

JOHN B. O. MITCHELL**We are probably not Sims**

In this article, I discuss the current state of the debate around the simulation hypothesis, the idea that the world we inhabit is a computer simulation in or within another universe. Considering recent work from a range of authors, I suggest that statistical arguments in favour of a simulated world are naive and fail to account either for Ockham's Razor or for alternative existential possibilities besides base reality and a simulation. Most significantly, I observe that it would be computationally impossible in our own universe to simulate a similar cosmos at fine granularity. This implies substantial differences in size and information content between simulating and simulated universes. I argue that this makes serious analysis of the simulation argument extremely difficult. I suggest that Christian theology has no reason to reinvent itself to accommodate simulism; the two should be viewed as mutually exclusive world-views. Further, I note that the existence of a human soul or spirit, or indeed any non-reductionist explanation of human consciousness, could undermine the assumption of substrate independence that simulism requires.

Keywords: Simulation hypothesis, limits of computation, information, Ockham's Razor, substrate independence, soul, spirit, consciousness.

1. Introduction

Bostrom¹ formalised and popularised the contemporary simulation hypothesis. In his paper, he claimed that one of the following statements is true:

- (a) Our species, or by extension a species like ours, is unlikely to survive long enough to reach a *posthuman* stage of highly advanced technology;
- (b) Species that do reach such a stage are unlikely to run a large number of simulations of societal evolution containing conscious simulated characters;
- (c) We are likely to be living in such a simulation.

His argument is known as the *simulation argument* and the scenario that our universe is in fact a simulation is called the *simulation hypothesis*. I illustrate an outline of Bostrom's line of reasoning in Figure 1.

Bostrom's argument concerns the likelihood of our universe actually, objectively being a computer (that word can be interpreted broadly) program or

¹ Bostrom, N. 'Are we living in a computer simulation?', *Philosophical Quarterly* (2003) 53(211), 243-255; doi: 10.1111/1467-9213.00309

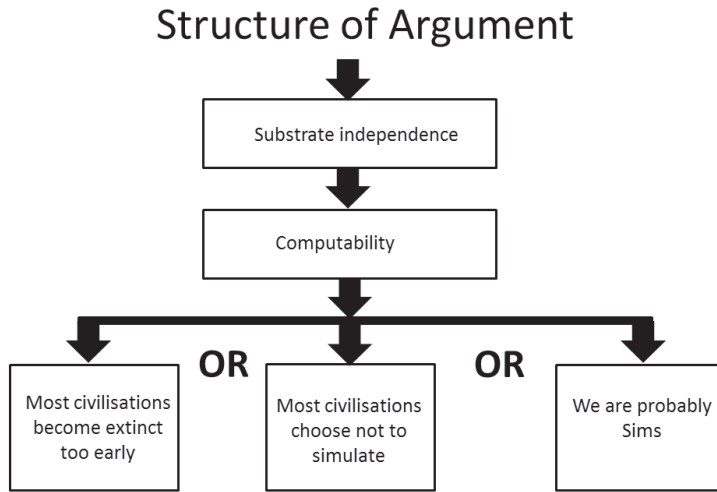


Figure 1. Structure and assumptions of the simulation argument

game being run by biological or machine intelligences in some other ‘base’ universe. It is of course entirely valid and reasonable to find and highlight analogies between simulism and many other ancient and modern speculations about the nature of reality. However, the possibility that the simulation hypothesis is truthful only as a metaphor for creation is not the main subject of this paper and discussion of it is postponed until Section 3.5.

Bostrom’s paper has generated a substantial quantity of comment and discussion, with 674 Google Scholar citations as of February 2019. Amongst these are some articles by respected thinkers in reputable publications, although only 153 are in academic journals indexed by Web of Knowledge. There are also sources and authors of the less rigorous or less mainstream varieties; within these, there are nonetheless some interesting ideas. This paper considers the various kinds of discussion that have been raised around the simulation argument and the simulation hypothesis. These ideas have also been aired in a seminar presentation which parallels this manuscript,² given at a meeting of the St Andrews Institute for Data-Intensive Research in August 2018 and in an undergraduate lecture on Science and Religion which is publicly available.³

2 Mitchell, J.B.O. ‘We are probably not Sims’, Summer Workshop of the Institute for Data-Intensive Research, University of St Andrews (2018); http://chemistry.st-andrews.ac.uk/staff/jbom/group/simulism_IDIR.pptx

3 Mitchell, J.B.O. ‘Fine tuning and the God of the gaps’, Module ID1003, University of St Andrews (2018); http://chemistry.st-andrews.ac.uk/staff/jbom/group/Belief_Lectures.html

2. State of the field

2.1 Logical, philosophical and probabilistic discussions

Probabilistic arguments are widely used both in serious academic discussion and in less formal forums. Such approaches have been used to argue both for and against the existence of God, for a multiverse, to claim that life is widespread or rare in the universe, and so on. These arguments are very dependent upon the range of possible options considered, the values ascribed to a priori probabilities, and the models and assumptions (for example those regarding independence and contingency) used to compute likelihoods of various scenarios. A number of discussions of these kinds, including some Bayesian presentations, have been applied to the simulation argument.

Some papers, including those by Lewis⁴ and Aranyosi, draw an analogy with the *doomsday argument*.⁵ Much of this material relates to setting reasonable values of prior probabilities of different scenarios. Francheschi⁶ raises some points related to the calculation of probabilities dependent on sets of states which occur at different times. Weatherson⁷ criticises what he sees as Bostrom's implicit probabilistic assumptions underlying the degree of belief in certain propositions and the estimation of conditional probabilities; Bostrom⁸ then replies defending his original paper. In essence these are arguments about which states one should sum over, and what prior probabilities one should assign to them.

Ćirković⁹ suggests that the existential risk to a civilisation of developing potentially powerful and hostile artificial intelligence (AI) directly affects the simulation argument. Specifically, AI risk makes Bostrom's¹⁰ condition (a), extinction before reaching a posthuman stage, more likely. One might surmise that mindfulness of this risk might also reduce the prospects of development of the kind of computer technology leading to *ancestor simulations*, hence also

4 Lewis, P. 'The doomsday argument and the simulation argument', *Synthese* (2013) 190(18), 4009-4022; doi: 10.1007/s11229-013-0245-9

5 Aranyosi, I.A. 'The doomsday simulation argument. Or why isn't the end nigh, and you're not living in a simulation', (2004); <http://cogprints.org/3404/>

6 Francheschi, P. 'On the disanalogy in the simulation argument', (2012); <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.693.5221&rep=rep1&type=pdf> (accessed 26 Nov 2018).

7 Weatherson, B. 'Are you a Sim?', *Philosophical Quarterly* (2003) 53(212), 425-431; doi: 10.1111/1467-9213.00323

8 Bostrom, N. 'The simulation argument: reply to Weatherson', *Philosophical Quarterly* (2005) 55(218), 90-97; doi: 10.1111/j.0031-8094.2005.00387.x

9 Ćirković, M.M. 'Linking simulation argument to the AI risk', *Futures* (2015), 72:27-31; doi: 10.1016/j.futures.2015.05.003

10 Bostrom *op. cit.*, (1).

affecting condition (b). Ćirković¹¹ is fairly dismissive of the possibility of numerous simulations being run by artificial intelligences themselves after the extinction of the precursor biological species, though other thinkers may consider that scenario realistic.

Some critics also raise the issue of summing over states corresponding to either known present or hypothetical future observers. Eckhardt¹² even argues that the simulation argument implies time-reversed causation. Bostrom himself acknowledged a numerical difficulty with the assumptions of the original argument in the case of a posthuman civilisation having an 'unusually brief pre-posthuman phase' and presented a slightly amended 'patched' version of his original argument.¹³ Wehr¹⁴ contends that even the patched simulation argument contains both vagueness and logical errors. Besnard¹⁵ attacks the simulation argument on a number of grounds, though it does not appear that he has found a valid logical refutation. Sturman¹⁶ uses Ockham's Razor to argue against simulism, saying that the idea of our living in a simulated reality is unnecessarily complex. He also raises the objection that Bostrom's argument applies a conclusion from our familiar world to an entirely hypothetical universe about whose physical laws we know nothing.

One limitation of Bostrom's paper¹⁷ is its expression of *Simulation v Base Reality* as a dichotomous choice between only two possibilities. The simulation hypothesis itself is a relatively new arrival on the intellectual landscape, though related ideas such as the dream hypothesis are much older. Readers of Borges will have encountered the idea that we have imagined the world in a dream, but have allowed into its fabric sufficient inconsistencies and paradoxes to let us conclude that it is false.¹⁸ For centuries, thinkers have wrestled with the idea that our physical universe is a single reality, whether created by God or otherwise, whether caused or uncaused, whether deterministic or stochastic,

11 Ćirković *op. cit.*, (9).

12 Eckhardt, W. 'The simulation argument', in *Paradoxes in Probability Theory*, Springer Briefs in Philosophy, Dordrecht: Springer (2013), pp. 15-17; doi: 10.1007/978-94-007-5140-8_4

13 Bostrom, N. & Kulczycki, M. 'A patch for the simulation argument', *Analysis* (2011) 71(1), 54-61; doi: 10.1093/analys/anq107

14 Wehr, R.D. 'Correcting errors in the Bostrom/Kulczycki simulation arguments', (2017); <https://philpapers.org/archive/ROBCEI-2.pdf> (accessed 26 Nov 2018).

15 Besnard, F. 'Refutations of the simulation argument', (2004); <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.143.9219&rep=rep1&type=pdf> (accessed 26 Nov 2018).

16 Sturman, H. 'Against the argument that we live in a simulation', (2004); <https://www.longecity.org/forum/topic/3402-against-the-argument-that-we-live-in-a-simulation/> (accessed 26 Nov 2018).

17 Bostrom *op. cit.*, (1)

18 . Borges, J.L. 'La Perpetua Carrera de Achilles e la Tortuga', in *Discusión*, Buenos Aires: M. Gleizer (1932)

and whether or not there exist some other spiritual or transcendent realities in addition to it. More recently, probabilistic arguments have been confidently made in favour of a multiverse¹⁹ which could function as an explanation for fine-tuning; a somewhat related idea also appears in the *many worlds* interpretation of quantum mechanics.²⁰ The specific idea that our universe is a simulation generated by a computing device is a comparatively novel possibility, beyond imagination only a few decades ago. Like the multiverse, an apparently powerful probability-based argument can be made for it, an argument embraced by entrepreneur Elon Musk.²¹ This line of reasoning is closely related to Bostrom's work, predicated on the idea that posthuman civilisations probably run very many such simulations containing vastly more observers than base reality. However, this thinking fails to account for all currently popular existential possibilities, let alone for whatever as-yet-unconsidered models of reality might be discussed alongside the unique physical universe, the multiverse, many worlds and the simulation hypothesis in philosophers' future deliberations. For instance, advanced alien societies could create potentially very many real, not simulated, universes.²²

2.2 Scientific ideas that impact upon the simulation argument

The original simulation argument²³ contains two assumptions which are not formally part of its logical trifurcation. Both of these assumptions are potentially points where critics might seek weaknesses in the simulation argument. The first is the *substrate independence* of consciousness, that the full experience of human consciousness could be faithfully reproduced by simulation within a computing device. That will be false if it is just not possible to reproduce humanlike consciousness in a computer, and Bostrom's assumption of substrate independence would not hold. Sturman,²⁴ for example, argues against the plausibility of *in silico* consciousness. I suggest that consciousness will probably be impossible to recreate if there is something fundamental about the biological substance of our brains that cannot be replicated *in silico*, and consciousness

19 Kragh, H. 'Contemporary history of cosmology and the controversy over the multiverse', *Annals of Science* (2009) 66(4), 529-551; doi: 10.1080/00033790903047725

20 Everett, H. "'Relative state' formulation of quantum mechanics", *Rev Mod Phys* (1957) 29(3), 454-462; doi: 10.1103/RevModPhys.29.454

21 Griffin, A. 'We are living in a computer simulation, Elon Musk says', *The Independent* 2 June 2016; <https://www.independent.co.uk/life-style/gadgets-and-tech/news/elon-musk-ai-artificial-intelligence-computer-simulation-gaming-virtual-reality-a7060941.html> (accessed 12 Feb 2019).

22 Stewart, I., Cohen, J. & Pratchett, T. *The Science of Discworld*, New York: Random House (1999), ISBN 978-0091865153; <https://www.terrypratchettbooks.com/book/the-science-of-discworld/>

23 Bostrom *op. cit.*, (1).

24 Sturman *op. cit.*, (16).

then turns out to be an emergent property dependent on the biological substrate as well as the complexity of the computation. There is also an inherent requirement that the mind be nothing but computation in the brain; in terms of an ancient but familiar model, dualists may counter-argue that the machine simply cannot be conscious without its ghost. I discuss this idea of a human soul or spirit below in section 3.3, and do so in a specifically Christian context.

The second main assumption of the simulation argument is that the future development of computer power will be sufficient to support such a simulation. Bostrom's original paper²⁵ contains a justification of this assumption, which however seems far from certain. Computation has both theoretical²⁶ and practical limits. Very possibly, such a simulation is not technically possible in our world because the amount of computation required in modelling the universe, or at least a character's observable and comprehensible universe, is infeasibly large. A number of authors have indeed attempted to oppose the simulation argument on grounds of the necessary kind or complexity or quantity of computation being inaccessible. Eckhardt²⁷ mentions the possibility that such a simulation is infeasible, though without full discussion. Beisbart²⁸ claims that the way in which computers operate is fundamentally different from, and incapable of replicating, the manner in which brains operate. Syropoulos²⁹ suggests that the universe is fundamentally incomputable. Lewis³⁰ argues that nested simulations within simulations, as sometimes advocated probabilistically by proponents of simulism, are impossible.

In order to present the simulation argument in a way that permits meaningful analysis, I claim here that it is necessary to assume that the simulating and simulated universes have similar physics. I read the core argument in Bostrom's original paper³¹ as assessing in essence whether a species such as us in a universe like this one could feasibly develop to the point of creating ancestor simulations with conscious characters, who would then experience a reality similar to ours. While one could in principle attribute all manner of magical properties to the simulators' base reality, the existence of such a world would be untestable and would push simulism squarely into the realm of pseudo-religious rather than scientific beliefs. It would be almost impossible to have a sensible discussion of any of the relevant factors such as the physical limits of

25 Bostrom *op. cit.*, (1).

26 Lloyd, S. 'Ultimate physical limits to computation', *Nature* (2000) 406(6799), 1047-1054; doi: 10.1038/35023282

27 Eckhardt *op. cit.*, (12).

28 Beisbart, C. 'Are we Sims? How computer simulations represent and what this means for the simulation argument', *Monist* (2014) 97(3), 399-417; doi: 10.5840/monist20149732

29 Syropoulos, A. 'Can we debug the universe?', arXiv:0910.2859 [cs.OH] (2009); <https://arxiv.org/abs/0910.2859>

30 Lewis *op. cit.*, (4)

31 Bostrom *op. cit.*, (1).

computation, the nature of consciousness, the life expectancy of an intelligent species, or the likelihood of their running ancestor simulations if the simulators' laws of nature were arbitrarily different from ours. Thus, we have little choice but to use feasibility in our universe as a proxy for feasibility in theirs, and limit our discussions to scenarios where the laws of physics in the simulation at least approximate those in the base reality.

To be clear, when in this paper I say that I or we must necessarily make assumptions, I do not mean that I assert these things to be factually true. What I mean is that I must necessarily limit my assessment of Bostrom's simulation hypothesis to those scenarios where he claims validity for it. In the present case, the apparently necessary assumption that the two worlds are alike seems to be somewhat undermined by strong arguments suggesting that the two universes must be quite different in their extents. The simulating universe contains the simulated universe, plus very much else. Therefore, it is necessarily many orders of magnitude bigger in terms of its size and therefore of its information content. The relationship between the universe's size and its entropy is discussed in detail by Egan & Lineweaver.³² Here, I link entropy as a thermodynamic measure of disorder with the quantity of information that is required to specify the state of a system; in this case the information needed to fully describe the universe. Technically that quantity of information is the Shannon entropy,³³ a measure of information content well known in computer and information sciences. I make the assumption that the total information needed to describe a possible universe tends to increase roughly linearly with its volume. Our observable universe is estimated to be around 3.65×10^{80} m³ in volume,³⁴ whereas even a large computer on which we might run a simulation will probably be significantly less than 1 m³, only a fraction of which is devoted to the computer's memory. Lloyd,³⁵ for instance, suggests a volume of 10^{-3} m³ for his hypothetical *ultimate laptop*. These scales differ by a little more than 83 orders of magnitude. This margin would be considerably greater without the assumption that most of the volume of the computer is information carrying.

Even for hypothetical planet-sized computers, there would still be a massive disparity with the size of an entire universe. In principle, one could imagine an alien computer whose information content approaches the Bekenstein bound for its size, the upper limit on the quantity of information that can be contained within a given volume,³⁶ though such a device seems improbably exotic. This

32 Egan, C.A. & Lineweaver, C.H. 'A larger estimate of the entropy of the universe', *The Astrophysical Journal* (2010) 710(2), 1825-1834 doi: 10.1088/0004-637x/710/2/1825

33 Shannon, C.E. 'A Mathematical Theory of Communication', *Bell System Technical Journal* (1948) 27(3), 379-423; doi: 10.1002/j.1538-7305.1948.tb01338.x

34 Egan & Lineweaver *op. cit.*, (32).

35 Lloyd *op. cit.*, (26).

36 Egan & Lineweaver *op. cit.*, (32); Bekenstein, J.D. 'Universal upper bound on the entropy-to-energy ratio for bounded systems', *Physical Review D* (1981) 23(2), 287-298; doi: 10.1103/

computer would be informationally equivalent to a black hole of the same size. Such a device would contain sufficient information to simulate a region of space substantially larger than itself, but still manifestly contain less information than an entire universe with the same physical laws. Although the disparity for such a device might be substantially less than 83 orders of magnitude, that disparity nonetheless remains very large indeed.

Thus we can safely conclude that a simulated version of our universe would not come anywhere close to fitting inside any feasibly imaginable computer. There are just far too few particles in the plausible volume of a computer to carry the requisite quantity of information. This suggests either that the simulated universe is necessarily vastly smaller than the simulating one, or else that it is represented at a very much coarser granularity. The latter possibility might correspond to a more pixelated or lower definition universe with a correspondingly smaller information density.

Ringel and Kovrizhin³⁷ recently published a paper on the complexity of simulating quantum effects, a somewhat superficial reading of which led at least one commentator to claim that ‘Physicists find we’re not living in a computer simulation.’³⁸ Others subsequently challenged that interpretation, suggesting instead that the results only ruled out simulating complex quantum systems on a classical computer and that simulation using quantum computing could not be excluded.³⁹ Estimating the cost of a simulation is complicated by the lack of knowledge of how extensive it needs to be. Does this involve simulating the whole universe at fine granularity, or only simulating at least billions of complex conscious minds? I exclude from serious consideration the logically coherent but unproductive solipsistic possibility that the simulators generate only a single conscious brain, with the rest of universe and all other persons filled in in a convincing-enough way.

2.3 *Potential tests of the simulation hypothesis*

I now consider potential ways in which one might test the simulation hypothesis. By this I mean experiments feasible either now or in the future, and thought experiments, whose results and interpretation might significantly affect our best estimate of the likelihood of the simulation hypothesis. An initial

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37 Ringel, Z. & Kovrizhin, D.L. ‘Quantized gravitational responses, the sign problem, and quantum complexity’, *Science Advances* (2017) 3(9), e1701758; doi: 10.1126/sciadv.1701758

38 Masterson, A. ‘Physicists find we’re not living in a computer simulation’, *Cosmos* 2 Oct 2017; <https://cosmosmagazine.com/physics/physicists-find-we-re-not-living-in-a-computer-simulation> (accessed 12 Feb 2019).

39 Thompson, A. ‘Sorry, scientists didn’t prove we’re not living in a simulation’, *Popular Mechanics* 4 Oct 2017; <https://www.popularmechanics.com/science/news/a28505/scientists-dont-prove-were-not-living-in-a-simulation/> (accessed 12 Feb 2019).

observation is that we do not know whether the laws of physics in a hypothetical simulated universe correspond exactly, closely, or hardly at all with that of the simulators' real universe; though the earlier assumptions would exclude serious examination of the simulation hypothesis in the latter case. An exact correspondence would imply that the simulators knew their laws of physics very precisely, which Barrow⁴⁰ thinks unlikely. It would also mean that, given the purpose of the simulation and cost considerations, approximation was not warranted.

While of course we do not know for sure why a hypothetical simulator might run a putative simulation, we can think about why we ourselves run simulations. Our principal purposes are entertainment and scientific research; both categories can be interpreted broadly. If we were to simulate the development of a society or of a universe, we might do it for entertainment, for education, as scientific research into how civilisations or universes operate and evolve, or maybe as part of an exercise to predict possible futures or better to understand history. One might imagine investigating what physical parameters might lead to a universe in which life could evolve, or perhaps how a society deals with an environmental or existential crisis. This could be analogous to running simulations, and typically very many of them, in contexts we are more familiar with: to forecast the weather, to predict optimal investment strategies on the stock market, to determine the tactics most likely to be successful in a Formula 1 race, or for the military to understand the likely consequences of possible strategies in a war. Possibly the key facet of such a simulation might be studying the mind, brain or consciousness. It is not clear whether simulators would care about detection of simulated status by characters within the virtual world, and whether they would be careful to avoid leaving clues in the design of that universe.

Depending on the nature and purpose of the simulation, our own scientific and computing communities use different models of physics in different contexts. Mostly, we use broadly Newtonian physics, though there are circumstances such as modelling a chemical reaction⁴¹ where we need to include quantum mechanics; relativistic simulations also exist. Generally, the physics is required only to be good enough for the purpose at hand, and Barrow⁴² suggests that this might be the case in a simulated universe. For example, video games will render water in a way that looks visually credible, but does not reflect the true complexity of fluid mechanics.

40 Barrow, J.D. 'Living in a simulated universe', in Carr, B. (ed.) *Universe or Multiverse*, Cambridge: Cambridge University Press (2017), pp. 481-486.

41 Ahmadi S., Barrios Herrera, L., Chehelamirani, M., Hostas, J., Jalife, S. & Salahub, D.R. 'Multi-scale modeling of enzymes: QM-cluster, QM/MM, and QM/MM/MD: A tutorial review', *International Journal of Quantum Chemistry* (2018) 118(9), e25558+doi: 10.1002/qua.25558

42 Barrow *op. cit.*, (41).

In the event that we are in a simulation with only approximately real physics, it is possible that the starting point of the simulation is not the temporal origin of the universe and hence that the physics of our universe need not be adequate to describe its earliest stages. This might suggest that, if at some future time we appear to have exhausted new physics, our best theories would still fail to describe cosmology accurately. A simulated world that did not start from $t=0$ might endlessly puzzle its cosmologists.

I also note that, if the simulating of minds is a substantial part of the cost of the whole simulation, then finding large numbers of sentient alien species in our galaxy would raise our best estimate of the expense of the computation required. Finding even one independent origin of sentient life cosmically close to ourselves would shift the assumed parameters of the Drake equation⁴³ towards suggesting that the universe contains very many minds indeed. This would be less relevant if the cost is largely that of simulating the physical universe.

Beane et al.⁴⁴ discuss the physics implied by a simulated world. Their work assumes that the simulation is based on an underlying three-dimensional grid of cubic symmetry. In principle, such a world would contain preferred directions, and hence not be rotationally invariant. Beane et al.⁴⁵ argue that this would imply breaking of both parity, the idea that the universe has no microscopic preference between left and right, and Lorentz invariance, the notion that all observers experience the same laws of physics. They also suggest that a lattice spacing larger than around 10^{-27} m would result in rotational asymmetry in the distributions of high energy cosmic rays. Their model requires quantisation of both space and time on some scale, neither of which has currently been observed. The Planck length is approximately 10^{-35} m, about eight orders of magnitude smaller than the threshold lattice spacing they discuss. The Planck time is around 10^{-43} s. Besnard⁴⁶ briefly mentions these issues of symmetry breaking and granularity or quantisation of space and time. Analogies with our own simulations might suggest that a simulated universe would probably either be finite or have periodic boundary conditions, rather than being infinite. However, it is also quite possible that a simulation would not use a cubic grid, or any other regular array of points. One might also speculate on whether the effects of the chosen coordinate system or of the finite precision of the computer's arithmetic might be detectable to the simulated beings as asymmetry, finite granularity, or indeed errors. Barrow⁴⁷ suggests that, in

43 Glade, N., Ballet, P. & Bastien, O. 'A stochastic process approach of the Drake equation parameters', *International Journal of Astrobiology* (2012) 11(2), 103-108; doi: 10.1017/s1473550411000413

44 Beane, S.R., Davoudi, Z. & Savage, M.J. 'Constraints on the universe as a numerical simulation', *The European Physical Journal A*. (2014) 50(9), 148. doi: 10.1140/epja/i2014-14148-0
45 *ibid.*

46 Besnard *op. cit.*, (15).

47 Barrow *op. cit.*, (41).

so extensive a simulation, numerical inaccuracies and inconsistencies would build up over time and that the simulators would be required to intervene to correct such errors. He proposes, speculatively, that errors might appear as inconsistencies and changes in the constants of nature. He posits that such occasional interventions might appear to us as glitches, observations that appear to contradict normal laws of physics. He does not use words like *miraculous*, *supernatural*, or *paranormal* to describe such events, but some might.

Campbell et al.⁴⁸ suggest that if we assume that the major cost of the simulation is simulating brains rather than modelling the physical universe, then a major saving could be made by rendering reality only when information becomes available for observation by a character. This, naturally, affects our interpretation of quantum mechanics, implying that the cat need not be either living or dead until someone looks into the box. They suggest a number of quantum mechanical experiments, using double slits rather than poisoned felines, to help elucidate whether our world resembles that which they would expect under simulism. They also mention that a simulation could easily permit non-local causation and faster than light transmission of information, since the computer would hold the states of objects arbitrarily distant, which could interact *in silico*, or more likely in some other computing medium, rather than through real space.

Bostrom himself⁴⁹ had originally suggested a similar ruse for limiting the size of an ancestor simulation; that microscopic or distant phenomena could be filled in as required to satisfy the demands of Sims' enquiring minds. As a civilisation's exploration of its astronomical and nanoscale environments becomes ever more fine-grained and its experimental apparatus more sophisticated, the informational demands upon the supposed simulation would increase without obvious limit. Increasingly sophisticated investigations of distant galaxies, subatomic particles, and cellular machinery would be required to yield results that made that made scientifically coherent sense.

2.4 Determinism and the simulation hypothesis

We can run either simulations such as Molecular Dynamics, which emulate deterministic Newtonian physics, or those like Monte-Carlo that emulate a stochastic process. Notwithstanding its association with randomness, the progress of a Monte-Carlo simulation is in practice deterministic once its random seed has been chosen, as it is based on pseudo-random numbers.⁵⁰ This allows

48 Campbell, T, Owahdi, H., Sauvageau, J. & Watkinson, D. 'On testing the simulation hypothesis', *International Journal of Quantum Foundations* (2017) 3(3), 78-99; <https://www.ijqf.org/archives/4105> & [arxiv.org:1703.00058](https://arxiv.org/abs/1703.00058) [quant-ph]

49 Bostrom *op. cit.*, (1).

50 Van Gelder, A. 'Some new results in pseudo-random number generation', *Journal of the ACM*

a failed or corrupted calculation to be replaced by one which will obtain the same result as if the original had proceeded as intended. However, this feature probably would not be obvious from the inside. As an alternative to an algorithm modelling deterministic or indeterministic physics, we can also run interactive programs. Many games are examples of this kind, with the course of events depending on inputs from users. If a simulation were of this type, some turns of events would depend on simulators' decisions.

Within the context of a broadly Monte-Carlo style simulation emulating random behaviour, one might speculatively suggest that any conscious characters would perceive their universe to operate stochastically. This seems essentially consistent with our current understanding of our own universe, though the opposite would have been the case through much of the history of scientific thought. Though the stochastic Copenhagen interpretation is the working assumption of many scientists, there are multiple different available interpretations of quantum mechanics. It is still not definitively established whether our own world is best described as deterministic or random at a fundamental level.

3. Relationship to Christian doctrine, theology and apologetics

3.1 God and the simulators

The notion that simulators are our God or gods, discussed for example by Steinhart,⁵¹ seems superficial. Across the broad church of contemporary Christianity, God is widely seen and portrayed as loving, benevolent, omnipotent, omniscient, omnipresent and eternal, having been made incarnate in Jesus, and uniquely possessing the full attributes of deity. Simulators, in contrast, are presumed by adherents of simulism to be *posthuman*, or indeed *postalien*, mortal and fallible creatures, though with high levels of intelligence and technological development. Their moral or ethical characteristics are unknown, beyond firstly their having been sufficiently benign to one another to survive technological development without blowing themselves up, and secondly having no scruples about playing masters to a simulated universe. They are, wherever they came from, essentially creaturely rather than divine in their attributes. While simulators could in principle have virtually unlimited power over our universe, such a version of omnipotence is far from reflecting the full nature of divinity as understood by the major strands of Christian theology. Further, the incarnation of God in the person of Jesus is central to Christian doctrine, but would be emptied of meaning in a simulist world-view. As discussed above in

(1967) 14(4), 785-792; doi: 10.1145/321420.321437

51 Steinhart, E., 'Theological implications of the simulation argument', *Ars Disputandi* (2010) 10(1), 23-37.

Section 2.4, a simulation could either start from defined initial conditions and be left to run by itself somewhat like the world conceived of in a deist view, or else be set up such that the simulators could actively intervene. Such intervention would, however, be more akin to the interaction between a player and a computer game than to the relationship that theologians consider God to have with the world.

Few would dispute that Christian views of God have been required to evolve over the centuries, changing in concert with developments in many strands of human knowledge and enquiry; in society, in morality, in science, in philosophy, in art, literature and music, and especially in biblical criticism. Nonetheless, to equate an intelligent but clearly mortal and fallible alien civilisation with God would be to cross a Rubicon of redefining deity as no more than an idealised version of ourselves. Thus, my view is that there is no benefit in Christian theologians or apologists making any attempt to accommodate such an alien notion of divinity. I would maintain that the Christian and simulist world-views have quite different notions of the nature of the Creator or creators, and indeed of the nature of reality itself. It is most realistic to see them as mutually exclusive accounts of the world.

3.2 A digital afterlife?

Authors including Steinhart,⁵² Graziano⁵³ and indeed Bostrom⁵⁴ have discussed the idea of a so-called digital afterlife. In this context, the phrase means preserving or reconstructing an individual's conscious mind after death within a computing device. This is the meaning I address here, although confusingly the same phrase is sometimes used to describe a deceased person's continuing footprint on the internet and social media platforms.

The majority of Western Christians take a dualist position, as reported somewhat anecdotally by Murphy,⁵⁵ and hence have a view of the afterlife that emphasises the immortal soul. From this perspective, this digital afterlife is a technological attempt to prolong either a form or facsimile of life, more conceptually akin to cryopreservation than to the usual modern Western understanding of Christian salvation; perhaps this is an afterlife – but not as we know it.

Nonetheless, Christian views of the afterlife are not uniform, containing

52 Steinhart *op. cit.*, (52).

53 Graziano, M. 'Why you should believe in the digital afterlife', *The Atlantic* 14 July 2016; <https://www.theatlantic.com/science/archive/2016/07/what-a-digital-afterlife-would-be-like/491105/> (accessed 12 Feb 2019).

54 Bostrom *op. cit.*, (1).

55 Murphy, N. 'Do humans have souls? Perspectives from philosophy, science, and religion', *Interpretation: A Journal of Bible and Theology* (2013) 67(1), 30-41; doi: 10.1177/0020964312463192

varying emphases on an immortal soul or bodily resurrection. Amongst academic theologians, there is significant support for physicalism, the view that there is no immaterial soul and that salvation should be understood in terms of bodily resurrection alone. Murphy⁵⁶ sees this as closer to the Hebrew belief system, while accepting that it is not popular amongst rank-and-file believers: 'however thoroughly dualism has been rejected in the academy, this information did not reach the Christians in the pews'.⁵⁷ While a physicalist perspective might perhaps make one more willing to consider seriously whether a digital afterlife could somehow be the real thing, technological resurrection is not to eternal life, but merely to a prolonged life expectancy that will ultimately and inevitably end; if not otherwise, then in some global or cosmic disaster – or perhaps when the off switch is pressed.

3.3 Substrate independence and Christian belief

There is a tension between the common dualist Christian belief and the simulation argument's assumption of substrate independence, that human consciousness could be generated directly by computations of sufficient complexity within a computer. In a fully reductionist world-view, substrate independence would seem a highly rational assumption. I indeed claim that the simulation argument relies on a substantial dose of reductionism, the kind of thinking that says that because thoughts can be described as signals in a network, therefore the mind *must be entirely characterised* by these impulses transmitted between neurons. It is only a small step from there to the epiphenomenalist position of T.H. Huxley, amongst others, holding that conscious mental events have no causal influence on any physical happenings.

The existence of a human soul or spirit, something that could not be described fully as a set of electrical impulses in a network of neurons, would undermine this key assumption of simulism if the soul influences conscious experience. A soul would be absent from a computed facsimile of a brain, unless it automatically comes into existence as a consequence of computational complexity. Belief in an incorporeal soul is not limited merely to dualist philosophies of the kind advocated by Descartes, but includes any theological or metaphysical viewpoint that goes beyond a purely material description of human consciousness.

Nancey Murphy characterises such viewpoints by the popular perception that imagines the soul to be what might be missing from a body engineered or cloned artificially. If technology could replicate a body alone without a soul, she says, then the dualist might consider it to be 'like the zombies in science

⁵⁶ Murphy, N. 'Immortality versus resurrection in the Christian tradition', *Ann. N.Y. Acad. Sci.* (2011) 1234, 76–82.

⁵⁷ *ibid.*

fiction'.⁵⁸ Murphy herself, in contrast, believes that 'none of us has a soul and we all get along perfectly well'.⁵⁹ Acceptance of the existence of such a soul or spirit is widespread amongst Christians, except for a small physicalist minority, and also in many other major religious traditions. Amongst academic thinkers, such belief is however much less prevalent; in 1998 Larson & Witham reported only 7.9% of leading scientists as believing in an immortal soul,⁶⁰ and Murphy describes a similar trend amongst theologians.⁶¹ The assumption of substrate independence is likely to seem more plausible to people without a prior conflicting belief, and is unsurprisingly not widely seen in academic circles as a major obstacle to the development of self-aware artificial intelligence.

3.4 Intelligent design for non-believers?

Even if it is meaningful or potentially factual to say that we live in a simulation, would this be knowable or scientifically testable? Metere argues that it is not, that simulism is more akin to a religious belief.⁶² Philosopher and theologian Keith Ward wrote: 'The question of God is certainly a factual one, but certainly not a scientific one'.⁶³ The same would apply to the existence of simulators if this did not have observable consequences, implying that the question could not be addressed by the scientific method. A related point refers not so much to the validity of the simulation argument as to the perceived need for it. Is some specific explanation required to account for the putative unlikeliness of the universe, for instance in terms of the apparent fine tuning of physical constants to precisely the values that permit the evolution of life?⁶⁴ The putative need to rationalise something so allegedly improbable is often used as an intellectual justification for Christianity or other theistic belief systems. In an analogous way, simulism could be seen as *intelligent design for non-believers*. That is, simulism provides a rationale for our world's existence, but does so without making any specific moral or behavioural demands of its adherents. As discussed above, the characteristics usually ascribed to the hypothetical simulators are those of a highly intelligent and technologically advanced civilisation, not those of a deity. Fine tuning could potentially be rationalised in other

58 Murphy *op. cit.*, (56).

59 *ibid.*

60 Larson, E.J. & Witham, L. 'Leading scientists still reject God', *Nature* (1998) 394(6691), 313; doi: 10.1038/28478

61 Murphy *op. cit.*, (57).

62 Metere, A. 'Science cannot tell us if we're living in The Matrix', *Cosmos* 12 Oct 2017; <https://cosmosmagazine.com/physics/science-cannot-tell-us-if-we-re-living-in-the-matrix> (accessed 12 Feb 2019).

63 Ward, K. *The Big Questions in Science and Religion*, West Conshohocken: Templeton Press (2008), p.30.

64 Rees, M. *Just Six Numbers*, London: Weidenfeld & Nicolson (2001), ISBN 978-0753810224

ways too, for instance through either a multiverse⁶⁵ or the anthropic principle. Simulism could equally well be seen as a twenty-first-century variant of the dream hypothesis,⁶⁶ taking the ancient idea that reality is some kind of illusion and couching it in the technological language of science fiction. The dream hypothesis itself does not appear to be scientifically testable, and is probably too nebulous for formal refutation. Nonetheless, few people would consider it to be a serious or productive theory of the world.

3.5 Simulated reality as a metaphor

My purpose in writing this article has been to discuss and evaluate the simulation hypothesis as an objective theory about the nature of the universe. I conclude that it is substantially less likely to be a truthful account of reality than its advocates claim. However, I do not intend to discourage the use of simulation as a metaphor for reality, creation, or the human condition. Simulated reality is established as a major trope of science fiction, from *The Matrix* and *Inception* to numerous episodes of the *Star Trek* series and *Doctor Who*. Clearly *The Matrix* can be interpreted as a metaphor for the human condition, for the uncertain nature of reality, or for societal struggles. Indeed, the briefest of internet searches reveals a plethora of individuals and groups claiming validity for and seeing value in such interpretations. My rejection of simulism as objective fact is designed neither to discourage philosophers, theologians, film directors and science fiction authors from using the simulation hypothesis metaphorically, nor to stop their readers, viewers and critics from interpreting simulated reality as an allegory for their own lives, experiences, causes or beliefs.

4 Conclusions

Firstly, I claim that considerations of universe size, and in particular of information content, make the simulation argument difficult to sustain. I note that Bostrom's argument⁶⁷ is an essentially statistical one. It assumes that we can sum over real observers whom we know to exist now and hypothetical simulated observers who might exist at some time in the future, while counting each alike. Clearly it is meaningful to ask whether our own descendants could one day run a simulation containing conscious characters. However, I argue here that our observable universe is 80 or more orders of magnitude bigger than a computer, yet information in the simulation must be carried by real particles in the real world. Thus, a universe like ours could not be simulated at fine granularity in a computer within our world. This suggests that simulated universes must be much smaller or simpler than real ones. Hence, any conscious characters that

65 Kragh *op. cit.*, (19).

66 Borges *op. cit.*, (18).

67 Bostrom *op. cit.*, (1).

we or our descendants simulate in the future would perceive themselves to inhabit a universe containing much less information than our own. Similarly, any creatures simulating us must inhabit a universe containing significantly more information than ours. I argue that one cannot meaningfully evaluate how the propositions comprising the simulation argument would apply to such a larger universe. I contend that the inevitable information disparity between simulating and simulated universes violates the assumption of similar worlds that is required meaningfully to assess the plausibility of ours being a simulated world. This implies that we cannot reasonably infer very much about a hypothetical simulating universe from comparison with our own. I claim that, under these circumstances, the simulation argument is not applicable to the world in which we live. We can infer nothing remotely quantitative about the likelihood of our being Sims.

Secondly, the simulation argument takes no account of the complexity of the simulation hypothesis. I argue that the simulation argument is unnecessarily complicated, which implies that it is disfavoured by Ockham's Razor. While not a new insight,⁶⁸ this aspect has been underemphasised in the existing literature discussing simulism. We have no reason to prefer simulism over other simpler explanations for our existence.

Thirdly, and without attempting to enumerate all possibilities, I suggest that it is unsafe to treat the question as if base reality and simulation are the only two kinds of universe that could exist. A *multiverse* model⁶⁹ might not strictly affect the logic of the simulation argument, but it would reduce the need for a complex explanation of the apparent unlikeliness of our world and the ostensible fine-tuning of the physical constants. As another example, technologically advanced aliens might be capable of creating physically real universes.⁷⁰ A Christian world-view, and indeed other theistic belief systems, will also meet the requirement to provide a reason for our world's existence.

Finally, I note that since the nature of a simulators' universe is unknown, and probably unknowable, it is impossible fully to refute the simulation hypothesis. However, meaningful analysis of the simulation hypothesis seems impossible if the simulators' universe is allowed to have magically unphysical properties. In that scenario, simulism would be more akin to a religious belief than a scientific one.

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68 Sturman *op. cit.*, (16).

69 Kragh *op. cit.*, (19).

70 Stewart et al. *op. cit.*, (22).

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