# 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 original models, which renders them less vulnerable to several objections. I then describe 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 casts new light on the reference class problem. This leads finally to a novel formulation of the argument that could well be more plausible than the original one.

In what follows, I will endeavor to present a solution to the problem arising from the Doomsday argument (DA). The solution thus described constitutes a third way out, compared to, on the one hand, the approach of the promoters of DA (Leslie 1993 and 1996) and on the other hand, the solution recommended by its detractors (Eckhardt 1993 and 1997, Sowers 2002).[1]

## I. THE DOOMSDAY ARGUMENT AND THE CARTER-LESLIE MODEL

For the sake of the present discussion, it is worth beginning with a brief presentation of DA. This argument can be described as reasoning which leads to a Bayesian shift, starting from an analogy between what was has been called the *two-urn case*[2] and the corresponding human situation.

Let us consider first the *two-urn case experiment* (adapted from Bostrom 1997):

> *The two-urn case experiment* An opaque urn[3] is in front of you. You know that it contains either 10 or 1000 numbered balls. A fair coin has been tossed at time $T_0$ and if the coin landed tails, then 10 balls were placed in the urn; on the other hand, if the coin landed heads, 1000 balls were placed in the urn. The balls are numbered 1,2,3,…. You formulate then the assumptions $H_{few}$ (the urn contains only 10 balls) and $H_{many}$ (the urn contains 1000 balls) with the initial probabilities P ($H_{few}$) = P ($_{Hmany}$) = 1/2.
>
> Informed of all the preceding, you randomly draw a ball at time $T_1$ from the urn. You get then the ball #5. You endeavor to estimate the number of balls that were contained at $T_0$ in the urn. You conclude then to an upward Bayesian shift in favor of the $H_{few}$ hypothesis.

The *two-urn case experiment* is an uncontroversial application of Bayes' theorem. It is based on the two following concurrent assumptions:

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

and the corresponding initial probabilities: P (H1) = P (H2) = 1/2. By taking into account the fact that E denotes the evidence according to which the randomly drawn ball carries the #5 and that P (E|H1) = 1/10 and P (E|H2) = 1/1000, an upward Bayesian shift follows, by a straightforward application of Bayes' theorem. Consequently, the posterior probabilities are such that P'(H1) = 0.99 and P'(H2) = 0.01.

Let us consider, on the second hand, the *human situation corresponding to DA*. While being interested in the total number of humans that humankind will finally count, it is worth considering the two following concurrent hypotheses:

($H3_{few}$) the total number of humans having ever lived will amount to $10^{11}$ (*Apocalypse near*)
($H4_{many}$) the total number of humans having ever lived will amount to $10^{14}$ (*Apocalypse far*)

It appears now that every human being has his own birth rank, and that yours, for example, is about $60 \times 10^9$. Let us also assume, for the sake of simplicity, that the initial probabilities are such as P(H3) = P(H4) = 1/2. Now, according to Carter and Leslie, the *human situation corresponding to DA* is analogous to the *two urn case*.[4] If we denote by E the fact that our birth rank is $60 \times 10^9$, an application of Bayes' theorem, by taking into account the fact that P(E|H3) = $1/10^{11}$ and that P(E|H4) = $1/10^{14}$, leads to an important Bayesian shift in favor of the hypothesis of a near Apocalypse, i.e., P'(H3) = 0.999. The importance of the Bayesian shift which results from this reasoning, associated with a very worrying situation related to the future of humankind, from the only recognition of our birth rank, appears counter-intuitive. This intrinsic problem requires that we set out to find it a solution.

In such context, it appears that a solution to DA has to present the following characteristics. On the one hand, it must point out in which ways the human situation corresponding to DA is similar to the two-urn case or possibly, to an alternative model, the characteristics of which are to be specified. On the second hand, such solution to DA must point out in which ways one or several models on analogy with the human situation corresponding to DA are associated with a frightening situation for the future of humankind.

In what follows, I will endeavor to present a solution to DA. In order to develop it, it will be necessary first to build up the space of solutions for DA. Such a construction is a non-trivial task that requires the consideration of not only several objections that have been raised against DA, but also the reference class problem. Within this space of solutions, the solutions advocated by the supporters as well as critics of DA, will naturally be placed. I will finally show that within the space of solutions thus established, there is room for a third way out, which is in essence a different solution from that offered by the proponents and opponents of DA.

## II. FAILURE OF AN ALTERNATIVE MODEL BASED ON THE INCREMENTAL OBJECTION OF ECKHARDT ET AL.

DA is based on the matching of a probabilistic model - the two-urn case - with the human situation corresponding to DA. In order to build the space of solutions for DA, it is necessary to focus on the models that constitute an alternative to the two-urn case, which can also be put in correspondence with the human situation corresponding to DA. Several alternative models have been described by the opponents to DA. However, for reasons that will become clearer later, not all these models can be accepted as valid alternative models to the two-urn case, and take a place within the space of solutions for DA. It is therefore necessary to distinguish among these models proposed by the detractors of DA, between those which are not genuine alternative models, and those which can legitimately be included within the space of solutions for DA.

A certain number of objections to DA were formulated first by William Eckhardt (1993, 1997). For the sake of the present discussion, it is worth distinguishing between two objections, among those which were raised by Eckhardt, and that I will call respectively: the *incremental* objection and the *diachronic* objection. With each one of these two objections is associated an experiment intended to constitute an alternative model to the two-urn case.

Let us begin with the *incremental* objection mentioned in Eckhardt (1993, 1997) and the alternative model associated with it. Recently, George Sowers (2002) and Elliott Sober (2003) have echoed this objection. According to this objection, the analogy with the urn that is at the root of DA, is ungrounded. Indeed, in the two-urn case experiment, the number of the balls is randomly chosen. However, these authors emphasize, in the case of the human situation corresponding to DA, our birth rank is not chosen at random, but is indeed indexed on the corresponding time position. Therefore, Eckhardt stresses, the analogy with the two-urn case is unfounded and the whole reasoning is invalidated. Sober (2003) develops a similar argument,[5] by stressing that no mechanism designed to randomly assign a time position to human beings, can be highlighted. Finally, such an objection was recently revived by Sowers. The latter focused on the fact that the birth rank of every human being is not random because it is indexed to the corresponding time position.

According to the viewpoint developed by Eckhardt et al., the human situation corresponding to DA is not analogous to the *two-urn case* experiment, but rather to an alternative model, which may be called the *consecutive token dispenser*. The consecutive token dispenser is a device, originally described by Eckhardt[6], that ejects consecutively numbered balls at regular intervals: "(...) 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 balls dispenser* - is also mentioned by Sowers, where the balls are ejected from the urn and numbered in the order of their ejection, at the regular interval of one per minute:[7]

> 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, under the terms of the viewpoint defended by Eckhardt et al., the human situation corresponding to DA is not analogous with the two-urn case experiment, but with the *numbered balls dispenser*. And this last model leads us to leave the initial probabilities unchanged.

The incremental objection of Eckhardt et al. is based on a disanalogy. Indeed, the human situation corresponding to DA presents a *temporal* nature, for the birth ranks are successively attributed to human beings depending on the time position corresponding to their appearance on Earth. Thus, the corresponding situation takes place, for example, from $T_1$ to $T_n$, where 1 and $n$ are respectively the birth ranks of the first and of the last humans. However, the two-urn case experiment appears *atemporal*, because when the ball is drawn at random, all the balls are already present within the urn. The two-urn case experiment takes place at a given time $T_0$. It appears thus that the two-urn case experiment is an atemporal model, while the situation corresponding to DA is a temporal model. And this forbids, as Eckhardt et al. underscore, considering the situation corresponding to DA and the two-urn case as isomorphic.[8]

At this stage, it appears that the *atemporal-temporal disanalogy* is indeed a reality and it cannot be denied. However, this does not constitute an insurmountable obstacle for DA. As we shall see, it is possible indeed to put in analogy the human situation corresponding to DA, with a temporal variation of the two-urn case. This can be done by considering the following experiment, which can be termed the *incremental two-urn case* (formally, the *two-urn case*$^{++}$):

> *The two-urn case*$^{++}$. An opaque urn in front of you. You know that it contains either 10 or 1000 numbered balls. A fair coin has been tossed at time $T_0$ and if the coin landed tails, then the urn

contains only 10 balls, while if the coin landed heads, then the urn contains the same 10 balls plus 990 extra balls, i.e. 1000 balls in total. The balls are numbered 1, 2, 3, .... You formulate then the $H_{few}$ (the box contains only 10 balls) and $H_{many}$ (the box contains 1000 balls) hypotheses with initial probabilities $P(H_{few}) = P(H_{many}) = 1/2$. At time $T_1$, a device will draw a ball at random, and will eject then every second a numbered ball in increasing order, from the ball #1 until the number of the randomly drawn ball. At that very time, the device will stop.

You are informed of all the foregoing, and the device expels then the ball #1 at $T_1$, the ball #2 at $T_2$, the ball #3 at $T_3$, the ball #4 at $T_4$, and the ball #5 at $T_5$. The device then stops. You wish to estimate the number of balls that were contained at $T_0$ in the urn. You conclude then to an upward Bayesian shift in favor of the $H_{few}$ hypothesis.

As we can see, such a variation constitutes a mere adaptation of the original two-urn case, with the addition of an incremental mechanism for the expulsion of the balls. The novelty with this variation[9] is that the experience has now a temporal feature, because the random selection is made at $T_1$ and the randomly drawn ball is finally ejected, for example at $T_5$.

At this stage, it is also worth analyzing the consequences of the two-urn case$^{++}$ for the analysis developed by Eckhardt et al. Indeed, in the *two-urn case*$^{++}$, the number of each ball ejected from the device is indexed on the range of its expulsion. For example, I draw the ball #60000000000. But I also know that the previous ball was the ball #59999999999 and that the penultimate ball was the ball #59999999998, and so on. However, this does not prevent me from thinking in the same manner 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 *two-urn case*$^{++}$ experiment leads to the following consequence: *the fact of being indexed with regard to time does not mean that the number of the ball is not randomly chosen*. This can now be confronted with the main thesis of the incremental objection raised by Eckhardt et al., i.e. that the birth rank of each human being is not randomly chosen, but is rather indexed on the corresponding time position. Sowers especially believes that the cause of DA is that the number corresponding to the birth rank is time-indexed.[10] But what the *two-urn case*$^{++}$ experiment and the corresponding analogy demonstrates is that our birth rank can be time-indexed and nevertheless be determined randomly in the context of DA. For this reason, the *numbered balls dispenser* model proposed by Eckhardt and Sowers can not be considered as an alternative model to the two-urn case, within the space of solutions for DA.

## III. SUCCESS OF AN ALTERNATIVE MODEL GROUNDED ON WILLIAM ECKHARDT'S DIACHRONIC OBJECTION

William Eckhardt (1993, 1997) also describes another objection to DA, which we shall call, for the sake of the present discussion, the diachronic objection. This latter objection, as we shall see it, is based on an alternative model to the two-urn case, which is different from the one that corresponds to the incremental objection. Eckhardt highlights the fact that *it is impossible to perform a random selection, when there exists many yet unborn individuals within the corresponding reference class*: “How is it possible in the selection of a random rank to give the appropriate weight to unborn members of the population?” (1997, p. 256).

This second objection is potentially stronger than the incremental objection. In order to assess its scope accurately, it is worth translating now this objection in terms of a probabilistic model. It appears that the model associated with Eckhardt's diachronic objection can be built from the two-urn case's structure. The corresponding variation, which can be termed the *diachronic two-urn case*, goes as follows:

*The diachronic two-urn case*. An opaque urn in front of you. You know that it contains either 10 or 1000 numbered balls. A fair coin has been tossed at time $T_0$. If the coin fell tails, 10 balls were then placed in the urn, while if the coin fell heads, 10 balls were also placed in the urn at time $T_0$, but 990 supplementary balls will be also added to the urn at time $T_2$, bringing up the total number of balls finally contained in the urn to 1000. The balls are numbered 1, 2, 3, ....

You then formulate $H_{few}$ (the urn finally contains only 10 balls) and $H_{many}$ (the urn finally contains1000 balls) hypotheses with the initial probabilities P ($H_{few}$) = P ($H_{many}$) = 1 / 2.

Informed of all the above, you randomly draw at time $T_1$ a ball from the urn. You get then the ball #5. You wish to estimate the number of balls that ultimately will be contained in the urn at $T_2$. You conclude then that the initial probabilities remain unchanged.

At this stage, it appears that the protocol described above does justice to Eckhardt's strong idea that it is impossible to perform a random selection where there are many yet unborn members in the reference class. In the *diachronic two-urn case*, the 990 balls, which are possibly (if the coin falls heads) added in $T_2$ account for these members not yet born. In such a situation, it would be quite erroneous to conclude to a Bayesian shift in favor of the $H_{few}$ hypothesis. But what can be inferred rationally in such a case is that the prior probabilities remain unchanged.

We can also see that the structure of the protocol of the *diachronic two-urn case* is quite similar to the original two-urn case experiment (which we shall now term, by contrast, the *synchronic two-urn case*). This will allow now for making easy comparisons. So we see that if the coin lands tails: the situation is the same in both experiments, *synchronic* and *diachronic*. However, the situation is different if the coin lands heads: in the synchronic two-urn case, the 990 balls are already present in the urn at $T_0$; on the other hand, in the model of the diachronic two-urn case, 990 extra balls are added to the urn later, namely at $T_2$. As we can see, the diachronic two-urn case based on Eckhardt's diachronic objection deserves completely to take a place within the space of solutions for DA.

## IV. CONSTRUCTION OF THE PRELIMINARY SPACE OF SOLUTIONS

In light of the foregoing, we are now in a position to appreciate how much the analogy underlying DA is appropriate. It appears indeed that two alternative models to model the analogy with the human situation corresponding to DA are in competition: on the one hand, the *synchronic* two-urn case advocated by the promoters of DA and, on the other hand, the *diachronic* two-urn case, based on Eckhardt's diachronic objection. It turns out that these two models share a common structure, which allows for making comparisons.[11]

At this step, the question that arises is the following: is the human situation corresponding to DA in analogy with (i) the *synchronic* two-urn case, or (ii) the *diachronic* two-urn case? In response, the next question follows: is there an *objective* criterion that allows one to choose, preferentially, between the two competing models? It appears not. Indeed, neither Leslie nor Eckhardt do provide objective reasons for justifying the choice of their favorite model, *and* for rejecting the alternative model. Leslie, first, defends the analogy of the human situation corresponding to DA with the lottery experiment (here, the synchronic two-urn case). At the same time, Leslie acknowledges that DA is considerably weakened if our universe is of an indeterministic nature, i.e. if the total number of people who will ever exist has not yet been settled.[12] But it turns out that such indeterministic situation corresponds completely with the *diachronic two-urn case*. For the protocol of this experiment takes into account the fact that the total number of balls which will ultimately be contained in the urn, is not known at the time when the random drawing is performed. We see it finally, Leslie liberally accepts that the analogy with the *synchronic two-urn case* may not prevail in certain indeterministic circumstances, where, as we have seen, the *diachronic two-urn case* would apply.

Otherwise, a weakness in the position defended by Eckhardt is that he rejects the analogy with the lottery experiment (in our terminology, the *synchronic two-urn case*) in all cases. But how can we be certain that an analogy with the *synchronic two-urn case* does not prevail, at least for a given situation? It appears here that we lack the evidence allowing us to reject such an hypothesis with absolute certainty.

To sum now. Within the space of solutions for DA resulting from the foregoing, it follows now that two competing models may also be convenient to model the human situation corresponding to DA: Leslie's synchronic two-urn case or Eckhardt's diachronic two-urn case. At this stage, however, it appears that no objective criterion allows for preferring one or the other of these two models. In these circumstances, in the lack of objective evidence to make a choice between the two competing models, we are led to apply a principle of indifference, which leads us to retain both models as roughly equiprobable. We attribute then (Figure 1), applying a principle of indifference, a probability P of 1/2 to the analogy with the *synchronic two-urn case* (associated with a terrifying scenario), and an identical probability of 1/2 to the analogy with the *diachronic two-urn case* (associated with a reassuring scenario).

| *Case* | *Model* | $T_0$ | $T_2$ | *P* | *Nature of the scenario* |
|---|---|---|---|---|---|
| 1 | synchronic two-urn case | ○ | | 1/2 | terrifying |
| 2 | diachronic two-urn case | ○ | ○ | 1/2 | reassuring |

*Figure 1.*

However, it appears that such an approach is of a preliminary nature, for in order to assign a probability to each specific situation inherent in DA, it is necessary to take into account all the elements underlying DA. But it appears that a key element of DA has not yet been taken into account. It is the notoriously awkward *reference class problem*.

## V. THE REFERENCE CLASS PROBLEM

Let us begin by recalling the *reference class problem*.[13] Basically, it is the problem of the correct definition of "humans". More accurately, the problem can be stated as follows: how can the reference class be objectively defined in the context of DA? For a more or less extensive or restrictive definition of the reference class can be used. An extensively defined reference class would include, for example, the somewhat exotic varieties corresponding to a future evolution of humankind, with for example an average IQ equal to 200, a double brain or backward causation abilities. On the other hand, a restrictively defined reference class would only include those humans whose characteristics are exactly those of - for example - our subspecies *Homo sapiens sapiens*. Such a definition would exclude the extinct species such as *Homo sapiens neandertalensis*, as well as a possible future subspecies such as *Homo sapiens supersapiens*. To put this in line with our current taxonomy, the reference class can be set at different levels, which correspond to the *Superhomo* super-genus, the *Homo* genus, the *Homo sapiens* species, the *Homo sapiens sapiens* subspecies, etc. At this stage, it appears that we lack an objective criterion allowing to choose the corresponding level non-arbitrarily.

The solution to the reference class problem proposed by Leslie's, which is exposed in the response made to Eckhardt (1993) and in *The End of the World* (1996), goes as follows: one can choose the reference class more or less as one wishes, i.e. at any level of extension or of restriction. Once this choice has been made, it suffices to adjust accordingly the initial probabilities, and DA works again. The only reservation mentioned by Leslie is that the reference class should not be chosen at an extreme level of extension or restriction.[14] According to Leslie, the fact that every human being can belong to different classes, depending on whether they are restrictively or extensively defined, is not a problem, because the argument works for each of those classes. In this case, says Leslie, a Bayesian shift follows for whatever class reference, chosen at a reasonable level of extension or of restriction. And Leslie illustrates this point of view by an analogy with a multi-color urn, unlike the one-color urn of the original two-urn case experiment. He considers an urn containing balls of different colors, for example red and green. A red ball is drawn at random from the urn. From a restrictive viewpoint, the ball is a red ball and then there is no difference with the two-urn case. But from a more extensive viewpoint, the ball is also a red-or-green ball.[15] According to Leslie, although the initial probabilities are different in each case, a Bayesian shift results in both cases.[16] As we can see, the synchronic two-urn case can be easily adapted to restore the essence of Leslie's multi-color model. It suffices in effect to replace the red balls of the original synchronic two-urn case with red-or-green balls. The resulting two-color model is then in all respects identical to the original synchronic two-urn case experiment, and leads to a Bayesian shift of the same nature.

At this stage, in order to incorporate properly the reference class problem into the space of solutions for DA, we still need to translate the diachronic two-urn case into a two-color variation.

*A. The two-color diachronic two-urn case*

In the one-color original experiment which corresponds to the diachronic two-urn case, the reference class is that of the red balls. It appears here that one can construct a two-color variation, which is best suited for handling the reference class problem, where the relevant class is that of red-or-green balls. The corresponding two-color variation is in all respects identical with the original diachronic two-urn case, the only difference being that the first 10 balls (#1 to #10) are red and the other 990 balls (#11 to #1000) are green. The corresponding variation runs as follows:

> *The two-color diachronic two-urn case*. An opaque urn in front of you. You know it contains either 10 or 1000 numbered balls (consisting of 10 red balls and 990 green balls). The red balls are numbered #1, #2, ..., #9, #10 and the green ones #11, #12, .., #999, #1000. A fair coin has been tossed at time $T_0$. If the room fell tails, 10 balls were then placed in the urn, while if the coin fell heads, 10 red balls were also placed in the urn at time $T_0$, but 990 green balls will be then added to the urn at time $T_2$, bringing thus the total number of balls in the urn to 1000. You formulate then the hypotheses $H_{few}$ (the urn contains finally only 10 red-or-green balls) and $H_{many}$ (the box finally contains 1000 red-or-green balls) with the prior probabilities $P(H_{few}) = P(H_{many}) = 1/2$.
>
> After being informed of all the above, you draw at time $T_1$ a ball at random from the urn. You get the red ball #5. You proceed to estimate the number of red-or-green balls which will ultimately be contained in the urn at $T_2$. You conclude that the initial probabilities remain unchanged.

As we can see, the structure of this two-color variation is in all respects similar to that of the one-color version of the diachronic two-urn case. In effect, we can considered here the class of red-or-green balls, instead of the original class of red balls. And in this type of situation, it is rational to conclude in the same manner as in the original one-color version of the diachronic two-urn case experiment that the prior probabilities remain unchanged.

*B. Non-exclusivity of the synchronic one-color model and of the diachronic two-color model*

With the help of the machinery at hand to tackle the reference class problem, we are now in a position to complete the construction of the space of solutions for DA, by incorporating the above elements. On a preliminary basis, we have assigned a probability of 1/2 to each of the one-color two-urn case - synchronic and diachronic - models, by associating them respectively with a terrifying and a reassuring scenario. But what is the situation now, with the presence of two-color models, which are better suited for handling the reference class problem?

Before evaluating the impact of the two-color model on the space of solutions for DA, it is worth defining first how to proceed in putting the two-color models and our present human situation into correspondence. For this, it suffices to assimilate the class of red balls to our current *subspecies Homo sapiens sapiens* and the class of red-or-green balls to our current *species Homo sapiens*. Similarly, we shall assimilate the class of green balls to the subspecies *Homo sapiens supersapiens*, a subspecies more advanced than our own, which is an evolutionary descendant of *Homo sapiens sapiens*. A situation of this type is very common in the evolutionary process that governs living species. Given these elements, we are now in a position to establish the relationship of the probabilistic models with our present situation.

At this stage it is worth pointing out an important property of the two-color diachronic model. It appears indeed that the latter model is susceptible of being combined with a one-color synchronic two-urn case. Suppose, then, that a one-color synchronic two-urn case prevails: 10 balls or 1000 red balls are placed in the urn at time $T_0$. But this does not preclude green balls from being also added in the urn at time $T_2$. It appears thus that the one-color synchronic model and the diachronic two-color model are not exclusive of one another. For in such a situation, a synchronic one-color two-urn case prevails for the restricted class of red balls, whereas a diachronic two-color model applies to the extended class of red-or-green balls. At this step, it appears that we are on a *third route*, of pluralistic essence. For the fact of matching the human situation corresponding to DA with the synchronic or the (exclusively) diachronic model, are well monist attitudes. In contrast, the recognition of the joint role played by both synchronic and diachronic models, is the expression of a pluralistic point of view. In these circumstances, it is necessary to analyze the impact on the space of solutions for DA of this property of *non-exclusivity* which has just been emphasized.

In light of the foregoing, it appears that four types of situations must now be distinguished, within the space of solutions for DA. Indeed, each of the two initial one-color models - synchronic and diachronic - can be associated with a two-color diachronic two-urn case. Let us begin with the case (1) where the *synchronic one-color* model applies. In this case, one should distinguish between two types of situations: either (1a) nothing happens at $T_2$ and no green ball is added to the urn at $T_2$, or (1b) 990 green balls are added in the urn at $T_2$. In the first case (1a) where no green ball is added to the urn at $T_2$, we have a rapid disappearance of the class of red balls. Similarly, we have a disappearance of the corresponding class of red-or-green balls, since it identifies itself here with the class of red balls. In such a case, the rapid extinction of *Homo sapiens sapiens* (the red balls) is not followed by the emergence of *Homo sapiens supersapiens* (the green balls). In such a case, we observe the rapid extinction of the sub-species *Homo sapiens sapiens* and the correlative extinction of the species *Homo sapiens* (the red-or-green balls). Such a scenario, admittedly, corresponds to a form of Doomsday that presents a very frightening nature.

Let us consider now the second case (1b), where we are always in the presence of a synchronic one-color model, but where now green balls are also added in the urn at $T_2$. In this case, 990 green balls are added at $T_2$ to the red balls originally placed in the urn at $T_0$. We have then a rapid disappearance of the class of red balls, which accompanies, however, the survival of the class of red-or-green balls given the presence of green balls at $T_2$. In this case (1b), one notices that a *synchronic one-color* model is combined with a *diachronic two-color* model. Both models prove to be compatible, and non-exclusive of one another. If we translate this in terms of the third route, one notices that, according to the pluralistic essence of the latter, the synchronic one-color model applies to the class, narrowly defined, of red balls, while a two-color diachronic model also applies to the class, broadly defined, of red-or-green balls. In this case (1b), the rapid extinction of *Homo sapiens sapiens* (the red balls) is followed by the emergence of the most advanced human subspecies *Homo sapiens supersapiens* (the green balls). In such a situation, the restricted class *Homo sapiens sapiens* goes extinct, while the more extended class *Homo sapiens* (red-or-green balls) survives. While the synchronic one-color model applies to the restricted class *Homo sapiens sapiens*, the diachronic two-color model prevails for the wider class *Homo sapiens*. But such an ambivalent feature has the effect of depriving the original argument of the terror which is initially associated with the one-color synchronic model. And finally, this has the effect of rendering DA innocuous, by depriving it of its originally associated terror. At the same time, this leaves room for the argument to apply to a given class reference, but without its frightening and counter-intuitive consequences .

As we can see, in case (1), the corresponding treatment of the reference class problem is different from that advocated by Leslie. For on Leslie's view, the synchronic model applies irrespective of the chosen reference class. But the present analysis leads to a differential treatment of the reference class problem. In case (1a), the synchronic model prevails and a Bayesian shift applies, as well as in Leslie's account, both to the class of red balls and to the class of red-or-green balls. But in case (1b), the situation goes differently. Because if a one-color synchronic model applies to the restricted reference class of red balls and leads to a Bayesian shift, it appears that a diachronic two-color model applies to the extended reference class of red-or-green balls, leaving the initial probability unchanged. In case (1b), as we can see, the third route leads to a pluralistic treatment of the reference class problem.

Let us consider now the second hypothesis (2) where the *diachronic one-color* model prevails. In this case, 10 red balls are placed in the urn at $T_0$, and 990 other red balls are added to the urn at $T_2$. Just as before, we are led to distinguish two situations. Either (2a) no green ball is added to the urn at $T_2$, or (2b) 990 green balls are also added to the urn at $T_2$. In the first case (2a), the diachronic one-color model applies. In such a situation (2a), no appearance of a much-evolved human subspecies such as *Homo sapiens supersapiens* occurs. But the scenario in this case is also very reassuring, since our current subspecies *Homo sapiens sapiens* survives. In the second case (2b), where 990 green balls are added to the urn at $T_2$, a diachronic two-color model adds up to the initial diachronic one-color model. In such a case (2b), it follows the emergence of the most advanced subspecies *Homo sapiens* *supersapiens*. In this case, the scenario is doubly reassuring, since it leads both to the survival of *Homo sapiens sapiens* and of *Homo sapiens supersapiens*. As we can see, in case (2), it is the diachronic model which remains the basic model, leaving the prior probability unchanged.

At this step, we are in a position to complete the construction of the space of solutions for DA. Indeed, a new application of a principle of indifference leads us here to assign a probability of 1/4 to each of the 4 sub-cases: (1a), (1b), (2a), (2b). The latter are represented in the figure below:

<table>
<tr><th colspan="2">Case</th><th>T<sub>0</sub></th><th>T<sub>2</sub></th><th>P</th></tr>
<tr><td rowspan="2">1</td><td>1a</td><td>○</td><td></td><td>1/4</td></tr>
<tr><td>1b</td><td>○</td><td>●</td><td>1/4</td></tr>
<tr><td rowspan="2">2</td><td>2a</td><td>○</td><td>○</td><td>1/4</td></tr>
<tr><td>2b</td><td>○</td><td>●<br>○</td><td>1/4</td></tr>
</table>

*Figure 2.*

It suffices now to determine the nature of the scenario that is associated with each of the four sub-cases just described. As has been discussed above, a worrying scenario is associated with hypothesis (1a), while a reassuring scenario is associated with the hypotheses (1b), (2a) and (2b):

<table>
<tr><th colspan="2">Case</th><th>T<sub>0</sub></th><th>T<sub>2</sub></th><th>P</th><th>Nature of the scenario</th><th>P</th></tr>
<tr><td rowspan="2">1</td><td>1a</td><td>○</td><td></td><td>1/4</td><td>terrifying</td><td>1/4</td></tr>
<tr><td>1b</td><td>○</td><td>●</td><td>1/4</td><td>reassuring</td><td rowspan="3">3/4</td></tr>
<tr><td rowspan="2">2</td><td>2a</td><td>○</td><td>○</td><td>1/4</td><td>reassuring</td></tr>
<tr><td>2b</td><td>○</td><td>●<br>○</td><td>1/4</td><td>reassuring</td></tr>
</table>

*Figure 3.*

We see it finally, the foregoing considerations lead to a novel formulation of DA. For it follows from the foregoing that the original scope of DA should be reduced, in two different directions. It should be acknowledged, first, that either the *one-color synchronic model* or the *diachronic one-color model* applies to our current subspecies *Homo sapiens sapiens*. A principle of indifference leads us then to assign a probability of 1/2 to each of these two hypotheses. The result is a weakening of DA, as the Bayesian shift associated with a terrifying assumption no longer concerns but one scenario of the two possible scenarios. A second weakening of DA results from the pluralist treatment of the reference class problem. For in the case where the *one-color synchronic* model (1) applies to our subspecies *Homo sapiens sapiens*, two different situations must be distinguished. Only one of them, (1a) leads to the extinction of both *Homo sapiens sapiens* and *Homo sapiens* and corresponds thus to a frightening Doomsday. In contrast, the other situation (1b) leads to the demise of *Homo sapiens sapiens*, but to the correlative survival of the most advanced human subspecies *Homo sapiens supersapiens*, and constitutes then a quite reassuring scenario. At this stage, a second application of the principle of indifference leads us to assign a probability of 1/2 to each of these two sub-cases (see Figure 3). In total, a frightening scenario is henceforth associated with a probability of no more than 1/4, while a reassuring scenario is associated with a probability of 3/4.

As we can see, given these two sidesteps, a new formulation of DA ensues, which could prove to be more plausible than the original one. Indeed, the present formulation of DA can now be reconciled with our pretheoretical intuition. For the fact of taking into account DA now gives a probability of 3/4 for all reassuring scenarios and a probability of no more than 1/4 for a scenario associated with a frightening Doomsday. Of course, we have not completely eliminated the risk of a frightening Doomsday. And we must, at this stage, accept a certain risk, the scope of which appears however limited. But most importantly, it is no longer necessary now to give up our pretheoretical intuitions.

Finally, the preceding highlights a key facet of DA. For in a narrow sense, it is an argument related to the destiny of humankind. And in a broader sense (the one we have been concerned with so far) it emphasizes the difficulty of applying probabilistic models to everyday situations,[17] a difficulty which is often largely underestimated. This opens the path to a wide field which presents a real practical interest, consisting of a taxonomy of probabilistic models, the philosophical importance of which would have remained hidden without the strong and courageous defense of the Doomsday argument made by John Leslie.[18]

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1 The present analysis of DA is an extension of Franceschi (2002).

2 Cf. Korb & Oliver (1998).

3 The original description by Bostrom of the two-urn case refers to two separate urns. For the sake of simplicity, we shall refer here equivalently to one single urn (which contains either 10 or 1000 balls).

4 More accurately, Leslie considers an analogy with a *lottery experiment*.

5 Cf (2003: 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 evidence with regard to the assumptions used in the original version of DA and with broadening the scope of the argument by determining the conditions of its application to real-life situations.

6 Cf. (1997: 251).

7 Cf. (2002: 39).

8 I borrow this terminology from Chambers (2001).

9 Other variations of the *two-urn case*$^{++}$ can even be envisaged. In particular, variations of this experiment where the random process is performed diachronically and not synchronically (i.e. at time $T_0$) can even be imagined.

10 Cf. Sowers (2002: 40).

11 Both synchronic and diachronic two-urn case experiments can give rise to an incremental variation. The incremental variant of the (synchronic) two-urn case has been mentioned earlier: it consists of the *two-urn case*$^{++}$. It is also possible to build a similar incremental variation of the diachronic two-urn case, where the ejection of the balls is made at regular time intervals. At this stage it appears that both models can give rise to such incremental variations. Thus, the fact of considering incremental variations of the two competing models - the *synchronic two-urn case*$^{++}$ and the *diachronic two-urn case*$^{++}$ - does not provide any novel elements with regard to the two original experiments. Similarly, we might consider some variations where the random sampling is done not at $T_0$, but gradually, or some variants where a quantum coin is used, and so on. But in any case, such variations are susceptible to be adapted to each of the two models.

12 Leslie (1993: 490) evokes thus: “(...) 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”.

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

14 Cf. 1996: 260-261.

15 Cf. Leslie (1996: 259).

16 Cf. Leslie (1996: 258-259): “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. [...] All this evidently continues to apply to when being-red-or-green is replaced by being-red-or-pink, or being-red-or-reddish”.

17 This important aspect of the argument is also underlined in Delahaye (1996). It is also the main theme of Sober (2003).

18 I thank Nick Bostrom for useful discussion on the reference class problem, and Daniel Andler, Jean-Paul Delahaye, John Leslie, Claude Panaccio, Elliott Sober, and an anonymous referee for the *Journal of Philosophical Research*, for helpful comments on earlier drafts.

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