How Science Engages with Ethics and Why It Should

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An Interdisciplinary Approach

Edited by
Kristen Renwick Monroe

DE GRUYTER

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Science is not perfect. It can be misused. It is only a tool. But it is the best tool we have, self-correcting, ongoing, applicable to everything. It has two rules. First: there are no sacred truths; all assumptions must be critically examined; arguments from authority are worthless. Second: whatever is inconsistent with the facts must be discarded or revised.....The obvious is sometimes false; the unexpected is sometimes true.

Carl Sagan

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Contents

Acknowledgments —— VII

Kristen Renwick Monroe
Introduction —— 1

Jeffrey A. Barrett
Chapter 1
The Pragmatic Nature of Empirical Science —— 13

James Hicks
Chapter 2
Ethics Training in Science: What We Miss in Health Research —— 27

Kristen Renwick Monroe
Chapter 3
When Things Go Wrong and Science Forgets About Ethics —— 39

Monica De Roche and Roxane Cohen Silver
Chapter 4
Ethical Issues in Research with Human Subjects —— 61

Rose McDermott
Chapter 5
Human Subjects Research: One Professional Association's Attempt to Establish Fair Institutional Guidelines —— 79

Kristen Renwick Monroe, Ali Ansari, Kendrick Choi, Hannah Dastgheib, Isabelle Dastgheib, David Han, Nate Kang, Alexis Kim, Connor Lee, Michelle Lee, Lauren O'Neill, Samuel Shih, and Anqi Wang
Chapter 6
Ethics in the COVID-19 Trenches: Research with Life and Death Implications and Limited Data Reliability —— 93

Mahtab Jafari
Chapter 7
Ethics and Pseudoscience in Our Daily Lives: The Status of the Science Behind Dietary Supplements — 103

Jessica M. Gonzalez
Chapter 8
Moral Cognition: An Introduction to the Field — 123

Peter H. Ditto, Shiri Spitz Siddiqi, and Mertcan Güngör
Chapter 9
The Social Psychology of Political Polarization — 139

Ashley J. Thomas, P. Kyle Stanford, and Barbara W. Sarnecka
Chapter 10
No Child Left Alone: Moral Judgments About Parents Affect Estimates of Risk to Children — 155

Brian Skyrms
Chapter 11
Trust, Risk, and the Social Contract — 221

Lawrence Sporty
Chapter 12
Good Science Is Not Enough: The Misapplication of Science as Seen Through America's Homelessness Crisis — 227

Teresa Sabol Spezio
Chapter 13
Climate Change: Policies, Politics, Science, and Equitable Solutions? — 239

Contributors — 257

Kristen Renwick Monroe

Introduction

Why a Scientific Analysis of Ethical Questions?

Abstract: Why a book on the scientific analysis of ethical questions? What is the scientific method? How does it differ from other analytical modes? What can it offer that these other methods of analysis do not? This book addresses these questions. We argue that too few people approach ethical questions – public or private ones – using methods involving any critical thinking, let alone scientific analysis or systematic approaches, grounded in empirical evidence. Many important and controversial public issues – such as climate change – seem surprisingly void of relevant science that can be subject to methodologically rigorous evidence-based assessment. This same lack of concern for solid evidence is evident in politics, where Trump's impeachment trial revealed a Senate where facts were ignored in favor of partisan politics. At the university level, students are not sufficiently trained in critical thinking and the skill of impartial and civil debate. This is especially disturbing since the ability to evaluate facts impartially often leads to important counter-intuitive findings. The scientific analysis of a real-life problem thus can help us – sometimes force us – to see the world differently. We hope our discussions will encourage both students and members of the general public to demand that evidence-based analyses form the foundation of our political discussions. It is time to turn away from partisan rants and to more nuanced and serious consideration of policies that affect our lives.

Keywords: Evidence-based arguments

We live in a time of extreme claims and weak consensus. Climate change is a hoax; climate change is destroying our planet. Vaccinations, masking, and social distancing can do much to protect us from COVID-19; such policies are an invasion of our personal liberty, designed by an all-powerful government intent on controlling its citizens. Donald Trump won the 2020 election; Joe Biden was legally elected in 2020. Disagreements over politics are not new. But when the stakes are so high – planetary existence, life and death from a pandemic, the future of democracy in one of the world's most stable democracies – how do we determine the validity of such conflicting claims, often broadcast by news agencies knowingly spreading falsehoods while claiming impartiality yet producing dramatically different presentations of the same basic facts? Introducing students – and members of the general public – to the tools necessary to evaluate

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evidence and engage in a systematic, impartial, and as objective analysis as possible is one purpose of this book.

But why a book on the scientific analysis of ethical questions? What is the scientific method? How does it differ from other analytical modes? What can it offer that these other methods of analysis do not? And what does it mean to utilize the tools of science to gain new insight into issues that relate to ethics at all? This book attempts to answer these questions.

The volume itself grew out of several interrelated concerns. The first is our concern that we live in an age when too few people approach ethical questions – public or private ones – using methods that involve any critical thinking, let alone scientific analysis or systematic approaches, grounded in empirical evidence. In a time when important public issues – such as climate changes that affect the very existence of life on earth – are controversial, we find too many public discussions surprisingly reluctant even to acknowledge that there is a "science" of climate change that is relevant and subject to methodologically rigorous evidence-based assessment.[1] The same claim could be made about COVID-19 and the proper policies to combat it. Life and death literally hang in the balance.

This same lack of concern for solid evidence is evident at the political level, where the impeachment trial of President Donald J. Trump made clear that a majority of members of the top legislative body in the United States refused to consider the evidence at all in its evaluation of whether the most powerful man in the world should continue his job. Facts were ignored in favor of partisan politics. So the need for careful, analytical evaluation of evidence becomes a strikingly important concern for public citizens and for the very life of our civic culture and our democracy.

Second, as educators, we believe students need to be taught about both ethics and about how to evaluate scientific evidence. In a course in the winter term of 2020 at the University of California at Irvine, during a discussion on how to study for the midterm examination, one of the best students in the class – I'll call him John, someone curious, bright, and destined for law school success – said that he usually tried to memorize the top five points of a lecture. I suggested that such memorization is only the first important step on the road to integrating knowledge into the student's way of thinking and examining the evidence analytically. To me, this process of thinking critically was clearly something that students should hold dear; for John, it was not. In another class, a large class, a student

1 The media is also at fault here. In an attempt to be fair and unbiased, to present every side of a controversial issue, the media will often have one so-called expert for *each side*: one climate change believer, one climate change denier. This gives a false impression, however, especially since among reliable scientists actively publishing about climate change the number of science change deniers is more like one to three out of 100 rather than 50–50.

came to complain about her grade; in doing so, she inadvertently let slip that she had not done the reading in my class; indeed, she informed me she never did ANY of the assigned readings for ANY of her classes. I was shocked and shared this knowledge with the teaching assistant. The teaching assistant then gently informed me that she had been a TA for three years and that this was the common policy. Worse, she told me I was the only professor she knew who expected the undergraduates to think for themselves on their exams. The other professors, she said, just wanted to check for knowledge, so they tested for memorization, as John had been taught to do. I was horrified and shocked. But this incident also underlined the strong need for classes that stress what should be a commonplace, almost everyday part of education: teaching students how to think analytically, as impartially, and objectively as they can. Students also need to learn to challenge their professors, and all of their elders, and they need to learn HOW to do this, using evidence and careful analysis, not just angry disagreement. If we do not want to return to a world in which people do as they are told by authorities – educational, parental, religious, or political – then helping people learn to think for themselves must be a critical part of our educational system.

As a corollary to this, I would argue that we need greater concern with ethics in our educational system. This is not a book about the nature of ethics, so let us say only that I would stipulate that most interactions between two or more human beings involve ethics. Thus, whenever one's behavior touches another, we encounter ethical issues, defined more succinctly and simply to refer to a system of moral principles that affect how people make decisions and lead their lives. While there are many different questions to be posed and discussed here, it seems clear that ethics relates in some way to what is good for individuals and society. One of our goals in preparing this book then was to present actual and engaging illustrations of how using tools of science can yield new, often surprising, and even counterintuitive insights into ethical issues, in a way that they are not usually revealed when we restrict our ethical approaches to those emanating from philosophy or religion.

This phenomenon is clear in the work presented throughout this book. I discovered this first-hand myself when I began my own empirical work on altruism (*The Heart of Altruism*, 1994) and compassion (*The Hand of Compassion*, 2004). This research illustrated for me the value of following the clues wherever they follow you. It also demonstrated that traditional wisdom, long accepted, can be so wrong, at least in certain cases. In my case, I had been trained as a scholar coming out of a rational choice tradition, a theory that argues that *ceteris paribus*, people act out of their self-interest, subject to information and opportunity costs. I wanted to examine altruism, behavior designed to benefit another, even if that behavior risks harming the altruist. Clearly, such behavior does not "fit" into theories based on self-interest. Altruism thus constituted a challenge to all of social

science and evolutionary biology that depended on the self-interest assumption. I conducted my research as I had been taught, taking several years to read everything I could find on the subject, and designing a careful survey that would test the specific findings concerning altruism. For example, kin selection is a popular explanation in evolutionary biology, suggesting people will give up their self-interest for their relatives. In times of famine, then, a sister may forego having her own biological children in order to help keep her nieces and nephews alive. Is this altruism? Or does it merely move the self-interest explanation to the level of the gene, as Richard Dawkins (2016) suggests? Another illustration came from economics, where economists speak of reciprocal altruism. Such behavior occurs when Jane does something to help John in the hope that, later, John will return the favor (I once had a colleague tell me he would be on leave and that he had a grant that provided him with a secretary. While on leave, he told me, he had decided to let his secretary work for me since he had decided I was the colleague most likely to return the favor). Is this behavior what altruism is? OR is it deferred, self-anticipated self-interest? I structured survey questions to pose to altruists that would ask them directly about their behavior in these situations, and whether it was designed to engender reciprocal altruism or gene selection, or any of the other explanations for altruism that smuggled in self-interest.

I chose as baseline data entrepreneurs, people who clearly operated on the self-interest assumption, taking an idea and trying to profit from it. For altruists, I conceptualized a continuum from philanthropists (people who give away some of their wealth but keep a portion of it) to Carnegie Hero commission recipients (ordinary people who had risked their lives to save others, such as people drowning or in a car accident) to people who rescued Jews during the Holocaust, a group at the more extreme end of a continuum running from self-interested to altruistic behavior, since rescuers risked their own lives and those of their families, with punishment instead of praise from the immediate society. When I conducted the interviews, however, I encountered odd responses from the altruists I interviewed. They clearly found it extremely strange to be asked my questions about how they decided to risk their own well-being for others. I found myself constantly being told “there was no decision to take.” Bewildered, I eventually had to conclude that traditional explanations of moral choice do not explain people who risked their lives to help others. Those great thinkers, from Immanuel Kant to all those economists – including a few Nobel laureates – who had taught me at the University of Chicago simply had missed something critical, at least for some areas of life. The power of their intellectual argument blinded scholars to the critical areas of life in which the self-interest assumption simply does not hold. I had to search for an alternative explanation to the traditional view of moral choice as an agonistic one, in which the heroes search their souls and consciences and, as

the sun comes up in the East, decide to do the right thing. Despite this widespread view, in literature and academia, all the morally courageous people I interviewed described their actions as involving little or no choice, agonistic or otherwise. Over and over, to my astonishment, altruists told me that it was quite simple. You did not walk away from another human being in need. There was no thought process involved. "The hand of compassion was faster than the calculus of reason," Otto Springer told me, in explaining why he saved Jews during the Holocaust and continued to do so even after he himself was arrested and put into a concentration camp. You had no choice, let alone the agonistic choice that dominates philosophical discussions of moral choice. One's sense of self in relation to others was so strong that it set and delineated the range of choice options altruists felt available, not just morally but cognitively. Turning away from another human being in need simply was not an option that even entered the minds of the altruists I interviewed. It was unthinkable. It was not on their cognitive menu, much as Sushi is not available on the menu of an Italian restaurant or pizza not found in an ice cream parlor. It was inconceivable because of the kind of person they were. Everything I had been taught, then, had to be reevaluated in light of a careful empirical analysis. I had to change the way I viewed the world as a scholar in light of striking empirical evidence.

My experience is but one illustration of how the scientific analysis of a real-life problem can help us – sometimes force us – to see the world differently. Other illustrations also demonstrate how a scientific analysis can lead to the surprising upending of traditional wisdom, often in ways that are counterintuitive.

Let me mention just two other examples, discussed at length later in this volume, of how a scientific analysis can yield new insight into an important ethical issue. Ashley J. Thomas, Kyle Stanford, and Barbara Sarnecka, philosophers and cognitive psychologists, present a thoughtful analysis of how our decisions about other people's preferences vary according to whether we assign moral overtones to them. Their chapter examines how moral intuitions affect risk assessment. Specifically, it shows that when people make a negative moral judgment about parents who leave children alone, then the estimate of how much danger the child faces in that situation goes up. These findings are important for evaluating decisions over when leaving a child alone should be considered abuse or neglect. Their study suggests that when people decide how much danger a child is in (including deciding when the danger constitutes abuse or neglect), they seem to base their estimates at least partly on their moral judgments of the child's parent. At a broader level, Chapter 10 of this work builds on Stanford's earlier work ("Ice Cream and Nazis") which notes that we do not care if people's preferences differ from our own on issues such as the choice of ice cream (you like vanilla. I like chocolate. Who cares?). But when moral considerations enter, we feel differently

about the preferences of our friends, family, and fellow countrymen (I like the Democratic Party. You like the Republicans. Ordinarily, fine. But not when Donald Trump is in office. Or not when the Nazi Party is on the ballot). Stanford notes that it is much easier for people to compromise when an issue is not cast in moral terms. People can find a middle ground on a budget issue but not on issues such as abortion. Ironically then, especially for people like me who often argue the need for increasing morality in politics, doing so may actually contribute to some of the polarization and intransigence that has recently characterized American national politics, with politicians more interested in scoring points and frustrating the opposition than in finding compromise leading to policies that help everyone. This is another instance when a careful, empirically-based analysis leads to surprising and somewhat counter-intuitive findings whose implications should make us re-think some of our basic assumptions.

Similarly, Mahtab Jafari addresses the important issue of replication and high-quality studies in science and brings it into the home with her work on dietary supplements. Is there anyone who has never taken any dietary supplements, she asked when she gave a guest lecture to a class on politics and ethics? Not one student in the class raised their hand. One student believed his brother had never taken any supplements but was not sure. All the rest of us had taken vitamins or "natural" medicine to ease our aches and pains or to make us faster or better, slimmer, more beautiful, intelligent, or stronger in some way. Jafari shocked the class by telling them how dietary supplements are not regulated the way pharmaceuticals are and how few of the studies that "proved" the value of these supplements have ever been replicated. She had personally purchased a popular supplement from the five top stores selling one such supplement. When she tested these supplements to determine if the pills (1) included any of the natural ingredients the manufacturers claimed made their pills work so well and (2) included synthetic molecules (and not natural products), Jafari found only one supplement actually contained any of the ingredients it was supposed to contain; further, that substance – that was supposed to contain an organic substance – was only one molecule of an artificial substance it claimed to give to its purchasers. What was claimed to be in the pill simply was not there. A scientific test could not replicate the claims of the manufacturers.

So one further impetus driving the production of this volume is to provide concrete illustrations of the value of using scientific tools to analyze ethical issues, issues more traditionally relegated to the domain of the religious scholar or philosopher.

Before we could discuss the values of scientific methods and approaches, however, we realized we had a prior question to address. What is the scientific method? How does it differ from other modes of analysis? What are its strengths? Its limitations? And why is it often so controversial and so seldom applied to ethi-

cal questions? These discussions may have seemed theoretical, of interest only to a few scientists or scholars. But then COVID-19 struck. After COVID, the idea of a scientific method, its politicization, and the need for an informed public, able to evaluate scientific data critically and independently, seemed abundantly clear to many. Yet not to all.

Part 1 of the volume thus begins by discussing the scientific method itself. Chapter 1 outlines the central components of the scientific method, drawing on knowledge of the origin of this scientific method within (largely) Western science. Jeff Barrett discusses the method itself and the limitations of this approach. His chapter suggests that empirical science is ideally suited to inform both individual decisions and public policy. This is not because the conclusions of empirical inquiry are always correct. Indeed, good science requires one to suppose that one's conclusions are always subject to error. Rather, science is useful for practical matters because it must always answer to success and failure in action. This is also the source of objectivity in empirical inquiry. Barrett's chapter reviews two belief-revision models of empirical knowledge that illustrate how this works: the first was proposed by C. S. Peirce; the second is a version that allows for degrees of belief. Barrett considers how the response to the COVID-19 pandemic provides an example of the logic of empirical inquiry.

If we advocate the use of a scientific approach to analyzing questions of public policy, or indeed the use of science to explore a whole series of questions that confront people as they think about ethical issues, we also must inquire about the value AND the limitations in the scientific method and the tools of science themselves. Part 1 also thus focuses on the ethical issues involved in doing research, especially with human subjects. We do not uncritically laud the scientific method; indeed, in Chapter 2, James Hicks notes some horrifying abuse of human beings by scientists, in medicine, in clinical work, and in scientific experiments in a wide range of fields.[2] In Chapter 3, I describe some atrocious violations of ethical standards of human decency in the pursuit of science. Surprisingly, sometimes these ethical lapses are by eminent and well-respected scientists who changed our world (Sigmund Freud, as viewers of *The Crown* know, performed horrible treat-

2 While the term "ethics" and "morals" are frequently used interchangeably, we do not attempt a full discussion of their differences here except insofar as to note that the most frequent distinction is to designate ethics as referring to rules provided by an external source, e.g., legal codes of conduct, rules in workplaces or principles in religions. In contrast, the term "morals" is more frequently utilized to refer to an individual's own principles concerning right and wrong. These include the Tuskegee experiment on black convicts, the Nazi experiments on World War II prisoners, and a whole range of famous experiments, such as the Stanford Prison experiments and the Milgram experiments on authority.

ment of patients, such as Princess Alice, mother of Britain's Prince Phillip. Nor was Alice the only victim of Freud's misplaced zeal to treat patients). Chapter 3 also describes the dreadful Tuskegee experiments, in which black prisoners involved in experiments about syphilis had penicillin withheld from them long after it was clearly a potential cure, all in the interests of science. Electric shocks have been given to children and to adults; often, the children are orphans and the adult members of minority groups against whom widespread societal prejudice exists, for example, Blacks and homosexuals. Abuse occurs among respected institutions, from governments to academia. Project NKUltra was conducted by the CIA and the Little Albert experiment with a young child and a white rat was conducted by the father of behaviorism, John Watson. The Stanford prison experiments, in which a group of young male students at Stanford were placed in a mock prison environment, showed how easily the situation could turn "normal" people into little monsters, and the Milgram experiments at Yale showed how easily ethical norms can be disregarded when an authority figure condones it. These are troubling experiments, then, not just because some of them clearly violate the rights of human subjects but also for what they alert us to in terms of policy and human behavior more generally.

These ethically reprehensible experiments are not all in the distant past, either (Dr. Levin's experiments on homosexuals in South Africa are frighteningly chilling and yet Levin now teaches in Canada). But fortunately, the scientific community has taken steps to prevent such ethical violations in the future, as is noted in the next two chapters. Roxanne Cohn Silver and Monica De Roche describe the response to these abuses, outlining the attempt from the Nuremberg Trials to the Belmont procedures to create ethical standards for scientific work (Chapter 4). We consider how these violations of ethical concerns led to the development of particular prohibitions and institutional review boards to help prevent future violations and help aid researchers as they construct future research with human beings. In Chapter 5, Rose McDermott then suggests how professional societies enter the discussion by trying to establish written guidelines for their members as they do in social science research. A member of the Ethics Committee for the American Political Science Association (APSA), McDermott treats the attempts/discussions by the APSA as a way to take us into the inner working of a professional society as it grapples with these ethical issues of scientific research. Her chapter reveals how challenging it can be to develop consensually acceptable principles to guide research with human subjects in general, and for experimental work more particularly. Nonetheless, McDermott cautions, it is imperative to try to do so in order to protect the rights and dignity of participants. In addition, it is also critical to prevent unwanted harm to large populations who might be impacted by field experiments, including work they may not even be aware exists. Chapter 5

provides a discussion of some of the critical issues raised by the committee working within the APSA to update ethical guidance around work involving human subjects, followed by an outline of one attempt to introduce a new principle for the protection of populations in the case of field experiments. The chapter concludes with some reflections on the political challenges associated with instituting more ethical considerations of subjects.

Chapter 6 raises the disturbing question of what to do when it is imperative to craft reliable public policy but the empirical data are unreliable. This was the case with COVID-19. As the unknown disease made its way throughout the world, governments and public health officials struggled to find reliable information, both on the medical nature of the disease and on what public policy measures would combat the virus. As the chapter makes clear, even now the question of the best response to pandemics such as COVID-19 remains unclear and certainly controversial.

Part 1 thus lays the groundwork for understanding both what the scientific method consists of, its uses and limitations, how it has been abused, and how scientists of goodwill are trying to establish ground rules that will protect human subjects and help guide researchers in the future. Part 2 offers specific illustrations where scientific analysis has lent insight into particular intellectual topics, as diverse as artificial intelligence, climate change, and childcare to the psychology of political polarization, the impact of social class on our decision-making, and the social contract. It describes several fascinating scientific techniques and how they have been successfully utilized to gain insights into critical problems. These techniques are as different as game theory, neuroscience, narrative interpretive analysis, and surveys. Unlike traditional approaches to ethics, emanating from philosophy and religion, our methodology asks how real people actually think about ethical dilemmas and choices.

Mahtab Jafari (Chapter 7) begins Part 2 by taking us from the inner working of a professional society concerned with politics to the importance of scientific standards in the area of dietary supplements. She paints a horrifying picture, where many unscrupulous venture capitalists establish companies in their garages; if and when they are charged and confronted with Federal Drug Administration agents who raid their "plants" (garages) they simply pay the fine, close down, and move into a neighbor's garage under a new company name. Jessica Gonzalez (Chapter 8) reviews the literature on experimental philosophy and moral cognition, an area at the intersection of several new fields that empirically test commonly held assumptions about human beings and how they actually behave.

We include a wide range of important behavior in our examples from voting and cooperating to making policy decisions on climate change and on the homeless. In

Part 2, we discuss issues in bioethics; social psychological surveys and interviews explain political trauma, such as that following 9/11 or among Syrian refugees. Chapter 9 by Peter Ditto, Shiri Spitz, and Mertcan Güngör tackles the important question of political polarization, and what can lessen it. This chapter provides another striking example of how careful, evidence-based, empirical work can provide counter-intuitive information about a pressing public problem. Similarly, we have already discussed the important question discussed in Chapter 10 by Ashley J. Thomas, Kyle Stanford, and Barbara W. Sarnecka of how moral judgments get formed and translated into public policies, sometimes to the detriment of the people involved. We include innovative work on game theory (Chapter 11), revealing new, counter-intuitive insight into cooperation. Lawrence Sporty (Chapter 12) provides a link between the world of medicine and the world of business, finance and politics, a link increasingly clear as the COVID-19 pandemic continues. His chapter sheds new and distressing light on the policies concerning mental health in the United States and provides a chilling illustration of how good intentions and good policy can lead to disastrous results. Teresa Spezio concludes the book with a discussion of the ethical issues involved in the politics of climate change (Chapter 13).

There are many other issues we could have addressed but did not, due to reasons of space and time. What are the ethical concerns involved in doing narrative interpretive analysis based on interviews with human beings? How does a researcher best navigate the difficult ethical terrain here, as when – for example – vulnerable human subjects, who have survived genocides or ethnic cleansing, human trafficking, or other traumatic experience, need to be protected? Will retelling their stories harm them? Free them from some of their pain and emotional isolation? What guidelines does a researcher have when conducting interviews with such people? With young children? Recognizing the value in conducting such research, while still acknowledging the potential power to harm, makes the establishment – or at least the need to be aware of the sensitive issues involved in such interviews – of guidelines an imperative if there are difficult questions. We hope to explore these issues in future work.

Most of the chapters in this book were written and presented in an ITS course, funded through a generous grant from the University of California at Irvine. But additional chapters were solicited from outstanding experts in the field, such as Rose McDermott (who discusses how professional societies attempt to encourage ethical work within the confines of its specific subject) or Barrett (who brings his expertise as a philosopher of science to the book) or Teresa Spezio (who addresses the surprisingly controversial topic of the science of climate change). All of these contributors brought their own expertise to reveal the wide range of scientific approaches that explicate the etiology of ethics.

We hope that our discussions will encourage both students and members of the general public to demand that evidence-based analyses form the foundation of our political discussions. It is time to turn away from partisan rants and to the more nuanced and serious consideration of policies that affect our lives.

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Jeffrey A. Barrett

Chapter 1
The Pragmatic Nature of Empirical Science

Abstract: Empirical science provides our best understanding of the world. While it is not infallible, we will consider here why it is nevertheless the best possible guide to practical action. On a belief-revision model of scientific knowledge, science is an ongoing process of trial and error. We are often unsuccessful in action. But we are committed to revise our beliefs in such a way that we eliminate the descriptive error that led to the failure. It is this commitment that explains the practical success of science in informing personal decisions and public policy.

Keywords: scientific method, belief-revision model of knowledge, pragmatism, public policy

Empirical science is both fallible and the best possible guide to practical action. These two features of inquiry are essentially related. The reliability of science as a guide to successful action depends on the fact that our best understanding of the world is always open to revision. The COVID-19 pandemic illustrates how empirical science works and how it serves to inform personal decisions and public policy.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first identified in late 2019. Within a few months, the virus had been detected worldwide. In January 2022, more than 800k COVID-related fatalities had been reported to the Centers for Disease Control and Prevention (CDC) in the United States alone.[1]

The manifest seriousness of the worldwide pandemic led to the rapid development of several vaccines. They were engineered using extensions of currently existing technology and what was known of similar viruses.[2] Some of these vaccines proved highly effective against the original SARS-CoV-2 virus and early variants. As of September 2021, the CDC reported that all FDA approved or authorized COVID-19 vaccines were safe and effective, demonstrating a high clinical efficacy (between 65% and 95%) against symptomatic, laboratory-confirmed COVID-19 in adults over 18 years of age and a high clinical efficacy (at least 89%) against COVID-19 severe

1 Reported in the CDC's *Trends in Number of COVID-19 Cases and Deaths in the US Reported to CDC, by State/Territory* as of 9 January 2022.

2 See Li et al. (2020) for an account of COVID-19 vaccine development.

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enough to require hospitalization.[3] The vaccines also exhibited a high level of real-world effectiveness. The average effectiveness of full vaccination against SARS-CoV-2 infection was 85–95% shortly after completion of vaccination for early infections.[4]

We subsequently also learned of the practical limits of the vaccines. There is good evidence that their effectiveness decreases over time.[5] And while there is reason to believe that the vaccines available as I write will reduce the seriousness of infections, they are not expected to be as effective in altogether preventing illness from new variants like Omicron (B.1.1.529) that implement many novel mutations.[6]

While the best science suggests that the current COVID-19 vaccines are safe and effective, is it possible that we also somehow got this wrong? Of course it is. We know a lot now about short- and medium-term safety, but there are issues of long-term safety for which we do not yet have much evidence. And while it is difficult to doubt the efficacy of current vaccines against the original SARS-CoV-2 virus and early variants, it is possible that we will always need new vaccines to keep up with new variants.

The reader may consider what we subsequently learned after this was written and how what we learned affected public policy. Empirical inquiry is an ongoing process. Indeed, this is why we can do no better than to use the results of careful empirical science to inform our decisions and public policy.

While our present conclusions are always fallible, they are the best guide we have for the decisions we make now. The reliability of empirical science is in part because science explicitly recognizes its own fallibility. It is also because the process of empirical inquiry is driven by objective considerations. Empirical science is objective because it must ultimately answer to success and failure in action. It is revised when it fails to make the right empirical predictions or provide satisfactory explanations for what actually happens, and it is revised with an aim to promoting reliably successful action.

Our best scientific theories are sometimes contrasted with common sense. Notions like curved spacetime from general relativity and superposition and entanglement from quantum mechanics are counterintuitive. But as the philosopher and logician W. V. O. Quine noted, “Science is not a substitute for common sense but an extension of it” (1957, p. 229). Indeed, science is perhaps best understood as a variety of refined common sense. The sort of empirical knowledge that results

3 See the section “Vaccine efficacy from human clinical trials” in the CDC *Science Brief: COVID-19 Vaccines and Vaccination*. See also the CDC *Frequently Asked Questions about COVID-19 Vaccination*.

4 See Kow and Hasan (2021) and Shapiro et al. (2021) for meta-analyses of the real-world data.

5 See the section “Duration of protection” in the CDC *Science Brief: COVID-19 Vaccines and Vaccination*.

6 See the tentative CDC assessments of the Omicron variant in the references.

from scientific inquiry is refined in precisely such a way that one should expect there to be nothing better for informing our deliberations with respect to the decisions we make and the policies we adopt.[7] At the same time, it is essential to how science works that even our best theories may well be mistaken.

To properly assess the nature of scientific inquiry and its present conclusions, one must have a clear understanding of the sense in which our best empirical knowledge is both objective and fallible. A good way of getting at this is by considering how empirical inquiry works and the relationship between common sense and our best empirical theories.

A Belief-Revision Model of Empirical Knowledge

The methodology of science meshes well with a belief–revision model of knowledge. One starts with what whatever beliefs and commitments one in fact has. Then one investigates the world, debates with other inquirers in the community, weighs the evidence, and updates one's beliefs. The conclusions that the community reaches along the way are the tentative content of scientific knowledge. This knowledge represents the product of our most careful inquiry, the best that we can do given where we started and what we have explored so far.

Inquiry begins with commonsense beliefs and increasingly yields more refined scientific commitments. We will start with C. S. Peirce's characterization of empirical inquiry,[8] then we will consider a model that allows for degrees of belief and probabilities.

Peirce sketched how empirical inquiry works in his essay "The Fixation of Belief" published in *Popular Science Monthly* in 1877. On his telling, the sole object of reasoning is "to find out, from the consideration of what we already know, something else that we do not know" (1992, p. 111). Knowledge, then, proceeds from one set of beliefs to another as one considers new evidence and arguments.

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7 Science as refined common sense is also suggested by the belief-revision model of knowledge that Quine sketches in section 6 of his paper "Two Dogmas of Empiricism" (1951, pp. 42–46). Regarding the sort of refinement involved, Quine held that the only significant difference between commonsense inquiry and empirical science is that the scientist is more careful than the average person (1957, p. 233). Here, as in his belief-revision model of knowledge, Quine was very much influenced by C. S. Peirce.

8 Charles Sanders Peirce (1839–1914) was the founder of American pragmatism. His research included work in philosophy, formal logic, physics, geology, psychology, and economics. See Burch (2021) for an overview of Peirce's philosophical contributions.

The aim of inquiry at every step in the evolution of knowledge is to form beliefs that will guide one to successful action.

Peirce understood inquiry as a natural consequence of the practical psychology of belief, doubt, and action. While doubt is an uneasy state where one is unprepared to act, belief is a calm state where one is prepared to act and confident of success when one does. As a result, Peirce held that we have a natural inclination to replace doubt with belief whenever possible. He took empirical inquiry to be nothing more than the process of replacing doubt with belief for the purpose of successful action. When one has formed beliefs salient to present action, one is comfortable. And with this inquiry ends (114–115). The central question, then, is how one ought to form new beliefs on the basis of one's old beliefs and new arguments and evidence.

Peirce famously considered four methods one might use to determine one's beliefs. On the *method of tenacity*, one simply aims to avoid doubt altogether by never giving up whatever one currently believes. There is clearly comfort in believing that one is never wrong, but it is hard to maintain this commitment in the context of others' often differing beliefs and the desire for successful action. On the *method of authority* one chooses, or often just finds oneself with, an authority, then one determines one's beliefs by whatever the authority stipulates to be the truth. The authority might be an oracle or Holy Scripture or a leader who unites the community. But again, it is difficult to maintain the commitment that one is following the one and only true authority in practice when there are incompatible authorities with their adherents. On the *a priori method* one's beliefs are determined by whatever is agreeable to reason. While this approach may sound philosophically respectable, it faces a similar problem to the first two. History suggests that what is agreeable to reason is largely a matter of fashion. Different people at different times find mutually incompatible beliefs to be agreeable to reason, and there is no reason on the face of it to suppose that what one finds reasonable will in fact lead to successful action.

Peirce took each of these methods to be manifestly subjective and hence ultimately unstable. Should even their practitioners carefully reflect on their methodological commitments, they would find that their beliefs are contingent on personal bias, historical accident, and fashion with nothing to square their conclusions with the nature of the world itself. It is psychologically difficult to maintain a commitment to the reliability of one's personal implementation of the methods above when it can have no advantages over incompatible implementations of the same method by others.[9] To satisfy such doubts "it is necessary that a method be found

9 See Peirce (1992, pp. 115–120) for a detailed account of each of these methods of fixing belief together with their virtues and vices.

by which our beliefs may be caused by nothing human, but by some external permanency – by something on which on thinking has no effect" (1992, p. 120).

In contrast to the three methods just considered, The *scientific method* is tightly bound to our actual success and failure in action and is hence objective in precisely this sense. Peirce characterized this method by appealing to a handful of considerations that he took to be of a piece with ordinary common sense. To begin, while we do not have infallible access to their properties, we tend to believe that there are real things whose properties are entirely independent of our opinions and that these real things affect our senses according to regular laws that we might determine by inquiry. As a result, we are led to believe that we might eventually determine the truth about the world we inhabit by means of empirical inquiry. While there is much to say about how Peirce understood inquiry, the core idea is that if we revise our beliefs to eliminate descriptive error whenever our beliefs lead to failure in action, then our descriptions of the world will become increasingly accurate and, hence, better serve to promote successful action.[10]

That said, Peirce took even the most careful results of empirical science to be provisional and potentially mistaken. We can never be sure that our present beliefs will continue to provide successful predictions and satisfactory explanations. Indeed, we will almost certainly need to revise them in some way in the future.[11] But we have done the best we can for now when we have accounted for our experience and responded to the relevant arguments of our colleagues to this point. On this view, then, scientific knowledge is fallible belief forged in the context of ongoing empirical inquiry. It is objective because it must always answer to success and failure in action, which is determined by the world itself, not by opinion.

While Peirce did not think that he could convince someone to be similarly optimistic regarding the results of empirical inquiry if they had radically different commitments, he did have a few things to say about his own sense of optimism. To begin, he noted that the scientific method is psychologically stable in practice. When he has used the method, no doubt has arisen regarding its reliability. Indeed, the psychology of belief and doubt underwrites the methodology of empirical science. That belief is a state where one feels prepared for successful action and doubt is an irritant that prevents action and leads to inquiry reflects our commitment to there being objective matters of fact, independent of thought, that determine success and failure in action and that empirical inquiry allows us

10 See Peirce (1992, pp. 120–121) for a description of scientific inquiry as he understood it. See Barrett (2001) for a more detailed reconstruction of his model of inquiry.

11 See Barrett (2003) and (2008) for descriptions of how this works.