

## *Fine-Tuning and Multiple Universes*

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### I. Introduction

John Leslie (1989) argues vigorously that the fact that our universe meets the extremely improbable yet necessary conditions for the evolution of life, supports the thesis that there exist very many universes. The view has found favor with a number of philosophers such as Derek Parfit (1998), J. J. C. Smart (1989) and Peter van Inwagen (1993).<sup>1</sup> My purpose is to argue that this is a mistake. First let me set out the issue in more detail.

The universe is said to be extraordinarily ‘fine-tuned’ for life. The inhabitability of our universe depends on the precise adjustment of what seem to be arbitrary, contingent features. Had the boundary conditions in the initial seconds of the big bang, and the values of various fundamental constants differed ever so slightly we would not have had anything like a stable universe in which life could evolve. In the space of possible outcomes of a big bang, only the tiniest region consists of universes capable of sustaining life. Most either last only a few seconds, or contain no stable elements or consist of nothing but black holes. This is a fairly standard story told by cosmologists—there is some controversy, concerning for instance the appropriate measure on the space of possible outcomes—but I will assume it is the right picture for the purpose of this discussion.<sup>2</sup> The situation is thought to be something like the following. Nuclear bombs are connected to a high security combination lock, such that dozens of dials have to be adjusted with extreme precision to avoid detonating the bombs. Had any one dial differed ever so slightly from its actual position, the world would have been destroyed. In the absence of an explanation of why the dials were adjusted as they were (suppose they had been spun at random) we would find it astonishing that we were here to consider the matter.

In response to this seemingly remarkable state of affairs, philosophers and physicists have suggested various hypotheses involving multiple universes. By

‘universe’ I do not mean *possible world*. Rather, according to the multiple universe theories, the actual world consists of very many large, more or less isolated sub-regions (universes) either coexisting, or forming a long temporal sequence. The crucial feature of the various Multiple Universe theories, is that those physical parameters which on which *inhabitability* depends, are understood to be assigned randomly for each universe.<sup>3</sup>

How are multiple universes relevant to the puzzle? The basic idea is straightforward. For any improbable outcome of a trial (e.g., dealing a royal flush, hitting a hole in one, throwing a bull’s eye) if you repeat the trial enough times you can expect to get an outcome of that type eventually. If we suppose that our universe is just one of very many universes, randomly varying in their initial conditions and fundamental constants, it is to be expected that at least one of them is life-permitting. Add to this the fact that we could only find ourselves in a life-permitting universe and we seem to have satisfyingly accounted for what at first seemed amazing, removing the temptation to suppose that there was a *Fine-Tuner*, who adjusted the physical constants for a purpose. It is widely thought therefore, that the fact that our universe is fine-tuned for life, *provides evidence* for the Multiple Universe theory. In fact almost everyone who has written on the topic accepts that the fine-tuning facts count in favor of multiple universes, even if they are not persuaded that there are other universes.<sup>4</sup> But they are mistaken, or so I will argue. Perhaps there is independent evidence for the existence of many universes. But the fact that our universe is fine-tuned gives us no further reason to suppose that there are universes other than ours. I will examine the two main lines of reasoning found in the literature from fine-tuning to multiple universes to see where they go wrong.

## II. Probabilistic Confirmation

The first strategy takes a probabilistic approach to confirmation, according to which confirmation is raising of probability. That is,

Evidence E confirms hypothesis H, given background knowledge K, if and only if  $P(H|E \ \& \ K) > P(H|K)$

A probabilistic understanding of confirmation supports the use of the common sense principle that, as Leslie (1989) puts it, “observations improve your reasons for accepting some hypothesis when its truth would have made those observations more likely.” (p. 121) A theorem of the probability calculus which underlies this principle is

$$P1: P(H|E \ \& \ K) > P(H|K) \leftrightarrow P(E|H \ \& \ K) > P(E|\sim H \ \& \ K)$$

A related theorem which will prove useful is

$$P2: P(H|E \ \& \ K) = P(H|K) \leftrightarrow P(E|H \ \& \ K) = P(E|\sim H \ \& \ K)$$

In applications of probability to confirmation, controversy often arises concerning the assignment of prior probabilities. How are we to determine the probability of  $M$ , that there are many universes, prior to the fine tuning evidence  $E$ ? One possible reason for concern is that if  $P(M|K)$  is extremely low, then  $P(M|E \& K)$  might not be much higher, even if  $P(E|M \& K)$  is much higher than  $P(E|\sim M \& K)$ . This need not concern us however, for the question at hand is whether  $E$  provides *any* support for  $M$  at all. We may grant, for the sake of argument, that the Multiple Universe hypothesis has a non-negligible prior probability, or is even quite probable. Principles P1 and P2 give us a handy test for whether the fine tuning evidence  $E$  provides *any* evidence for  $M$ : it does so if and only if,  $E$  is more likely given  $M$  than given its denial.

Now the appealing idea here is that a *single* life-permitting universe is exceedingly improbable, but if we suppose there are or have been very many universes, it is to be expected that eventually a life-permitting one will show up, just as if you throw a pair of dice long enough you can expect to get a double six sometime (you cannot, of course, expect it on any particular throw). It is tempting then to suppose that the fine-tuning evidence confirms the Multiple Universe theory by P1, since the latter raises the probability of the former.

But here we need to be clear about what our evidence is. For simplicity, let us suppose that we can partition the space of possible outcomes of a big bang into a finite set of equally probable configurations of initial conditions and fundamental constants:  $\{T_1, T_2, \dots, T_n\}$  (think of the universes as  $n$ -sided dice, for a very large  $n$ ).<sup>5</sup> Let the variable 'x' range over the actual universes. Let  $\alpha$  be our universe<sup>6</sup> and let  $T_1$  be the configuration which is necessary to permit life to evolve. Each universe instantiates a unique  $T_i$ , i.e.,  $(\forall x)(\exists !i)T_i x$ . Let  $m$  be the number of universes that actually exist, and let

$$\begin{aligned} E &= T_1 \alpha = \alpha \text{ is life-permitting} \\ E' &= (\exists x)T_1 x = \text{Some universe is life-permitting} \\ M &= m \text{ is large (the Multiple Universe hypothesis)} \end{aligned}$$

It is important to distinguish  $E$  from the weaker  $E'$ . For while  $E'$  is more probable given  $M$  than it is given  $\sim M$ ,  $M$  has no effect on the probability of  $E$ . First let's consider  $E'$ : In general,

$$\begin{aligned} P((\exists x)T_1 x | m=k) &= 1 - (1 - 1/n)^k \text{ for any } i^7 \\ \text{so } P((\exists x)T_1 x | M) &> P((\exists x)T_1 x | \sim M) \text{ for any } i \\ \text{so } P((\exists x)T_1 x | M) &> P((\exists x)T_1 x | \sim M) \\ \text{i.e., } P(E' | M) &> P(E' | \sim M) \end{aligned}$$

$E$ , on the other hand, is just the claim that  $\alpha$  instantiates  $T_1$ , and the probability of this is just  $1/n$ , regardless of how many other universes there are, since  $\alpha$ 's initial conditions and constants are selected randomly from a set of  $n$  equally

probable alternatives, a selection which is independent of the existence of other universes. The events which give rise to universes are not causally related in such a way that the outcome of one renders the outcome of another more or less probable. They are like independent rolls of a die. That is,

$$P(E|M) = P(T_1\alpha|M) = 1/n = P(T_1\alpha|\sim M) = P(E|\sim M)$$

Given  $M$ , it is likely that some universe instantiates  $T_1$ , and it is true that  $\alpha$  instantiates some  $T_i$ , but it is highly improbable that the  $T_1$  instantiated by  $\alpha$  is  $T_1$ , regardless of the truth of  $M$ . So by P2,  $P(M|E) = P(M)$ , i.e., the fact that our universe is life-permitting does not confirm the Multiple Universe hypothesis one iota. Perhaps the claim that it does results from a confusion between  $E$  and  $E'$ .

Ian Hacking (1987) has made a similar criticism with respect to J. A. Wheeler's oscillating universe theory, according to which our universe is the latest of a long temporal sequence of universes. Hacking labels the mistake involved the Inverse Gambler's Fallacy, suggesting that it is related to the notorious Gambler's Fallacy. The Gambler's Fallacy: After throwing a pair of dice repeatedly without getting a double six, the gambler concludes that he has a much better chance of getting it on the next roll, since he is unlikely to roll several times without a double six. The Inverse Gambler's Fallacy: The gambler is asked 'Has this pair of dice been rolled before?' He asks to see the dice rolled before he makes a judgment. They land double six. He concludes that they probably have been rolled several times, since they are so unlikely to land double six in one roll, but are quite likely to after several.

There is no doubt that Hacking has identified a fallacy here. He suggests that this is what is at work in the inference from the fine-tuning of our universe, to Wheeler's hypothesis that ours is just the most recent in a long sequence of universes. We note that against all odds, the big bang has produced a life-permitting universe—extremely unlikely in one shot, but highly likely after several. So we conclude that there have probably been many big bangs in the past. The mistake is in supposing that the existence of many other universes makes it more likely that *this* one—the only one that we have observed—will be life-permitting. The Inverse Gambler's Fallacy combines the Gambler's Fallacy with P1, so the usual antidotes to the gambler's reasoning should be instructive here also. Wheeler universes, like dice, 'have no memories', the individual oscillations are stochastically independent. Previous big bangs in the sequence have no effect on the outcome of any other big bang, so they cannot render it more likely to produce a life-permitting universe. Although Hacking does not mention them, similar points apply to models of coexisting universes. These universes are usually taken to be causally isolated, or if there is any causal relation between them, it is not of a type that could increase the probability of this universe being life-permitting.

### III. Our Universe vs. Some Universe

Let us now turn to a common response to the arguments above. I have been insisting that  $\alpha$  is no more likely to be life-permitting no matter how many other universes there are, but of course the more universes there are, the more likely it is that *some* universe supports life. That is, M raises the probability of E' but not E. But now, the response goes, we know that E' is true since it follows from E. So E' confirms M even if E does not. In other words, our knowledge that *some* universe is life-permitting seems to give us reason to accept the Multiple Universe hypothesis, even if our knowledge that  $\alpha$  is life-permitting does not.<sup>8</sup>

We can quickly see that there is something going wrong here. A known proposition, the probability of which is not raised by the hypothesis, is being set aside in favor of a *weaker* proposition, the probability of which is raised by the hypothesis. The weaker proposition is then taken as evidence for the hypothesis. Suppose I'm wondering why I feel sick today, and someone suggests that perhaps Adam got drunk last night. I object that I have no reason to believe this hypothesis since Adam's drunkenness would not raise the probability of *me* feeling sick. But, the reply goes, it does raise the probability that *someone* in the room feels sick, and we know that this is true, since we know that you feel sick, so the fact that someone in the room feels sick is evidence that Adam got drunk. Clearly something is wrong with this reasoning. Perhaps if all I knew (by word of mouth, say) was that someone or other was sick, this would provide some evidence that Adam got drunk. But not when I know specifically that *I* feel sick. This suggests that in the confirming of hypotheses, we cannot, as a general rule, set aside a specific piece of evidence in favor of a weaker piece.

What has gone wrong here seems to be a failure to consider the *total evidence* available to us. If the extent of our knowledge was just E', then this would count as evidence for M, since  $P(M|E') > P(M)$ . But we also know E, and must not leave that out of our calculation of the probability of M. What matters is the probability of M given E' and E. But now since E entails E', (E' & E) is equivalent to E. So  $P(M|E' \& E) = P(M|E)$ . But as we have seen above,  $P(M|E)$  is just equal to  $P(M)$ . Hence  $P(M|E' \& E) = P(M)$ . So while the Multiple Universe hypothesis may be confirmed by E' alone, it is not confirmed by E' in conjunction with the more specific fact E, which we also know. It does not matter in which order we calculate the relevance of E and E', our confidence in M on our total evidence should remain the same as it is without considering E or E'.

Consider how this fits with our intuitions about the gambler's reasoning. Suppose on being asked how many times the pair of dice have been rolled, the gambler asks if a double six has been rolled. Upon learning that one has, he is more confident than he was that the dice have been rolled a number of times. Here his reasoning is sound, for the more times the dice have been rolled, the greater

the chance that a double six has been rolled. However, when the gambler witnesses a single roll and is then more confident that the dice have been rolled before, he is clearly making a mistake. The difference is that in the first case, the information he has gained is just that *some* roll or other landed double six, in the second case, he witnesses a specific roll. Compare this with the case where astronomers discover that one or more other big bangs have occurred, and ask us to guess if there have been one or many. We might ask whether any had produced a universe containing life, and on learning that one did, be more inclined to suppose that there have been many. This reasoning would be correct. But this is not our situation. Like the gambler in the second case we have simply witnessed a single big bang producing this universe. And no number of other big bangs can affect the probability of the outcome we observed.

#### IV. Carter's Hypothesis

Puzzlingly, Hacking believes there is a version of the Multiple Universe hypothesis which avoids the errors that we have been considering. He interprets Brandon Carter as proposing a set of coexisting universes instantiating *all* possible configurations of initial conditions and fundamental constants. Hacking argues that there is no fallacy of probability involved here since the inference is deductive: "Why do we exist? Because we are a possible universe, and all possible universes exist ... Everything in this reasoning is deductive. It has nothing to do with the inverse gambler's fallacy" (1987, p. 337).

I believe Hacking is making a similar mistake as that identified above. Carter's hypothesis can be represented as  $M^*: (\forall i)(\exists x)T_1x$ . Now  $M^*$  certainly entails  $E' : (\exists x)T_1x$ . But it does not entail, nor does it raise the probability of  $E: T_1\alpha$ . From the hypothesis that each of the possible configurations of initial conditions and constants is instantiated in some actual universe, it follows that *some* universe meets the conditions required for life. It by no means follows that  $\alpha$  does. The situation here is parallel to the standard Multiple Universe hypothesis  $M$ . Where  $M$  raised the probability of  $E'$ , but not  $E$ ,  $M^*$  entails  $E'$ , but does not entail  $E$ .

In saying that "our universe follows deductively from  $[M^*]$ " (p. 339) Hacking may mean to say that the existence of a universe of the same *type* as ours—one instantiating the same set of conditions and constants—follows deductively from  $M^*$ , and this would certainly be correct. He may wish to maintain that it is the existence of a universe of our type, that constitutes evidence for Carter's hypothesis. But if this move worked, we could likewise argue that this same fact confirms Wheeler's hypothesis, for the existence of a long sequence of universes does raise the probability that a universe of our type will exist at some time. Since Hacking, correctly in my view, finds fault with the argument for Wheeler's hypothesis, he should likewise find fault with the argument for Carter's.

### V. The Observational Selection Effect

Hacking's inverse gambler's fallacy argument has received a series of replies and I will turn now to consider these. Leslie's first complaint is that "Hacking's story *involves no observational selection effect.*" (1988, p. 270). An observational selection effect is a feature of a process which restricts the type of outcomes of an event which are observable. In the case of the big bang, had the universe not instantiated  $T_1$  then neither we nor anyone else would be around to notice, since the necessary conditions for life would not have been met. So even though big bangs can so easily result in dud universes, no one ever has the misfortune of seeing one. In an attempt to show how such an effect can be crucial to the inference to multiple universes, a number of intriguing analogies have been suggested. I will focus on two analogies suggested by P. J. McGrath, as I believe they capture the essence of each of the stories suggested in the literature (my critique of these carries over to the other stories). In each case I will argue that the inference involved in the story is correct, but the story is not analogous to our situation with respect to the universe.

The first case involves an analogy with Wheeler's oscillating universe theory.

Case A: Jane takes a nap at the beginning of a dice rolling session, on the understanding that she will be woken as soon as a double six is rolled and not before. Upon being woken she infers that the dice have been rolled a number of times.<sup>9</sup>

The reasoning here certainly seems legitimate, but it will pay us to be clear on why this is so. Note that it seems that even *before* she takes a nap, she should predict that she will be woken after a number of rolls. This is roughly because it is unlikely that a double six occurs in just a few rolls, and hence the first double six is likely to occur *later* than a few rolls. Now if it is reasonable to predict this *before* she takes the nap, it is just as reasonable to believe this afterward. But there is an implicit assumption involved here, namely that *there will be many rolls*, or at least as many as it takes to get a double six.

It is not clear that McGrath intended that this assumption be made in the story, but it is in fact necessary for his conclusion that she "is entitled to conclude, when roused, that it is probable that the dice have been rolled at least twenty-five times" (p. 266). How do we calculate the figure *twenty-five*? This calculation crucially depends on a prior probability distribution over hypotheses concerning the maximum number of times the dice rollers will roll. Suppose Jane knows that they are planning to roll just once, unless they happen to win the lottery that day, in which case they will roll many times. In this case Jane is certainly not entitled to the conclusion that McGrath suggests.

To consider the matter more carefully, we can let  $W$  = Jane is woken, and partition this into two hypotheses  $W_L$  = Jane is woken in twenty-five rolls or

more, and  $W_E =$  Jane is woken in less than twenty-five rolls. The prior probability of there being *no* double six in the first 24 rolls,  $P(\sim W_E) = (35/36)^{24} \approx 0.5$ . When Jane is roused and hence knows  $W$  is true, how confident should she be that twenty-five or more rolls have occurred?

$$\begin{aligned} P(W_L|W) &= P(W_L \& W)/P(W) \\ &= P(W_L)/P(W) && \text{(since } W_L \text{ entails } W) \\ &= [P(W) - P(W_E)]/P(W) \\ &= P(\sim W_E) && \text{if and only if } P(W) = 1 \end{aligned}$$

If  $P(W)$  is significantly less than one, then  $P(W_L|W) < 0.5$ . So Jane is entitled to conclude, when roused, that it is probable that the dice have been rolled at least twenty-five times, only on the assumption that the prior probability of her being woken was close to one, i.e., that it was almost guaranteed that the dice would be rolled many times, or at least enough times for a double six to appear.<sup>10</sup>

Now it should be clear that this assumption is not welcome in the case of the universe. It will be useful here to make use of some propositions which Hacking distinguishes for a different purpose:

- $W_1$ : Our universe is one of a large temporal sequence of universes
- $W_2$ : Our universe has been preceded by very many universes<sup>11</sup>

$W_2$  is quite probable given  $W_1$ . For on the basis of  $W_1$  we know that there exists, speaking timelessly, a temporally ordered sequence of universes in space-time. But we do not know which position in the sequence our universe holds. Whenever we have a large sequence of objects, the probability that a particular object will be very early in the sequence will be very low. So if the sequence of universes entailed by  $W_1$  is large enough, it renders  $W_2$  highly probable (note that this reasoning has nothing to do with fine-tuning).<sup>12</sup> But of course we do not know that  $W_1$  is the case. We only know that our universe is fine-tuned for life. The truth of  $W_1$  is part of what we are trying to figure out. So McGrath's story is not relevant to the question at hand.

Now let us consider McGrath's second analogy, which is drawn with a model of coexisting universes.

Case B: Jane knows that an unspecified number of players will simultaneously roll a pair of dice just once, and that she will be woken if, and only if, a double six is rolled. Upon being woken she infers that there were several players rolling dice.<sup>13</sup>

Once again Jane's reasoning seems to be cogent. However, McGrath is mistaken in supposing that this case is essentially the same as Case A, and that as before, Jane is entitled to infer that there were probably at least *twenty-five* play-



ers rolling dice. The judgment concerning the twenty-five rolls had to do with the position within a sequence that the first double six occurred. There is no such sequence in Case B, and in fact the reasoning should proceed along very different lines. The probability of Jane being woken is raised by the Multiple Rolls hypothesis, since she is to be woken if and only if *some* player rolls a double six. And the more players there are, the greater the chance that at least one of them will roll a double six. There is no inverse gambler's fallacy here. Jane's evidence is not about the outcome of a particular roll, but simply the fact that she has been woken. And the probability of this fact *is* raised by the Multiple Rolls hypothesis, given the policy of the dice rollers to wake her upon *any* double six.

To see what is fishy about this case however, let us compare it with the following

Case B\*: Jane knows that she is one of an unspecified number of sleepers each of which has a unique partner who will roll a pair of dice. Each sleeper will be woken if and only if *her* partner rolls a double six. Upon being woken, Jane infers that there are several sleepers and dice rollers.

Jane's reasoning here is unsound. She may of course have independent grounds for the Multiple Rolls hypothesis, but her being woken adds nothing. The crucial difference here concerns the nature of the observational selection effect involved. In each case, if there is no double six rolled then Jane will not be woken. But in Case B, the converse holds also: if some double six is rolled, then Jane will be woken, whereas in Case B\*, Jane's being woken depends on a single roll. It is this *converse* observational selection effect at work in Case B that provides a link between the evidence (her having been woken) and the Multiple Rolls hypothesis. Since this is lacking in Case B\*, the Multiple Rolls hypothesis does not raise the probability of Jane being woken. So Jane has no grounds to infer that there were many dice rollers.

The crucial question therefore, is whether the case of our observership in the universe involves a similar *converse* selection effect. It strikes me that it obviously does not. As Leslie admits, it is not as though we were disembodied spirits waiting for a big bang to produce some universe which could accommodate us. We are products of the big bang which produced this universe. It is certainly not sufficient for us to exist in some universe  $\beta$ , that  $\beta$  is fine-tuned, or even that  $\beta$  is qualitatively exactly as  $\alpha$  actually is. After all, if we postulate enough universes, the chances are that there exist several life-permitting universes, perhaps even universes with precisely the same initial conditions and fundamental constants as our universe, and containing human beings indistinguishable from us. But *we* do not inhabit these universes, other folks do. If we accept Kripke's (1980) thesis of the necessity of origins, we should hold that no other big bang could possibly produce us. But even if this thesis is denied, even if it is metaphysically possible for us to have evolved in a different uni-

verse, or be products of a different big bang, we have no reason to suppose that we would exist if a different universe had been fine-tuned. In order for the Multiple Universe hypothesis to render our existence more probable, there must be some mechanism analogous to that in Case B linking the multiplicity of universes with our existence. But there is no such mechanism. So the existence of lots of universes does not seem to make it any more likely that *we* should be around to see one. So the converse selection effect does not hold, and hence McGrath's analogy fails to vindicate the reasoning from the fact that we are alive to see a fine-tuned universe to the hypothesis that our universe is one of many.

## VI. Improbable and Surprising Events

Let us turn to the second and perhaps more tempting of reasoning in support of the Multiple Universe hypothesis. At some points, Leslie insists that although multiple universes do not render the fine-tuning of our universe, or even our existence, less *improbable*, they do render it less *surprising*, and it is the latter which is significant. The distinction between surprising and unsurprising improbable events is easily illustrated with examples. It is unsurprising that Jane won a lottery out of a billion participants, but it is surprising that Jim won three lotteries in a row each with a thousand participants (even though the probability in each case is one in a billion). It is unsurprising that a monkey types "nie348n sio 9q;c", but when she types "I want a banana!" we are astonished.

Now it is a familiar theme in the philosophy of science that scientific knowledge often advances by making that which is puzzling understandable. We should not be content with events like a monkey typing English sentences, we must seek some account that makes these events understandable. It seems then that any theory which could remove the surprising nature of the fine-tuning data would thereby be confirmed. As Leslie suggests "a fairly reliable sign of correctness is ability to reduce amazement." (1988, p. 112) And the Multiple Universe theory does seem to do just that. For given enough universes it is unsurprising that there is a life-permitting one, and it is unsurprising that we happen to be in a life-permitting one since we could not be in any other kind. Doesn't the fact that this story satisfyingly accounts for what is otherwise puzzling make it plausible?

The idea here can be brought out in another way. That the universe, by pure chance, should have such a fine adjustment of physical parameters to allow for the evolution of life would be *extraordinary*, and it is contrary to reason to believe in the extraordinary (like believing that a monkey wrote *Hamlet*, or that Rembrandt's works are entirely the result of randomly spilt paint). One way to avoid believing that an extraordinary coincidence has occurred is to accept that the universe is the product of intelligent design, another is to suppose that ours is one of very many universes. One or the other of these, it is argued, must be preferred to the Extraordinary Fluke hypothesis. So if the Design hypothesis is not to your liking, the Multiple Universe hypothesis is a plausible alternative.

This intuition is not entirely misguided. In many cases where a hypothesis renders an event less surprising, the hypothesis is thereby confirmed. For one way to make an event less surprising is to make it less *improbable*. And according to P1, raising the probability of an event is one way that a hypothesis can be confirmed. But according to the probabilistic account of confirmation this is the *only* way that a hypothesis is confirmed by the occurrence of an improbable event. I hope to remove the temptation to suppose that *any* hypothesis which reduces the surprisingness of an event is thereby confirmed, by considering a counter-example (ironically one of Leslie's) and by giving a satisfying probabilistic account of how a hypothesis can render an event less surprising without being confirmed.

The distinction between surprising and unsurprising improbable events is an important one that deserves much attention, yet it has received very little in the literature. There is not the space here to consider the matter in depth. I will sketch an account of surprisingness, drawing on suggestions by Paul Horwich (1982), which is adequate for the purposes of our discussion. The crucial feature of surprising events seems to be that they challenge our assumptions about the circumstances in which they occurred. If at first we assume that the monkey is typing randomly, then her typing "nie348n sio 9q" does nothing to challenge this assumption. But when she types "I want a banana" we suspect that this was more than an accident. The difference is that in the second case there is some alternative but not wildly improbable hypothesis concerning the conditions in which the event took place, upon which it is much more probable. On the assumption that the monkey is typing randomly, it is just as improbable that she types "nie348n sio 9q" as it is that she types "I want a banana". But that the second sequence is typed is more probable on the hypothesis that it was not merely a coincidence, but that an intelligent agent had something to do with it, either by training the monkey or rigging the typewriter, or something similar. There is no such hypothesis (except an extremely improbable *ad hoc* one) which raises the probability that the monkey would type the first sequence. Of course by P1, the human intervention hypothesis is confirmed in the case of "I want a banana". So what makes the event surprising is that it forces us to reconsider our initial assumptions about how the string of letters was produced (of course someone who already believes that the typewriter was rigged should not be surprised).

Why is it surprising that the universe is fine-tuned for life? Perhaps because on the assumption that the big bang was just an accident it is extremely improbable that it would be life-permitting, but it is far more likely on the assumption that there exists an intelligent designer, for a designer might prefer to bring about a universe which is inhabitable by other intelligent creatures, rather than a homogeneous cosmic soup. The event is surprising in that it forces us to question whether the big bang really was an accident (someone who already believes in a designer should not be surprised that the universe is life-sustaining).<sup>14</sup>

### VII. Leslie's Shooting Analogy

To see the way that different hypotheses can affect the surprisingness of an event, consider one of Leslie's analogies.<sup>15</sup> You are alone in the forest when a gun is fired from far away and you are hit. If at first you assume that there is no one out to get you, this would be surprising. But now suppose you were not in fact alone but instead part of a large crowd. Now it seems there is less reason for surprise at being shot. After all, someone in the crowd was bound to be shot, and it might as well have been you.

Leslie suggests this as an analogy for our situation with respect to the universe. Ironically, it seems that Leslie's story supports my case, against his. For it seems that while knowing that you are part of a crowd makes your being shot less surprising, being shot gives you no reason at all to suppose that you are part of a crowd. Suppose it is pitch dark and you have no idea if you are alone or part of a crowd. The bullet hits you. Do you really have any reason at all now to suppose that there are others around you?

Let us examine the case more carefully. While it is intuitively clear that the existence of many people surrounding you should reduce the surprisingness of your being shot, there does not exist an adequate account of why this is so. I will present an original analysis of this surprisingness reduction, which both helps us see why reduction of surprisingness need not involve confirmation, and serves as a model for a deeper understanding of the relation between fine-tuning data and multiple universes. Let

E = You are shot

D = The gunman was malicious and not shooting accidentally (the Design hypothesis)

M = You are part of a large crowd (the Multiple People hypothesis)

We begin with the assumption that you are alone and the gun was fired randomly.  $P(E|\sim D \ \& \ \sim M)$  is very low, i.e., there is a slim chance that a randomly fired bullet would hit you, for there is a wide range in which the bullet could move, equal intervals of roughly equal probability, those in which the bullet hits you constituting only a small proportion. But  $P(E|D \ \& \ \sim M)$  is greater, since if there is no other interesting target about you, then a malicious shooter is more likely to aim at you. So

$$P(E|D \ \& \ \sim M) > P(E|\sim D \ \& \ \sim M),$$

and hence by P1,

$$P(D|E \ \& \ \sim M) > P(D|\sim M)$$

i.e., the fact that you have been shot confirms the malicious gunman hypothesis, on the assumption that you are alone. This is what makes your being shot surprising, it challenges you to reconsider whether the shooting really was accidental (if you already knew that the gunman was a psychopath, you should not be surprised at getting hit).

Now consider the case where you know that you are part of a crowd.  $P(E|\sim D \& M)$ , is still very low, for the same reason that  $P(E|\sim D \& \sim M)$  is. But unlike  $P(E|D \& \sim M)$ ,  $P(E|D \& M)$  is not much higher than  $P(E|\sim D \& M)$ , if higher at all. The reason is that while a malicious shooter may be expected to shoot a person, there is little reason to suppose that he would intend to shoot *you* in particular (unless perhaps you are the President). The probability that he will shoot *someone* is high, given that there is a crowd there, but the probability that it will be *you* remains very low, regardless of whether the shooting is deliberate. So

$$P(E|D \& M) \approx P(E|\sim D \& M)$$

and hence

$$P(D|E \& M) \approx P(D|M)$$

i.e. the fact that you have been shot does not confirm the malicious gunman hypothesis on the assumption that you are part of a crowd.

What happens here is that the Multiple People hypothesis  $M$  *screens off* the probabilistic support that  $D$  lends to  $E$ , and hence also screens off the support that  $E$  lends to  $D$ , i.e., relative to  $M$ ,  $E$  and  $D$  are probabilistically independent. So if you first assumed that you were alone, your being shot may count as evidence that the gunman was firing deliberately. But if you later discover that you are part of a large crowd (perhaps it was pitch dark before), there is no longer any reason to question your original assumption that the shooting was accidental. So the Multiple People hypothesis renders your having been shot less surprising.

However, the Multiple People hypothesis does not *raise the probability* that you would be shot. No matter how many people are about you, a randomly fired bullet has the same chance of hitting you. So  $P(E|M \& \sim D) = P(E|\sim M \& \sim D)$ . But now it follows by P2 that  $P(M|E \& \sim D) = P(M|\sim D)$ . So the Multiple People hypothesis is not confirmed by the fact you have been shot, on the assumption that the bullet was fired randomly.<sup>16,17</sup>

Someone may still be tempted to suppose that being shot gives them some reason to suppose that there are many people about. For getting shot all alone in an open field from far away would be extraordinary, and we should not believe in the extraordinary. One way to avoid accepting that something extraordinary has occurred is to suppose that the shot was fired deliberately, but another is to suppose that there are many people about. So if the Malicious Gunman

hypothesis seems ruled out on other grounds (just as many find the Designer of the Universe hypothesis hard to swallow) then the Multiple People hypothesis might seem a plausible alternative.

I suggest that anyone who is still inclined to think this way might like to put their money where their mouth is in the following simulation experiment (we can use paint-balls instead of bullets). You are blindfolded and ear-muffled in a large area, knowing that there is an  $n\%$  probability that you are in a large crowd, otherwise you are alone. (A ball is drawn from a hundred,  $n$  of which are red. A crowd is assembled just in case a red is drawn). Clearly if asked to bet that you are in a crowd, you should accept odds up to  $n:100-n$ . But now a paint-ball is fired randomly from a long distance and happens to hit you. Are you now more than  $n\%$  confident that you are part of a crowd? If so you should be willing to accept odds *higher* than  $n:100-n$ . And if so, I suggest we play the game repeatedly, with you betting at higher odds on each of the rare occasions that a bullet hits you. On this strategy I should win all your money in the long run. For we will find that in only  $n\%$  of those occasions in which you are shot, you are part of a crowd. If we take reasonable betting odds as a guide to reasonable degrees of confidence, this experiment supports my claim that being shot gives you no reason to suppose that you are part of a crowd.

### VIII. Conclusion

The example illustrates that removal of surprise need not involve confirmation. A hypothesis can be such that if we knew it to be true, it would make a certain event less surprising, yet the fact that it makes this event less surprising gives us no reason to suppose that the hypothesis is true.<sup>18</sup> We are now in a position to give a deeper analysis of the way that the Multiple Universe hypothesis reduces the surprisingness of the fine-tuning data. Assuming there is just the one universe, the fact that it is life-permitting is surprising. For this otherwise extremely improbable outcome of the big bang is more probable on the assumption that there is a cosmic designer, who might adjust the physical parameters to allow for the evolution of life. So the fine-tuning facts challenge us to question whether the big bang was merely an accident.

However, on the assumption that our universe is just one of very many, the existence of a designer does not raise the probability that our universe should be life-permitting. For while we might suppose that a designer would create some intelligent life somewhere, there is little reason to suppose it would be *here* rather than in one of the many other universes. It is only on the assumption that there are no other options that we should expect a designer to fine-tune *this* universe for life. Given the existence of many universes, it is already probable that some universe will be fine-tuned; the Design hypothesis does not add to the probability that any particular universe will be fine-tuned. So the Multiple Universe hypothesis screens off the probabilistic link between the Design hypothesis and the fine-tuning data. Hence if we happened to know, on independent grounds,

that there are many universes, the fine-tuning facts would give us little reason to question whether the big bang was an accident, and hence our knowledge of the existence of many universes would render the fine-tuning of our universe unsurprising. However, postulate as many other universes as you wish, they do not make it any more likely that ours should be life-permitting or that we should be here. So our good fortune to exist in a life-permitting universe gives us no reason to suppose that there are many universes.<sup>19</sup>

### Notes

<sup>1</sup> See also Clifton (1991), Leslie (1988), McGrath (1988), Smith (1986) and Whitaker (1988).

<sup>2</sup> See Leslie (1989) for a summary of the fine-tuning data, and Barrow and Tippler (1986) for a detailed account.

<sup>3</sup> See the above references for accounts of multiple universe theories.

<sup>4</sup> A partial exception is Hacking (1987), who as we will see, agrees only in a special case. Earman (1987) expresses his doubts about the inference, but does not argue the point at any length.

<sup>5</sup> For convenience, I use “ $T_1$ ” and the like sometimes as *names* for configurations, sometimes as *predicates*. The use should be clear from the context.

<sup>6</sup> The name ‘ $\alpha$ ’ is to be understood here as *rigidly designating* the universe which happens to be ours. Of course, in one sense, a universe can’t be *ours* unless it is life-permitting. But the universe which happens actually to be ours, namely  $\alpha$ , might not have been ours, or anyone’s. It had a slim chance of containing life at all.

<sup>7</sup> This can be seen briefly as follows: for any  $i$ , the probability that a particular universe is  $T_i$  is  $1/n$ , so the probability that it is not is  $1 - 1/n$ , and the probability that each of  $k$  universes is not  $T_i$  is  $(1 - 1/n)^k$ . Hence the probability that some universe is  $T_i$ , given that there are  $k$  universes, is  $1 - (1 - 1/n)^k$ .

<sup>8</sup> The point is sometimes made in terms of explanation, where explanation is understood to involve raising of probability. What is surprising, and needs explanation, the argument goes, is just that there is a life-permitting universe, not that there is *this* one. The Multiple Universe hypothesis does explain the existence of a life-permitting universe by rendering it probable. Once this is explained, the specific question of why *this* universe is fine-tuned for life does not require an answer, since it is not surprising. The issue of surprisingness and reduction of surprisingness is addressed in §§VI–VII; *explanation* is briefly discussed in note 17.

<sup>9</sup> Adapted from McGrath (1987, p. 265). Leslie (1987) considers an equivalent story in which a person is created *ex nihilo* upon a double six. Whitaker’s (1987) first story involves a two month period during which a casino is allowed to open on a night only if a double six is rolled in one go that night. We see a photo of the open casino in the gossip column and conclude that it was taken much later than the first night. In the second story, you send out researchers to knock on doors until they find a particular unusual kind of family. When they return, you conclude that they were not successful at the first house, but at one much later. I believe my objections to McGrath’s case are equally relevant to these cases.

<sup>10</sup> Without this assumption Jane is not entitled to conclude that there have been *twenty-five* rolls, but she does have evidence that there have been multiple rolls. The crucial point here is that *she* will be woken no matter which roll lands double six. The problem that this raises will be discussed in relation to Cases B and B\*.

<sup>11</sup> Adapted from Hacking (1987, p.399)

<sup>12</sup> Both Whitaker and Hacking are mistaken on this point. Whitaker (p. 264) claims that  $W_2$  follows from  $W_1$ . Hacking claims that “ $W_2$  does not follow from, nor is it made probable by  $W_1$ ” (p. 399) The correct view is that  $W_2$  does not follow from but is made probable by  $W_1$ . The reasons here are slightly different than in the dice case, since we do not know that we inhabit the *first* life-permitting universe in the sequence.



<sup>13</sup> Adapted from McGrath (1987, p.267). Whitaker adapts his story of the casino such that the rule applies only one night, but to more than one casino. If there are several casinos, we should expect to see photos of one of them open, since the photographer will visit an open one. As before, I believe my objections apply equally to this case.

<sup>14</sup> Some will object that the Design hypothesis is so improbable given our background knowledge that it is not significantly confirmed by the fine-tuning data, and hence does not challenge our assumption that the outcome of the big bang was an accident. I disagree, but there is no need to argue the point here. The argument for multiple universes under consideration depends on the assumption that the life-permitting character of the universe is *surprising*, which is the case only if there is some, not wildly improbable hypothesis, which renders it far more probable than it is given that it was the result of chance. If the hypothesis is not one of intelligent design, I am not sure what it could be. If there is no such hypothesis, we should not be puzzled by universe containing life, but view it as just one of the many highly improbable possible outcomes of the big bang—in which case the current motivation for multiple universes loses its force.

<sup>15</sup> This is adapted from Leslie's (1988) version of the story. In the discussion that follows, it should be distinguished from Leslie's (1989) version which is told from the point of view of the shooter.

<sup>16</sup> On the assumption of D, E *disconfirms* M, for if the gunman is firing deliberately, he is less likely to shoot you, if there are many equally interesting targets about.

<sup>17</sup> One reason that it is tempting always to take a theory's ability to reduce the surprisingness of data as evidence in its favor is that it is plausible that a theory's ability to *explain* data, is always evidence in its favor. And a central role of explanation is the reduction of surprisingness. I think that the example shows that reduction of surprisingness is not *sufficient* for explanation. It seems wrong to say that the Multiple People hypothesis *explains* your being shot, for at least three reasons. First, explanations should answer why-questions, but the answer to 'Why were you shot?' is not 'Because there were many people surrounding you'. Second, the fact that you were part of a crowd is not causally relevant to your being shot, and third, your being in a crowd does not raise your chances of being shot. (Similarly, the answer to 'Why is  $\alpha$  life-permitting?' is not 'Because there are lots of other universes'. Nor is the existence of many universes causally or probabilistically relevant to  $\alpha$  containing life). If there is a sense of 'explains' in which your being in a crowd explains your being shot, this can only show that in this sense of the term, explanation is not sufficient for confirmation.

<sup>18</sup> Numerous examples illustrate this point. In Case B\*, Jane has reason to be surprised when woken if she thinks she is the only sleeper (we can make it more surprising by using ten dice landing all sixes, instead of a pair), but not if she knows there are many sleepers and dice rollers. But here being woken gives her no reason to suppose that there are other sleepers and dice rollers. Or consider one of Leslie's (1989) favorite analogies of fine-tuning and multiple universes. You stand before a firing squad, the guns go off, but you are still alive! Astonishing if you are alone in this situation; not so amazing if there are billions of people about before similar firing squads. Yet again, your surviving the firing squad gives you no reason to accept the Multiple Firing Squad hypothesis, even if this hypothesis is plausible to begin with.

<sup>19</sup> My thoughts in the early sections of this paper owe a great deal to numerous discussions with Phil Dowe. I must also thank William Alston, Adam Elga, Ned Hall, Neil Manson, Brent Mundy, Robert Stalnaker, Peter van Inwagen and two anonymous referees for helpful discussions on this topic and/or comments on earlier drafts.

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