

Induction Ain't What It Used to Be: Skepticism About the Future of Induction

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Abstract: We argue that, in all probability, the universe will become less predictable. This assertion means that induction, which some scientists conceive of as a tool for predicting the future, will become less useful. Our argument claims that the universe will increasingly come under intentional control, and objects that are under intentional control are typically less predictable than those that are not. We contrast this form of skepticism about induction, "Skeptical-Dogmatism," with David Hume's Pyrrhonian skepticism about induction.

Keywords: Induction; David Hume; Skepticism; Skeptical-Dogmatism

1. Introduction

Consider these two claims:

Increasing Predictability: Our ability to predict the future will increase in the future.

Decreasing Predictability: Our ability to predict the future will decrease in the future.

The first claim may seem more likely. Fifty thousand years ago, our ancestors would marvel at the accuracy of our weather forecasts, even though we today tend to grumble about them due to our high expectations of modern life. It is easy to imagine that these same ancestors cowered in fear during a solar eclipse, whereas we can make predictions of an eclipse years in advance. Scientists characterize the origin of modern science during the Copernican Revolution through the dramatic increase in our ability to predict various natural phenomena and the outcomes of our experiments. Since then, the value of predictability as an ideal of scientific theory has continuously risen to become the foundational methodology of mainstream science. Nevertheless, despite the seeming plausibility of the former claim, we argue in favor of the latter; that is, the value of

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decreasing predictability. Specifically, we contend that induction as a tool for predicting the future based on the study of the past will become less effective over time.¹

In other words, we argue for a type of skepticism in relation to induction. However, this section contrasts our own approach to skepticism with that of David Hume. Hume famously emphasized the difficulty of providing a philosophical justification for induction. While the details of Hume's argument continue to generate scholarly dispute, a brief characterization of his view on skepticism will suffice for the purposes of our argument. Hume asks how we might justify the following sort of inference (where "P" stands for premise and "C" for conclusion):

P1: The sun has risen every day in the past.

C: The sun will rise tomorrow.

As Hume points out, the above conclusion is incomplete without at least one more premise, which he addresses with the addition of "UP" to stand for the "uniformity of the universe premise":

UP: The universe "continues always uniformly the same".²

Hume challenges his readers to justify the validity of UP. However, for us to recognize the difficulty of this task, it is helpful to divide UP into two separate claims:³

UPP: The universe continued uniformly in the past.

UPF: The universe will continue uniformly in the future.

Hume asserts that an argument in support of UPF must be either deductive or inductive. UPF does not follow deductively from UPP in the same way that saying a shape with more than two sides is a triangle. Or, to put the point another way, there is no logical contradiction in saying that UPP is true and UPF is false. Hence, the former statement does not logically imply the latter. An inductive justification of UPF is less ambitious in that it attempts to support a merely probabilistic conclusion. The resulting argument thus implies that, since UPP is true, we have good reason to think that UPF is also true. However, if this line of reasoning is successful, then it depends on the truth of UP itself, which is the very thing we were trying to establish. In other words, there is a circularity in using inductive reasoning to justify inductive reasoning. The upshot of Hume's reflection is that there is no justification for UPF; hence, his theory does not justify UP. Hume does not go so far as to say that UP is false. Rather, he argues that there is no reason to either believe or disbelieve it. Hume's skepticism, then, is "Pyrrhonian" in nature in that, at least from a theoretical point of view, it upholds that we ought to suspend judgement about induction. Hume's skepticism thus challenges what we refer to as "Dogmatism" about induction, or the notion that we can justify both induction and a belief in UP.⁴

¹ We do not mean to suggest that this example is the only type of induction. However, many scholars consider "predictive inference" to be the most important use of inductive reasoning (Carnap 1962, p. 207).

² Hume (2012, 1.3.6.4). We use "universe" where Hume uses "nature" for reasons that we will explain below.

³ We will not detail complications relating to the metaphysical rejection of (i) the flow of time or (ii) the direction of that flow, or even (iii) our capacity to distinguish past and future. In the rest of this paper, we use the terms "past" and "future" in the most mundane sense possible, assuming standard (or "naïve") scientific realism. We also assume the simple linear topology of time, which is supported by our best cosmological theories.

⁴ The Skepticism vs. Dogmatism contrast originates with the ancients, see Sextus Empiricus (1996).

Here, we argue for a darker form of skepticism, one that maintains that we have reason not to believe UP. This idea is what we will refer to as "Skeptical-Dogmatism" about UP. To summarize the differences: while those who hold Dogmatic views about induction are "believers" of UP, Hume offers reason to suspend judgement or be "agnostic" about it. In our own approach to UP, we offer reasons to be "disbelievers."

2. The Natural vs the Social Sciences: The Great Predictive Asymmetry

An important premise of our argument is that there is an asymmetry in the predictive powers of the natural and social sciences. Typically, the former has a better track record of making successful predictions, which we can confirm by reflecting on the history of science. One notable success in the natural sciences during the Enlightenment period was Edmond Halley's prediction in 1705 that a comet (that now bears his name) would return to the Solar System in late 1758 or early 1759. Unfortunately, Halley did not live to see his prediction bear out in 1758 (he died in 1742). Nevertheless, he secured the predictive power of the new natural sciences in the public's mind.

Fueled by the predictive successes of the natural sciences, there was much optimism among thinkers that a historical study of human society would yield similar results in the social sciences. Perhaps the most famous of these ambitions is Karl Marx's prediction that capitalism would collapse and usher in communism as a new economic order. A diverse group of thinkers share the idea of establishing strong predictive foundations in the social sciences, including (but not limited to) Ibn Khaldun, Giambattista Vico, Auguste Comte, Émile Durkheim, and Pitirim Sorokin. However, the failure of Marx's prediction, along with other miscalculations about the future of human society, supports what is now a near consensus among scholars who favor the idea of an asymmetry in the predictive powers of the sciences. Specifically, these thinkers uphold that the natural sciences have a far greater predictive power than the social sciences.

The primary reason for a Skeptical-Dogmatist approach to induction is due to the likelihood that surveying the universe will come more under the scope of the social sciences and less under the predictive auspices of the natural sciences. To illustrate this point, consider again Halley's Comet. The Comet last reached its perihelion (its closest point to the Sun) on February 9th, 1986. The 1945 forecast that announced this event was of no surprise, since astronomers had long predicted the Comet's progress. Yet we can reasonably hold the greatest confidence in this early prediction of Halley's perihelion. One might wonder how this situation could be so. After all, astronomers have predicted that the next perihelion will occur on July 28th, 2061. Furthermore, our astronomical instruments and modes of calculating orbits are as good, if not better, than in 1986. The reason for our lack of confidence in the 2061 prediction is that the world will have a greater technological means to interfere with the Comet's trajectory by the latter part of the twenty-first century. For example, the Society for Thwarting Astronomical Predictions (STAP) have considered sending a rocket with a bomb to destroy a chunk of the Comet and thus obstruct the July 28th prediction. Admittedly, this proposal is not particularly likely, but the probability that some group of humans will pursue a similar goal is certainly not zero. Indeed, the probability is rising. In 1986, few countries had the technology to knock Halley's Comet off its course. However, it is likely that far more countries, along with a number of privately held space companies, will have the appropriate technology to interfere with the Comet's path during its next projected perihelion. Hence, with these additional possibilities, we should be less confident today about the July 28th, 2061 prediction for the return of Halley's Comet than we were in 1945. Both predictions are forty-one years in the future (2020/2061 and 1945/1986). Given that

our scientific techniques, instruments, and theories are better than they were in 1945, then, we should remain skeptical about the 2061 prediction.⁵

The above example illustrates a general tendency we refer to as the "pessimistic meta-induction." We offer the following arguments in support:

Technology Premise: over time, intentional action as a result of technological advances will affect or potentially affect more of the universe.

Predicting Intelligent Behavior Premise: parts of the universe that intelligent behavior can affect or potentially affect are less predictable than those that intentional activity does not affect.

Pessimistic Meta-Induction: hence, over time, our ability to predict the course of the universe will diminish.⁶

The term "pessimistic meta-induction" (PMI) needs unpacking. PMI is an inductive inference about inductive inferences; hence, we refer to it as "meta-induction." The term is pessimistic because it upholds that our best method for predicting the future, induction, will become increasingly ineffective. PMI could be a source of discomfort for those concerned about the future of humanity, and particularly those who hope to predict the future. If the future becomes increasingly harder to predict, we will have an increasingly difficult time attempting to steer humanity towards a better future or avoid potential disasters. However, accepting PMI does not imply that no predictions are possible. Rather, it merely limits the scope of such occurrences.

After some further clarification of our thesis, we will provide a defense of the two premises of the PMI argument.

3. What is the Pessimistic Meta-Induction?

We intend the term "induction" to encompass broadly the statistical and probabilistic reasoning that scientists employ when making predictions like the return of Halley's Comet.⁷ As we indicate below, while there is already evidence of PMI, scientists might not realize its full ramifications for centuries, perhaps even millennia. Still, relative to the age of the universe, the phenomena that PMI covers will emerge very rapidly.

In thinking about the effectiveness of predictions, there are at least two important dimensions of evaluation. The most obvious dimension is that of truth: we aim for true predictions. Precision is another important dimension, which we will illustrate with a brief anecdote. One of the authors of this paper once boasted to his class that he could successfully predict a coin flip one hundred times in a row. If his prediction failed, the author promised that he would excuse the class from their assigned homework. The class was very skeptical (but also hopeful). We are happy to report that the author did not make

⁵ There is an additional reason why this situation is so, one that is unrelated to human society. Some alien civilization or individual alien actor may interfere with the motion of Halley's point. Although the probability of this interference currently remains small, it increases with time. This claim is pure astrobiology. As the Galaxy becomes more habitable with cosmic time, there is more time to impact one's physical environment, for example. For further details, see Ćirković and Balbi (2020).

⁶ We borrow this term from Larry Laudan, who uses it in an entirely different way (Laudan 1981).

⁷ To clarify: predicting the return of Halley's Comet with the degree of precision above is not as simple as saying that it has always returned exactly 75 years later and, therefore, will return in 2061. In fact, the orbital period of Halley's Comet for the last thousand years or so has been between 74 and 79 years. To predict with the above precision, scientists must calculate the gravitational effects of the Sun and other bodies in the Solar system, as well as more complex, non-gravitational forces that affect the cometary nuclei near the perihelion (Davidsson and Gutiérrez 2006). Scientists have historically grounded each of these models and predictive techniques in inductive inference from many astronomical observations.

his boast in vain. He achieved this feat by predicting that the coin would land on either heads or tails.⁸ The prediction was true, but not precise.

Predictability is relative to one's epistemic capacities. A dog, with its superior sense of sound, might be better at predicting the presence of a stranger approaching the front door than its human companion. By "less predictable" here, we mean less predictable by the standards of human beings. This point will become important later in our discussion.

Our thesis is comparative: to say that our ability to predict the course of the universe will diminish is to compare our future ability with our present ability. To illustrate this comparative claim, consider three "toy" universe types:

Type 1 Universe: A deck of cards is turned over one card at a time. The deck is never reshuffled. Thus, the three of hearts appears every 52nd time a card is turned over, and the nine of clubs appears every 52nd time, and so on.

Type 2 Universe: A deck of cards is turned over one card at a time. After the entire deck has been turned over, the deck is reshuffled.

Type 3 Universe: A deck of cards is turned over one card at a time. After each card is turned over, it is then replaced. The deck is then reshuffled.

These simple universes are easy to rank in terms of their predictability: Universe 1 is more predictable than Universes 2 and 3, and Universe 2 is more predictable than Universe 3. Even so, Universe 3 is not entirely unpredictable: we know that the cards are regularly shuffled and turned over in Universe 3, so the outcome is predictable to a certain extent. In terms of this analogy, our universe is moving from something like a Type 1 Universe to a Type 2 Universe, and perhaps eventually to a Type 3 Universe. Our claim is thus a matter of degree: our universe will become less predictable. Here, we do not offer a means to quantify the increased unpredictability of the universe with great precision. Indeed, such a measurement may not even be possible. However, this recognition in itself should not affect the validity of our argument. As noted above, the social sciences are far less predictive than the natural sciences. To the best of our knowledge, though, scholars have never quantified the lower degree of predictability in any meaningful way.⁹

4. The Technology

Human beings have already done much to engineer our planet. With the aid of technology, we have destroyed about 80% of the world's forests in just over 10,000 years. We use about 37% of all landmass for agricultural production ("Statistics FAO" 2020). We have changed the physical landscape of the planet with dams to create artificial lakes and canals to join oceans. These dams and other systems of irrigation have radically changed some of the geological features of our planet. Cities are another key example of how the marvels of engineering have completely changed the local environment. We have unintentionally re-engineered our environment to such an extent that anthropogenic causes of global warming are, according to many authorities, a major threat to the stability of our civilization.

In the same way that we have re-engineered much of our planet, we may also be able to re-engineer our solar system over the upcoming century. We have had the technology

⁸ This example is not quite a tautology. Some coins can stand on their sides, hence there is a small chance that they might land this way. A coin landed on its side in a coin toss in a soccer match between Columbia and Paraguay in 2016: see https://www.youtube.com/watch?v=4_n-HlDe5hQ. Quantum physics tells us that there is as much chance as the coin simply vanishing.

⁹ In 1725, Giambattista Vico was most likely the first figure to attempt to gauge the issue from a conservative theist and historicist perspective (Vico 1968). Bizarrely enough, he argued that we should actually have more confidence in predictions about human institutions than in those about nature!

to support the permanent habitation of space for nearly forty years. Although the cost for doing so to date has been largely prohibitive, the price has been continuously falling. Some scientists have considered the possibility and feasibility of establishing permanent populations on the Moon and Mars. Our solar system could support trillions of people if engineers dismantled asteroids and whole planets to make large space stations or other astronomical engineering projects such as the Dyson sphere/swarm.¹⁰

With only the smallest extrapolation from today's technology, humans might start re-engineering the universe over the next century or two. By sending self-replicating intergalactic von Neuman probes out to other star systems at around 1/100 or 1/10 of the speed of light, astronomical engineers could populate the Milky Way with human life, where each star has its local matter constructed into space stations. However, these figures are merely an indication of when the project might start. At 1/10 of the speed of light, it would take more than forty years for the first von Neuman probe to reach our closest neighbor. Even at a rate close to that of the speed of light, it would take more than 100,000 years to traverse the Milky Way. If astronomers were to send tens of thousands of von Neuman probes at 1/100th of the speed of light, human beings could traverse and repopulate the Milky Way from Earth in about ten million years.¹¹

We are not claiming that societies should use their future technologies in the manner that we have indicated above. To say that in the next hundred years we could send von Neuman probes to other solar systems is not to say that we necessarily should, nor indeed that doing so would be wise. This assertion pertains especially to the emergence of radical transformative technologies in the context of transhumanist and techno-optimist circles, including aspirations to geoengineer the Earth's atmosphere, upload human minds into computers, or terraform other planets. We are merely pointing out the potential scope that technology has for altering the makeup of our universe.

Also note the wording of our premise, which states that intentional activity affects or potentially affects the universe. Our premise includes both intended and unintended consequences. Thus, it is far less controversial than a premise that says human activity will be able to control with intent how we affect the universe. Consider the example that we introduce above. One of the most dramatic examples of the effects of intentional activity on our world is global warming. At least in part, intentional activity has caused this phenomenon: human beings have intentionally burned fossil fuels to warm their homes, produce electricity, power their transportation, and so on. However, those who burn fossil fuels do not do so with the intention of causing or sustaining global warming; rather, global warming is an unintended side-effect of this activity.

5. Predicting Intelligent Behavior Premise

To provide some initial understanding of the above premise, we will now consider the rise and fall of historicism. Karl Popper offers the following understanding of this term:

It will be enough if I say here that I mean by 'historicism' an approach to the social sciences which assumes that *historical prediction* is their principal aim, and which assumes that this aim is attainable by discovering the 'rhythms' or the 'patterns,' the 'laws' or the 'trends' that alter the evolution of history. Since I am convinced that such historicist doctrines of method are at bottom responsible for the unsatisfactory state of the theoretical social sciences (other than economic theory), my presentation of these doctrines is certainly not unbiased (Popper 2002).

¹⁰ For a comprehensive current review, see Wright (2020).

¹¹ For a comprehensive survey and analysis of this issue, including related matters, see Cirkovic (2018).

If historicism had proven plausible for the social sciences, then we might have aspired to predict the leaders of government in 2061, the level of the stock market, and the football champions in the same year. Of course, we have no hope of making such predictions with any reasonable degree of certainty. Historicism in the social sciences has failed—and miserably so. Scholars have abandoned all hope of predicting intentional phenomena with anywhere near the level of specificity as non-intentional phenomena. In general, the task of the social sciences has turned from prediction to explanation after the fact. The qualification "in general" is important here. The social sciences have not entirely abandoned prediction. For instance, social scientists may still venture the prediction that more people will carry an umbrella on rainy days. However, prior to the twentieth century, these scientists also drastically reduced their ambitions and expectations for predictive success in the social sciences.

Furthermore, we should also be wary of overstating the predictive success of the natural sciences. While it is true that physics, for example, has shown impressive results when predicting planetary motion, physicists have also widely admitted that their predictive power dramatically falls as astronomical systems become more complicated. For example, the so-called n-body problem shows that there is a huge increase in difficulty when predicting the motion of three or more celestial bodies as compared with a two-body problem. Most predictions by physicists are about the results of experimental apparatus that they have specifically designed to reduce the number of confounding variables. This situation means that physics is not particularly good at analyzing more complex physical organizations. For example, physicists tend to believe that humans are aggregates of physical substances such as atoms and molecules, but no physicist has come anywhere close to predicting human behavior by modelling the interactions between this matter. In contrast, the social sciences have found some patterns in human behavior that are at least mildly predictive. For example, there is a general tendency for birth rates to fall in proportion to increasing female literacy. The correlation is not fully predictive because it is rather vague. Not only does it overlook how much the birth rate tends to fall, but it also has notable exceptions. For example, the American Midwest has a higher birthrate in proportion to female literacy than most other places in the world. Therefore, the claim here is that the difference in the predictive power of natural versus social sciences is one of degree, not kind. That said, however, there is no denying that the physical sciences have thus far had more success in making accurate predictions than the social sciences.

It is not within our scope to explain why the social world is so much less predictable than the natural world. Our argument only requires the observation that it is less predictable.

6. The Pessimistic Meta-Induction

The conclusion of the Pessimistic Meta-Induction argument follows from our two premises. The technology premise contends that, over time, technological manipulation will or potentially will affect more of the universe. The Intentional activity premise asserts that intentional activity is inherently less predictable than those systems that are beyond its scope. Combining these two premises, we conclude that our ability to predict the course of the universe will diminish over time. Thus, induction will be increasingly less useful as a tool for thinking about the future.

7. Case Study: Climate Change

To illustrate our argument further, we will apply the above argument to the issue of predicting climate change. Climate models tend to agree upon a prediction of a global temperature rise from 1990 levels to the order of 2 to 6 degrees Celsius by the year 2100. However, we must address the largest source of uncertainty in this prediction. As already

intimated, the answer is intentional activity. Specifically, the vast majority of uncertainty in climate change models is due to uncertainty about which policies and technology the world should adopt. In other words, if climate change scientists knew how the socioeconomics of the twenty-first century would unfold, then climate change prediction would be far more accurate.

In recognition of this fact, scientists have attempted to develop different socioeconomic models based on distinct assumptions about how human intentions and activity might develop in the next century. The climate change community refer to these assumptions as "Shared Socioeconomic Pathways" (SSP). To give readers a sense of these SSPs, we will quote two of the five narratives that the climate change community has recently developed:

SSP1	Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation) The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.
SSP3	Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation) A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions (Riahi et al. 2017).

Unsurprisingly, when the climate change community used these socioeconomic models in conjunction with other physical processes (for example CO₂ emissions and carbon sequestering), the SSP3 model showed that there was virtually no hope of achieving the targets set by the Paris Climate Agreement to keep global warming below 2 degrees centigrade. The assumptions of SSP1 also showed that the targets were not feasible.

For the purposes of our argument, then, there are two important points. First, the variance in climate parameters between the different physical models was far lower than the variance in climate parameters between the SSP models. Thus, if given the choice, we would be much better at predicting the future of climate change if we understood which socioeconomic model was correct, as compared with which physical model was correct. In other words, the shortfall in the predictive ability of the social sciences leads to the most unpredictability when scientists model climate change.

Second, climate change scientists did not attempt to assess the likelihood of each SSP model, nor the likelihood that the five SSP models are anywhere near accurate. Even though the SSP models are the most important variable in predicting climate change, the reluctance of scientists to make any predictions here further supports our intentional premise: that human intentional activity is extremely hard to predict, especially as a whole and over time. We underscore these concerns over the probability of the five models by inquiring into the probability of additional SSP scenarios. For example, a sixth potential model states that emerging technologies might make it possible to rapidly and cheaply perform climate reclamation through processes such as sequestering large amounts of CO₂ with advanced technology. A seventh possible model is that a nuclear war or emerging technology like genetic engineering or nanotechnology might cause damage to the environment and thus completely eclipse all fossil fuel emissions. This damage would cause a far greater change in global temperature than any of the models that assume fossil fuels are the greatest contributor to global temperature variance. Presumably, the climate change community did not include this possibility because they deemed it extremely unlikely. Naturally, one wonders how can predict this outcome when they have provided no probability assessment of their five models. For example, suppose that one thinks that each of the five models has only a 1% chance of accuracy. This figure would leave the vast majority of probability (95%) unaccounted for. Without providing a probability figure for each of the individual models, or at least collectively, they are almost entirely useless for making predictions or for setting climate policy. Since scientists and policymakers take these five models so seriously, the most generous assumption is that they deem the probability of disjunction between them quite high.

One may object that we are asking more of the climate models than their authors actually intended. Rhetorically, one might ask whether we really need to preambulate *every* single prediction of future climate with a phrase to the effect of “In the absence of global nuclear war, runaway nanotechnology, genetic engineering disaster, and so on, we predict...” The absence of such a statement is an assumption under the terms of each model. Since all scientific models of this kind make assumptions, it would be disingenuous to criticize climate change scientists for also doing so.

In response, we agree that one should not criticize scientists for making models with assumptions. Indeed, these assumptions are the very nature of modeling itself. Our point is that when using a model for decision-making or setting policy, the lack of plausibility assessments greatly curtails the utility of the model. You might become elated to discover that your friend's model of economic spending for next year includes buying you a new car. However, if the assumption of this model were that she must win the lottery first, you would probably feel less elated. As noted above, if scientists think that their predictions about climate change are plausible, then they must consider the joint probability of their assumptions about the five models to be true as well. At least in the typical case, if the joint assumptions of all the models are very unlikely, then the predictions of the models are similarly unlikely.¹² Presumably, scientists and policymakers take the models so seriously under the premise that their assumptions are at least more probable than not.

¹² We speak typically here. At least in some cases, scientists might use a model to reliably predict phenomena despite false assumptions. For example, imagine that the two false assumptions of a model effectively cancel each other out when it comes to making predictions.

Furthermore, scientists and policymakers deem the assumptions to be plausible because the models assume that socio-economic conditions in the future will resemble those of the past.

Nevertheless, we are not claiming that the only models that scientists should work with are those where the assumptions have a high probability of accuracy. There are many good reasons to model with assumptions that have low probability. Thus, we do not assert that people should ignore such models. However, we do say that if you think the prediction of a given model is likely to be true, and your only reasoning is the model itself, then consistency demands that you also accept the assumptions of the model.

8. Noetic Beings and Universe-Engineering

Thus far, we have underplayed our position by concentrating on “universe engineering”. When we consider “person-engineering” —using advanced technologies to reengineer the biological basis of people (also known as “human enhancement”)—we reinforce our reasons for validating the technology premise. By “person engineering,” we mean the idea of re-engineering the “hardware” of human beings or their biological aspects. To some extent, we have already commenced “person engineering” through things like vaccines: the intentional manipulation of our immune system. We are now on the cusp of being able to use genetic engineering to radically redesign and enhance the biological basis of humanity. Possible targets of enhancement include intelligence, memory, happiness, ethical behavior, and longevity.

The enhancement of intelligence (“cognitive enhancement”) is probably the most discussed type of enhancement on our list. Even here, though, most discussions underestimate just how powerful emerging technologies might become. According to our best science, *Homo sapiens* have existed in evolutionary terms for a short period. Nothing about our evolution implies that more evolutionary-advanced beings could usurp our level of intelligence, wisdom, power, or moral goodness. For this reason, if the same sequence of evolution that resulted in the development of the *Hominid* line from the *Australopithecine* line were to continue, the outcome would result in a new species or perhaps genus. Genetic engineering may allow us to control and expedite this process. One approach is to aim for larger brains. The hypothetical species, *Homo bigheadus*, for instance, has a brain mass of 2200 cc, whereas our brains are a mere 1300 cc.¹³ The 900 cc difference of gross brain matter is the same as that which separates us from chimpanzees—creatures with a similar body weight. Assuming that the *Homo bigheadus* has a similar body size to that of the *Homo sapiens*, the familiar correlation between intelligence, brain size, and bodyweight implies that the *Homo bigheadus* would be a lot more intelligent than us.¹⁴ With their greater intelligence, we could reasonably expect the *Homo bigheadus* to be more knowledgeable than humans, just as humans are more intelligent and knowledgeable than chimps.

Since the technology necessary for genetic engineering is already available to us, the real issue is finding the appropriate genes that control the growth of the brain. This task may not be that difficult. The crude map of the human genome that we currently possess could certainly be of some assistance, along with useful evidence from our phylogenetic cousin: the common chimpanzee. As is well known, there is an incredible genetic similarity between these two species. For instance, King and Wilson conclude that “the average [human] polypeptide is more than 99 percent identical to its chimpanzee counterpart” (1975). The idea would be to discover the genes that have altered the allometric curve of the brain in humans and then compare these genes with those of chimps. From there, it would be a relatively simple matter to manipulate these genes in

¹³ The discussion of genetic engineering intelligence in this and the next couple of paragraphs borrows from Walker (2002).

¹⁴ The most authoritative voice on this subject is Jerison (1973).

the genome of a human zygote, and thus potentially complete the recipe for genetic engineering.¹⁵

The fairly recent discovery in developmental genetics of homeobox genes underscores the ease with which we might create a larger brain through genetic engineering. These homeobox genes control the development of an organism's body plan. For our own purposes, the homeobox genes that control the growth of various brain regions are of most interest (Holland, Ingham, and Krauss 1992). For example, when making a larger brain in a frog embryo, one must simply insert some RNA from the gene *X-Otx2*. Specifically, this procedure increases the mid and forebrain mass (Boncinelli and Mallamaci 1995). Homeobox genes also come in various forms of generality. While *Otx2* is obviously very general in its scope, *Emx1*, to provide a contrasting example, controls the growth of the isocortex. Thus, if we believe in improving intelligence and wisdom by tweaking certain areas of the brain, there may be just the right homeobox gene for this task. Modifying our descendants along these lines is only the beginning of a longer process. If our children were to become *Homo bigheadus*, then *Homo bigheadus* may go on to create *Homo biggerheadus*, and then on to create *Homo evenbiggerheadus*, and so on.¹⁶

We have sketched an account where genetic engineering presents the possibility to create intelligences that surpass that of the unmodified human brain. This example is only one such possibility. There are a number of other technologies that might be capable of achieving the same ends. These technologies include the use of advanced pharmaceuticals, neurosurgery, and nanotechnology to augment the size of the human brain. Other non-organic possibilities include creating artificial super intelligences, or computer-human "cyborgs," to achieve the same ends. However, time considerations prohibit us from outlining how these ideas might be technologically possible.

We uphold that scientists can use at least some of the technologies from this section to create people who are far more intelligent than their unenhanced counterparts. Our claim here is qualified in two ways. First, we are only committed to the non-trivial probability that scientists will use one or more of these technologies to create enhanced intelligences. That said, we do not assume that the project would necessarily succeed. In fact, the agent of such a project should always consider it a scientific experiment. As previously indicated, it would be surprising to learn that humans represent the pinnacle of a physically possible intelligence. However, this situation is beyond the realm of possibility. Science often yields surprising results. Thus, although we deem this circumstance improbable, there is no reason to suppose that it is not a possible result of scientific experiment. We are only committed to the probability that technologies such as nanotechnology, advanced genetic engineering, or advanced pharmaceutical could allow the creation of advanced intelligence. We allow that one or more of these technologies may prove unworkable. In other words, anyone who upholds that it is impossible to create advanced intelligences must also uphold that each of the aforementioned technologies will fail. Otherwise, our claim is true. Second, to say that such experiments will likely happen in the coming decades or centuries is not to say that they should. In this paper, then, we take no position on the moral permissibility of such experiments, we merely predict the likelihood that scientists will perform some of them. The myth of Pandora's Box reminds us of the perennial temptation of seeking power after power.

Suppose that humans are successful in creating Noetic beings, or those whose intellectual prowess stands in relation to human beings as human beings do to apes. In terms of the implications for induction, it is likely that such beings will have superior (perhaps transcendent) universe engineering powers as compared with humans. Hence,

¹⁵ In fact, it might be best to look at the genetic differences between the common chimpanzee and the "pygmy chimpanzee." The latter's brain is smaller, and probably neotenuous, compared with the former's.

¹⁶ For considerations on how to conceive this example as a scientific experiment and its implications for science more generally, see Walker (2004).

this hypothesis provides us with independent reason to suppose that these beings will subject the universe to extensive, and therefore unpredictable, technological manipulation. To underscore the above point: just as apes have little understanding or ability to predict the development of a human-dominated world, so too will humans have little ability to understand and predict a world that Noetic beings dominate.

One could regard what we have said in this section as an example of a wider concept of *postbiological evolution*. At least until a few million years ago, biological evolution on Earth has produced a plethora of incredibly complex behaviors through purely stochastic processes like random mutations or genetic drift. However, even though the processes involved were stochastic does not mean that the outcomes were chaotic and unpredictable. In fact, the opposite holds: within a stable or slowly changing ecosystem, evolutionary outcomes are highly predictable (Conway Morris 2010). On the other hand, after we cross the threshold of complexity for intentional modification of the environment, the above trend fails for multiple reasons. First, intentional changes in *all* ecosystems are fast and dramatic; they entirely change the rules of the game and any fitness calculation thereof. This phenomenon is something that scientists have recently encapsulated in the domain of Earth-system science through the concept of the *Anthropocene*. Second, the evolutionary processes themselves are no longer stochastic: practices such as medicine or agriculture have already interfered with evolution in an intentional, non-stochastic manner. Third, forthcoming transformative technologies will enable the complete *ab initio* design of (post)human morphology—and presumably the morphology of many other animal and plant species—which exceeds the part of morphological space that biological evolution accesses.

Therefore, in this domain of post-biological evolution, we find ourselves on the verge of losing predictability in our models of biological evolution. Whether we will be able to develop analog models for the post-biological case is, at best, uncertain. This uncertainty extends into the realm of cognitive and neuroscience and then ultimately into that of social science. Scholars have established disciplines such as sociobiology and evolutionary psychology to employ predictive models of biological evolution in psychology and social science. An entirely new framework, a kind of “post-sociobiology,” will be necessary in order to achieve the same connection in the post-biological domain. At present, however, we are completely ignorant as to which elements or instruments this domain will comprise. Indeed, due to the complexity of nature thresholds, it is entirely conceivable that we will *necessarily remain ignorant* of these things until we or our descendants cross into the post-biological realm and become Noetic beings ourselves.

9. The Incompleteness of Contemporary Science

The possible existence of Noetic beings has implications in terms of the completeness and hence predictive powers of contemporary science. Consider the familiar history of the emergence of phenomena associated with specific sciences. Approximately 13.8 billion years ago, the first physical phenomena appeared as a result of the big bang. The first objects of physics thus came into existence. A few hundred thousand years later, the universe had cooled enough for the first hydrogen atoms to appear, and so the first phenomena for the study of chemistry emerged. The formation of stars 13.7 billion years ago continued the process of creating heavier elements on the periodic table through nuclear fusion. Around the earth's local star, the first organic life appeared about 4.5 billion years ago. As far as we know, these lifeforms were the first instance of biological phenomena in the universe. Economic phenomena, the object of study for the science of economics, did not emerge until less than 100,000 years ago.

Consequently, we must ask whether there will emerge phenomena that require the development of new sciences. It is clear that we cannot simply extrapolate from phenomena that exist at any given moment to that which will later emerge. The fact that there were no economies for economists to study for over 99.99% of the life of the universe does not mean that economic phenomena were nonexistent. Likewise, any simple

extrapolation from what scientific phenomena there are to what scientific phenomena there will be faces similar issues. It may well be that noetic science stands to Noetic beings as economic science stands to humans. The trend is clear: novel phenomena have developed over the course of the history of the universe. Novel sciences are required to understand these phenomena. Since it seems likely that novel phenomena like Noetic beings and their artifacts will emerge in the future, it follows to reason that we do not have the scientific resources at present to understand, much less predict, these emergent phenomena. Indeed, the relevant sciences currently do not even exist in their infancy.

This statement provides independent reason to suppose that the future will be less predictable. Contrary to what we have suggested above, suppose that current social sciences were good at predicting human behavior, this supposition is still compatible with the claim that current science cannot predict emergent phenomena. To provide the following analogy, even if biology were adept at predicting biological phenomena, this assumption is consistent with biology failing to predict emergent phenomena like economic activity.

10. Objections:

In this section, we clarify and reinforce our argument by addressing several likely objections.

10.1 Self-Undermining

The first potential objection is that our argument undermines itself. PMI is a prediction about the future, but PMI also asserts that predictive induction will become less reliable in the future. Hence, if PMI is true, then it provides reason to believe that PMI will also turn out to be false.

We allay any seeming contradiction or self-undermining here with the observation that this objection is a second order or meta-prediction: a prediction, in other words, about our abilities to predict. Our ability to predict first-order phenomena, such as the course of the natural and social worlds, will lessen over time. It is no more self-undermining than if a weather forecaster were to announce on television one night that all future weather will be harder to predict. More generally, our claim is not that all predictions will fail, which means that PMI does not have an inherent problem of reflexivity. Our claim that inductive prediction will become less reliable overall is consistent with particular predictions that have proven very accurate. Suppose one had reason to assume that the universe was about to evolve from a Type 1 Universe to a Type 2 Universe. There is nothing inconsistent about such a prediction. By assumption, there is reason to suppose that the universe will evolve in such a manner, so there is good reason to believe that this one prediction is likely to be true. Still, this assertion is consistent with the number of successful predictions that decline as the universe evolves.

Proponents of the self-undermining objection might regroup and point out that we too have made a prediction: the advancement of technology in the future. Hence, by our own logic, we must acknowledge that the future is predictable. Alternatively, they might point out that conjecturing about post-biological evolution as we have done reduces unpredictability of the future.

In response, we are happy to concede that our argument somewhat depends on predictions about the future. However, the kind of prediction that we envisage is very uninformative. It is much like the prediction that a coin will not land on its side on the next toss. This statement is certainly a prediction, but a very imprecise one. Similarly, we are committed only to the very imprecise claim that, so long as we survive as a civilization, our technological sophistication will increase and thus allow technology to potentially control or affect more of the universe. This prediction is as true as it is uninformative.

We should emphasize here that we are only indicating a general tendency of the universe. There is no need for us to throw up our hands in despair when making any kind of prediction. Consider analogies about making predictions in even the hardest of

sciences. Astrophysics tells us with a high degree of certainty that, barring intentional astroengineering influences, our Sun will end its Main Sequence lifetime in about 7 billion years. First, the sun will transition into the red giant phase and then into the asymptotic giant phase before finally ending its life as a white dwarf (Schröder and Connon Smith 2008). As a result, the expanding atmosphere of the future red giant Sun will physically destroy the planet Venus. However, planetologists need not abandon their search for an adequate theoretical account of Venus due to our prediction of what is highly likely to happen to it in 7 billion years. While these planetologists will acknowledge the truth of solar astrophysics, they will most certainly disregard the findings in practice.

Huge time horizons play the same role here as imprecision does in the coin example above. As John B. S. Haldane wrote in *Daedalus* almost a century ago: “To sum up, then, science is as yet in its infancy, and we can foretell little of the future save that the thing that has not been is the thing that shall be; that no beliefs, no values, no institutions are safe.” This sort of prediction does not invite the self-undermining charge in the same way that former US vice-president Dan Quayle's prognosis does: “I believe we are on an irreversible trend toward more freedom and democracy, but that could change.” We, on the other hand, have tried to adopt more nuance in our approach to PMI.

10.2 Natural Sciences will Get More Predictive

One might protest that our argument misunderstands the nature of predictions in the natural sciences. For natural science, so the objection goes, the task is to predict natural events, not human activity. There is every reason to suppose that natural science will improve at predicting the course of natural objects and events in the future. Thus, we have every reason to suppose that, within a century, natural science will improve at predicting the time it takes for an apple to fall to the ground, or the perihelion of Halley's Comet, so long as these events are natural. It does not in any way harm the predictive claims of natural science if one objects that a person might snatch the apple out of the air as it falls, or that STAP might interfere with the orbit of Halley's Comet.

Incidentally, the above objection seemingly implies that there are no objective, inherent limitations to the predictive power of natural science. However, several scientific disciplines have already falsified this implication. Quantum mechanics—as long as one considers that this discipline offers a true description of microscopic physical systems—clearly limits the predictability of quantum measurement outcomes. In general relativity and cosmology, there are event horizons that fundamentally limit the predictions of any observer. The phenomenon of deterministic chaos has limited even purely classical disciplines such as celestial mechanics within our Solar System. The objector may argue that these inherent limitations are still distant from the practical predictions available now. With a large margin for future improvement, though, this claim is far from obvious. In some areas, it is entirely plausible that our predictions—especially with the potential help of the Noetic beings—will very soon challenge the inherent limits of predictability, if such a limit exists.

To a certain extent, we agree with the aforementioned objection. To explain this point in an alternative way, the conditional in the following example seems plausible:

Predictions of Purely Natural Objects and Events: *If* objects and events are "purely natural" in the sense that intentional activity does not subject them to possible manipulation, *then* natural sciences will likely improve at predicting purely natural objects and events in the future.

However, this conditional does not undermine the overall arc of our argument. The scope of objects and events that the conditional's antecedent covers is likely to shrink over time.

To return to our earlier example, Halley's Comet was in 1910 among a set of purely natural objects and events. When it reappeared in 1986, the Comet had crossed into the category of being not a purely natural object. As noted above, it was technically possible that at least two countries at this time could send nuclear missiles to knock Halley's Comet slightly off its course. Thus, while natural sciences will gradually improve at predicting the outcomes of purely natural objects and events, this category of phenomena will also shrink over time. In other words, the natural sciences will become increasingly accurate at predicting fewer and fewer objects and events. This anticipated decline is because the number of "purely natural" objects, such as those we identify above, will continue to decrease. While scientists a century ago regarded asteroids and comets as purely natural, this judgement no longer holds. Likewise, in the not-too-distant future, it is likely that moons, planets, and stars will no longer comprise the purely natural objects of our universe.

It is worth exploring this distinction in terms of Hume's aforementioned discussion of UP. Hume wrote the full sentence as follows: "If reason determin'd us, it wou'd proceed upon that principle, *that instances, of which we have had no experience, must resemble those, of which we have had experience, and that the course of nature continues always uniformly the same*" (2012, 1.3.6.4) We use the term "universe" rather than "nature" to express UP precisely because there is a systematic ambiguity in how scholars understand the word "nature." Scholars sometimes use the word broadly to include humans and their activity. Other times, their understanding of the term is narrower in that it excludes humans and their activity. If scholars understand UP in terms of the narrower definition, then nothing that we have argued thus far falsifies UP. However, as just indicated, this rationale means that UP will apply to a diminishing part of the universe over time. If scholars understand UP in the broader sense to include the intentional activity of humans and potential Noetic beings, then our argument shows that UP is likely false.

10.3 Social Science Will Become More Predictive

One might protest that the social sciences will become more predictive over time. The history of the social sciences is relatively short compared with the natural sciences, with many classifying the birth of the social sciences as a recognizable discipline in the eighteenth and nineteenth centuries. Given this comparatively short history, then, it is too soon to be pessimistic about the predictive powers of the social sciences.

It is certainly possible for the social sciences to become more predictive than they are today, perhaps by integrating with cognitive and neurosciences or with advanced AI. We have no theoretical argument to discount this possibility. If this development were to occur, then our central hypothesis would fail. However, recognizing the possibility of this situation does not mean that we have to accept its probability.

Indeed, there are good reasons to believe that such predictiveness is highly improbable. Here, we will concentrate on one such reason, which has played a large part in our discussion: technological innovation.¹⁷ It is clear that technological innovation can have profound effects on the social world. An obvious example is the invention of agriculture. Prior to the advent of agriculture, the world experienced severe limits on the density of its human populations. Cities were near impossible because their inhabitants had to procure food through hunting and gathering techniques. Technological inventions like trains, canals, airplanes, writing, the printing press, and computers have had a

¹⁷ For further reasons see Chapter 8 of MacIntyre (1984). We might also add considerations here from the "value free" literature in the philosophy of science. If we concede, as many do, that values and political ideologies have influenced the course of science, and that we are unable to predict how these ideologies might develop, then the future of science inherits some of this unpredictableness. Science is not an impartial discipline. Moreover, since the social sciences reflect directly on our self-conception, the above problem will be particularly acute for the social sciences.

massive influence on how human society has evolved. Given that technology has a large influence on forms of human social organization, it is clear that predicting the course of humanity also depends upon our ability to predict the course of technology. Since we cannot predict the course of technology with any great precision, we cannot predict the course of humanity. To further reinforce this point, we should consider that Noetic beings may initiate the most transformative change in human history, one where humans cease to be the most intelligent beings in existence.

Likewise, even if advances in social science were to make human behavior more predictable, humans need not be the creators of this advanced social science, nor even comprehend its theories. Just as a rat does not comprehend its behavior in a maze experiment, so too might humans remain ignorant about advanced social science. One way to reinforce this point is to note that language formulates all inductive scientific reasoning, and there are no a priori reasons to suppose that humans comprehend all languages (Walker 2002). Thus, even if there were an advanced social science that made it easier to predict intentional behavior, or at least that of humans, one should not assume that humans themselves will be able to grasp this science.

We also concede that the social sciences might become more predictable if social phenomena do as well. Suppose, for example, that the Great Inter-Galactic Conservative Party wins office and then forbids change or innovation. Under these circumstances, social scientists would presumably become very good at predicting the future. Again, while we admit that this situation is possible, we also acknowledge that it is extremely unlikely.

11. Skeptical-Dogmatism about Induction

Hume believed that his Pyrrhonian challenge to induction would have little practical effect. He reasoned that people are naturally inclined to assume UP. Thus, even if his theoretical challenge were effective in showing that UP is unsubstantiated, people would still use induction. Merely discovering the validity of something does not make it easier to modify our behavior in response.

If UP is false, as we have argued, and Hume is correct in claiming that people naturally tend to accept UP, then we seemingly face a potentially serious problem. Namely, in thinking, planning, and predicting the future, our natural tendency to accept UP will lead to mistakes in each of these areas. We will conclude with two examples of this hypothesis.

First are the aforementioned SSP scenarios. These scenarios highly underestimate the potential of technological development in the future. When one thinks seriously about technological development, these SSP scenarios reflect similar concerns of the nineteenth century regarding how society might build cities to cope with a growing horse manure problem. Of course, with the benefit of hindsight, we can only smile at this anxiety about a looming "poopocalypse". The internal combustion engine and the electric engine completely undermined these worries, even though they caused problems of their own. We do not mean to suggest here that SSP scenarios are naive because future technology will fix all our ills. However, we do contend that these reports overlook the possibility that they have failed to grasp the potential problems and solutions of the twenty-second century. Ultimately, the climate change community embodies Hume's claim that we naturally assume UP in our thinking.

The UN similarly demonstrates naive thinking in their population prediction models for the year 2300 (United Nations 2004). Certainly no one could fault the study for its lack of ambition: it attempts to forecast the world's population by 2300. Again, the authors of the UN study exemplify Hume's claim about the assumption of UP in so much of human thought. The authors remain unaware of how the models in their study fail to address technological change. To cite but one example, the study presupposes that the maximum human lifespan will not increase significantly during the period in question. The authors do allow that the average lifespan will increase due to a greater abundance and equality of resources. The idea that humans or noetic beings will be unable to manage aging

processes significantly better by 2300 is extremely naive. The same goes for using technology in reproductive processes.¹⁸

If we accept Skeptical-Dogmatism about induction, then should we give up on prediction? And if we give up on prediction, should we stop worrying about the future? We will address these questions in reverse order.

Of course, we should remain attentive to the future. Suppose one thinks that the economy will become increasingly unpredictable in the coming decades. For most, the answer is not to stop worrying about one's financial future. Rather, a rational strategy would be to tackle uncertainty by diversifying one's financial portfolio in areas such as stocks, bonds, real estate, gold, art, and so on. Similarly, in thinking about the future of intelligent life on Earth, Skeptical-Dogmatists recommend confronting an uncertain future. As part of risk mitigation, the world pays far too much attention to climate change as *the* risk of the future. This assertion does not mean that we should devote fewer resources to climate change. However, it does imply that we should focus on other risks as well. Moreover, too much climate change thought presupposes the truth of UP, which, we have argued, is a false theoretical position to assume.

As we have indicated above, our argument does not uphold the futility of making predictions. However, it does show that making relatively precise predictions by uncritically assuming UP is likely to cause errors. Making vague predictions is perhaps better than making no predictions at all. A varied collection of relatively precise predictions may also be better than nothing. Thus, one of the many incompatible scenarios of science fiction literature is more likely to predict the future than the SSPs or UN population report. This prediction is of course imprecise: it does not say which of the tens of thousands of science fiction works are closer to the truth than another. Nevertheless, admitting our epistemic limitations is at least a start.

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¹⁸ In future work, we hope to show how the same reasoning errors affect the thought of many futurists and transhumanists.

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