A Critical Engagement of Bostrom's Computer Simulation Hypothesis

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Abstract

In 2003, philosopher Nick Bostrom presented the provocative idea that we are now living in a computer simulation. Although his argument is structured to include a "hypothesis," it is unclear that his proposition can be accounted as a properly scientific hypothesis. Here Bostrom's argument is engaged critically by accounting for philosophical and scientific positions that have implications for Bostrom's principal thesis. These include discussions from Heidegger, Einstein, Heisenberg, Feynman, and Dreyfus that relate to modelling of structures of thinking and computation. In consequence of this accounting, given that there seems to be no reasonably admissible evidence to count for the task of falsification, one concludes that the computer simulation argument's hypothesis is only speculative and not scientific.

Keywords: Bostrom; simulation hypothesis; Heidegger; Dreyfus; Feynman; falsifiability

1. Introduction

In a paper published in 2003, Nick Bostrom argued that at least one of several propositions is likely to be true: (1) the human species is very likely to go extinct before reaching a "posthuman" stage, i.e., $(f_p \approx 0)$; (2) any posthuman civilization is extremely unlikely to run a significant number of simulations of their evolutionary history (or variations thereof), i.e., $(f_I \approx 0)$; (3) we are almost certainly living in a computer simulation, i.e., $(f_{sim} \approx 1)$. (Bostrom 2003) Proposition (3) is characterized as the simulation *hypothesis*, thus only a part of Bostrom's simulation argument. The argument is thus basically a statement of possibilities:

Either $(f_p \approx 0)$ *or* $(f_I \approx 0)$ *or* $(f_{sim} \approx 1)$—such that, Bostrom claims, we should distribute our credence more or less evenly among them.[1] But this leaves us with the problem of justification, i.e., why we should distribute our belief in one or another of these propositions more or less evenly.

Bostrom uses the words "living in" to stipulate that, whatever "we" *are* is to be understood in terms of the following points concerning a posthuman simulation of present-day humans (Bostrom 2003):

(1) "a computer running a suitable program would be conscious."

(2) "it would suffice for the generation of subjective experiences that the computational processes of a human brain are structurally replicated in suitably fine-grained detail, such as on the level of individual synapses."

(3) "Simulating the entire universe down to the quantum level is obviously infeasible, unless radically new physics is discovered. But in order to get a realistic simulation of human experience, much less is needed – only whatever is required to ensure that the simulated humans, interacting in normal human ways with their simulated environment, don't notice any irregularities."

(4) "a posthuman simulator would have enough computing power to keep track of the detailed belief-states in all human brains at all times. Therefore, when it saw that a human was about to make an observation of the microscopic world, it could fill in sufficient detail in the simulation in the appropriate domain on an as-needed basis. Should any error occur, the director could easily edit the states of any brains that have become aware of an anomaly before it spoils the simulation. Alternatively, the director could skip back a few seconds and rerun the simulation in a way that avoids the problem."

[1] f_p is "the fraction of civilizations at our current stage that eventually become technologically mature;" f_I is "the fraction of technologically mature civilizations that apply some non-negligible portion of their computational power to running ancestor-civilizations;" and f_{sim} is "the fraction of all people with human-like experiences who live in simulations."

Despite these observations, Bostrom is not adequately clear how we are to understand the term 'simulation'. For example, we conceive of humans as having "organic" intelligence (assuming here some mind-brain interaction) and distinguish this from "artificial" intelligence. The former is associated with a biological (carbon-based) entity, while Bostom anticipates the latter is of a different material substrate. Bostrom allows for posthumans implementing a process of mechanized intelligence that operates on some kind of material substrate that need not be organic. There would then be a causal relation of orders of being: A *simulation, S,* (3^{rd} order), i.e., *what is being processed*, is operationally dependent on a *model, M,* (2^{nd} order), i.e., *the programming*, that re-presents a *reality, R,* (1^{st} order), i.e., *what is fundamentally real* and, as such, is the presupposition of any model, thus: ($R \rightarrow M \rightarrow S$, i.e., *if and only if* there is that which is fundamentally real can there then be a model which is the representation of that reality by way of a programming experienced as a simulation). Hence, when he says humans may be "living in" a simulation, Bostrom means that literally: They have their being only as *3^{rd} order artificial intelligence processes* and they are not "really" biologically independent organic intelligent entities such as we presently understand the members of the set, *Homo sapiens*, to be. All that we *are*, all that we *think* and *do*, whether seemingly mental or corporeal activity, *all* are the manifestations of a simulation, or said otherwise, what posthumans would call "ancestor-simulations."

Bostrom's extended argument presupposes a historical relation between a species of posthumans and contemporary humans, such that (1) posthumans are *objectively real* beings (1^{st} order), (2) contemporary humans are *simulated* beings (3^{rd} order), while (3) there is a universe (i.e., a physical reality) that is objectively real (1^{st} order), although the perceived universe of the simulated beings may be nothing more than a simulation. Bostrom conjectures:

> …later generations…with their super-powerful computers [might] run detailed simulations of their forebears or of people like their forebears…They could run a great many such simulations. Suppose that these simulated people are

> conscious…[It] could be the case that the vast majority of minds like ours do not belong to the original race but rather to people simulated by the advanced descendants of an original race. It is then possible to argue that, if this were the case, we would be rational to think that we are likely among the simulated minds rather than among the original biological ones. (Bostrom 2003)

He concludes, "Therefore, if we don't think that we are currently living in a computer simulation, we are not entitled to believe that we will have descendants who will run lots of such simulations of their forebears." (Bostrom 2003) But there are questions begging here: Why should anyone think we are currently living in a computer simulation? Why would anyone believe, or want to believe, that we will have descendants who will run many simulations of forebears such as ourselves? And how is it that the former proposition entitles one to believe the latter?

2. The Discursive Context

Bostrom's simulation hypothesis is one among a number of papers produced in the latter part of the 20th century that concern the same basic question and issues. Jürgen Schmidhuber, for example, reported a few years ago that, "In the 1940s, Konrad Zuse already speculated that our universe is computable by a deterministic computer program (Horst Zuse, personal communication, 2006), like the virtual worlds of today's video games." (Schmidhuber 2012; Zuse 1967) Schmidhuber himself argued that, "Zuse's hypothesis is compatible with all known observations of quantum physics." Linking this hypothesis to its mathematical implications, Schmidhuber added: "Somewhat surprisingly, there must then exist a very short and in a sense optimally fast algorithm that not only computes the entire history of our own universe, but also those of all other logically possible universes." (Schmidhuber 2012]

Similarly, F. J. Tipler, in his "omega point theory" of 1988-89, conceived of a time in which "there will be sufficient computer capacity to simulate our present-day world by…creating a simulation of all logically possible variants of our world." (Tipler 1997; Tipler 1995) Indeed, Tipler argued, a simulated person "would observe herself to be as real, and as having a body as solid as the body we currently observe ourselves to have. There would be nothing 'ghostly' about the simulated body, and nothing insubstantial about the simulated world in which the simulated body found itself." Writing in 2004, Gordon McCabe considered Tipler's position as "a special case of epistemological scepticism," Tipler's argument being that, "our experience is indistinguishable from the experience of someone embedded in a perfect computer simulation of our own universe," the logical consequence of which is that, "hence, we cannot know whether or not we are part of such a computer program ourselves." (McCabe 2004)

By contrast, writing in 1989, mathematical physicist Roger Penrose challenged the "strong AI [artificial intelligence]" view of his day that human consciousness can be run on a computer, accounting in his argument for implications of mathematical theorems such as Gödel's incompleteness theorem and empirical understanding in neurophysiology. (Penrose 1989) Given his firm commitment to strong AI research, Tipler recorded his disagreement with Penrose. (Tipler 1989) In short, Bostrom's hypothesis is by no means unusual for many involved with the strong AI school of cognitive studies that herald evolutionary advances in computational methods, to the degree that such simulations are reasonably supported by theoretical considerations.

3. Discussion

It is not Bostrom's conclusion that interests us here. Since we do not normally think—and do not find it normatively rational to think—that we are currently "living in" a computer simulation, rather than each human today being an objective, material (biological, organic) reality, then it is by no means problematic to us to be concerned with the likelihood of ancestor-simulations or our logical "entitlement" to any such belief. As a matter of what at the least appears to us to be objectively probable real fact, we may or may not have descendants (posthumans) who will run simulations of humans. There is no epistemological obligation to believe this proposition, although we may entertain it, at minimum, as a prediction having probability value (where truth value=1 and probability-value is >0 but <1).

However, what is of interest to us is Bostrom's *proposition (3)*—'*we are almost certainly living in a computer simulation*.' This is not a predictive statement. It is structured (at least initially) as an empirical proposition having high probability value (near 'truth=1')—if Bostrom's reasoning stands the test of critical engagement. Despite the "almost certain" feature of this proposition ($f_{sim} \approx 1$), Bostrom has stated he believes the probability that this hypothesis is true is less than 0.5; and he adds, "A degree of belief of something like 20% would seem quite reasonable given our current information." (Bostrom 2005b) Notwithstanding, this proposition is sufficiently provocative to elicit our critical engagement, and to engage it critically as a proposition that, if true, presents a necessary and sufficient condition for thereafter considering the normativity of the belief Bostrom proposes in his conclusion.

Here one can concur with several propositions already articulated by Danila Medvedev in 2003 as "necessary assumptions" for Bostrom's simulation argument: (1) there is a basic reality; (2) it is possible to run a world simulation inside a reality; (3) the complexity of the simulation is less than the complexity of the parent universe; (4) the laws of logic and mathematics are absolute. [Medvedev, no date) We may also accept as reasonable "several less general assumptions" that Medvedev identifies: (1a.) the base reality contains at least one [post-]human civilization; (2a.) a human civilization has non-zero probability of becoming a posthuman civilization; and (3a.) a posthuman civilization has non-zero chances to launch at least one simulation.

Of course, one may consider whether we have in Bostrom's discourse the presentation of *a genuine problem of science*, thus whether we may consider his hypotheses scientific, i.e., hypotheses that are "open in some way or other to empirical falsification," thus to empirical testing. Methodologically construed, a hypothesis is "proposed in an attempt to solve some genuine problem or at least to answer some genuine query." (Miller 2007) Consider, for example, Eric Winsberg's understanding of 'simulation', when he says that, "Many complex systems in the physical sciences are studied by developing models of their underlying physics on a computer, and by using computationally intensive methods to learn about the behaviour of those systems." (Winsberg 2003) A posthuman running an ancestor-simulation would be doing the same—using computationally intensive methods to learn about the behaviour of "the complex systems" that the species *H. sapiens* is (or was) in its environmental setting. However, what matters here, as Winsberg clarifies, is that, "the mathematical models that drive these particular kinds of simulations are motivated by theory. Prima facie, they are nothing but applications of scientific theories to systems under the theories' domain." (Winsberg 2003)

Thus, in running an ancestor-simulation, a posthuman would apply scientific theories to those systems that fall under the domain of a given theory. This would include the basics and complexities of contemporary theoretical computer science. Thus, e.g., in considering Zuse's hypothesis (noted above) and considering constraints, Schmidhuber has argued for "a very short algorithm [denominated FAST] that computes all possible universes, *as long as they are computable*." (Schmidhuber 2012, italics added) He then proposed, "For any God-like *Great Programmer*, FAST offers a natural, optimally efficient way of computing all logically possible worlds." Indeed, "If our universe is one of the computable ones, then FAST will eventually produce a detailed representation of its first few billion years of local time (note that nearly 14 billion years have passed since the big bang)." (Schmidhuber 2012)

Schmidhuber's conditional proposition is not to be underestimated—this is the basic question: *Is our universe* (the one we presume to know by way of our sciences) *one of the computable ones?* Accounting for "the weak anthropic principle," Schmidhuber argues, "Since we exist, we already know that at least one of the programs has computed enough to enable our existence…" He asserts further, "With high probability it will be one of the shortest and fastest compatible with our existence…[We] are already part of one of the simplest, fastest, non-random worlds compatible with our very being." (Schmidhuber 2012) But there is a problem here. This latter statement is true only if it is true that, indeed, our "existence" is a computation-effect—which is precisely the question that goes begging here. It makes no sense to say, "we exist," without qualifying that statement so as to avoid equivocation, thus to mean that the "we" here and the "existence" that is referent here are only expressions for a simulation as such. We also have to explain how or why it is that we would not have, as an effect of computation, a detailed representation of the complete 14 billion years of local time since the Big Bang.

We are pressed, therefore, to consider all the more seriously Richard Feynman's musings about simulating physics with computers, including the physics investigated by quantum theory. (Feynman 1982) Feynman asked, "What kind of computer are we going to use to simulate physics?" Bearing in mind what was known at the time (1982) about digital computing (theoretical computer science), Feynman asked, "Can physics be simulated by a universal computer?" Assuming a posthuman would obviously have a technological sophistication well beyond what was known in 1982 and what is known today (2015), the fact is that, given what we perceive to be physical reality, we would have to say, at minimum, that this is what a posthuman has decided to represent in simulation. This simulation could include whatever physical reality is to be known by way of classical mechanics, relativity, and quantum mechanics (given the current state of theoretical representations of our physical reality).

Feynman argued that, because "the physical world is quantum mechanical…therefore the proper problem is the simulation of quantum physics…" (Feynman 1982) Presumably, a posthuman would face and then solve the same problem theoretically. (Bear in mind that Bostrom has already asserted that, "simulating the entire universe down to the quantum level is obviously infeasible.") Feynman considers "the possibility that there is to be an *exact* simulation, that the computer will do *exactly* the same as nature. If this is to be proved…then it's going to be necessary that *everything* that happens in a finite volume of space and time would have to be exactly analyzable with a finite number of logical operations." There is a problem with this proposal, however, Feynman argued: "The present theory of physics is not that way, apparently. It allows space to go down into infinitesimal distances, wavelengths to get infinitely great, terms to be summed in infinite order, and so forth; and therefore, if this proposition is right, physical law is wrong." This raises questions concerning what a posthuman would be doing in running ancestor-simulations that include (1) simulated humans (2) interacting with an environment that (3) includes "*everything* that happens in a finite volume of space and time."

Feynman is not averse to the possibility that physical law is wrong (although the probability of this is low to moderate, given present theoretical constructs). Hence, allowing for this possibility of low probability, he considers altering our idea of space: We could have "the idea that space is a simple lattice and everything is discrete (so that we can put into it a finite number of digits) and that time jumps discontinuously." Given these ideas, Feynman proposed a "rule of simulation," viz., "the number of computer elements required to simulate a large physical system is only to be proportional to the space-time volume of the physical system." (Feynman 1982) The question, then, is: What follows from observing this rule, and what might follow with more or less moderate to high probability if we drop the rule for any simulation conceived?

The fact is that we currently have quantum theory as part of the theoretical and experimental apparatus of our survey of physical reality. If posthumans are in fact simulating what we take to be our present reality, then (we would have to say) quantum theory (as we understand or do not understand it) *is* being simulated. Yet, without explanation, Bostrom already stated that simulating the entire universe down to the quantum level is obviously infeasible. Why is this "obviously" infeasible? Infeasible for whom? For us? Yes, perhaps we should say it is infeasible for us. But, would this be infeasible for a technologically sophisticated posthuman? It seems we can reasonably answer "maybe not," given Bostrom's proposal with his probability value of $p \sim 0.2$. Of course, Feynman himself argued that, with quantum mechanics "we know immediately that here we get only the ability, apparently, to predict probabilities;" in which case, since "quantum mechanics seem to involve probability," we can ask whether probabilistic theory can be simulated. (Feynman 1982)

Given Feynman's analysis, we would have to say that a posthuman could not simulate by calculating the probability of quantum effects: "We can't expect to compute the probability of configurations for a probabilistic theory," Feynman argued, unless such computation occurs by way of a "probabilistic computer" that simulates a "probabilistic nature" in which "the output is not a unique function of the input." (Feynman 1982) And here, it seems, a posthuman would face a dilemma in computation. Feynman states the problem thus: "You see, nature's unpredictable; how do you expect to predict it with a computer? You can't—it's unpredictable if it's probabilistic." However, a posthuman surely would have the capacity to do what Feynman says one *can* do:

> But what you really do in a probabilistic system is repeat the experiment in nature a large number of times. If you repeat the same experiment in a computer a large number of times (and that doesn't take any more time than it does to do the same thing in nature of course), it will give the frequency of a given final state proportional to the number of times, with approximately the same rate (plus or minus the square

> root of *n* and all that) as it happens in nature. In other words, we could imagine and be perfectly happy, I think, with a probabilistic simulator of a probabilistic nature, in which the machine doesn't exactly do what nature does, but if you repeated a particular type of experiment a sufficient number of times to determine nature's probability, then you did the corresponding experiment on the computer, you'd get the corresponding probability with the corresponding accuracy (with the same kind of accuracy of statistics). (Feynman 1982)

If we assume a posthuman does what Feynman describes, then there is a way to produce *some* features of the quantum reality that we currently describe by way of quantum mechanics, in which case the simulation would include both *macro*-level and *quantum*-level elements according to the causal relationship *(R→M→S)*. This computing ability, however, would not include Fermi particles, says, Feynman, in which case the fact that we do include such particles as elements of current quantum theoretical description means that this counts (for contemporary humans, at least, if not for posthumans) as an empirical fact in the present context of scientific knowledge *against* the validity of the simulation hypothesis, i.e., it counts as an element in the falsification of the simulation hypothesis.

However, one would have to consider here what computational capacity we expect from a posthuman conducting an ancestor-simulation when the posthuman is spatiotemporally future to the humans being simulated. In his review of Alan Turing's position on machine intelligence in relation to the mathematical objection associated with Gödel's incompleteness theorem, Gualtiero Piccinini cites Turing's observation that, of course, machines have a storage capacity that limits the machine's "adaptability." This then counts against the ascription of intelligence. (Piccinini 2003) Put in its "aggressive" form, the argument is this: "It has…been shown that with certain logical systems there can be no machine which will distinguish provable formulae of the system from unprovable, i.e., that there is no test that the machine can apply which will divide propositions with certainty into these two classes. Thus if a machine is made for this purpose it must in some cases fail to give an answer." (Piccinini 2003)

Turing accordingly argues the point that, "if a machine is expected to be infallible, it cannot also be intelligent. There are several mathematical theorems which say almost exactly that. But these theorems say nothing about how much intelligence may be displayed if a machine makes no pretence at infallibility." Thus, to be fair to his proposal, we must bear in mind that Bostrom allows for a material substrate that enables massive storage. Operating on an assumption in the philosophy of mind, Bostrom says, "The idea is that mental states can supervene on any of a broad class of physical substrates. Provided a system implements the right sort of computational structures and processes, it can be associated with conscious experiences." Bostrom thus accounts for what we currently conceive as "theoretical limits on information processing in a given lump of matter."

Bostrom considers both the computing power and the memory requirements. Concerning the latter, he says: "…since the maximum sensory bandwidth is $\sim 10^8$ bits per second, simulating all sensory events incurs a negligible cost compared to simulating the cortical activity. We can therefore use the processing power required to simulate the central nervous system as an estimate of the total computational cost of simulating a human mind." Moreover, Bostrom allows for a technological sophistication such that, "a rough approximation of the computational power of a planetary-mass computer is 10^{42} operations per second, and that assumes only already known nanotechnological designs…A single such a [sic] computer could simulate the entire mental history of mankind (call this an *ancestor-simulation*) by using less than one millionth of its processing power for one second." Thus, any concern for falsifiability of the simulation hypothesis must account for the probability of a *nano*-level technological architecture and correlative processing of human mental events.

Despite the foregoing survey of conceptually plausible ideas, we are nonetheless faced with criticisms such as follow from Heidegger's phenomenological analysis of Dasein and what it implies for the difference between computation and thinking. And here, importantly, Bostrom seems to identify the two, based on his reductionist account from the philosophy of mind. Hubert Dreyfus provides a ready contribution that relates to Bostrom's proposal.

3.1 Heidegger, Dreyfus, and the Problem of Reality

To anticipate Dreyfus's critique, it behoves us to recall the early Heidegger's pronouncements on modern science. A century ago (1912) before he published *Being and Time*, in a paper entitled "The Problem of Reality in Modern Philosophy," Heidegger cited the Frenchman Brunetière, who said: *"Je voudrais bién savoir, quell est le malade ou le mauvais plaisant, et je devrais dire le fou, qui s'est avisé le premier de metre en doute 'la réalité du monde extérieur,'et d'en faire une questión pour les philosophes. Car la questión a-t-elle me me un sens?"* ["I should very much like to know which sick person or sorry jokester—and I must also say fool—it was who first got it into his head to doubt the reality of the external world and make it a question for philosophers. Does such a question even make any sense?"] (Heidegger 2007) Heidegger answered in the affirmative: The question makes sense. It still makes sense in the context of Bostrom's simulation argument as we account for the 19^{th} century's lack of settlement in Kant's efforts to resolve the tension between the empiricists and rationalists of the modern period concerning the sources and possibility of knowledge, the failure of German idealism, the shortcomings of Husserl's transcendental idealism, and, finally, Heidegger's phenomenological hermeneutic of *Dasein* that was a response to the ontological and epistemological problems of the early 20^{th} century and, indeed, the entire onto-theo-logical tradition since Plato.

Heidegger remarked, in the paper of 1912:

> ...the undeniable, epoch-making state of affairs of the natural sciences has brought our problem to the focus of interest. When the morphologist determines the structure

> of plants and animals, when the anatomist explicates the internal structure of living creatures and their organs, when the cellular biologist undertakes the study of the cell, its construction and development, when the chemist investigates the elements and combinations of chemical compounds, and when the astronomer calculates the position and orbit of the celestial bodies, the researchers in these various branches of science are convinced that they are not analyzing mere sense data (*Empfindungen*] or working on pure concepts, but rather positing and defining *real* objects that exist independently of *them* and their scientific research. (Heidegger 2007)

Heidegger then proceeded to answer the question, "How is positing the real possible?" He answered: "The spatiotemporal character of the objects of experience, their coexistence and succession, the pauses in perception, and the relations among the contents of consciousness which *force themselves upon us* and are *not determinable by our will*—all of this reveals indubitably a lawfulness that is independent of the experiencing subject. The positing of realities transcendent to consciousness is demanded above all by the fact that one and the same object is immediately communicable to different individuals." (Heidegger 2007) In short, for Heidegger, while one may reasonably raise the question concerning the problem of external reality, there is ample reason to find ourselves faced with a given that permits, but also limits, our interrogation. We are rational to proceed with our scientific research and engage this given reality for the multitude of answers we seek to theoretical queries. We may then consider Bostrom's proposal in this light.

The early Heidegger, of course, while rejecting naïve empiricism, transcendental realism, and phenomenalism, seems to present a position of "critical realism," and thus seems to side with neither the realists nor the anti-realists concerning the veracity of science. By 'realism' we mean "the view that the vocabulary of science corresponds, at least in outline, to the actual structure of the world as it is exists [sic] independently of human cognition;" a position that is in contrast to antirealism, according to which "our scientific vocabularies are simply one more way to describe the world—that they have no privileged access to the structure of things…" ("Heidegger and the Natural Ontological Attitude," no date) The philosopher of science Bas C. Van Fraasen characterized scientific realism thus: "Science aims to give us, in its theories, a literally true story of what the world is like; and acceptance of a scientific theory involves the belief that it is true." (Van Fraasen 1980) He then spoke of anti-realism (including here his own view of "constructive empiricism") thus: "Science aims to give us theories that are empirically adequate; and acceptance of a theory involves as belief only that it is empirically adequate." (Van Fraasen 1980) Thus, while not a full theory *per se*, Bostrom's proposal includes hypotheses that could be elements of a *bona fide* theory, since one could in principle have empirical reasons to hold the belief in the hypothesis (as highly probably true) that we are almost certainly living in a computer simulation. One could hold the belief either as a realist (claiming literal truth) or as an anti-realist (claiming only empirical adequacy). Either way, the epistemological question of justification remains to be answered.

However, in *Being and Time*, Heidegger wrote:

> Along with Dasein as Being-in-the-world, entities within-the-world have in each case already been disclosed. This existential-ontological assertion seems to accord with the thesis of *realism* that the external world is really present-at-hand. In so far as this existential assertion does not deny that entities within-the-world are present-at-hand, it agrees—doxographically, as it were—with the thesis of realism in its results. But it differs in principle from every kind of realism; for realism holds that the reality of the 'world' not only needs to be proved but also is capable of proof. *In the existential assertion both of these positions are directly negated*." (Heidegger 1962 *Being and Time*, 252; H: 207; italics added)

We must here underscore Heidegger's two negations:

(1) It is not the case that the reality of the world needs to be proved;

(2) It is not the case that we are capable of proving the reality of the world.

As Heidegger said earlier, "The question of whether there is a world at all and whether its Being can be proved, makes no sense if it is raised by Dasein as Being-in-the-world; and who else would raise it?" [Heidegger 1962, *Being and Time*, 247; H. 202) Further, "Our task is not to prove that an 'external world' is present-at-hand or to show how it is present-at-hand, but to point out why Dasein, as Being-in-the-world, has the tendency to bury the external world in nullity 'epistemologically' before going on to prove it." (Heidegger 1962, *Being and Time*, 250; H:206) Heidegger moves here to eliminate the priority of the epistemological question, thereby to clarify the multiple ways in which our human way to be discloses our way of being in the world.

3.2 The Logic of Bostrom's Proposal

At this point it may be useful to clarify what seems to be the logic of Bostrom's "proposition (3)," i.e., that we are almost certainly living in a computer simulation. Two claims are central:

1. Posthumans (*who live at a real space-time T_F*) run simulations of humans (*who live at real space-time T_P),* but the latter are *not simulations* at real space-time T_P. We give a symbolic notation for this proposition, thus: $P_{TF}\ (rs)\ H_{TP} \neq Sim$.
2. Posthumans (*who live at a real space-time T_F*) run simulations of humans (who "live" at *virtual space-time T_P*, i.e., in programmed computational design features only,) who are thus *mere simulations* of humans and thus *not really biological humans*. We give a symbolic notation for this proposition, thus: $P_{TF}\ (rs)\ Sim_{VTP} \neq H$.

Bostrom claims, "…the main computational cost in creating simulations that are indistinguishable from physical reality for human minds in the simulation resides in simulating organic brains down to the neuronal or sub-neuronal level…[For] a realistic simulation of human history, we can use ~10^{33}-10^{36} operations as a rough estimate." He argues further, "we would be rational to think that we are likely among the simulated minds rather than among the original biological ones."

Bostrom's foregoing statements point to two distinct propositions:

3. $(x)[(H_x \rightarrow \sim Sim_x)]$, meaning 'For all *x*, if *x* is a human, then *x* is not a simulation.' That is to say, all humans such as we know them are *real* minds and *not simulated* minds.
4. $(x)[LM_x \rightarrow (LM_x = M_x)]$, meaning 'For all *x*, if *x* is *a mind like ours* (i.e., *x* has a only a *simulated* consciousness and is not a *real* consciousness), then *x* with a mind like ours is really/identically our mind.' That is to say, LM_x, the mind like ours, is *a virtual reality* (better, a *virtuality*) having *virtual experiences*. M_x, i.e., a (non-biological) human who *believes* s/he is a real mind, has only virtual experiences that deceive him/her into having and holding this false belief. In short, M_x is a virtuality and not a reality.

Given (3) and (4) above, we are presented with a disjunctive syllogism, the second premise of which remains undetermined and in question:

5. P1: **(3)** v **(4)**

   <u>P2: **~(3)**? /**~(4)**?</u> [undecided (yet to be determined) negation of one of the disjuncts]

   C: **(4)** *[if P2 is decidedly ~(3)];* **(3)** *[if P2 is decidedly ~(4)]*

Alternatively, one could argue, there is an *x* such that 'some humans (*seemingly living* today) are simulations' and 'some humans (*really living* today) are not simulations.' This can be represented in symbolic notation, thus: $(\exists x)[(H^*_x \rightarrow Sim_x) \bullet (H_x \rightarrow \sim Sim_x)]$

The question thus arises: How do we *falsify* the hypothesis that, 'Some humans are simulations'?

3.3 Considering Relativity, Quantum Theory, and Falsifiability

In his introduction to Heisenberg's *Physics and Philosophy* (1959), F.S.C. Northrop commented that, "There is a general awareness that contemporary physics has brought about an important revision in man's conception of the universe and his relation to it." Adding further, in a way that relates to the consternation now associated with Bostrom's hypotheses, Northrop remarked, "The suggestion has been made that this revision pierces to the basis of man's fate and freedom, affecting even his conception of his capacity to control his own destiny." (Northrop 1959) And, indeed, today the debate between relativists and quantum theorists adds to our conundrum concerning the nature of physical reality and the empirical adequacy of the language we use to represent it.

Working through the meaning of his general theory of relativity, Einstein commented in 1923, "We already know that Euclidean geometry and the law of the constancy of the velocity of light are valid, to a certain approximation, in regions of a great extent, as in the planetary system." (Einstein 1923) Thus, when he communicated his general theory of relativity, advancing beyond both Euclidean geometry and classical mechanics, Einstein spoke of "the space-time continuum" in advancing *the absolute reality* of space and time, and said:

> The principle of inertia, in particular, seems to compel us to ascribe physically objective properties to the space-time continuum. Just as it was necessary from the Newtonian standpoint to make both the statements, *tempus est absolutum*, *spatium est absolutum*, [*time is absolute, space is absolute*] so from the standpoint of the special theory of relativity we must say, *continuum spatii et temporis est absolutum* [*the space-time continuum is absolute*]. In this latter statement *absolutum* means not

only "physically real," but also "independent in its physical properties, having a physical effect, but not itself influenced by physical conditions.

Einstein added, "As long as the principle of inertia is regarded as the keystone of physics, this standpoint is certainly the only one which is justified."

Einstein was here concerned with the field properties of space ("analogous" to the electromagnetic field); and, accounting for the presence of a gravitational field, he argued, "the geometry is not Euclidean," thus introducing a four-dimensional system of coordinates as space-time points and a mathematical apparatus "necessary to formulate the laws of the general theory of relativity"—without claiming completeness of results, as is "suited to the present provisional state of our knowledge." (Einstein 1923) Thus, from the perspective of both the special theory and the general theory, Einstein held these scientific claims to be inductively valid insofar as they characterize our physical reality—i.e., they have *probability*-value if not *truth*-value. From this perspective, a simulation argument such as Bostrom proposes seems out of place, at least to the degree we accept the objective probability we associate with such scientific claims. Philosopher of science Van Fraasen instructs us: "probability as a measure of objective features of the world—or of features of the model that is meant to fit the world—must be dealt with in the philosophical analysis of the scientific description of nature." (Van Fraasen 1980)

Like Einstein, Werner Heisenberg was well aware of the transformations in philosophical conceptions of a substantive reality from the time of the ancient Greeks through to late modern (19th century) philosophy and science. This included changes in belief about the structure of matter. For the moment, given the conceptual distinction of biological human and virtual human that Bostrom introduces, we are concerned with the structure of the human organism, whether we speak of this structure in terms of contemporary biology, chemistry, or physics. Heisenberg noted at the time that, "…there has been an increasing tendency in modern biology to explain biological processes as consequences of the laws of physics and chemistry. But the kind of stability that is displayed by the living organism is of a nature somewhat different from the stability of atoms or crystals. It is a stability of process or function rather than a stability of form. There can be no doubt that the laws of quantum theory play a very important role in the biological phenomena." (Heisenberg, no date) Citing Niels Bohr, Heisenberg then issued a caveat: "As Bohr has pointed out, it may well be that a description of the living organism that could be called complete from the standpoint of the physicist cannot be given, since it would require experiments that interfere too strongly with the biological functions." This presents both an epistemological and ethical limit on experimentation in humans, in contrast to the experimental possibilities associated with sub-atomic matter. On the basis of this latter type of experimental data, Heisenberg argued for the unity of matter, stating, "All the elementary particles are made of the same substance, which we may call energy or universal matter; they are just different forms in which matter can appear."

Accounting for differences between Einstein's special theory of relativity and quantum theory as concerns measurement of simultaneous events, Heisenberg wrote: "…in quantum theory the uncertainty relations put a definite limit on the accuracy with which positions and momenta, or time and energy, can be measured simultaneously. Since an infinitely sharp boundary [as stipulated in the special theory of relativity] means an infinite accuracy with respect to position in space and time, the momenta or energies must be completely undetermined, or in fact arbitrarily high momenta and energies must occur with overwhelming probability." (Heisenberg, no date) We have, in short, mathematical inconsistency between the two theories, which claim then raises more basic questions about the reality that is represented by the mathematical formulae. Notwithstanding, Heisenberg wrote later, "the concepts of the general laws must in natural science be defined with complete precision, and this can be achieved only by means of a mathematical abstraction." (Heisenberg, no date)

Consequent to these laws and the experiments that presuppose them, there is "an infinite variety of solutions to these equations" that "then corresponds to the infinite variety of particular phenomena that are possible in this part of nature." Thus, whatever one concludes about any representation of physical reality, there is an operative epistemological theory of correspondence (*adequatio*) between mathematical formulae and the phenomena that are described thereby. Of course, there is also a problem of language here: "The real problem behind these controversies," Heisenberg remarked, "was the fact that no language existed in which one could speak consistently about the new situation." Thus, the language of quantum theory "is not a precise language," said Heisenberg, "in which one could use the normal logical patterns; it is a language that produces pictures in our mind, but together with them the notion that the pictures have only a vague connection with reality, that they represent only a tendency toward reality." (Heisenberg, no date)

Hence, in the absence of an unambiguous conceptual equivalent of natural language, quantum theory cannot but rely on its mathematical formalism. Yet, there is more to this statement than meets the eye. Ross Rhodes aptly puts it this way: "Even though the mathematical formulas were initially developed to *describe* the behaviour of the universe, these formulas turn out to *govern* the behaviour of the universe with an exactitude that defies our concept of mathematics…It is as though our universe is being *produced* by the mathematical formulas." (Rhodes 2001) For the scientific realist, this assertion may well be intellectually disturbing, insofar as it presents "a backwards logic"—"the mathematical formalism seems to be more 'real' than the things and objects of nature," with the mathematics holding true for both our observations and our predictions.

Importantly, Einstein understood this limitation in language and said, "Any serious consideration of a physical theory must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates. These concepts are intended to correspond with the objective reality, and by means of these concepts we picture this reality to ourselves." (Einstein *et al.*, 1935) Einstein said this out of concern for both "correctness" and "completeness" of any proposed physical theory. Considering the latter issue in the case of quantum mechanics, Einstein defined 'reality' thus: "*If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element corresponding to this physical quantity."* Einstein held this definition to be consistent of both classical mechanics and quantum mechanics, in the latter case concerning the complementarity of position and momentum. Notably, in quantum theory, "*when the momentum of a particle is known, its coordinate has no physical reality*." Problematically, then, "any attempt to determine the latter experimentally will alter the state of the system in such a way as to destroy the knowledge of the first." (Einstein 1935) Einstein concluded: "the quantum-mechanical description of physical reality given by wave functions is not complete." (Einstein 1935) But, then, as noted above, Heisenberg did not find this a disturbing claim, given his Uncertainty Principle (issued in 1927)—"The more precisely the position is determined, the less precisely the momentum is known in this instant, and vice versa."

The significance of these early theoretical accounts is that both theoretical and experimental physicists continue in our day to debate the empirical adequacy of the two theories. Philosophers of science, of course, are well aware of the defeasibility that characterizes scientific hypotheses. That is, given a logical context of inductive or abductive reasoning in science, the introduction of new empirical evidence may be sufficient to defeat the warrant of a given scientific claim. Falsifiability requires that a scientific hypothesis (some, like Karl Popper, might say 'conjecture') be testable, i.e., subject to tests that may lead to its refutation. Accordingly, bearing in mind the foregoing theoretical context, one may reasonably ask whether Bostrom's hypothesis counts as a scientific statement. That is to say: Is the hypothesis consistent with some specifiable "canons of scientific method?" By this one means something like a "second-order critical tradition" such as advanced by Popper, or "paradigms" governing "normal science" such as discussed by Thomas Kuhn, or "research programmes" such as proposed by Imre Lakatos. (Nola 1987) Bostrom's proposal, if it is to have *scientific* merit as a genuine *empirical* problem and not be merely speculative, must be testable. That is to say, we should be able to falsify the proposition, the *hypothesis*, that asserts 'we are almost certainly living in a computer simulation'.

We may therefore ask: What observations might we make, and admit into evidence, to judge the validity of the probability-claim that 'we are almost certainly living in a computer simulation'? Do we have any admissible evidence, i.e., empirical observations, that are inconsistent with Bostrom's hypothesis, thus to falsify the hypothesis? Said otherwise, is there, at a minimum, some "signature" or "trace" evidence accessible to us that is amenable to scientific testing for the purpose of falsifying Bostrom's hypothesis? In asking these questions, we pose the matter differently from Bostrom, who asserts, "The whole point of the simulation argument was to argue that *we have evidence* that is interestingly relevant to the hypothesis that we are a simulation!" (Bostrom 2005a) That said, Bostrom does allow that, "It may well be that we have some evidence that is not entirely independent of (SIM) conditionalized on $f_{sim} \approx x$." Here Bostrom is accounting for what he calls his "Bland Indifference Principle (BIP), such that he argues, "The credence of (SIM) obtained by conditionalizing on $f_{sim} \approx x$, where x has a value that is very close to 1, would remain fairly close to 1 unless we had strongly relevant specific evidence to the contrary…" (Bostrom 2005a)

Our observations, of course, may be in error, in which case a significant problem with our effort to falsify a hypothesis may rest with our observations rather than with the hypothesis. Moreover, as A.E. Musgrave has argued, falsification is not disproof, keeping in mind here the difference between inductive and deductive inference: "arguments to the falsity of scientific hypotheses proceed from premises that are themselves hypothetical and fallible." (Musgrave, no date) How is this so in the case of Bostrom's hypothesis? If one claims that there is *at least one* entity (a supposed biological human) that is a computer simulation, i.e., that is in fact not really a human but merely a *virtuality* (or, otherwise said, one *living in* a computer simulation, as Bostrom says), then one cannot conclude therefore that *all* entities who construe themselves to be real human beings are computer simulations, despite this self-construal. This conditional proposition is an instance of the well-known logical claim that one cannot reasonably infer a justified universal generalization from such limited observations.

Since what is required for falsification is empirical refutation, observations must be empirically evaluated. Suppose one "apparently biological" human says, in response to Bostrom: 'I am *not* a computer simulation. I am *not* a merely virtual consciousness. I *am* truly a flesh-and-blood human being.' We represent this ostensible fact of human reality, logically, as $\exists x(xHb)$. The *complementary property* would be the entity that is a virtuality, logically represented as $\exists x(xHv)$. Thus, the one who asserts the set of statements to the effect of $\exists x(xHb)$ insists that s/he *knows* s/he is a biological human living in a real space-time, and, thereby, does not know that s/he is a virtuality, $\exists x(xHv)$. S/he presupposes (1) s/he has *a reliable test* for the claim $\exists x(xHb)$, and presupposes further (2) the test is *positive*. We could then say: We *know* this person's property, $\exists x(xHb)$—i.e., s/he is a biological human living in a real space-time. Of course, this set of assertions may be taken to represent a *merely subjective* state of a given individual and, hence, lack the sort of objectivity such as is sought in the validation of scientific pronouncements. However, the very fact that we are presented with this set of assertions, which we understand, means that we have inter-subjectively valid meaning. This allows us to say this person's claim, $\exists x(xHb)$, may reasonably count as evidence of inter-subjectively valid statements having truth-value (T=1), such that $\exists x(xHb)=1$. If so, we have a plausible instance of falsification of Bostrom's hypothesis that is hardly trivial, the ostensible objectivity of which merits examination according to the methodological requirement of falsifiability.

4. Conclusion: Learning from the Paradox of Refutation

Let's take the foregoing observation to be so, for the sake of argument. What follows from this falsifying observation? With this set of assertions, an individual asserts thereby that s/he *knows* something, despite implications of Bostrom's claims to the effect that this individual does not know, but must now *learn*, that s/he is "living in" a computer simulation. For all purposes, this means the same as what Hubert Dreyfus means when he says, with reference to *The Matrix*, "in The Matrix version of the brain-in-the-vat situation, those who have been hauled from the vat into what they experience as the real world can see that much of what they took for granted was mistaken. They can, for example, understand that what they took to be a world that had been around for millions of years was a recently constructed computer program." (Dreyfus *et al.* 2005) Following David Miller (Miller 2007) in his exposition of Popper, we could say that this individual must now learn "the opposite" of what s/he already knows: S/he must now learn that, contrary to estimates from the European Space Agency's Planck telescope observations and calculation that the universe is approximately 13.82 billion years old, *s/he is "living in" a simulation* ('living' here means a merely virtual process, i.e., appearance in the deficient sense of semblance) and *s/he is a simulation*, thus $\exists x(xHv)$. (European Space Agency 2013; Peplow 2013)

First, then, given a methodological concern for falsification, one has to *verify* (somehow) that the one who utters the set of assertions is *really* not a computer simulation, is *really* not a merely virtual consciousness, and *really* is a flesh-and-blood human being living in a universe that is *really* 13.82 billion years old. But, such acts of verification are at best inductive inferences. If successfully defended, they qualify as *justified true beliefs* with high degree of probability only, which means of course that they can never be apodictically certain in the way in which deductive inference provides indefeasible proof. They remain assertions characterized by probable truth and, thus, remain defeasible, no matter whether one's methodological approach is one of falsification or verification. Moreover, given that Miller has argued that "the generalization of falsificationism," as outlined by Popper, "renders obsolete the traditional, but still obtusely prevalent, characterization of human knowledge as something along the lines of justified true belief," on this latter line of argument, we remain in an epistemological conundrum. (Miller 1994) But, then, the logic of complementarity suggests that if one knows $\exists x(xHb)$, then there is a random probability associated with the claim, $\exists x(xHv)$, *the probability of which we cannot know while knowing* $\exists x(xHb)$.

We, of course, recognize that Bostrom's hypothesis—insofar as we take it to be a problem of science and not merely a problem of logic or mathematics—is conjectural. The fact that Bostrom can pose the hypothesis, however, would (*prima facie* at least) constitute *an anomaly in the simulation system*, if in fact occurring within such a simulation process. Of course, *as a matter of fact, Bostrom* (whether himself a biologically real or virtual consciousness) *has indeed posed the hypothesis*, thereby eliciting our consternation so as to engage it critically. Assuming the hypothesis to be true, it seems *we thereby have an anomaly* in this system, for which we must have some explanation, if the hypothesis is to be sustained as (probably) true rather than rejected as (probably) false. That is to say: If one such as Bostrom can and does say, 'we are almost certainly living in a computer simulation,' then Bostrom has presumably moved—through his logic of discovery—from a state of heretofore accepted scientific *knowledge* and a *real* personal identity to a moment of *learning* (or virtual learning) that now contradicts the whole of his experience and that of all humans (both past and contemporary) who believe themselves to be *real* flesh-and-blood humans in a *real* physical universe as understood by contemporary science.

In short, if his hypothesis is true, it is a consequence of his hypothesis that Bostrom cannot but find, sooner or later, the whole of his own experience to date falsified. He will have "realized" the deception, even if he is yet unclear as to the "deep structure" of the simulation that constitutes the whole of a virtuality in which he has found himself "living." (And, it is to be noted, this realization is more powerful than the sort of "awakening" as if from a dream that is attributed to the character Neo in *The Matrix*.) Indeed, if Bostrom is correct, then this counts firmly as an instance of Popper's philosophy of science that, "our knowledge [to the extent we make any claim to having it] consists of conjectures."

But, there is a paradox here: It may be that even the refutations of all conjectures hitherto would themselves be elements of the grand deception that we are living in a computer simulation—and, thus, the epistemological conundrum would remain with both our conjectures and their refutations. Despite traditions of scientific inquiry, despite claims of "increasing verisimilitude" or "greater predictive capacity" (Nola, 1987), despite belief in the apparent progress of the physical sciences to validate the features of our physical reality, the whole of this would remain, consequent to validation of Bostrom's hypothesis, only a virtuality. We would be, in short, in the equivalent of Descartes' radical doubt. (Grau, no date; Chalmers, no date) While allowing for this possibility of our finding ourselves in the equivalent of Descartes's radical doubt, we do not say, as Grau says in the case of *The Matrix*, that a person trapped in the Matrix is "doubly trapped," i.e., that he is "incapable of knowing that he is in the Matrix, and even incapable of successfully expressing the thought that he might be in the Matrix." We have the decidedly different situation of having Bostrom's hypothesis (proposition 3).] Given our reasoning thus far, however, we would be irrational to sustain the proposition that we remain in a situation of radical, even hyperbolical, doubt. That is, we may comfortably say: $\exists x(xHb)=1$—i.e., It is *true* that 'I' am a biological human, whatever the random probability associated with the complementary claim, $\exists x(xHv)$, whether with a probability value ≈ 0.2 (as Bostrom thinks) or a probability value ≈ 0.5 (consistent with the indifference principle).

Thus far, then, we have subjected Bostrom's hypotheses to philosophical and mathematical scrutiny and arrive at an interim, tentative conclusion that falsifies his simulation hypothesis. Nevertheless, we must yet consider what empirical testing, such as might be undertaken in contemporary physics, may reasonably conclude concerning this problem of falsifiability. The point here is not to report on actual empirical testing, but to engage in a thought-experiment that illuminates our interrogation further.

As part of his reasoning, Bostrom attempts to account for "some empirical reasons" that posthumans could run ancestor-simulations with a technological capacity "that can already be shown to be compatible with known physical laws and engineering constraints." (Bostrom 2003) He allows for the possibility of "novel physical phenomena, not allowed for in current physical theories," that may enable posthumans to "transcend those constraints that in our current understanding impose theoretical limits on the information processing attainable in a given lump of matter." (Bostrom 2003) Even so, if one is to take Bostrom's proposition (3) seriously, whatever we may speculate about a future time of superseded limits on computation, we must be able to test this hypothesis today, with reference to current physical theory and observations of natural phenomena available to our inspection. Some physicists such as Martin Savage concur.

On the basis of research related to quantum chromodynamics (QCD)— study of "the fundamental force in nature that gives rise to the strong nuclear force among protons and neutrons, and to nuclei and their interactions"—and what we know from contemporary high-performance computing (HPC), Savage informs us that we now have the capacity to perform "simulations…in femto-sized universes where the space-time continuum is replaced by a lattice, whose spatial and temporal sizes are of the order of several femto-meters or fermis (1 fm=10^{-15}m), and whose lattice spacings (discretization or pixilation) are fractions of fermis." (Beane *et al.* 2012)

Central to the approach of Savage's team is the operative assumption that we may construe parts of the universe not as a space-time continuum but as a lattice, in which case those parts are subject to study empirically consequent to detection of lattice spacing, i.e., the discretization or pixilation at the level of femto-measurement. Accepting the parameters of their research construct, we can yet consider what this presupposes of strong AI research that connects to the operative assumption here.

As noted earlier, grounded in Heidegger's Dasein analytic, Hubert Dreyfus has been a consistent critic of artificial intelligence (AI) research that presupposes a Cartesian epistemological approach to natural human intelligence, according to which a human is essentially "a thinking thing" (*res cogitans*), with mind entirely distinct from body (i.e., corporeal entities having extension, *res extensae*) and all natural entities *represented in the mind* on the basis of adventitious ideas, consistent with a correspondence theory of truth. Dreyfus has articulated his concerns in two prominent works, the later *What Computers Still Can't Do: A Critque of Artificial Reason* (Dreyfus 1992) pointedly describing the limitations of any cognitive science (e.g., "Cognitive Simulation") that is grounded in such epistemology. Even when such research learns from criticism, such as Dreyfus sets forth, and moves in a direction that learns from Dreyfus's Heideggerian critique of Cartesian epistemological presuppositions, the limitations remain because of ongoing deficiencies in the way in which the problem of artificial intelligence is framed. (Dreyfus 2007) Dreyfus surveyed developments in AI research and remarked, "by combining representationalism, conceptualism, formalism, and logical atomism into a research program, AI researchers condemned their enterprise to confirm a failure." This approach, Dreyfus objected, faces a serious "frame problem." Cognitive simulation research such as that undertaken in the 1960s at MIT's AI lab proceeded with a thesis that:

> …representing a few million facts about objects including their functions, would solve what had come to be called the commonsense knowledge problem. It seems to me, however, that *the real problem* wasn't storing millions of facts; it was *knowing which facts were relevant in any given situation*. One version of this relevance problem is *the frame problem*. If the computer is running a representation of the current state of the world and something in the world changes, how does the program

> determine which of its represented facts can be assumed to have stayed the same, and which might have been updated? (Dreyfus 2007; italics added)

This basic question remains unanswered in the "hypothesis" Bostrom proposes, in which case the simulation argument also suffers from the frame problem, and, hence, leaves its proponents with a more fundamental problem as to what evidence is to be accounted admissible for the purpose of falsification. In the absence of an answer to this question, there is little reason to take Bostrom's proposal as a *scientific* hypothesis, in which case it remains at best a philosophically speculative proposition only.

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