A Third Route to the Doomsday Argument

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ABSTRACT In this paper, I present a solution to the Doomsday argument based on a third type of solution, by contrast to on the one hand, the Carter-Leslie view and on the other hand, the Eckhardt et al. analysis. I begin by strengthening both competing models by highlighting some variations of their ancestors models, which renders them less vulnerable to some objections. I describe then a third line of solution, which incorporates insights from both Leslie and Eckhardt's models and fits more adequately with the human situation corresponding to DA. I argue then that this two-sided analogy also holds when one takes into account the issue of indeterminism and the reference class problem. This leads finally to a novel formulation of the argument that could well be more consensual than the original one.

In this paper, I present a solution to the Doomsday argument (DA, for short) based on a third type of solution, by contrast to on the one hand, the Carter-Leslie view and on the other hand, the Eckhardt et al. analysis. In section 1, I describe the Carter-Leslie view. In section 2, I review the Eckhardt et al. line of reasoning. I point out then in section 3 an atemporal-temporal disanalogy in the Carter-Leslie analogy, which leads to the description of a strengthened variation of this latter model. In section 4, I raise some criticisms against the Eckhardt et al. analogy, thus leading to reformulate this latter analogy more accurately. I argue in section 5 that both competing models are capable of handling an indeterministic situation. I present then in section 6 a two-sided analogy that incorporates insights from both Carter-Leslie's and Eckhardt et al.'s models. Finally, I show in section 7 that this two-sided model is capable of handling the reference class problem and leads to a novel formulation of the argument.[1]

1. The Carter-Leslie View

Let us begin by sketching briefly the Doomsday argument. The argument can be described as a reasoning leading to a Bayesian shift, from an analogy between what has been termed the *two-urn case*[2] and the corresponding human situation. Consider, first, the *two-urn case* (slightly adapted from Bostrom 1997):[3]

[1] The solution to DA presented here is a somewhat condensed and enhanced version of the ideas expressed in Franceschi (2002), that also discusses at length the problems related to DA: *God's Coin Toss*, the *Sleeping Beauty Problem*, the *Shooting-Room Paradox*, the *Presomptuous Philosopher*.
[2] Cf. Korb & Oliver (1998).
[3] Cf. Bostrom (1997): 'Imagine that two big urns are put in front of you, and you know that one of them contains ten balls and the other a million, but you are ignorant as to which is which. You know the balls in each urn are numbered 1, 2, 3, 4 ... etc. Now you take a ball at random from the left urn, and it is number 7. Clearly, this is a strong indication that that urn contains only ten balls. If originally the odds were fifty-fifty, a swift application of Bayes' theorem gives you the posterior probability that the left urn is the one with only ten balls. (Pposterior (L=10) = 0.999990)'.

The two-urn case An urn[4] is in front of you, and you know that it contains, depending on the flipping at time T_0 of a fair coin, either 10 (tails) or 1000 (heads) numbered balls. The balls are numbered 1, 2, 3, ... At this step, you formulate the H_{few} and H_{many} assumptions with $P(H_{few}) = P(H_{many}) = 0.5$ and you try to evaluate the number of balls which were contained at T_0 in the urn. You know all the above and you randomly draw a ball from the urn at time T_1. Now you get the ball #5 at T_1. You conclude then to an upward Bayesian shift in favour of the H_{few} hypothesis.

The *two-urn case* constitutes an uncontroversial application of Bayes' theorem. It is based on the two following competing hypotheses:

($H1_{few}$) the urn contains 10 balls
($H2_{many}$) the urn contains 1000 balls

and the corresponding prior probabilities: P(H1) = P(H2) = 0.5. Taking into account the fact that E denotes the available evidence that the random ball is #5 and P(E|H1) = 1/10 and P(E|H2) = 1/1000, a Bayesian shift ensues from a straightforward application of Bayes' theorem. As a result, the posterior probability is such that P'(H1) = 0.99.

Let us consider, on the other hand, the *human situation corresponding to DA*. Now being concerned with the final size of the human race, you consider the two following competing hypotheses:

($H3_{few}$) the number of humans having ever lived will reach 10^{11} (*doom soon*)
($H4_{many}$) the number of humans having ever lived will reach 10^{14} (*doom later*)

Now it appears that each human has his own birth rank, and that yours is roughly 60×10^9. Let us assume then, for the sake of simplicity, that the prior probabilities are such that P(H3) = P(H4) = 0.5.[5] Now according to Carter and Leslie, the *human situation corresponding to DA* is analogous to the *two-urn case*.[6] Let us denote by E the fact that your birth rank is 60×10^9. Thus, an application of Bayes' theorem, taking into account the fact that $P(E|H3) = 1/10^{11}$ and $P(E|H4) = 1/10^{14}$, leads to a vigorous Bayesian shift in favor of the hypothesis that Doom will occur soon: P'(H3) = 0.999. For this reason, the Carter-Leslie line of thought can be summarized as follows:

(5) in the *two-urn case*, a Bayesian shift of the prior probability of H_{few} ensues
(6) the situation corresponding to DA is analogous to the *two-urn case*
(7) ∴ in the situation corresponding to DA, a Bayesian shift of the prior probability of H_{few} ensues

From the Carter-Leslie's viewpoint, the analogy with the urn is well-grounded. And this legitimates DA's conclusion according to which a Bayesian shift in favor of doom soon ensues. This last conclusion appears paradoxical or at least counter-intuitive. But the task of diagnosing what is wrong, if any, with the Doomsday Argument proves to be very difficult and remains an open question.

At this point, it is worth mentioning in passing that the reasoning based on the two-urn case does not yield absolute certainty. This last reasoning is probabilistic and as such, it leads to a true conclusion *in most cases*. If the experiment is repeated many times and you bet accordingly, you will win in most cases. But it must be acknowledged that you will sometimes lose. For consider the situation where the coin lands heads and the number of balls in the urn is 1000. In this last case, if you get the ball #5, the reasoning based on the two-urn case leads to the false conclusion that the urn contains only 10 balls. However, this does not preclude us from regarding the corresponding reasoning as sound. For in the long run, it is reliable and yields many more true conclusion than false ones. The following table summarizes this situation:

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[4] Bostrom's original description of the two-urn case refers to two urns. For the sake of simplicity, I refer here to one single urn (containing either 10 or 1000 balls) instead of two, since it is equivalent to the original two-urn case.
[5] The reasoning remains unaltered if we consider some alternative prior probabilities (with 0 < P(H3) < 1).
[6] More precisely, Leslie considers an analogy with the *lottery case*.

two-urn case (numbered balls)				
toss outcome	*reference class (numbered balls)*	*#*	*prediction*	*reasoning*
tail (doom soon)	10 numbered balls	#5	true	sound
heads (doom later)	1000 numbered balls	#5	false	sound

2. The Eckhardt et al. Analysis

A line of objection to the Doomsday argument initially raised by William Eckhardt (1993, 1997) and recently echoed by George Sowers (2002) and Elliott Sober (2003) runs as follows. The analogy with the urn at the origin of DA, so the objection goes, is ill-grounded. For in the *two-urn case*, the ball number is randomly chosen. But in the human situation corresponding to DA, our birth rank is not randomly chosen, but rather indexed on the corresponding temporal position. Hence, the analogy is ill-grounded and the whole reasoning is invalid. Eckhardt notably stresses the fact that it is impossible to make a random selection when there exists numerous unborn members in the chosen reference class.[7] Sober (2003) argues along the same lines,[8] by pointing out that no mechanism having the effect of randomly assigning a temporal location to human beings, can be exhibited. Lastly, such a line of objection has been recently revived by Sowers. He emphasizes that the birth rank of each human is not random, because it is indexed on the corresponding temporal position.[9]

In parallel, according to the Eckhardt et al. analysis, the human situation corresponding to DA is not analogous to the *two-urn case*, but rather to an alternative model, the *consecutive token dispenser*. The consecutive token dispenser is a device, initially described by Eckhardt,[10] that expels consecutively numbered balls at a constant rate: "(...) suppose on each trial the *consecutive token dispenser* expels either 50 (early doom) or 100 (late doom) consecutively numbered tokens at the rate of one per minute". A similar device - call it the *numbered ball dispenser* - is also mentioned by Sowers:[11]

> There are two urns populated with balls as before, but now the balls are not numbered. Suppose you obtain your sample with the following procedure. You are equipped with a stopwatch and a marker. You first choose one of the urns as your subject. It doesn't matter which urn is chosen. You start the stopwatch. Each minute you reach into the urn and withdraw a ball. The first ball withdrawn you mark with the number one and set aside. The second ball you mark with the number two. In general, the n^{th} ball withdrawn you mark with the number *n*. After an arbitrary amount of time has elapsed, you stop the watch and the experiment. In parallel with the original scenario, suppose the last ball withdrawn is marked with a seven. Will there be a probability shift? An examination of the relative likelihoods reveals no.

Thus, according to the Eckhardt et al. line of thought, the human situation corresponding to DA is not analogous to the *two-urn case*, but rather to the *numbered ball dispenser*. And in this latter model, the conditional probabilities are such that P(E|H1) = P(E|H2) = 1. As a consequence, the prior probabilities of the two alternative hypotheses H_{few} and H_{many} are unchanged. Hence, the corresponding line of reasoning goes as follows:

(8) in the *numbered ball dispenser*, the prior probabilities remain unchanged

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[7] Cf. (1997, p. 256): 'How is it possible in the selection of a random rank to give the appropriate weight to unborn members of the population?'.

[8] Cf. (2003, p. 9): 'But who or what has the propensity to randomly assign me a temporal location in the duration of the human race? There is no such mechanism.'. But Sober is mainly concerned with providing empirical evidence against the hypotheses used in the original version of DA and with broadening the scope of the argument by determining the conditions of its application to concrete situations.

[9] Cf. (2002, p. 40): 'My claim is that by assigning a rank to each person based on birth order, a time correlation is established (...).' and also (2002, p. 44): 'The doomsday argument has been shown to be fallacious due to the incorrect assumption that you are a random sample from the set of all humans ever to have existed.'.

[10] Cf. (1997, p. 251).

[11] Cf. (2002, p. 39).

(9) the situation corresponding to DA is analogous to the *numbered ball dispenser*
(10) ∴ in the situation corresponding to DA, the prior probabilities remain unchanged

thus yielding $P(H_{few}) = P'(H_{few})$ and $P(H_{many}) = P'(H_{many})$.

3. Strengthening the Carter-Leslie Analogy

As we have seen, according to the Carter-Leslie view, DA is based on an analogy between the human situation corresponding to DA and the *two-urn case*. By contrast, from the Eckhardt et al. standpoint, the analogy associates the human situation corresponding to DA and the *numbered ball dispenser*. In what follows, I shall argue that both analogies suffer from some defects and consequently do not prove fully adequate. This leads finally to reformulating the analogy more accurately.

Consider, to begin with, the analogy with the two-urn case inherent to the Carter-Leslie view. Let us consider the characteristics of the human situation corresponding to DA. A summary analysis reveals indeed that this last situation is *temporal*. In effect, the birth ranks are successively attributed to human beings in function of the temporal position corresponding to their appearance on Earth. Thus, the corresponding situation takes place, say, from T_1 to T_n, 1 and *n* being respectively the rank numbers of the first and of the last human. By contrast, the two-urn case is *atemporal*, for at the moment where the ball is randomly drawn, all balls are already present in the urn.[12] Consequently, the two-urn case takes place at a given time T_0. At this step, it appears that the two-urn case is rendered in an atemporal model while the situation corresponding to DA needs to be modeled in a temporal one. In short, the situation corresponding to DA being temporal, and the two-urn case being atemporal precludes us from regarding the two situations as isomorphic.[13] The importance of the *atemporal-temporal disanalogy* will become clearer later. Roughly, its importance rests on the fact that an atemporal model leads to one single model, while considering a temporal one engenders several competing probabilistic models. In addition, considering a temporal model is best suited for taking into account the issue of indeterminism and the reference class problem. In any case, at this step, it is apparent that the human situation corresponding to DA being temporal should be put in analogy more accurately with a *temporal* experiment.

The atemporal-temporal disanalogy being stated, let us investigate now how this inconvenient could be overcome. Consider then the following experiment, which can be termed the *incremental two-urn case* (let us denote it by *two-urn case*$^{++}$):

> *The synchronic and deterministic two-urn case*$^{++}$ An urn is in front of you, and you know that it contains, depending on the flipping at time T_0 of a fair coin, either 10 (tails) or 1000 (heads) numbered balls. At time T_1, you randomly draw the ball #*e* from the urn. Then a device expels at T_1 the ball #1, at T_2 the ball #2..., and finally at T_e the ball #*e*.[14] Once the ball #*e* expelled, the device stops. You formulate the H_{few} and H_{many} assumptions with $P(H_{few}) = P(H_{many}) = 0.5$ and you try to evaluate the number of balls which were contained at T_0 in the urn. Now you know all the above and you get the ball #5 at T_5 when the device stops. You conclude then to an upward Bayesian shift in favour of the H_{few} hypothesis.

The novelty in this variation is that the experiment presents a temporal feature, given that the random selection is made at T_1 and the chosen ball is ultimately expelled at T_5. It is also worth pointing out that in the *synchronic and deterministic two-urn case*$^{++}$, the total number of balls in the urn is definitively fixed at T_0, when the experiment begins. For this reason, the corresponding situation can be termed *deterministic*. An instance of the *synchronic and deterministic two-urn case*$^{++}$ is as follows:

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[12] It could be pointed out that a small amount of time is necessary to perform the Bayesian shift, once the problem's data are known. But this can be avoided if one considers ideal thinkers, who perform Bayesian shifts at the time when they are informed of the data relevant to the corresponding situation.
[13] I borrow this terminology from Chambers (2001).
[14] From now on, I assume that the intervals of time, i. e. from T_1 to T_n, are regular. Considering alternatively irregular intervals of time would not result in significant differences in the present account.

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping	tails					
range		1-10				
random #		5				
ball #		1	2	3	4	5

At this step, it should be emphasized that anyone who accepts the conclusion of the *two-urn case* would also be committed to accepting the Bayesian shift resulting from the *incremental two-urn case*.

Furthermore, it appears that other variations of the incremental two-urn case can even be envisaged. For consider the following variant:

> *The diachronic and deterministic two-urn case*$^{++}$ An opaque device contains an urn that has, depending on the flipping at time T_0 of a fair coin, either 10 (tails) or 1000 (heads) numbered balls. At time T_1, a robot inside the device draws a ball at random in the urn (containing the balls #1 to #*n*) and then replaces it in the urn. The device expels then the ball #1; if the ball #1 has been drawn then the device stops at T_1; else at T_2, the robot draws a ball at random in the urn (now containing the balls #2 to #*n*) and the device expels the ball #2; if the ball #2 has been drawn then the device stops at T_2; ...; else at T_i, the robot draws a ball at random in the urn (now containing the balls #*i* to #*n*) and the device expels the ball #*i*; if the ball #*i* has been drawn then the device stops at T_i; else at T_{i+1}, etc. Now you know all the above and you get the ball #5 at T_5 when the device stops.[15] You formulate the H_{few} and H_{many} assumptions with $P(H_{few}) = P(H_{many}) = 0.5$ and you conclude to an upward Bayesian shift in favor of the H_{few} hypothesis.

In this last case, the random selection is performed gradually and is only made effective when the number of the randomly drawn ball equals the number corresponding to the temporal position, i. e. when the ball #*i* is drawn at T_i. This contrasts with the synchronic version of the experiment, where the random selection is made definitively at time T_1. Nevertheless, in the *diachronic and deterministic two-urn case*$^{++}$, the probability of drawing the ball #*n* at T_n still equals 1/*n*. Let us denote by E the fact of drawing the ball #5 at T_5. It follows that the probability of drawing the ball #5 at T_5 if the urn contains 10 balls is such that $P(E) = 9/10 \times 8/9 \times 7/8 \times 6/7 \times 5/6 \times 1/5 = 1/10$. An instance of the *diachronic and deterministic two-urn case*$^{++}$ is as follows:

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping	tails					
range		1-10	2-10	3-10	4-10	5-10
random #		4	7	9	6	5
ball #		1	2	3	4	5

where the random selection is only made effective at time T_5.

At this step, it should be pointed out that the incremental two-urn case (whether synchronic or diachronic) does not face the above-mentioned criticisms concerning the atemporal-temporal disanalogy between the human situation corresponding to DA and the original two-urn case. For it has been shown that the human situation corresponding to DA, being temporal, cannot be put in analogy with the two-urn case, which is atemporal. By contrast, the incremental two-urn case is a temporal experiment. Thus, the incremental two-urn case meets the above mentioned requirements concerning the analogy and can be put legitimately in analogy with the human situation corresponding to DA. In this context, we now face a variation of DA which can be stated explicitly as follows:

(11) in the *incremental two-urn case*, a Bayesian shift of the prior probability of H_{few} ensues
(12) the situation corresponding to DA is analogous to the *incremental two-urn case*

[15] This can be equivalently rendered with the following computer algorithm: at T_1, draw randomly a number between 1 and *n*; if 1 is issued then display 1 and stop; else at T_2, draw randomly a number between 2 and *n*; if 2 is issued then display 2 and stop; ...; else at T_i, draw randomly a number between *i* and *n*; if *i* is issued then display *i* and stop.

(13) ∴ in the situation corresponding to DA, a Bayesian shift of the prior probability of H_{few} ensues

And this last variation is not vulnerable to the above objection. The analogy with the urn is now plainly plausible, since both situations are *temporal*.

At this point, it is also worth scrutinizing the consequences of the *incremental two-urn case* (whether synchronic or diachronic) on the Eckhardt et al. analysis. For in the incremental two-urn case, the number of each ball expelled from the device is indexed on the rank of its expulsion. For example, you draw the ball #60000000000. But you also know that the preceding ball was #59999999999 and that the penultimate ball was #59999999998, etc. However, this does not prevent you from reasoning in the same way as in the original two-urn case and from concluding to a Bayesian shift in favor of the H_{few} hypothesis. In this context, the incremental two-urn case has the following consequence: *the fact of being time-indexed does not entail that the ball number is not randomly chosen*. Contrast now with the central claim of the Eckhardt et al. analysis that the birth rank of each human is not randomly chosen, but rather indexed on the corresponding temporal position. Sowers in particular considers that the cause of DA is the time-indexation of the number corresponding to the birth rank.[16] But what the incremental two-urn case and the corresponding analogy demonstrates, is that our birth rank can be time-indexed and nevertheless considered as random for DA purposes. And this point can be regarded as a significant objection to Sowers' analysis. This last remark leads to consider that the concrete analysis presented by Sowers does not prove however sufficient to solve DA. For the problem is revived when one considers the analogy between on the one hand, the human situation corresponding to DA and on the other hand, the incremental two-urn case. One can think that it is this latter analogy which constitutes truly the core of the DA-like reasoning. In this context, Sowers' conclusion according to which his analysis leads to the demise of DA appears far too strong. Echoing Eckhardt, he has certainly provided additional steps leading towards a resolution of DA and clarified significant points, but Sowers' analysis does not address veritably the strongest formulations of DA.

4. Refining the Eckhardt et al. Analogy

Let us consider, on the other hand, the analogy with the *numbered ball dispenser*, which is characteristic of the Eckhardt et al. line of thought. As mentioned above, Eckhardt describes the *consecutive token dispenser*, where the tokens are expelled from the urn at constant rates ("one per minute"). Sowers also describes an analogous experiment, where the balls are expelled from the urn and numbered accordingly, at the constant[17] rate of one per minute. In this last experiment, the balls are numbered in the order of their expulsion from the urn.

However, the numbered ball dispenser can be criticised on the grounds that its protocol seems inaccurately defined. This inaccuracy concerns in particular the mechanism that expels a given ball #*n* at T_n. What makes the device stops at T_n after the ball #*n* has been expelled? The numbered ball dispenser seems to be designed for whatever way of choosing a given ball. So, could it be said, whatever mechanism allowing the choice of the ball #*n* would be acceptable. But this won't do as a response, I think. For consider for example a deterministic situation, where the total number of balls in the urn is already settled before the experiment begins. And suppose that a device chooses a ball at random at T_1 in the urn, say #5, and expels then accordingly the balls #1 at T_1, #2 at T_2, #3 at T_3, #4 at T_4, #5 at T_5 and then stops. It appears then that the corresponding situation is fully isomorphic with the

[16] Cf. Sowers (2002, p. 40): 'My claim is that by assigning a rank to each person based on birth order, a time correlation is established in essentially the same way that the stopwatch process established a correlation with the balls.'.

[17] It could be pointed out that both Eckhardt's and Sowers' experiments do not exactly correspond to the human situation corresponding to DA. For in this latter situation, the humans appear on Earth at variable intervals of time, while Eckhardt and Sowers consider constant rates. However, this last disanalogy can be regarded as a minor qualm. For both Eckhardt's and Sowers' experiments could be eventually restated with items which are expelled at irregular rates instead of constant ones. In this context, a constant rate numbered ball dispenser can even be regarded as a useful simplification, for our present purposes of modeling the human situation corresponding to DA.

synchronic and deterministic two-urn case^{++}. Thus, at least on one particular interpretation, the numbered ball dispenser proves to be identical to the *synchronic and deterministic two-urn case*$^{++}$. But as we have seen, this latter experiment leads to a straightforward Bayesian shift in favour of the H_{few} hypothesis, in complete opposition with the numbered ball dispenser which leaves the prior probabilities unchanged. Arguably, such interpretation of the numbered ball dispenser should be discarded, given that it is at the opposite of the Eckhardt et al. viewpoint. But this shows that the protocol of the numbered ball dispenser stands in need of refinement and must be defined more accurately. This urges us to search another interpretation of the protocol of the numbered ball dispenser that fits more adequately with the spirit of the Eckhardt et al. line of thought.

Let us consider, second, another interpretation. Such interpretation arises from Sowers' description of the numbered ball dispenser. Sowers mentions in effect that the last ball is #7 ("In parallel with the original scenario, suppose the last ball withdrawn is marked with a seven"). Now let us repeat the experiment many times. In the long run, the numbered ball dispenser will always yield the ball #7 (or alternatively, a small number). Under this interpretation, the repeatability of the experiment shows that the numbered ball dispenser has a *bias* towards #7. Although it should be acknowledged that this biased numbered ball dispenser is also one *possible* interpretation of the numbered ball dispenser, I don't think neither that it fits adequately with what Sowers' has in mind. For it seems that Sowers is concerned with a last ball expelled which is marked with whatever number (recall "In general, the *n*th ball withdrawn you mark with the number *n*"). For that reason, this second interpretation should also be rejected.

Let us consider then a third alternative interpretation. For it seems that an adequate interpretation of the numbered ball dispenser must do justice to Eckhardt' idea that *it is impossible to make a random selection when there exists numerous unborn members in the reference class*. Both previous interpretations of the numbered ball dispenser fail to incorporate this latter idea. But consider now the following variation of the numbered ball dispenser:

> *The synchronic and deterministic numbered ball dispenser* An opaque device contains an urn that has 10 balls at T_0, but will ultimately have either 10 or 1000 numbered balls. The final number of balls in the urn will be determined by the flipping of a fair coin at T_0. If heads, it will add 990 numbered balls (#11 to #1000) in the urn a given time T_i ($1 \leq i < 10$), say at T_6. If tails, it will do nothing at T_6. At time T_1, you randomly draw the ball #*e* from the urn and then replace it in the urn. Then a device expels at T_1 the ball #1, at T_2 the ball #2..., at T_n the ball #*n*. Now, according to the outcome of the random drawing performed at T_1, the device stops at T_e when the ball #*e* is expelled. At this step, you formulate the H_{few} and H_{many} assumptions with $P(H_{few}) = P(H_{many}) = 0.5$ and you try to evaluate the number of balls which were contained at T_0 in the urn. You formulate the H_{few} and H_{many} assumptions relating to the total number of balls in the urn at T_6 with $P(H_{few}) = P(H_{many}) = 0.5$. Now you know all the above and you get the ball #5 at T_5 when the device stops. You conclude then that the prior probabilities remain unchanged.

An instance of the *synchronic and deterministic numbered ball dispenser* is then as follows:

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping	tails					
range		1-10	2-10	3-10	4-10	5-10
random #		5				
ball #		1	2	3	4	5

The novelty in this variation is that the urn contains 10 balls at the beginning but 990 other balls are eventually added later, say at T_6, depending on the outcome of a coin's toss. If the coin lands tails, nothing is done at T_6 and the urn remains with only 10 balls, the ball being drawn continuously in the range [1, 10]. If the coin lands heads, 990 balls are added in the urn at T_6. In this last case, the ball is drawn in the range [1, 10] until T_6, but from T_6 onwards, the ball is drawn in the range [1, 1000]. The protocol of this experiment can be described more generally in the following terms: if the urn contains only 10 balls, a ball is drawn randomly in the range [1, 10]. But if the urn contains 1000 balls, a ball is drawn randomly in the range [1, 1000]. Thus, the ball is drawn randomly, according to the *actual* number of balls in the urn. At this step, it should be apparent that this latter protocol does justice to Eckhardt's idea that it is impossible to make a random selection when there exists numerous unborn members in the reference class. In the present experiment the 990 balls that are added at T_6 represent those unborn members and the random process operates in the range [1, 10] until T_6, even in the case where the reference class will ultimately contain 1000 balls. Under these conditions, the *synchronic and deterministic numbered ball dispenser* appears well as a more robust variation of the numbered ball dispenser, which fully incorporates Eckhardt's insight. This latter variation does not face the above criticism of inaccuracy in its protocol. In this last situation, it would be plainly erroneous to conclude to a Bayesian shift in favor of the H_{few} hypothesis. What is rational to infer in this situation, though, is that the prior probabilities remain unchanged.

At this step, it is worth pointing out that the *synchronic and deterministic numbered ball dispenser* has another virtue. In effect, it now incorporates an element of randomness, given that the number of the ball is first drawn randomly in [1, 10]. The corresponding variation is much in line with the intuition that we are in some sense random humans. Consequently, this variation does justice to the idea that at least in some sense, our birth rank can be considered as random.

At this step, it is worth pointing out that a diachronic variation of the preceding experiment can even be envisaged. For consider the following variant of the numbered ball dispenser:

> *The diachronic and deterministic numbered ball dispenser* An opaque device contains an urn that has 10 balls at T_0, but will ultimately have either 10 or 1000 numbered balls. The final number of balls in the urn will be determined by the flipping of a fair coin at T_0. If heads, it will add 990 numbered balls (#11 to #1000) in the urn a given time T_i ($1 \leq i < 10$), say at T_6. If tails, it will do nothing at T_6. At time T_1, a robot inside the device draws a ball[18] at random in the urn (containing the balls #1 to #10) and the device expels the ball #1; if the ball #1 has been drawn then the device stops at T_1; else at T_2, the robot draws a ball at random in the urn (now containing the balls #2 to #10) and the device expels the ball #2; if the ball #2 has been drawn then the device stops at T_2; ...; else at T_i, the robot draws a ball at random in the urn (now containing the balls #*i* to #*n*) and the device expels the ball #*i*; if the ball #*i* has been drawn then the device stops at T_i; else at T_{i+1}, etc. You formulate the H_{few} and H_{many} assumptions relating to the total number of balls at T_6 with $P(H_{few}) = P(H_{many}) = 0.5$. Now you know all the above and you get the ball #5 at T_5 when the device stops. You conclude then that the prior probabilities remain unchanged.

An instance of the *diachronic and deterministic numbered ball dispenser* is then as follows:

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping	tails					
range		1-10	2-10	3-10	4-10	5-10
random #		8	3	9	9	5
ball #		1	2	3	4	5

5. The Issue of Indeterminism

Let us examine now whether both preceding models are affected or not by the issue of indeterminism which arises in the context of DA. This latter issue is important, since Leslie notably considers that DA is considerably weakened if our world is of an indeterministic nature. Leslie acknowledges in effect that DA must be weakened if the fate of the human race is indeterministic when he evokes:[19] "(...) the potentially much stronger objection that the number of names in the doomsday argument's imaginary urn, the number of all humans who will ever have lived, *has not yet been firmly settled* because the world is indeterministic".

[18] After the ball is drawn, it is replaced in the urn.
[19] Cf. Leslie (1993, p. 490).

At this step, it should be pointed out that some variations of the preceding experiments are capable of handling an *indeterministic* situation, namely where the total number of balls in the urn is unknown at the time where the experiment begins and is only settled with certainty during the course of the experiment. As an example, the following variation of the two-urn case^{++} takes into account an indeterministic situation:

> *The diachronic and indeterministic two-urn case*$^{++}$ An opaque device contains an urn that has 10 balls at T_0, but will ultimately have either 10 or 1000 numbered balls. The final number of balls in the urn will remain undetermined until an internal mechanism will flip a quantum coin[20] at a given time T_i ($1 \leq i < 10$). If heads, it will add 990 numbered balls (#11 to #1000) in the urn at T_i. If tails, it will do nothing. At time T_1, a random generator inside the device issues a number in the range [1, 1000] and the device expels the ball #1; if the number 1 has been issued then the device stops at T_1; else at T_2, the random generator issues a number in the range [2, 1000] and the device expels the ball #2; if the number 2 has been issued then the device stops at T_2; ...; else at T_{i-1}, the random generator issues a number in the range [*i*-1, 1000] and the device expels the ball #*i*-1; if the number *i*-1 has been issued then the device stops at T_{i-1}; else at T_i ($1 \leq i < 10$), the random generator issues a number in the range [*i*, *n*] (the total number of balls in the urn after the flipping of the coin is *n*) and the device expels the ball #*i*; if the number *i* has been issued then the device stops at T_i; else at T_{i+1}, etc. Now you know all the above and you get the ball #*e* at T_e when the device stops. You formulate the H_{few} and H_{many} assumptions relating to the total number of balls in the urn after the flipping of the coin with $P(H_{few}) = P(H_{many}) = 0.5$. Now you know all the above and you get the ball #5 at T_5 when the device stops. You conclude then to an upward Bayesian shift in favor of the H_{few} hypothesis.

An instance of the *diachronic and indeterministic two-urn case*$^{++}$ is then as follows:

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping				tails		
range		1-1000	2-1000	3-1000	4-10	5-10
random #		857	326	92	9	5
ball #		1	2	3	4	5

The novelty in this variation is that it handles an indeterministic situation. In effect, the number of balls present in the urn is unknown at the time where the first ball is expelled and is only settled at T_i. Such a variation shows that a random selection can even be made when the number of balls in the urn is unknown at the time where the random process begins. And this appears as a counter-example to Eckhardt's attack against the random sampling assumption in DA, based on the impossibility of making a random selection when there exists many unborn members in the given reference class. The *diachronic and indeterministic two-urn case*$^{++}$ shows that a random selection can even be made, under certain indeterministic circumstances.

However, it should be acknowledged that this only partly undermines Eckhardt's point. For it could be retorted that the above experiment does not handle every type of indeterministic situation and that Eckhardt could provide a counterpart of both the *diachronic and indeterministic two-urn case*$^{++}$. In effect, Eckhardt could reply that what he has in mind is an experiment of the following type:

> *The diachronic and indeterministic numbered ball dispenser* An opaque device contains an urn that has 10 balls at T_0, but will ultimately have either 10 or 1000 numbered balls. The final number of balls in the urn will remain undetermined until an internal mechanism will flip a quantum coin at a given time T_i ($1 \leq i < 10$). If heads, it will add 990 numbered balls (#11 to #1000) in the urn at T_i. If tails, it will do nothing. At time T_1 a robot inside the device draws a ball at random in the urn (containing the balls #1 to #10) and the device expels the ball #1; if the number 1 has been issued then the device stops at T_1; else at T_2, a robot inside the device draws a ball at random in the urn (containing the balls #2 to #10) and the device expels the ball #2; if

[20] This works as well if one chooses a fair coin instead.

the number 2 has been issued then the device stops at T_2; ...; else at T_{i-1}, a robot inside the device draws a ball at random in the urn (containing the balls # *i*-1 to #10) and the device expels the ball #*i*-1; if the number *i*-1 has been issued then the device stops at T_{i-1}; else at T_i, a robot inside the device draws a ball at random in the urn (containing the balls #*i* to # *n*) (the total number of balls in the urn after the flipping of the coin is *n*) and the device expels the ball #*i*; if the number *i* has been issued then the device stops at T_i; else at T_{i+1}, etc. Now you know all the above and you get the ball #5 at T_5 when the device stops. You formulate the H_{few} and H_{many} assumptions relating to the total number of balls in the urn after the flipping of the coin, with $P(H_{few}) = P(H_{many}) = 0.5$. You conclude then that the prior probabilities remain unchanged.

An instance of the *diachronic and indeterministic numbered ball dispenser* is as follows:

time	T_0	T_1	T_2	T_3	T_4	T_5
flipping				tails		
range		1-10	2-10	3-10	4-10	5-10
random #		7	6	10	7	5
ball #		1	2	3	4	5

To the difference of the preceding case, the random drawing of the ball is made here in the range [1, 10] until the flipping of the coin. This increases the probability that the device stops, says at T_5, even if the urn will ultimately contain 1000 balls, after the coin has eventually landed heads. In such a case, the drawing of the ball #5 at random gives us no grounds for concluding to a Bayesian shift in favor of the H_{few} assumption. In effect, in this last situation, it is very probable to draw a number in the range [1, 10], even if the coin lands heads at T_i.

At this step, it should be apparent that taking into account the issue of indeterminism gives us no clue for deciding whether the incremental two-urn case or the numbered ball dispenser is an adequate model for the human situation corresponding to DA. In effect, both models admit of a variation which is capable of modeling a human situation of an indeterministic nature.

6. The Third Route

Given the above developments, we are now in a position to evaluate the adequacy of the analogy underlying DA. We now face two competing analogies with the human situation corresponding to DA. At this stage, the question that arises is the following: Is the human situation corresponding to DA analogous to (i) the *two-urn case*$^{++}$ or to (ii) the *numbered ball dispenser*? As we have seen, each model comes in three variations – i.e. deterministic-synchronic, deterministic-diachronic, indeterministic-diachronic) – which constitute strong variations of their respective original models, since they are not vulnerable to several objections that can be pressed against their original ancestors. At this step, the following question arises: Does there exist an objective criterion allowing the preferential choice of one of the two competing models? Is there any clue that allows for preferring the two-urn case^{++} or the numbered ball dispenser to model the human situation corresponding to DA? Let us proceed now to review whether any such objective criterion is available.

Both Leslie and Eckhardt give reasons to justify the preferential choice of their favorite model. I shall examine these latter justifications in turn. To begin with, Leslie's motivation for the preferential choice of the two-urn case^{++} results from countering a commonly raised objection based on the consideration that people of the future are not alive yet. The corresponding line of defense notably results from the emerald experiment (1996, p. 20):[21]

> Imagine an experiment planned as follows. At some point in time, three humans would each be given an emerald. Several centuries afterwards, when a completely different set of humans was alive, five thousands humans would again each be given an emerald in the experiment. You have no knowledge, however, of whether your century is the earlier century in which just three people were to be in this situation, or the later century in which five thousand were to be in it. Do you say to yourself that if yours

[21] Cf. also Leslie (1993, p. 489).

> were the earlier century then the five thousand people wouldn't be alive yet, and that therefore you'd have no chance of being among them? On this basis, do you conclude that you might just as well bet that you lived in the earlier century?
>
> Suppose you in fact betted that you lived there. If every emerald getter in the experiment betted in this way, there would be five thousand losers and only three winners. The sensible bet, therefore, is that yours is instead the later century of the two.

Leslie's remark is targeted at demonstrating (successfully, I think) that a DA-like reasoning can validly take place, even if there exist some unborn members in the reference class. However, Leslie acknowledges that DA is weakened if our world is indeterministic, i.e. if the total number of humans who will ever have lived is not presently settled. As we have seen, this latter situation corresponds to some variations of the numbered ball dispenser, notably the indeterministic numbered ball dispenser.

On the other hand, Eckhardt's justification for the preferential choice of the numbered ball dispenser is twofold. Eckhardt stresses first the fact that our birth rank is nonrandom. But there is a strong intuition that we are, at least for a given reference class, random humans and consequently, our birth rank can also be random. But Eckhardt argues, second, and more convincingly, for the impossibility of drawing a random number without knowing the total size of the reference class. The different variations of the numbered ball dispenser described above incorporate this latter insight. However, one possible weakness in Eckhardt's account is that he denies the analogy with the lottery case (in our framework, the *two-urn case*++) in all cases. But how can we have the certainty that an analogy with the *two-urn case*++ does not hold, for a given reference class?

Although both Leslie and Eckhardt offer strong justifications for their favorite model, it appears that they do not provide sufficient objective motivation for ruling out the opposite model. For Leslie openly accepts that his favorite analogy with the lottery case could fail in some indeterministic cases, thus allowing for the numbered ball dispenser to apply. On the other hand, Eckhardt does not expose the objective motivation for rejecting the analogy with the *two-urn case*++ in all cases. As a result, we are still left with an indeterminate situation. Let us then investigate whether any of the two competing models has an advantage over the other for modeling accurately the specific features of the human situation corresponding to DA. It is worth pointing out preliminarily that from an external viewpoint, there is no difference between the two models. In effect, from an observer's viewpoint, the external sequence consists in the expulsion of the balls #1 at T_1, #2 at T_2, #3 at T_3, ..., #*e* at T_e, whether one considers the *two-urn case*++ or the *numbered ball dispenser*. This corresponds adequately to the temporal feature of the human situation corresponding to DA. Hence, from this viewpoint, the analogy proves to be strongly established in both cases.

Let us turn now to the internal part of both experiments, concerning in particular what relates to the random process. As we have seen, both models admit of a synchronic variation where the random drawing is made at T_0 and a diachronic variation where the random drawing is made gradually from T_1 to T_e. In consequence, both models are capable of modeling adequately the random process[22] that determines the birth rank of each human. Whether such random drawing has been made before the beginning of humankind or perhaps more plausibly, during the course of the existence of the human race doesn't matter. For the *two-urn case*++ and the *numbered ball dispenser* both admit of respective variations which are capable of handling adequately these two types of situations. At this stage, it appears that both models are capable of modeling adequately the random process that determines the birth rank of each human. From this viewpoint, the two competing models are still on a par for the modelization of situations which differ according to the synchronic/diachronic distinction.

Let us consider then the deterministic/indeterministic distinction. Does any of the two models has an advantage over the other for modeling adequately a deterministic or an indeterministic situation? From the above, it results that both alternative models admit of variations which are capable of handling either a deterministic or an indeterministic situation.

To sum up now. From the above, it results that both models admit of respectively three variations, i.e. deterministic-synchronic, deterministic-diachronic, indeterministic-diachronic. An immediate consequence is that the two models are equally suited for modeling adequately the different modalities of the human situation corresponding to DA, depending on the synchronic/diachronic or on the

[22] To put it metaphorically. Needless to say, such random process need not be taken at face value.

deterministic/indeterministic distinction. The upshot is that this equally powerful modeling ability of the two competing models still leaves us with an indeterminate situation.

At this stage, it appears that we lack an objective criterion allowing for deciding rationally whether the two-urn case^{++} or the numbered ball dispenser is the relevant model for the human situation corresponding to DA. In the lack of objective evidence, it is then wise to apply a principle of indifference, which leads to retain both models as roughly equiprobable. What remains then in force, is an indeterminate situation. At this stage, it appears that we are on a third route: either the two-urn case^{++} or the numbered ball dispenser applies to the human situation corresponding to DA. In this context, both Leslie's and Eckhardt's positions can be regarded as monist attitudes. For the preferential choice of either the two-urn case^{++} or the numbered ball dispenser appears well as a *one-sided* attitude. By contrast, the present view, based on a third route, is of a pluralist nature. For it seems that an adequate model should reflect the fundamental property of being *two-sided*. Perhaps if the present view were grounded on a purely *disjunctive* model, i.e. corresponding to the definition that either Leslie's or Eckhardt's position were true, there would be serious grounds for doubting that there would be something interestingly novel in the third route. But as will become clearer later, the truth is that the third route entails that both two-urn case^{++} and numbered ball dispenser apply to the human situation corresponding to DA. The essence of the third route is then pluralistically based on a *conjunctive* treatment of both Leslie's and Eckhardt's models. In short, both models work. But explaining how both models apply without appealing to any paraconsistent logic requires that we delve more deeply into the underpinnings of the reference class problem.

7. The Reference Class Problem

Let us recall first the *reference class problem*.[23] Roughly, it is the problem of how to define 'humans'. More accurately, it can be stated as follows: How can the reference class be objectively defined for DA-purposes? For an extensive or restrictive definition of the reference class can be provided. An extensively defined reference class would include for example the somewhat exotic future evolutions of humankind, for example with an average I.Q. of 200 or with backward causation abilities. Conversely, a restrictively designed reference class would only include those humans who correspond accurately to the characteristics of, say, *homo sapiens sapiens*, thus excluding the past *homo sapiens neandertalensis* and the future *homo sapiens supersapiens*. To put it more in adequation with our current taxonomy, the reference class can be defined at different levels which correspond respectively to the supergenus *superhomo*, the *homo* genus, the *homo sapiens* species, the *homo sapiens sapiens* subspecies, etc. At this step, it appears that we lack an objective criterion to choose the corresponding level non-arbitrarily.

Leslie's treatment of the reference class problem is exposed in the response made to Eckhardt (1993) and in Leslie (1996).[24] Leslie's solution to the reference class problem goes as follows. According to Leslie, one can choose the reference class more or less as one wishes, i.e. at a somewhat arbitrary level. Once the relevant choice performed, it suffices to adjust the prior probabilities accordingly to get the argument moving. Leslie's sole condition is that the reference class should not be chosen at an extreme level of extension or of restriction.[25] Furthermore, Leslie addresses the resulting fact that each human belongs to several different classes, restrictively or extensively defined. However, this is not a problem from Leslie's standpoint, since the argument works for all these classes. In effect, a Bayesian shift ensues for whatever reference class arbitrarily chosen, at a somewhat reasonable level of extension or of restriction. Leslie illustrates this point with an urn analogy. To the difference of the two-urn case, he considers an urn that contains balls of different colors, say red and green. A red ball

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[23] The *reference class problem* in probability theory is notably exposed in Hájek (2002, s. 3.3). For a treatment of the reference class problem in the context of DA, see notably Eckhardt (1993, 1997), Bostrom (1997, 2002, ch. 4 pp. 69-72 and ch. 5), Franceschi (1998, 1999). The point of Franceschi (1999) can be construed as a treatment of the reference class problem in confirmation theory.

[24] In the part entitled 'Just who should count as being human?' (pp. 256-63).

[25] Cf. 1996, p. 260: 'Widenings of reference class can easily be taken too far.' and p. 261: 'Again, some ways of *narrowing* a reference class might perhaps seem inappropriate.'.

is drawn from the urn. In this context, from a restrictive viewpoint, the ball is a random red ball and there is no difference in this case with the classical two-urn case. But from a more extensive viewpoint, it is also a random red-or-green ball.[26] According to Leslie, although the prior probabilities are different in each case, a Bayesian shift ensues in both cases.[27] In sum, on Leslie's view, the reference class problem can be overcome because the argument works for *all* somewhat reasonably defined reference classes.

By contrast, Eckhardt's treatment of the reference class problem stresses the difficulty, for the same individual, of being simultaneously random in several different classes: "(...) do we have better reason to believe that we are random human than random vertebrates or random social animals? Can the same item be random in all these classes? Isn't a *random* human a rather exceptional vertebrate?" (1993, p. 483). We shall return to these reservations later.

At this step, one might wonder what treatment of the reference class problem results from the third route. To begin with, it is worth reframing the reference class problem into the above-mentioned taxonomy of experiments. Now it appears that the two-urn case++ and the numbered ball dispenser can be easily adapted, in order to incorporate the elements of the reference class problem. In both models, it suffices to consider in replacement of the original one-color experiment a two-color one, i.e. where the 10 first balls are red and the 990 other balls are green. Now the urn is filled with red-or-green balls and a given red ball (or a green ball) can also be considered as a red-or-green ball. From the third route's viewpoint, there exists some classes for which Leslie's model works and some other classes for which Eckhardt's model prevails. Let us examine this in more detail. Suppose then that for a given reference class, we have the absolute certainty that the *two-urn case*++ holds (whichever variation – whether synchronic or diachronic, deterministic or indeterministic – will do the job). A Bayesian shift then ensues for this latter reference class. Now it could well be that the extinction of this latter class will be followed by the appearance of another class, slightly different. For such type of situation is very common among evolutionary species. Now the consequence is that for a slightly more extended class, the *numbered ball dispenser* is the adequate model. In this case, the *two-urn case*++ holds for a given reference class, while the *numbered ball dispenser* applies for a slightly more extended reference class which includes the former. Consequently, for the same individual which belongs to both classes, the *two-urn case*++ holds for a given reference class while the *numbered ball dispenser* also holds for a slightly more extended class. To put it otherwise, according to the conjunctive essence of the third route, the *two-urn case*++ holds from a restrictive viewpoint and the *numbered ball dispenser* applies from an extensive standpoint.

Let us illustrate now the above remarks through an example related to our past situation. This will also deserve the purpose of highlighting a second important point. Leslie addresses then the case of a neandertalian who would have implemented a DA-like reasoning:[28]

> Consider the protest that any Stone Age man who had used the argument would have been led to the erroneous conclusion that the human race would soon die out. A first reply is: So what? It is not a defect in any merely probabilistic argument if it leads someone improbably situated - someone very early in time, maybe, or someone who has thrown a dozen dice with eyes shut and expects (mistakenly, in view of what is actually on the table) not to see a dozen sixes upon opening them - to an erroneous conclusion.

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[26] Cf. Leslie (1996, p. 259): 'Suppose all the balls in the urn are numbered. A ball is drawn. It turns out to be bright red. Note that it is not only a bright red ball whose number has been drawn *at random* from the numbers of all the *bright red* balls in the urn, but also a red-or-reddish ball whose number has been drawn *at random* from the numbers of all the *red-or-reddish* balls in the urn.'.

[27] Cf. Leslie (1996, pp. 258-9): 'The thing to note is that the red ball can be treated either just as a red ball or else as a red-or-green ball. Bayes's Rule applies in both cases. When we're interested in how many red balls there are in the urn, we need to treat the ball just as a red ball. The 'prior probabilities' entering into our Bayesian calculation are then probabilities for such and such numbers of red balls. When, in contrast, what interests us is how many red-or-green balls the urn contains, then we have to treat the red ball as red-or-green. Correspondingly, the prior probabilities entering into the calculation are the prior probabilities of various numbers of balls in the red-or-green-ball class. [...] All this evidently continues to apply to when being-red-or-green is replaced by being-red-or-pink, or being-red-or-reddish.'.

[28] Cf. (1992, pp. 527-8).

From the fact that Leslie considers the neandertalian's conclusion as erroneous, it is implicit here that the corresponding reference class is the somewhat extensively defined *homo sapiens* species. Leslie's treatment of the neandertalian case is fully in adequation with the *two-urn case*$^{++}$. Leslie acknowledges the fact that a neandertalian who would have implemented a DA-like reasoning related to the *homo sapiens* reference class would have been led to a false conclusion. But on Leslie's view, this is due to the above-mentioned[29] fact that the reasoning based on the two-urn case does not yield absolute certainty. It works in most cases but exceptionally early members of the reference can be led to an erroneous conclusion, despite the soundness of their DA-like reasoning.

Let us analyze now the neandertalian case from the third route's standpoint. I shall assume in the following that our current taxonomy is the best objective guide at our disposal for drawing relevant distinctions among reference classes. Historically, the *homo sapiens neandertalensis* subspecies has appeared on the earth near -200.000 BCE and then became extinct near -35.000 BCE. On the other hand, our current subspecies *homo sapiens sapiens* has appeared near -120.000 BCE. From the above, it results that, from the viewpoint of a neandertalian, we need to distinguish two cases: (i) from -200.000 to -120.000 BCE, where *homo sapiens neandertalensis* has been the sole representative on the earth of the *homo sapiens* species. By contrast, from (ii) -120.000 to -35.000 BCE, the earth has been populated simultaneously with two coexistent members of the *homo sapiens* species, i.e. *homo sapiens neandertalensis* and *homo sapiens sapiens*.

Let us begin then (i) with the first period, i.e. from -200.000 to -120.000 BCE. At this time, *homo sapiens neandertalensis* is the unique representative on the earth of the *homo sapiens* species, but also of the *homo* genus, of the *superhomo* supergenus, etc. Now the question is: Which reference class is relevant for DA-purposes? The point is that the neandertalian can consider herself at a somewhat restrictive level, as a member of the *homo sapiens neandertalensis* subspecies, or at a slightly more extensive level as a member of the *homo sapiens* species. [30] Now it appears that there would have been nothing wrong had the neandertalian identified the reference class with *homo sapiens neandertalensis*. For the neandertalian had serious grounds for considering herself as a random sample of the somewhat restrictively defined *homo sapiens neandertalensis* class. In this case, the neandertalian would have concluded, in virtue of the third route's line of reasoning, that either the two-urn case^{++} or the numbered ball dispenser applies to the *homo sapiens neandertalensis* class.

On the other hand, had the neandertalian identified the reference class with the wider *homo sapiens* species, an immediate qualm would have pressed: Is a member of the *homo sapiens neandertalensis* class (red balls) representative of the wider *homo sapiens* (red-or-green balls) class? For this latter class, the reasoning of the neandertalian goes, could include further members such as, say, *homo sapiens sapiens* (green balls), who could well appear during the course of evolution. And the point is, the neandertalian could pursue, that I only see members of the *homo sapiens neandertalensis* subspecies around me, and no other representative of other subspecies belonging to the *homo sapiens* species is present. This gives me strong grounds for not considering myself (and my associated birth rank) as a random sample of the *homo sapiens* class. To put it in terms of balls: since I only draw red balls, I cannot reasonably consider these latter as representative samples of the class of red-or-green balls, in order to draw inductive conclusions. Put otherwise: drawing only red balls give me strong grounds for preferring the hypothesis that the urn contains only red balls over the hypothesis that it contains red and green balls. Now the fact that she cannot consider herself as a random sample of the wider *homo sapiens* class, precludes the neandertalian from applying the DA-like reasoning to this latter class. Considering then that it is well possible that some unborn members belonging to other species of the *homo sapiens* class are not currently taken into account, the neandertalian would then better leave her prior probabilities unchanged, in accordance with the *numbered ball dispenser*.

Let us envisage now (ii) the second period from (ii) -120.000 to -35.000 BCE. At this time, there are simultaneously two representative subspecies of the *homo sapiens* species (red-or-green balls) which cohabit on the earth: *homo sapiens neandertalensis* (red balls) and *homo sapiens sapiens* (green balls). Now the neandertalian could choose, just as previously, the *homo sapiens neandertalensis* class and reason in a similar fashion. But in this case, the neandertalian could also legitimately choose the wider

[29] Cf. §1.

[30] To simplify matters, only two competing reference classes are envisaged here. The same goes if one extends the choice to other wider subdivisions of the taxonomy, such as the *superhomo* supergenus, etc.

homo sapiens class. For now the neandertalian has strong grounds for considering that she is randomly drawn from the *homo sapiens* (red-or-green balls), since she observes both representatives of the *homo sapiens neandertalensis* (red balls) subspecies and of the *homo sapiens sapiens* subspecies (green balls).

Let us turn now to our present situation. Begin with the choice of the appropriate reference class. Will we consider the *homo sapiens sapiens* subspecies or the *homo sapiens* species as relevant for DA-purposes? At present time, there is only one single representative subspecies – *homo sapiens sapiens* – of the *homo sapiens* species on the earth. For the same reason that for the neandertalian during the first period from -200.000 to -120.000 BCE, this precludes us from choosing the *homo sapiens* species as the appropriate reference class. This leaves us with a reference class which identifies itself with the *homo sapiens sapiens* subspecies. Now according to the third route, there exists equal grounds for applying either the *two-urn case*$^{++}$ or the *numbered ball dispenser* to this latter reference class. Suppose now that the *two-urn case*$^{++}$ holds. Then it could well be the case that the extinction of *homo sapiens sapiens* subspecies will be followed by the appearance of the much-evolved *homo sapiens supersapiens* subspecies. Finally, this renders finally DA innocuous. Put in terms of the third route's viewpoint on the reference class problem, it entails that the *two-urn case*$^{++}$ applies to the restricted *homo sapiens sapiens* class while the *numbered ball dispenser* applies to the wider *homo sapiens* class. This ambivalent effect has the effect of depriving the original argument from its initial terror. Finally, this gives a way of accepting its conclusion by rendering the argument less counterintuitive than in its original formulation.

This leads finally to a novel formulation of the argument. What results from the foregoing developments is that the Doomsday Argument must be weakened in two ways. On the one hand, for a given reference class, it should be acknowledged that either the *two-urn case*$^{++}$ or the *numbered ball dispenser* holds. On closer scrutiny, this is not very far from Leslie's own position. Recall: DA is significantly weakened if our world is indeterministic. But Leslie's conception of an indeterministic world fits well with the sort of device that constitutes the *numbered ball dispenser*. On the other hand, the reference class problem must be taken into account, thus leading to the conclusion that DA could work for a given reference class. But if there existed a given reference class for which the argument were conclusive, this latter class could well be incorporated into a more extensive class for which a two-color version of the *numbered ball dispenser* would apply. This finally renders the argument innocuous, by depriving it of its initially associated terror. At the same time, this leaves room for the argument to be successful for a given reference class, but without its counterintuitive consequences. Given these two sidesteps, the resulting novel formulation of the argument could well be more consensual than the original one.

Lastly, what precedes casts light on an essential facet of the Doomsday Argument. For on a narrow sense, it is an argument about the fate of humankind. But on a broad sense (the one I have been concerned with) it emphasizes the difficulty of applying probabilistic models to real-life situations,[31] a difficulty which is usually largely underestimated. This opens a path to a whole field of practical interest, consisting of a taxonomy of probabilistic models, whose philosophical importance would have been unravelled without John Leslie's robust and courageous defence of the argument.[32]

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[31] This important underpinning of the argument is also underlined in Delahaye (1996). This is also the main point of Sober (2003).

[32] I am grateful to Claude Panaccio and Daniel Andler for comments on an ancestor version of this paper. I especially thank Jean-Paul Delahaye for very useful comments and discussion. I am also indebted to John Leslie and Elliott Sober for comments on an earlier draft. I thank Nick Bostrom for very helpful discussion on the reference class problem.

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