Replication Ethics

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Suppose some future technology enables the same consciously experienced human life to be repeated, identically or nearly so, $N$ times, in series or in parallel. Is this roughly $N$ times as valuable as enabling the same life once, because each life has value and values are additive? Or is it of roughly equal value as enabling the life once, because only one life is enabled, albeit in a physically unusual way? Does it matter whether the lives are contemporaneous or successive? We argue that these questions highlight a hitherto neglected facet of population ethics that may become relevant in the not necessarily far distant future.

INTRODUCTION

Relatively few people are strict utilitarians. Indeed, most probably don’t believe there is any generally applicable way of deciding ethical questions based on a utility function calculus. Nonetheless, many think that some form of utilitarian reasoning is sometimes valid, or at least that it gives a simple and useful policy guide for some practical issues. Killing two random unknown people as a consequence of some policy choice seems worse than killing one, ceteris paribus. For most people, it seems roughly twice as bad.

More complex examples such as trolley problems \cite{trolley}, in which strict utilitarianism suggests that costs to one group may be offset against benefits to another, cause much more controversy. Utilitarian reasoning is more controversial still when it comes to questions of existential risk and the future of life. For example, Parfit’s Repugnant Conclusion \cite{parfit} that $M$ lives barely worth living are preferable to $M’$ fulfilled and happy lives, for sufficiently large $M \gg M’$, highlights a clash between utilitarianism and many people’s intuitions, including Parfit’s. Nozick’s Utility Monster \cite{nozick}, which gains such great utility from resources that utilitarianism suggests everyone else’s interests should be sacrificed in its maw, similarly troubles many. To sustain the intuitions that the conclusion is incorrect as well as repugnant and that we should not overfeed the utility monster, without giving up on utility calculus entirely, seems to require drawing some boundaries between “normal” and “extreme” cases. The lack of obvious bright lines or consensus on principles that could establish such boundaries somewhat undermines confidence in the applicability of utilitarian reasoning, even in more realistic policy decisions where it seems in line with common sense.

Nonetheless, quasi-utilitarian arguments do seem to capture many people’s intuitions even on some existential questions. Many agree both that the extinction of human life would be a much greater disaster than the death of 99% of the human population and that one can base a good argument for this on a comparison of the numbers of all future lives lost that would otherwise be lived in each case \cite{parfit,city}. Many also accept the corollary that we should devote significant resources to accelerating human migration from Earth, to mitigate the extinction risk from a planetary catastrophe. Some, though probably far fewer, also believe we have a moral imperative to colonize as much of the cosmos as possible, even at the cost of great present and future sacrifices, in order to maximize the number of lives well lived in our future light cone.

Further problems arise if we try to give utility calculus a scientific foundation. Must an agent be conscious in order to have utility? Are there degrees or different qualities of consciousness, and are they ethically relevant? Could there be a meaningful sense in which two agents have the same experiences but one has a “thicker” consciousness than the other, and hence more utility, and hence more ethical weight? Is the utility of experience reducible to the utilities of individual qualia? There is no consensus on whether these questions are meaningful, nor on the most plausible answers if they are.

In short, most of us are in an uncomfortable position intellectually. We are embarrassed that we do not really know what utility is or how to compare utilities of different agents. Even in situations where we accept a given model of utility, we use utilitarian reasoning inconsistently. Sometimes it feels reasonable; sometimes it feels unpersuasive or clearly wrong. Most of us struggle to articulate where and why we draw boundaries. We may be clear enough about some cases on one side or the other to argue for some boundary criteria, but these tend to be very incomplete, leaving many cases undecided. We may perhaps accept health care rationing \cite{health} based on utility guesstimates, such as that a year of life for two typical individuals is of comparable value, perhaps with some quality of life adjustment factor that might typically range from $10^{-1}$ or so to 1. But if we do, our acceptance tends to be pragmatic – some politically defensible policy is needed, and there seem few alternative candidates. On more general policy questions, where costs and benefits apply to different subsets, we flounder.

These problems deepen still further when we consider the possibilities of transhumanism, the development of general purpose artificial intelligence at human or superhuman level, and our options for steering the evolution and spread of life through the cosmos. We are very poorly equipped to address these increasingly pressing questions. A dappled view of future population
ethics, combining the most valuable insights from many perspectives, may be the best we can hope for. One way to improve our understanding of the possibilities is to consider thought experiments that allow us to test out and illuminate utilitarian and other ideas and to identify points where different plausible intuitions produce very different conclusions.

A THOUGHT EXPERIMENT

In this note I propose a thought experiment which could become a real dilemma for programmers, researchers and policy makers in the not necessarily far distant future.

Human emulations

Suppose, for the sake of argument, that something roughly like an individual human life can be lived through software running on a computer. Here “computer” means something like, although more advanced than, the things we conventionally call computers at present. Very roughly speaking, this means a device assembled from raw materials into a specific architecture, by mechanical means, in order to process classical or quantum information, in a way that can be programmed by a choice of inputs. The “software” could, for the sake of the argument, perhaps be obtained from scanning the brain of a biological human with sufficient resolution to allow every relevant detail of brain function to be transferred to and simulated on the computer.

We will suppose without further discussion that we have reasons that seem to us compelling enough for treating such simulated lives as comparably valuable to an ordinary human life. Suppose also that this has become practical: we can create a human emulation relatively cheaply. If we can emulate a human individual once in software, it seems very plausible that we can easily create many emulations of the same human. Let us assume this too, for the sake of argument.

Most likely, we will then find it easier to create N emulations of the same human than to create emulations of N different humans. For example, if brain scanning is the relevant technology, we would only need one brain scan rather than N. It seems very plausible that brain scanning would require significantly more resources than copying the software that results from brain scanning. If so, scanning one brain and then making N copies of a single emulation would require fewer resources than scanning N different brains and making simulacations of each. It might also be possible to improve the efficiency of a human emulation significantly, with some analysis and optimization work, so that it needs significantly fewer gates and/or less energy, and perhaps runs significantly faster. Again, this is work that only needs to be done once if we create N emulations of the same human. So, if emulating the same human N times seems to us to be just as worthwhile as emulating N different humans, efficiency would motivate us to prefer the former.

Further assumptions

To make our thought experiment as clear as possible, we need to make further simplifying assumptions. We assume that our emulations are in a self-contained and effectively isolated computer. They have no effect on the world outside the computer; in particular they are not observed by outsiders. We are creating these emulations purely because we believe that a typical human life is an intrinsic good.

1 I do not mean to suggest this is evidently true. I think it’s quite possible we could yet find facts about the world that make it seem implausible. It’s also possible that it will always continue be a plausible position that remains open to reasonable doubt.

2 We want the term “computer” to exclude biological humans here, even though human children can be said to fit most of these definitions. We also want to avoid considering skeuomorphic boundary cases, not because these are implausible or uninteresting, but because they complicate the discussion in a way that obscures the key points. We are interested in discussing human emulations whose physical substrate is radically different from our own.

3 Scenarios in which such emulations dominate the world population, at least temporarily, are discussed in Ref. 7.

4 It is not necessary for the discussion here to assume specific reasons. Thoughtful people who agree that there may well be good reasons disagree on what the reasons may be. For example, some think it likely that simulated humans are conscious in essentially the same way as their biological counterparts, and feel happiness, pleasure, pain and other qualia with just the same qualities in just the same quantities. Others believe or suspect that this language is misleading or ill-defined, and would say that what ultimately matters when considering whether an entity is valuable is the functionality of its information processing.

5 Again, I do not mean to suggest this is evidently true. For example, it could turn out to be a fact of the matter that human identity is uncopiable, just as unknown quantum states are 8,9, and possibly even for that very reason.

6 Even if the work itself is quite resource-intensive, it becomes worthwhile if N is sufficiently large.
It may reasonably be argued that a single human life in isolation would be a miserable existence, and so not an intrinsic good. To counter this, we assume that along with the emulation we simulate an environment rich enough that it seems to the emulated human that they are interacting with many other humans in an interesting world. This may perhaps still seem unrealistic. One might query whether it is possible to simulate the experience of interacting with other humans without actually simulating the other humans. Even if it is possible, it might be argued that there is no value in an emulated human life so deceived about their true situation, whatever the emulation’s beliefs on the matter. We could counter such arguments by considering instead emulations of a large community of humans interacting with one another and with a rich environment, running over many generations if desired. Our options then would be to emulate exactly the same community and environment \( N \) times, or to emulate \( N \) different communities in different environments. For definiteness, and to keep the language simple, we will speak about emulating one human \( N \) times or \( N \) humans below. However, the discussion is meant to generalize: “emulated human life” may be read as shorthand for however large and however long-lasting an emulated community and environment are required to assure us that the emulation is an intrinsic good.

The experiment

Suppose for some reason that we are restricted to four choices:

- Emulating the same life of the same human, Alice, \( N \) times, in parallel on different computers, so that the lives all run simultaneously.
- Emulating the same life of the same human, Alice, \( N \) times, in series on the same computer, so that the lives run sequentially.
- Emulating \( N \) different lives of \( N \) different humans, Alice, Bob, . . . , in parallel on different computers, so that the lives all run simultaneously.
- Emulating \( N \) different lives of \( N \) different humans, Alice, Bob, . . . , in series on the same computer, so that the lives run sequentially.

Suppose also that in all cases the relevant humans cannot continue living in the world outside the emulation. Alice, Bob, and the others are 21 year old adults who are terminally ill today, with a disease that has ravaged their bodies but has left their brains intact. We just have time to scan their brains before they die. We can then emulate them in software, and, so to speak, continue their lives as emulations from age 21 onwards. Suppose further that all the candidates are equally admirable and will have equally valuable emulated lives, by any reasonable criteria.

In each case, the emulated lives are unobserved and have no effect on the rest of the world, which continues just as it otherwise would were no emulations run at all. The only reason for thinking any of these courses of action is worthwhile is because the lives have intrinsic value.

Are any of these choices preferable, and if so why?

Temporal considerations

Does it matter whether the lives are run in parallel or series? Is it more worthwhile to create a present life than to create a future life, assuming that in either case the lives are self-contained?

Evidently, the two cases would be different if there were some risk that some of the future lives might in fact not be created. Emulating \( N \) lives in series takes longer than \( N \) lives in parallel. For large \( N \), there could be a significant risk of a catastrophe destroying us and our technology before a series of \( N \) lives ends. For the sake of the argument, let us assume there is no such risk: we are certain that all the emulations will complete, whichever choice we make.

Another possible reason for preferring present human lives to future human lives is that we may expect to have more in common — more common memories, attitudes, overlaps and continuities of thought — with contemporaries than with descendents. As Parfit has argued, this may also be a reason to give more weight to the interests of our present selves than our future selves. However, it does not apply in our experiment. Alice, Bob, and the others are all contemporaries of ours. Their emulations will

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7 Here and below different computers could also be used: the precise physical instantiation is not relevant to our arguments.
begin with the same memories, attitudes and thoughts, whether they are run immediately or in the distant future. Since they do not interact with the world outside the emulation, they will continue in the same way, whenever the emulation is run.

Discounting these reasons, it seems hard to find any justification for preferring either parallel or series emulations. They have the same total intrinsic value, and it is hard to see why it should matter whether that value is realised during one emulated lifetime or in the course of \( N \) sequential emulated lifetimes, ceteris paribus.\(^8\)

### Replication considerations

Does it matter whether \( N \) different lives are emulated, or the same life is emulated \( N \) times? This seems trickier to adjudicate.

One way to think about the problem is that each emulated life has a value \( V \), which by assumption is positive. Emulating \( N \) different people thus has value \( NV \). But emulating Alice \( N \) times independently also has value \( NV \). These valuations give no reason to prefer one option over the other. On this view, if, as seems plausible, it costs fewer resources to emulate Alice \( N \) times, then we should prefer to do that.

Opposing this are intuitions that have a weak and strong form. The weak form – *replication inferiority* – is that emulating Alice \( N \) times in sequence seems less valuable than emulating \( N \) different people. The strong form – *replication futility* – is that emulating Alice \( N \) times is no more valuable than emulating her once.

Neither of these intuitions can be justified in our experiment on the grounds that any of Alice’s emulations know about the others and find this distressing. By assumption, each emulation is independent, and has no memory, awareness or foreshadowing of the others.

### Replication futility

Rather, the intuition behind replication futility is that, having written Alice’s life into the universe once, we add nothing to the total value of the universe (integrated over space and time) by doing so again. In particular, we add no value for Alice by repeating her emulation, even though each emulation of Alice has the sense of appreciating their life.

This intuition can be held even if one believes that repeated emulations are distinct lives, in some meaningful sense that may some day be justified by fundamental physics. Suppose one believes that there are facts of the matter about experiences in time and space, and that it is a fact of the matter that the first emulation has experiences, and the other emulations have the same experiences, at different times or in different places. One can still consistently believe that repeating these experiences is valueless.

There is another possible view that more strongly implies replication futility. This is that there is no meaningful sense in which repeated emulations (whether in time or space) are distinct lives. The strongest form of this view is that there is a fact of the matter about experiences in time and space, and that it is a fact of the matter that all the emulations correspond to only one set of experiences, and so effectively define only one life. While this might at first blush seem a peculiar idea, it is consistent with some views about the relation between material physics and conscious experience. If consciousness is defined only by the functionality of information processing, no facts about its physical instantiation – including whether or not it is multiply instantiated in space or time – should affect the nature of the conscious experience.

Indeed, it is hard even to define a sharp and general distinction between single and multiple instantiations. Does a computer running an algorithm constitute a single instantiation? Or can it equally well be seen as several parallel instantiations, by subdividing each wire of the circuit? One can ask similar questions of other macroscopic information processing systems, including our own brains. This gives some way to build an intuition that replicated emulations in space, even if well separated, might correspond to a single set of experiences. It may seem less intuitive that replicated emulations over time also could. Indeed, there could conceivably be a fundamental distinction between the two cases.\(^9\) Still, if we accept the principle that the functionality of information processing is key, and hence that replicated emulations in space could correspond to a single set of experiences, it is hard to see a presently compelling reason why replications in time could not also. Our perception of a flow of time is even less well understood and more fundamentally puzzling than our consciousness: we have no firm facts on which to base a refutation.

\(^8\) Thinking relativistically, can it really matter whether two emulated lives are spacelike separated, with life \( A \) just to one side of the future light cone of life \( B \), or timelike separated, with life \( A \) moved just to the other side of the future light cone?

\(^9\) Again, thinking relativistically gives some reason to query how plausible it is that the cases really are separate. One would have to suppose that \( N \) spacelike separated instantiations correspond to a single set of experiences, which splits into multiple sets of experiences if any instantiation crosses the future light cone of any others, and recombines again if it crosses back.
One intuition that might lie behind replication inferiority is that, even if we do perhaps add some value to the universe by replicating Alice’s life, the first replication adds less than the original, the second less than the first, and so on. This may seem to follow from the general assumption that utility functions should be convex. However, the standard reasons for convexity do not directly apply. We are less grateful for the eleventh orange than the first. It is not so clear whether we should also value the eleventh Alice less than the first. We become jaded with oranges, but cannot become jaded with Alices in the same way, since we do no interact with any of them. Nor can Alice become jaded with lives in the same way, since each emulation has no memory of the others. Nonetheless I find it hard to escape the intuition that a universe with a billion independent identical emulations of Alice is less interesting and less a good thing to have created than a universe with a billion different individuals emulated. I find it hard too to escape the intuition that, while I might be happy for the promise of an extra year of life in a future emulation, my gratitude if promised also that the same year would be replicated precisely in independent emulations would be at best muted.

Another intuition that might also lie behind replication inferiority is a sense of cosmic justice. Even if we think a replicated emulation benefits Alice just as much as the original, we might still think it unjust, or at least less than optimally beneficent, to give Alice the benefit of \( N \) lives and no one else the benefit of any, when we have the alternative of giving \( N \) people each.

PARFIT ON REPLICATED SELVES

In “Reasons and Persons”, Parfit considers thought experiments involving duplicated selves. One of these is a hypothetical brain splitting, in which an individual’s two brain hemispheres are transplanted into two separate donor bodies. The hypothesis, for the sake of discussion, is that this can be done so that not only do both operations produce fully functioning humans, but each of them has psychological continuity with the original individual. In another thought experiment, a Replicator machine scans an individual’s brain and body at location \( A \), destroying them, but sending data allowing the individual to be reconstructed at two other locations, \( B \) and \( C \).

The brain splitting hypothesis involves a number of assumptions – that hemispheres can have separate consciousnesses, that these can survive transplantation, and that each consciousness can fully psychologically represent the individual who once had a unified consciousness arising from the two connected hemispheres. Parfit cites some evidence for the first of these, and the second seems conceivable in principle. However, the third seems unlikely to be precisely correct. All in all, the combined hypotheses raise many doubts and complications. Brain splitting involves messy biological and psychological questions that seem very unlikely to have the idealized answers hypothesized.

The second thought experiment also involves questionable assumptions, of course. Human scanning and reconstruction may never be viable; scanning of classical information about the human would have to suffice for it to be possible to reconstruct more than one copy, and we do not know whether classical information suffices; we do not know whether Replicas can or would be conscious, or even functional, and if so under what conditions. Still, it seems a cleaner thought experiment, in that the assumptions involve the fundamental relations between matter, consciousness and identity, and it seems at least possible that these could take forms that make the experiment viable in principle.

Another significant difference between Parfit’s hypothetical duplicates and our hypothetical emulations is that Parfit imagines his duplicates will continue living in the same world, able to interact with one another and with friends and lovers of the individual from whom they originated. As Parfit comments, this complicates any measure of their value. It could be unpleasantly uncanny to live in a world with a duplicate, and upsetting to find your friend or lover duplicated, and these outcomes would subtract value. On the other hand, duplicates could possibly satisfy two deeply held but incompatible ambitions of their originator, and this could add value.

In considering value, Parfit’s focus is on the value to the original individual. Should he consider his destruction and recreation in duplicate as equivalent to – roughly as bad as – death? One possible reason for doing so is that he cannot justify identifying himself with one specific successor, and it seems incompatible with most intuitions about personal identity to identify oneself with two successors. The remaining option, identifying oneself with no successor, appears then to fit both our understanding of duplication and our understanding of death.

Parfit rejects this conclusion. He argues that psychological continuity is all that matters; there is no special further fact about personal identity. Having two future duplicates who have psychological continuity with your present self is not the same as

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10 Related points are made in critiques of attempts to use decision theory to explain the relevance of probability in many-worlds versions of quantum theory; see in particular Refs. [1][2].
having no future individual who has psychological continuity with your present self: “Two does not equal zero.” (Ref. [2], p.278.)

But does “Two equal one”? On this, Parfit is less clear. He notes that a relevant consideration in comparing his own duplication and his survival in the ordinary sense is

“the fact that these two lives, taken together, would be twice as long as the rest of mine.” (op. cit., p. 264)

Parfit allows that this may indeed be a reason for preferring duplication to survival:

“Instead of regarding division as being somewhat worse than ordinary survival, I might regard it as being better. The simplest reason would be the one just given: the doubling of the years to be lived. I might have more particular reasons.” (op. cit., p. 264)

However, after discussion, he concludes:

“The best description is that I shall be neither resulting person. But this does not imply that I should regard division as nearly as bad as death. As I argued, I should regard it as about as good as ordinary survival. For some people, it would be slightly better; for others, it would be slightly worse. Since I cannot be one and the same person as the two resulting people, but my relation to each of these people contains what fundamentally matters in ordinary survival, the case shows that identity is not what matters.” (op. cit., p.279.)

Duplication may be better or worse than survival in Parfit’s scenario because of the complicating factors already mentioned – there are potential pros and cons to having duplicates interacting in the same world. It may also be preferable because of a doubling of the years to be lived. But the net result of all these considerations, in Parfit’s view, is that it should be about as good as survival. Now it is true that the phrases “For some people” and “for others” do not logically cover all the options. Logically, the text is consistent with the possibility that Parfit regards duplication as about as good as survival, some people regard it as slightly better, others as slightly worse, but others still as greatly better or greatly worse. That said, a natural reading is that Parfit thinks that for most or all people duplication is likely to be at best slightly better than survival and at worst slightly worse. If so, then none of the relevant factors, including the doubling of years to be lived, can generally carry much weight.

Parfit does not explain why doubling the years lived carries little weight for him. This is a rather surprising omission, given that it is explicitly considered as a factor. However, Parfit’s central concern is to argue that duplication is a form of survival rather than a form of death. It may be that he did not think it necessary to articulate a precise position on the relative values of duplication and survival. The quotations above, though, suggest an inclination towards the view that replication futility applies, at least approximately, in our thought experiment. This would imply that replication inferiority certainly applies.

NOISY EMULATIONS

We now return to our thought experiment involving independent self-contained emulations, isolated from each other and the rest of the world. Suppose we have concluded that either replication inferiority or replication futility applies in the experiment. And suppose now we vary the experiment slightly, by assuming that the emulations are not quite perfect and not quite identical. Perhaps once or twice in an emulated life, a pixel of the visual field is briefly a slightly different shade, or an emotion is very subtly modulated, or something of the sort, because of a brief and minor glitch in the emulation. Suppose too that these brief alterations have no longer term consequences for the emulation.

These differences seem too minor to significantly affect our value judgements. If a duplicated emulation has no more value than a single emulation, then a duplicated emulation with small glitches in one copy surely can at most have very little more value. Our own life would have almost exactly the same value if it were slightly and briefly modulated in this way; not only that, but the modulated life would seem almost precisely equivalent to ours. Intuitively we imagine a sort of continuity principle applying to the value of lives, along with some bounds on the derivatives. And we imagine the same sort of principle applying to \( N \) emulations: \( N \) perfect emulations should have almost precisely the same value as \( N \) slightly and briefly modulated emulations. This should be true even though the original \( N \) emulations are precisely identical and none of the modulated \( N \) emulations need be precisely identical (because their slight and brief modulations are all different). It follows that, if replication futility holds for identical emulations, it should also hold to very good approximation for near-identical emulations. Similarly, if replication inferiority holds for identical emulations, it should also hold for emulations that are not identical but are sufficiently close to being identical.

We can press a little further. Even if the modulations persist throughout an emulated life, the same conclusions should hold, so long as the modulations are sufficiently small. It should not matter that much if an emulation has slightly modulated experiences of shades of the colour red throughout his life, so long as these have no other significant experiential consequences.
It seems good to be as clear as possible on how we value lives, before we unwittingly set in motion well-intentioned research that could end with an artificial intelligence trying to optimize the number of emulated human lives per unit 4-volume in our future light cone. Unless we want it to find the most easily emulated human life and run it everywhere, we should give it different value rules. Suppose we have concluded that replication futility applies in our thought experiment. We can then tell it (say) that identical lives do not have independent value. However, if we tell it only this, its next attempt at optimization is likely to involve small and easily implemented variations on a single life. To avoid that, we need to tell it that, as we have argued, $N$ sufficiently similar lives have at most little more value than $N$ identical lives.

It will then, of course, ask for definitions of “sufficiently similar” and “little more value” and for more general rules. Can we give it a general calculable measure $d(L, L')$ of distance between lives $L$ and $L'$, and some continuous function $\delta: \mathbb{R} \to \mathbb{R}$ with $\delta(0) = 0$, such that “$L$ and $L'$ are sufficiently similar to be of roughly equivalent value” translates as

$$d(L, L') < \epsilon \implies |V(L) - V(L')| < \delta(\epsilon)? \tag{1}$$

And then can we give it a value function on $N$ lives,

$$V(L_1, \ldots, L_N) \tag{2}$$

and bounds on $V(L_1, \ldots, L_N)$ as functions of (say) $V(L_1)$ (or $L_1$) and of the distances $d(L_i, L_j)$?

By this point we realise that we have introduced the thin edge of a potentially very large and very contentious wedge. For example, we have allowed the logical possibility that there are sets \{L_1, \ldots, L_N\} of existing human lives that have sufficient similarities (pairwise or collectively) that some defensible value measures $V$ might give them significantly less value than $N$ lives randomly chosen from the Earth’s present human population. This possibility need not be realised in practice for any value measure we regard as defensible, of course. We can politely, plausibly and perhaps wisely take the view that any sensible similarity measure $d$ necessarily has the property that $d(L, L') = \infty$, for all practical purposes, for any pair of distinct presently existing human lives $L, L'$. We might further hope that plausible axioms can be found that justify this view.
However, other views are possible. As the song goes:

\[ \ldots \text{the people in the houses} \\
\text{All went to the university,} \\
\text{Where they were put in boxes} \\
\text{And they came out all the same,} \\
\text{And there\'s doctors and lawyers,} \\
\text{And business executives,} \\
\text{And they\'re all made out of ticky tacky} \\
\text{And they all look just the same.} \]

One gets the sense that Reynolds and Ball might have valued $N$ of these people less than some other sets of $N$ humans, not because of their professions and lifestyles but because of their perceived similarity.\textsuperscript{11}

Even if we are comfortable that present day humans are dissimilar enough for replication inferiority considerations to be irrelevant, are we so sure this applies to all denizens of Earth? Is the life of one worker ant really significantly dissimilar from that of another of the same species, in a similar environment? What about a cow or sheep? Or a flatworm or an amoeba?

And are these considerations more pressing when we think about filling our future light cone with human and post-human life? Even if the human species were to continue with traditional sexual reproduction, and continue with phenotypes and genotypes broadly in the spectrum of ours, in environments broadly similar to ours, questions of replication inferiority may not ultimately be avoidable. If the “space of possible lives” is modelable by a compact set, and the similarity function $d$ by a metric, then for any $\epsilon > 0$ there must be some population size $N$ such that at least one pair $L, L'$ necessarily have $d(L, L') < \epsilon$. In other words, there must be some population size such that at least one pair have sufficiently similar lives for replication inferiority considerations to come into play. Perhaps we may end up concluding that a compact set with metric is not a good model. Or we might conclude that, for sensible measures $d$, the relevant $N$ is much larger than the number of humans that can populate our future light cone between now and the end of the universe. But these are not \textit{a priori} obvious conclusions.

In any case, in the long run, our descendents are mostly unlikely to have similar genotypes, phenotypes or psyches to ours. They may well include genetically engineered humans, humans in varying types of symbiosis with artificial intelligences, emulated humans, and skeuomorphic hybrids of several of these. These technologies will greatly stretch the possibilities, but they may plausibly also make intelligent life in the cosmos (at least that of terrestrial origin) much less diverse.\textsuperscript{7} The value of (near-)replication may well be a clear and pressing concern for them. In so far as we can influence this future world by present decisions, it is a question we need to take seriously.

\section*{CONCLUSIONS}

Decisions we are beginning to make now about the future of life involve hard questions of principle. One of those is what we mean by saying that lives are very similar, and how to value sets of lives that are. We have tried here to clarify the questions somewhat, and to suggest ways of categorising possible types of answer. We do not have fully satisfactory answers; so far as we are aware, no one presently claims to. These problems deserve further consideration.

Our lines of thought give new perspectives on existing problems. For example, if (pace Tolstoy), the $M$ lives in the Repugnant Conclusion scenario that are barely worth living are – necessarily, as a consequence of their very low utility – also very similar in their drabness, then replication inferiority or futility offer ways to avoid the Conclusion. However replication considerations, if anything, add to the case for feeding Nozick’s Utility Monster: we have similarities to one another, whereas the Monster is unique.

Some may perhaps wish to align the idea of suboptimal utility of replication with political programmes aimed at altering the characteristics of current human societies. We strongly urge caution. As noted earlier, it is plausible that any sensible distance measure obeys $d(L, L') = \infty$ for any pair of human lives in the near future. Measures with other properties are also logically arguable but such arguments risk being no more than lightly coded attempts to dehumanize some disfavoured groups.\textsuperscript{13}

\textsuperscript{11} Or not mainly.
\textsuperscript{12} I like the song. Still, anyone entirely comfortable with replication futility applying axiomatically to doctors, lawyers and business executives ought also to consider the many other groups – including their own – to whom it might equally be applied.
\textsuperscript{13} Again, no one should assume that replication inferiority considerations self-evidently support a particular party line. If applicable at all, they could potentially be applied to plutocrats and peasants, babies and bankers, academics and assembly line workers, activists and the aged.
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