, and this scrutiny would be more effective if it were more centralized and coordinated.

The level, range and consistency of expertise on ethical review boards must also be increased. Such boards should include an expert in statistics and experimental design to guarantee the scientific rigor of the study, as well as an expert in the relevant in vitro technologies to determine whether it is possible to use these instead of animals. Moreover, experts from a wide range of disciplines (e.g. epidemiology, public health, clinical research) should be involved in ethically reviewing and authorizing studies so that wider questions may be asked about the appropriateness of the research question and whether animal research is the best way to answer it. Funders, journal reviewers and licensing bodies should pay greater attention to the possibilities for reducing suffering by mandating the consistent use of anesthesia and analgesia. Shockingly, severe harms continue to be permitted within current regulatory frameworks. Both Directive 2010/63/EU [41] and current US policy [62] allow severe unalleviated pain, suffering or distress, although it is supposed to require strong justification. Clearly, if regulators are at all serious about animal welfare, there is a very pressing need to review regulations that permit animals to suffer severe harms.

Arguably, an expectation of sufficient net benefit to humans must be a condition of morally responsible animal research [63], yet little attention is given to the problem of prospectively assessing the benefit of animal studies [44]. An objective view of benefit is difficult since scientists tend to be overly optimistic about the potential benefits of their research, particularly when seeking funding [64, 65]. This optimism, together with an implicit confidence in animal research [24, 66], is likely to bias assessments towards a prediction of benefit. Yet increasing doubts about the validity of findings derived from animal studies and their translation to humans suggest that this confidence is unwarranted. To increase transparency and allow reviewers to assess the status and strength of the animal data, we recommend that funding and licensing bodies make it a requirement that project applicants, as part of their application, conduct a systematic review of existing animal studies in their field [56, 67, 68] and where possible compare the findings with the comparable human data. We also urge funding and licensing bodies, peer reviewers, and ethical review boards to adopt a precautionary approach when assessing animal studies so that—in line with the evidence—they assume that the research is *unlikely* to benefit humans. This would place the burden of proof on those submitting proposals and encourage them to make a much stronger case for any anticipated benefits.

Finally, it would be easier to assess the prospective benefits of individual animal research projects if the relevance to humans of preclinical animal research *in general* was systematically evaluated [63]. This is an undertaking that a previous UK government's chief scientific advisor also thought important. In his 2016 lecture to the animal research community, he asked: "To what extent have we as a community, ever subjected our claims about how vital animal research has been to human health to the same level of scrutiny we'd apply to those claiming to have discovered a new cure? And I think if not, we must" [69].

The evidence suggests that animal research into TBI is crude, harmful and ineffective. Given that animal models of TBI have used countless animals and resources yet have failed to result in even one beneficial drug for humans, surely a good argument could be made for refusing to approve any further animal studies of TBI and, instead, for investing resources into prevention—which is of proven effectiveness—and into developing and evaluating the potential of new, human-relevant technologies for drug discovery.

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