

Classical Anthropic Everett model: indeterminacy in a preordained multiverse.

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Invited contribution for *Journal of Cosmology* **14**, 2011.

Abstract. Although ultimately motivated by quantum theoretical considerations, Everett’s many-world idea remains valid, as an approximation, in the classical limit. However to be applicable it must in any case be applied in conjunction with an appropriate anthropic principle, whose precise formulation involves an anthropic quotient that can be normalised to unity for adult humans but that would be lower for infants and other animals. The outcome is a deterministic multiverse in which the only function of chance is the specification of one’s particular identity.

1. Introduction

Before the twentieth century, classical probabilistic models – such as those developed by Maxwell and Boltzmann for the treatment of many particle systems – were commonly considered as approximations of an objective deterministic reality of which the details were unknown or at any rate too complicated to be tractable. However since the advent of quantum theory, it has come to be widely recognised that – as Berkeley had warned – such an objective material reality may not exist. A purported refutation of the bishop’s scepticism had been provided by Johnson’s famous stone kicking experiment [1], but the learned doctor might not have remained so cockily confident if, instead of a tamely decoherent stone, he had tried kicking the closed box containing Schroedinger’s superposed live-and-dead cat.

According to our modern understanding, classical probabilistic models should be considered as approximations, not of illusory material reality, but of more elaborate quantum theoretical models, whose interpretation is to a large extent subjective rather than objective. A complete understanding would therefor require a theory of the sentient mind – as distinct from, though correlated with, the physical brain.

The question of the relationship between our physical brains – the object of study by neurologists – and the thoughts and feelings in our “conscious” minds was already a subject of philosophical speculation long before the development of quantum theory. As very little substantial progress had been

achieved, it was natural that some people should wonder whether a resolution of the mystery of quantum theory might provide a resolution of the mystery of the mind. A more common opinion has however been expressed by Steven Weinberg, who wrote[2] “Of course everything is ultimately quantum mechanical: the question is whether quantum mechanics will appear directly in the theory of the mind, and not just in the deeper level theories like chemistry on which the theories of the mind will be based ... Penrose may be right about that, but I doubt it.”

I am inclined to share this common opinion, and will proceed here on that basis, not just because of the relatively macroscopic (multiparticle) nature of the neurons constituting the brain, but because quantum theory is not really essential for what is commonly considered to be the crux of the mind to matter relationship, namely what is known as the “collapse” of the “wave function” which is supposed to result from an observation of the kind exemplified by Schroedinger’s gedanken experiment in which a cat in a box is liable to be killed by a pistol triggered by a Geiger counter.

2. The trouble with the traditional doctrine

According to the “Copenhagen” interpretation, the relevant “wave function” collapses either to a pure state in which the cat is unambiguously alive, or else one in which it is unambiguously dead, when a human “observer” opens its box. The trouble with the Copenhagen interpretation is that it denies “observer” status to the occupant of the box, which is questionable even in the case of a humble cat, and would clearly be quite inadmissible if the cat were replaced by another human.

However as well as the underlying symmetry between the person at risk and the person who observes, the point I want to emphasize here is that the issue is not essentially quantum mechanical, because it subsists even if one goes over to the (decoherent) classical limit. In the human case, an analogous classical experiment can be – and historically has been – done with the Geiger triggering mechanism replaced by use of an old fashioned Russian roulette revolver. The classical analogue of the “collapse of the wave function” would be the Bayesian reduction of the corresponding classical probability distribution, from an *a priori* configuration, in which the outcome is uncertain, to an *a posteriori* configuration in which the subject of the experiment is either unambiguously alive or else unambiguously dead.

To the question of which protagonist has the privilege of making the observation whereby the definitive “collapse” occurs, it is traditionally presumed that Bishop Berkeley’s reply would have been been “God!”. However physicists (since the time of Laplace) have tried to avoid such ad hoc invocation of a “deus ex machina”, and (in the spirit of Ockham’s razor) are therefore inclined to prefer the alternative reply that is expressible succinctly as “None!”. Such negation was originally proposed by Everett, and was advocated – but not adequately elucidated – first by Wheeler and subsequently by

DeWitt [3]. By thus denying the Copenhagen doctrine of the occurrence of “collapse” as an objective physical process – rather than merely a subjective allowance for new information as in the familiar classical case of Bayesian reduction – Everett got off to a good start. However his attempt to provide a positive interpretation of the meaning of the “wave function” was not entirely successful.

Part of the trouble arose merely from misunderstanding, due to injudicious choice of wording, whereby what I would prefer to refer to as alternative “channels” were called “branches”, thereby conveying the misleading idea of a continual multiplication of worlds [5], whereas (since Everett’s idea was that evolution remains strictly unitary) the “worlds” in question are strictly conserved, having neither beginning nor end: what changes is only the resolution of distinction between different “channels”, which may become finer (or coarser!) as observational information is acquired (or lost!). A more serious – since not merely semantic – problem by which many people have been puzzled is what Graham [4] has called the “dilemma” posed by Everett’s declaration that the alternative possible outcomes of an observation are all “equally real” though not (if their quantum amplitudes are different) “equally probable”. As I have argued previously [6], and will maintain here, the resolution of this dilemma requires the invocation of an appropriate anthropic principle.

3. The concept of reality

It was recognised long ago by Berkeley, and has been emphasized more recently by Page [7], that the only kinds of entities we know for sure to be real are our mental feelings and perceptions (including dreams). The material world in which we have the impression of living is essentially just a theoretical construct to account for our perceptions. In the dualist (Cartesian) picture that used to be widely accepted, this material world was supposed to have a reality of its own, on par with the realm of feelings and perceptions. However under closer scrutiny such separate material reality has turned out to be illusive, so we find ourselves glimpsing a more mysterious but apparently unified quantum picture. Following the approach initiated by Everett [3, 4], diverse attempts to sketch the outlines of such a unified picture have been made, albeit with only rather limited success so far, by various people [8, 9, 10], and in particular – from a point of view closer to that adopted here – by the present author [6], and by Page [7].

Assuming, as remarked above, that mental processes have an essentially classical rather than quantum nature, this essay has the relatively modest purpose of attempting to sketch the outlines of a simpler, more easily accessible, classical unification that may be useful pedagogically and, in appropriate circumstances, as an approximation to a more fundamental quantum unification that remains elusive. The picture proposed here is based on the use of an appropriate anthropic principle in conjunction with the Everett approach, which is relatively well defined in the classical limit, so that the notions of

“equal reality” and “unequal probability” can be clarified in a coherent manner.

Deutsch, Wallace, and Greaves have developed an alternative approach [8, 9, 10] that attempts to do this in terms of the kind of probability postulated in decision theory, on the debatable supposition that the relevant observations are performed by “rational agents”.

The essentially different approach advocated here is based on probability of a kind proportional to the amount of perception that is “real”, in the sense not of Deutsch [1] but of Page[7] – as based on sentience rather than rationality. Following a line of thought originated by Dyson [11], I have suggested [6, 12] that the relevant amount of perception should in principle be measured by the corresponding Shannon type information content, but in practice that does not tell us much, as it leaves us with the unsolved question of which of the many processes going on in the brain are the ones that actually correspond to sentient perception. This fundamental question does not matter so long as we are concerned only with the standard, narrowly anthropic, case of adult humans, for whom (as in the example of the next section) it can reasonably be assumed that such processes go on at roughly the same average rate. However for more general applications it would be necessary to face the intractible problem of estimating the relevant anthropic quotient q , meaning an appropriate correction factor that might be larger than unity for conceivable extraterrestrials, but that would presumably be smaller for extinct hominids, and much smaller for other animals as well as for infants of our own species. The easiest non-trivial case to deal with would presumably be that of ordinarily senile members of our own species, as their mental processes are similar to those of adults in their prime except for a reduction in speed that can be allowed for by a factor q that should be clinically measurable (and of practical interest for therapeutic purposes).

4. Russian roulette: a historical example

It is customary [10] to demonstrate the application of such ideas by idealised gedanken experiments in which, if there are just two protagonists, their initials are commonly taken to be A for Alice and B for Bob (while to illustrate merely logical, rather than physically conceivable possibilities, it is common [13] to consider examples that are not just idealised but frankly fantastic, in which case the protagonists are referred to as “Adam and Eve”). However to emphasise that I am concerned with what is “real” I shall take as a (simplified and approximate, but not artificially idealised) example an experiment that is not merely hypothetical, but that really occurred as a historical event during the XXth century, with a principle protagonist whose initial was actually not A but G.

To illustrate the basic idea, I propose to consider a modified Schroedinger type experiment in which G – an unbalanced adolescent at the time – voluntarily and crazily took the role of the cat, in a solitary game of Russian

roulette. The role of the external observer was taken by his big brother (the owner of the revolver) to whom I shall refer by the letter B. Having first heard about it privately from someone who had been neighbour at the time, I read about it many years later in published memoirs of G, who not only survived the experiment but recovered his mental equilibrium and lived to a ripe old age – at least in our particular branch-channel of the multiverse.

To keep the arithmetic simple, I shall postulate that the revolver was just a five-shooter, of the compact kind that is most convenient as a concealed weapon. (In reality it may well have been a six-shooter of the kind familiar in cowboy movies, but it can safely be presumed that it was not what was originally used by the reputed inventors of Russian roulette, namely Czarist officers, whose standard service revolvers were actually seven-shooters.) The protocol of the potentially suicidal game is to load just one of the cartridge chambers and then to whirl it to a random position before pulling the trigger. In such a case, starting from initial conditions that are imperceptibly different, there will be five equally likely outcomes, of which four will be indistinguishable for practical purposes, whereas the other one will be fatal.

According to the traditional single-world doctrine of deterministic classical physics (as still taken for granted at the time of the incident in question) only one of the five possible outcomes would have actually occurred. However according to the Everett type many-world doctrine, a complete description will involve many separately conserved “strands” (commonly but misleadingly referred to as “branches”) meaning single worlds of all the five types, in a multiverse consisting of five equally numerous sub-ensembles or “channels”, one for each qualitatively distinct possibility. Such sub-ensembles will be characterised by a physical measure given by the fraction \mathbf{p} of the total number of strands, which in this case is $\mathbf{p} = 1/5$ for each one. Since the four possibilities in which G survives would have been effectively distinguishable (by an examination of the weapon) only for a very short time after the experiment, it will in practice be sufficient for most subsequent purposes to use a coarser representation in which they are regrouped into a single larger multistrand “channel”, which will thus have measure $\mathbf{p} = 4/5$. When Everett refers to things as “equally real” it is clear that he should be understood to have in mind the individual (single world) strands, rather than their weighted groupings into broader “channels”.

The stage at which the original presentation of the Everett approach becomes unclear is when it is suggested that the physical weighting introduced as described should somehow be interpreted as a probability, despite the fact that (as the classical limit of evolution that is strictly unitary in the quantum case) the behaviour of the many worlds involved is entirely deterministic, so that when their initial configurations have been specified no uncertainties remain.

To give a meaning to the concept of probability in this context, the purely materialistic framework of the classical many-world system described so far

needs to be extended to include allowance for the role of mind. For the simplified classical model considered here, it will be good enough to do this in the usual way, by supposing that mental feelings and perceptions correspond to physical states of animate brains that are roughly localisable on time parametrised world lines of the animals concerned within the single world “strands”.

5. Anthropic quotient

Within the foregoing framework, the incorporation of probability into the model is achieved by an appropriate application of the anthropic principle. In the simple (weak) version that is adequate for the present purpose, the anthropic principle [12, 16] prescribes that the probability of finding oneself on a particular animate world line on a single strand within a small time interval dt is proportional to $q dt$, where the “anthropic quotient”, q , is normalised to unity in the average (adult) human case. This coefficient q is interpretable as a measure of the relative rate of conscious sentient thought (which might be very low compared with the rate of subconscious but perhaps highly intelligent information processing, such as could be performed by an insentient computer). Whereas it might be higher than unity for conceivable extraterrestrials, q would presumably be lower for other terrestrial species (such as chimpanzees) as well as for infants and senile members of our own species (see Figure 2). On short (diurnal) timescales the anthropic quotient of an individual would fluctuate between high waking levels and low dreaming values, and it would of course go to zero at and after the instant of death, as also before conception (though perhaps not before the instant of birth).

In the CAE (classical anthropic Everett) model set up in this way, the meaning of the weighting fraction \mathbf{p} of a channel constituted by an ensemble of very similar single-world strands is now clear. It does not directly determine the total probability of finding oneself in that channel, but it does determine the probability dP of finding oneself within a time interval dt on a world line of a particular kind (such as that of G, or alternatively that of B in the example described above) within the channel in question, according to the specification $dP \propto \mathbf{p} q dt$ (with the proportionality factor adjusted so that the total probability for all possibilities adds up to unity).

Let us see how this works out in the simple example of the roulette gamester G and his brother B, as shown in Figure 1, on the assumption that both can be considered as average adults characterised by $q = 1$. To keep the figures round, let us take it that in the first channel, labelled \mathbf{a} , with $\mathbf{p}_a = 4/5$, both roulette gamester G and his brother B survived 6 times longer (to an age of about 90) than G did in the second (fatal) channel, labelled \mathbf{b} , with $\mathbf{p}_b = 1/5$, where the life of B would have been unaffected (while that of G would have been truncated at about age 15). This can be seen to imply that one is 20 per cent more likely to find oneself to be B than

G. In the former case, one will have a 20 per cent chance of being in the fatal channel, and thus of witnessing the death of one's younger brother. In the latter case, that is to say conditional on being G, one will have a 20 per cent chance of finding oneself in the time interval before the game, and thus with only a 4 per cent chance of being in what will turn out to be the fatal channel.

If B and G had been the only sentient inhabitants of the world it can be seen that the *a priori* odds against channel **b** would have been 48 to 7 which is almost 7 to 1. However when account is taken of all the rest of the population (who would not have been significantly affected by the outcome of the roulette game) it can be seen that the *a priori* odds against finding oneself in channel **b** (and thus deprived of access to G's later literary output) would actually have been barely greater than 4 to 1 (the value given by the ratio $\mathbf{p}_a/\mathbf{p}_b$ of the naive physical probabilities designated by \mathbf{p}).

A more complete picture, allowing for the many other inhabitants of the world, would of course require a much finer decomposition involving far more than two qualitatively distinct channels. Indeed a complete multibiography just of G alone would probably require many more channels to allow for the vicissitudes of his later life, which extended not just through the Second World War but even through the Cold War. In particular – to be fully realistic – an adequate multi-history of the latter would presumably require the inclusion of non-negligibly weighted channels in which an incident such as the Cuban missile crisis terminated in the disastrous manner envisaged by Shute [14].

6. Commentary

Although the interpretations – and perhaps the ethical implications – are different, there is no effectively observable distinction between what is predicted by the deterministic many-world CAE model presented here (in which only one's identity is unforeseeable) and what is predicted by the corresponding classical model of the ordinary single-world type (in which the material physical outcome depends on chance). It might therefore be argued that the traditional single-world model should be preferred on the grounds that it is simpler, or less ontologically “bloated”. It is however to be recalled that a classical model cannot claim to represent ultimate reality, but merely provides what is at best an approximation to a more accurately realistic quantum model, a purpose for which the traditional single world-model is not so satisfactory.

Another point to be emphasised is that the ontology in question involves only mental feelings and perceptions. As foretold by Berkeley, but contrary to what used to be taught by “positivists” such as Mach, matter, as incorporated in physical fields over spacetime, should not be considered to have objective “reality”, but has the status merely of mathematical machinery (that might be replaced for predictive purposes by an equivalent action at a

distance formulation based on Green functions).

Having recognised that the relevant ontology does not involve matter but only mind, one is still free to entertain different opinions about how extensive or “bloated” [15] it may be. The anthropic measure characterised by the coefficient q merely determines the relative probability of the perceptions in question, but not the absolute number of times they occur. If ontological economy is a desideratum, it might seem preferable to postulate the actual occurrence only of a fraction of the perceptions admitted by the theory. On the other hand for those concerned with economy only in the sense of Ockham’s razor, and particularly for those who are unhappy with the concept of probability except when it can be prescribed in terms of relative frequencies, the most attractive possibility would presumably be to suppose that all the perceptions admitted by the theory actually occur (in the indicated proportions). Although it is more ontologically extravagant, the latter alternative has the advantage of conforming to the requirement that was expressed in metaphorical language by Einstein’s edict that “God does not play dice”. However that is not for us mere mortals to judge: as far as scientific observation is concerned there is no way of telling the difference.

A more mundane issue (with ethical implications concerning protection from inhumane treatment) is the evaluation of the appropriate anthropic quotient q for non-human terrestrial animals (such as the cat considered by Schroedinger) and particularly for infants of our own species. It is to be presumed that q should be of the order of unity for extinct hominids such as *homo erectus*, whose integrated population time is at most comparable with our own [16]. However the observation that we do not belong to the far more numerous populations of animals of other, less closely related, kinds suggests that their anthropic quotients should be much lower, and hence, by analogy, that the same may apply to infants.

Acknowledgement

The author is grateful for stimulating discussions with John Wheeler, Roger Penrose, and Bryce DeWitt on various past occasions, and also for more recent discussions with John Leslie and Don Page.

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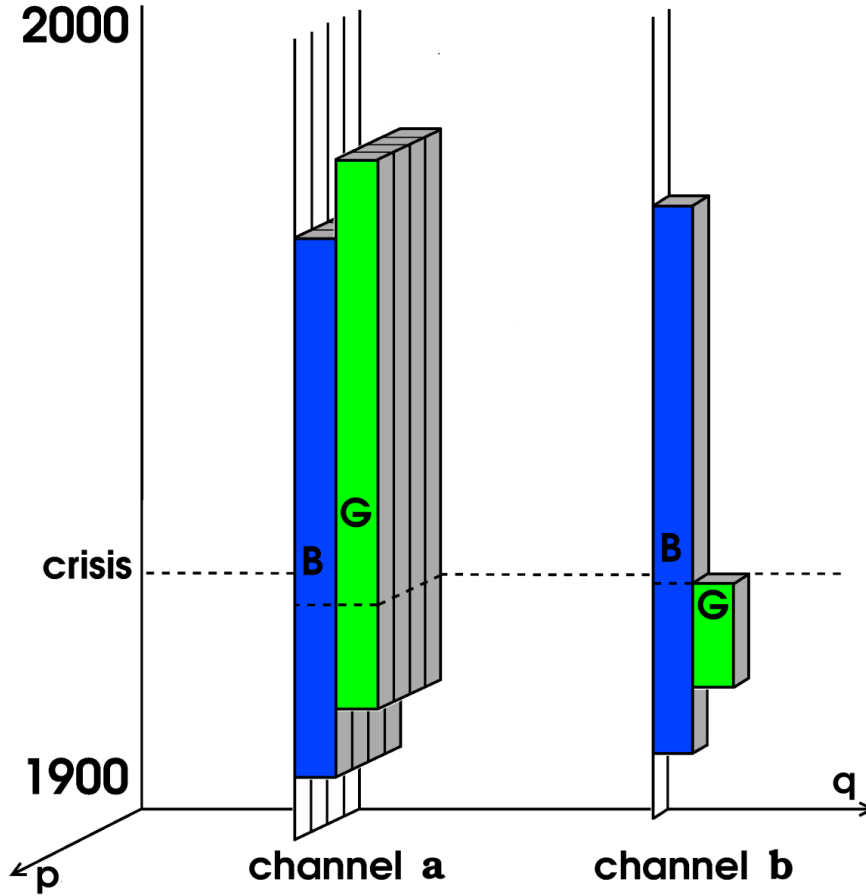


Figure 1: Crude anthropic biography of XXth century roulette gamester G (pale shading) and his brother B (dark shading) using the vertical direction for time, while the thickness of a worldline in the sideways direction measures subjective anthropic probability weighting per unit time, as specified by the anthropic quotient q which is set to zero before birth and after death, and is taken here to have a uniform unit (average) value during life – whereas in a less crude version it would taper off at the beginning (infancy) and the end (senility). For each of the (Everett type) channels, the 3rd dimension – out of the page or screen – measures the number of “strands”, representing the objective physical probability p (the square of a corresponding quantum amplitude) which is conserved. In such an anthropic diagram, the probability of finding oneself to be in a particular state of a particular person during a particular time interval is proportional to the relevant volume (the time integral of the product pq of the anthropic and physical probability measures). In channel **a** – the one we know about historically, because we are on it ourselves – both brothers survived through a complete life span until old age, the younger naturally outliving the elder. In channel **b**, for which the life of G was truncated after only one 6th of its natural span, it is supposed that the subsequent life of B would not have been substantially affected.

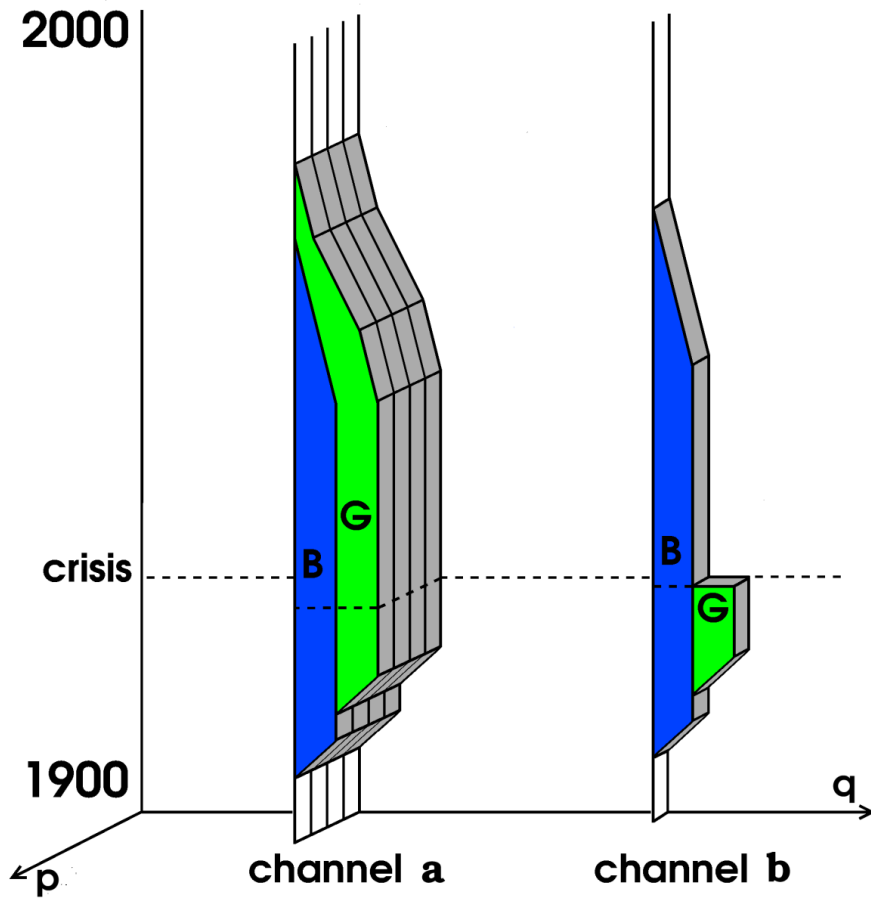


Figure 2: Refined anthropic biograph for Russian roulette gamester G and his brother B, using same conventions as in Figure 1, but allowing for non uniformity of the anthropic quotient q , which (for each protagonist) is taken to have a piecewise linear dependence on age, rising rapidly in infancy, and declining more slowly as senility sets in.