Philosophy of quantum mechanics

VU University Amsterdam: W_MASP_TF013 Lecture 8: 26/2/2015
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Today's lecture

- Recap
  - The probability problem for Everett.
  - Papineau's "no worse off" defence of many worlds.
  - The decision-theoretic program (DW-proof)
- Albert's response to Papineau
  - The conceptual connection between probability & frequency.
- Albert's objections to the decision-theoretic program
  - General abstract objection
  - Specific objection to equivalence
- Dizadji-Bahmani's objection to branching indifference.
  - Many worlds is committed to branch counting.
- Wither many worlds?

Recap

The Everett interpretation

- The Everett interpretation:
  - The physical universe is *completely* described by the wave-function and the wave function *only* ever evolves linearly (e.g. via the Schrödinger equation).

- Interpreted correctly, the linear dynamics guarantees that observers have definite post-measurement observations...

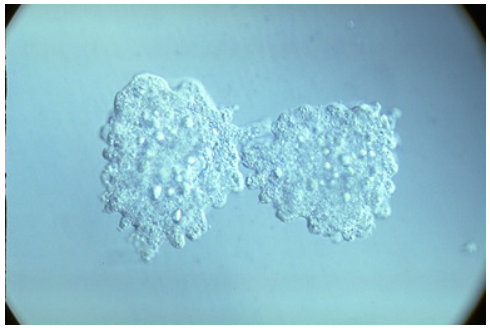
$$\frac{1}{\sqrt{2}}|"hard" >_o |"hard" >_m |hard >_e$$
$$+\frac{1}{\sqrt{2}}|"soft" >_o |"soft" >_m |soft >_e$$

- ...observer O has literally split into *two* observers.
  - One observes a hard result the other observes a soft result.

The probability problem

- Sean Carroll (advocate) vs David Albert (critic)
  - Albert defines the **incoherence problem** as follows:
    - Imagine doing one million hardness measurements on (distinct) white electrons and finding ALL of them to be hard.
      - Why should an Everettian be *surprised* by this finding?
    - In many worlds we are no different from splitting amoeba!
    - Amoeba to itself:

      "what's the probability that I will be the amoeba on the left?"

      
    - http://bloggingheads.tv/videos/1728?in=40:42&out=58:04

- Assuming *we can* make sense of non-trivial (≠ 0 or 1) probabilities in a branching multiverse, why would *those* probabilities match *Born rule* probabilities?
  - **Quantitative problem**

Papineau's "no worse off" defence

- Recall Sean Carroll's remark:
  - "This is an issue of probability theory generally, not of quantum theory in particular."
- Papineau tries to justify this claim by showing that all the objections that can be made to Everett can equally well be made to orthodoxy.
  - Everett cannot explain why the probability of getting white (after a colour measurement of a hard electron) is 0.5 in terms of Everettian ontology.
    - But the orthodox view also cannot make sense of this *in terms of their ontology* either.
    - Let's consider an example…

Being surprised by "improbable" results

- Objection:
  - Imagine doing one million hardness measurements on distinct white electrons and finding ALL of them to be hard.
    - Why should an Everettian be *surprised* by this finding?
    - The theory predicts that *there will be an observer (on some branch)* that observes those results.

- Papineau's rejoinder:
  - An objection to everyone so an objection to no one.
    - Why should *orthodoxy* be *surprised* by this finding?
    - The theory predicts that *there is a possible future observer* that observes those results.

Frequency to probability inferences

- Objection:
  - On the Everett theory we cannot find out about probabilities from actual sequences *at all*.
    - If all possible frequencies occur then how could we ever infer *the true* probability from them?
- Papineau's response:
  - Statistical inference in Everett is effectively the same as in the orthodox view.
    - Note the frequencies of outcomes (on your branch),
    - Infer that the probability is "close" to the frequency,
    - Hope you're not the unlucky victim of an "improbable" sample.

Probability and frequency

- There *is* a connection between probability and frequency but it is *circular*:
  - Probability is what long term relative frequency tends to...*probably*.

- But then, do we actually understand probability?
  - Probability is also connected to rational action…

Probability and rational action

- Rational agents *act* to make desired outcomes *probable*.
  - Desired outcome: gaining more $ over time.
    - Now imagine you have a *choice* among *jobs*.
    - You may compare the prospects of getting a raise, for each job.
    - You then *act*: you make the choice that makes your desired outcome (more $) more probable.
- Rational agents *bet* according to their *credences* (what they believe is probable).
  - I flip a coin: heads you get $50 tails you get $0. It costs you $25 to play.
  - Do you want to play?
    - If you believe the coin is biased, *that tails has high probability*, then *yes* you will!

Probability and rational action

- Objection to Everett:
  - If you are sure both to win and to lose whenever you bet on some chancy outcome, then what does the probability of winning matter?
- Papineau's response:
  - If you are sure to get one result (win or lose) whenever you bet on some chancy outcome, then what does the probability of winning matter?
    - Rational agents want their desired results *to happen*, they don't want their desired results to merely *be probable*.
  - It is a "primitive fact" about rational choice that you ought to weight future possibilities according to known probabilities.
    - Orthodoxy cannot explain this principle (any more than Everettians can).

Principal principle

- (Objective) probability is that objective physical quantity that constrains rational *credence*.
  - By implication: probability is that physical quantity that you ought to weight future possibilities by.
    - E.g. in your deliberations, you weigh the future possibility of getting $50, in accordance with your *credence in tails*.

- Credence = degree of belief
  - Understood as dispositions to behaviour, e.g., the odds at which you'd think it fair to bet on some proposition.
    - Note: not (necessarily) degree of belief that something *will happen*.
      - At least according to the Everettians!

- Note: "credence" often called "subjective probability" while "chance" is used for "objective probability".

Probability and frequency (again)

- Recall:
  - Probability is what long term relative frequency tends to...*probably*.

- Wallace believes that the (non-circular?) analysis (in terms of rational action) should be substituted in for "probably":
  - Probability is what long term relative frequency tends to ...*in such a way that it would be irrational to not bet in accordance with the long term relative frequencies*.

Goal of the Deutsch/Wallace proof

- If Papineau is right, then Everettians fair equally well as orthodoxy, regarding explaining probability.

- The Deutsch/Wallace proof serves to tip the scales, allowing the Everettians to *explain* probability.
  - Or at least, the aspect of probability relating to the principal principle.

- It's a proof that a rational agent who believes she lives in an Everettian multiverse will nevertheless "make decisions as if" the Born rule gives the probabilities of outcomes.

The Deutsch-Wallace proof

- Key axioms…
  - State supervenience
    - An agent's (betting) preferences depend on what physical state they actually leave her branch in.
  - Equivalence
    - A rational agent is indifferent between any two quantum bets that agree, for each possible reward, on the mod-square measure of branches on which that reward is given.
  - Branching indifference
    - An agent doesn't care about branching *per se*: if a certain operation leaves her future selves in N different macrostates but doesn't change any of their rewards, she is indifferent as to whether or not the operation is performed.

Equivalence

- Equivalence:
  - A rational agent is indifferent between any two quantum bets that agree, for each possible reward, on the mod-square measure of branches on which that reward is given.
- Which game (A or B) would you prefer to play in a branching multiverse?
  - A: $\sqrt{1/2}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/2}\,|\downarrow\rangle\,|{\sim}\$\rangle$
  - B: $\sqrt{1/2}\,|\downarrow\rangle\,|\$\rangle + \sqrt{1/2}\,|\uparrow\rangle\,|{\sim}\$\rangle$
    - Equivalence implies that rational agents will be indifferent between these two quantum games.
- Why believe it?
  - The only difference between A and B is inessential labelling.
    - The rational agent is indifferent as to whether we erase the labels.
  - So by state supervenience the agent must be *indifferent* between A and B.
  - The agent then ***acts as if*** spin-$\uparrow$ and spin-$\downarrow$ are ***equally probable***.
  - So *in this example* the rational agent's *credences* are given by the Born rule!

Branching indifference (BI)

- Branching indifference:
  - An agent doesn't care about branching *per se*: if a certain operation leaves her future selves in N different macrostates but doesn't change any of their rewards, she is indifferent as to whether or not the operation is performed.
- Why believe it?
  - The pragmatic defense:
    - "A preference which is not indifferent to branching *per se* would in practice be impossible to act on: branching is uncontrollable and ever-present" (2012: 170).
  - The non-existence defense:
    - A preference which is not indifferent to branching per se is meaningless: it would require there to be a determinate branch count.

Unequal superpositions and BI

- Which game (C or D) would you prefer to play in a branching multiverse?
  - C: $\sqrt{2/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
  - D: $\sqrt{1/3}\,|X\rangle\,|\$\rangle + \sqrt{1/3}\,|Y\rangle\,|\$\rangle + \sqrt{1/3}\,|Z\rangle\,|{\sim}\$\rangle$
- Note that a spin measurement in the $|\uparrow\rangle\,|\$\rangle$ branch of C gives:
  - C': $\sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
- By branching indifference you are indifferent between C and C':
  - C: $\sqrt{2/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
  - C': $\sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
- Our question then reduces to:
  - Would you prefer game C' or game D?

Unequal superpositions & symmetry

- Which game would you prefer to play in a branching multiverse?
  - C': $\sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
  - D: $\sqrt{1/3}\,|X\rangle\,|\$\rangle + \sqrt{1/3}\,|Y\rangle\,|\$\rangle + \sqrt{1/3}\,|Z\rangle\,|{\sim}\$\rangle$
- The only difference between C' and D is inessential labeling.
  - So you ought to be *indifferent* between these two games.
  - So you act as if spin-$\uparrow$ and X-or-Y are equally probable.
  - So you act as though the probability of spin-$\uparrow$ is $\sqrt{2/3}$.
- Furthermore, you must be *indifferent* between:
  - C: $\sqrt{2/3}\,|\uparrow\rangle\,|\$\rangle + \sqrt{1/3}\,|\downarrow\rangle\,|{\sim}\$\rangle$
  - D: $\sqrt{1/3}\,|X\rangle\,|\$\rangle + \sqrt{1/3}\,|Y\rangle\,|\$\rangle + \sqrt{1/3}\,|Z\rangle\,|{\sim}\$\rangle$

Unequal superpositions & symmetry

- The rational agent must be *indifferent* between:
  - C: $\sqrt{2/3}\,|\uparrow\!>|\$> + \sqrt{1/3}\,|\downarrow\!>|\sim\$>$
  - D: $\sqrt{1/3}\,|X>|\$> + \sqrt{1/3}\,|Y>|\$> + \sqrt{1/3}\,|Z>|\sim\$>$
- But the only relevant physical feature C and D have in common…
  - that is, the only thing that could constrain rational credence…
- …is the fact that the *combined weight* of reward-branches is $\sqrt{2/3}$.
  - So the mod square of these weights quantify rational credence.
  - So probability (in a branching universe) is given by the Born rule.
- That's the Deutsch-Wallace proof!

What does this prove?

- That some rationality "axioms" entail branch weights constrain the credences of rational agents (who believe they live in a branching multiverse).
  - Now recall our analysis of probabilty:
    - (Objective) probability is that objective physical quantity that constrains rational *credence*.
    - Proof of the Born rule!

- But what if there are *other* ways of acting rationally?

- The proof only works if it rules out **all** other proposals for rational action...

Branch counting (2012: 190)

- **Description:** each branch is given an equal probability, so that if there are N branches following a particular experiment, each branch is given probability 1/N. Utility is then maximised with respect to this probability.

- **Rationale**: Each branch contains a copy of me; I have no reason to privilege any given copy.

- **Why it is irrational**:
  - Violates diachronic consistency and branching indifference...

Violates diachronic consistency

- Consider the following set-up:
  - t_0: One branch at time (t_0).
  - t_1: The branch splits into branches A and B.
    - Observer on A gets $, observer on B does not.
  - t_2: Branch A splits into branches A1 and A2.
    - Observer on A with $ splits. B remains unsplit.
- Now ask: at t_0, what probability should the observer assign to getting $?
  - Branch counting rule:
    - The probability is ½ at t_1.
    - The probability is 2/3 at t_2.
  - Standard rule of probability calculus:
    - $Pr(\$@t_2 \setminus \$@t_1) \times Pr(\$\&t_1) + Pr(\$@t_2 \setminus \sim\$@t_1) \times Pr(\sim\$@t_1) = ½$.
    - $1 \times ½ + 0 \times ½ = ½$ (in words: having got the $, I never lose it!)

Response 2: no number of branches

- **Wallace** (2012: 120-1): "Very small changes in how the decoherence basis is defined, or the fineness of grain that is chosen for that basis, will lead to wild swings in the branch count. […] And if there is no such thing as branch count then there can be no branch count rule."
- **Greaves** (2007: 121): Decomposing the quantum description of the quantum state into branches allows for some vagueness as to what is the 'right' set of worlds:
  - The space of worlds can be "coarse grained" but there's no fact of the matter as to which "coarse graining" is correct.
    - But different coarse-grainings yield different branch counts.
  - The decoherence basis can be rotated slightly without loosing (approximate) decoherence.
    - But such slight rotations can yield different branch counts.

Albert's (2015: 174-5) response to Papineau

Preliminary: "caring measure"

- The DW-proof (tries to) show that the square of a branch weight is going to *play the same formal role* in rational deliberations in a branching universe, *as the probability of an outcome* plays in analogous deliberations in the orthodox worldview.
- Greaves thinks the DW-proof establishes that rational agents must treat the square amplitude as a "caring measure" – a measure of the degree to which "we care" about the situation on this or that branch.
  - Our goal in making decisions is to maximise the average over all the branches of: the product of how well we do on a branch and the degree to which we *care* about that branch.
- Why *speak* this way? Greaves thinks there is *no probability* in a branching universe, but that doesn't matter, because there is something analogous to a probability measure: a caring measure.
  - Compare: solidity (lecture 7).
- Albert follows Greaves by talking of "caring measures".

Albert's (2015: 174-5) response to Papineau

- Chances and frequencies and credences are all intimately linked.
- Everettians are constantly reminding us that we have no analysis of these links.
- They insist that because of this, objections to Everett are guilty of a double standard.
  - "The thought (I take it) is that the absence of such an analysis somehow makes it clear that the chance of E can have no more to do with questions of whether or not E is going to occur than the caring measure of E does; that the absence of such an analysis somehow makes it clear that caring measures can be no less fit to the tasks of explanation and confirmation then chances are."

Albert's (2015: 174-5) response to Papineau

- "But all this strikes me as wildly and almost willfully wrong."
  - The point of a philosophical analysis of chance is not to establish *that* chances are related to frequencies, but to show *how* chances are related to frequencies.
  - And if it should somehow become clear that such an analysis is impossible, then the very idea of chance will have been exposed as nonsense, and the project of statistical explanation will need to be abandoned. Period.
  - But things are unlikely ever to get that bad.
  - Many worlds denies that there is any determinate fact about the frequency of measurement outcomes, so the possibility of explaining frequencies like that is out of the question from the word go.
- Is this a fair response?

Albert's objections to the decision-theoretic program

Probability problem: two formulations

- (1) No room in the many worlds ontology for ignorance about the future. It's deterministic and nothing about "ignorance of initial conditions" will make sense of probability.

- (2) Many worlds is not susceptible of confirmation or disconfirmation by means of experiment: why would it come as a surprise to see an "improbable" sequence of outcomes? Why should such results cast doubt on many worlds (when they in fact cast doubt on quantum mechanics)?

2 objections to decision-theoretic program

- The abstract general objection
  - "The questions at which this entire program is *aimed*, seem like *the wrong questions*. The questions to which this program is addressed are questions of what we would do if we *believed* that many worlds theory were *correct*. But the question *at issue* here is precisely *whether* to believe that many worlds theory is correct! And what needs to be looked into, in order to *answer* that question, has nothing whatsoever to do with how we would act if we believed that the answer to that question were "yes"; what needs to be looked into, is whether or not the truth of many worlds theory is *explanatory* of our *empirical experience*. And that experience is of *certain specific* frequencies. And many worlds theory (since it's committed to all possible frequencies) is *structurally incapable* of explaining anything like *that*."
- The concrete technical objection
  - Deutsch-Wallace proof fails: equivalence is false.

The abstract general objection

- "The decision-theoretic program seems to act as if what primarily stands in need of explanation is why we bet the way we do. But this is crazy!"(p166)
  - Assume the DW-proof works.
    - Assume that any rational Everettian would *bet* just as orthodoxy does.
  - Only shows that circumstances can be imagined, in which betting on X has nothing to do with guessing at whether or not X is going to occur, in which we would bet just as we do now.
    - For us, betting on X has everything to do with guessing at whether or not X will occur.
    - These guesses are a rational reaction to previously observed frequencies.
    - It is these frequencies, and not the betting behavior that they give rise to, which must be explained.
    - Decision-theoretic program is trying to get away *without* explaining those frequencies.
  - The sceptic is merely shown that if she held an altogether different world-view than the one she actually holds, she would still bet the same way.

The abstract general objection

- How should an Everettian respond?
  - Whether the appeal to betting behaviours solves the problem depends on what the problem is.
    - Has Albert defined the problem precisely enough so as to make clear that appeal to betting behaviours insufficient?
  - The Everettian should concede: we want to know *whether* to believe Everett before asking questions about how we would act were we to believe Everett.
    - But isn't enough to say that we should believe Everett because we have no empirical evidence against the Schrödinger equation?
      - Decision theory is only used to show that a certain objection doesn't work.
  - Is Albert right that Everttians are fallaciously trying to "make an end run" around explaining the frequencies?
    - What is meant by "explaining the frequencies"?
    - What would it take to explain them?
    - Does orthodoxy explain them (more adequately)?

The concrete technical objection

- Recall equivalence:
  - A rational agent is indifferent between any two quantum bets that agree, for each possible reward, on the mod-square measure of branches on which that reward is given.
- Which game (A or B) would you prefer to play?
  - A: $\sqrt{1/2}\,|\uparrow X> |\$> + \sqrt{1/2}\,|\downarrow Y> |{\sim}\$>$
  - B: $\sqrt{1/2}\,|\downarrow Y> |\$> + \sqrt{1/2}\,|\uparrow X> |{\sim}\$>$
    - X and Y just represent the different world-states not including the agent's rewards. Because you are (by stipulation) indifferent as to whether X or Y obtains, you must be indifferent to playing A versus B. But then mod-square values quantify your credences (in this example).
- Albert: why not adopt a caring measure that *do*es depend on the difference between X and Y?

The fatness measure

- "Suppose I decide that the degree to which it is reasonable for me to care about what transpires on a future branch ought to be proportional to how *fat* I am on that branch."
  - **Rationale**: since there is more of me on the branches where I'm fatter, those branches deserve more of my concern for the future.

- **Question**: is the fatness measure any less rational or coherent than the born rule measure (in a branching universe)?

The fatness measure

- Which game (A or B) would you prefer to play?
  - A: $\sqrt{1/2}\,|\uparrow X> |\$> + \sqrt{1/2}\,|\downarrow Y> |{\sim}\$>$
  - B: $\sqrt{1/2}\,|\downarrow Y> |\$> + \sqrt{1/2}\,|\uparrow X> |{\sim}\$>$
- According to the fatness measure:
  - If your mass on X equals your mass on Y, then your credence (expressed by betting behavior) is proportional to *Born rule values*.
  - But, if your descendant's masses are distinct, then your credence is proportional to *Born rule values multiplied by your mass*.
- Why would it be more rational to act in accord with the Born rule measure than act in accord with the fatness measure?

The fatness measure

- By stipulation the agent only has a preference for $.
  - The agent does *not* also have a preference for being fat.
  - The agent is (by stipulation) indifferent as to whether or not she is fat or thin.
    - "When faced with a choice between two different nonbranching deterministic future evolutions, in one of which I get fat and in the other I get thin, I may have no preference at all."
    - "But when I am faced with an upcoming branching event I am eager to arrange things so as to ensure that things are to my liking on the branch where I am fatter."
      - "For where branching events are concerned, but *only* where branching events are concerned, there is more of me to be concerned about on those branches where I am fatter. In the nonbranching cases, no such considerations come into play as the entirety of me, fat or thin, is on the single branch to come."

Wallace's response

- See (10.55 – 17.00):
  - http://users.ox.ac.uk/~everett/videodiscussion.htm
- The fatness measure violates diachronic consistency.
  - **Diachronic consistency**: rational action takes place over time and is incompatible with widespread conflict between stages of an agent's life.
- Illustration:
  - Albert's agent is indifferent (by stipulation) to dieting; but is *not* indifferent to whether future selves diet: descendants with good outcomes should gain weight!
    - Imagine an equally weighted quantum lottery ticket:
      - Win: holiday in Mauritius; lose: no holiday.
      - It's expensive – so don't bother. But wait – just eat lots when you're there! That will make it worthwhile.
      - But *when there* you won't want to get fat (you're in Mauritius after all!).
      - So you better *conspire against your future self* by hiring minders that force you to get fat on holiday!
        - This is hardly rational behaviour!

Albert's rejoinder (2012: 169)

- See also (17.20 – 19.10):
  - http://users.ox.ac.uk/~everett/videodiscussion.htm
- True, one can make up stories to show that the caring measure would be difficult to act out in practice.
  - So we can make it depend on physical features of the world (of X or Y) that (unlike fatness) don't yield such difficulties.
    - Such as?
- But more importantly:
  - "It hardly counts as news that it can sometimes be difficult to bring about the sorts of situations that we judge desirable – but it would be absurd to pretend that those situations are any less desirable for that."
    - I might desire movie A over movie B, but (unfortunately), watching movie A leads to the death of millions. Doesn't make the choice of movie irrational!

Greaves' "relevance of socks"

- Greaves (2007: 122) formulates a caring measure similar to Albert's (roughly: just replace the agent's fatness with the agent's sock number).
  - We are supposed to be imagining that we literally believe we are in a branching multiverse.
  - We then ask ourselves which game (A or B) would be rational to play.
  - Via the symmetry argument we take ourselves to be indifferent.
    - If someone then says "I think it would be just as rational take sock number (or fatness) into account" – would we take them seriously?
    - We can take indifference (and hence, Born rule measure) to be by far the most natural option, and that is sufficient.

Foad Dizadji-Bahmani's objection to branching indifference

FDB's defense of branch counting

- "The Probability Problem in Everettian Quantum Mechanics Persists" (2013).
  - Rather than focusing in equivalence (as Albert does), FDB focuses on *branching indifference*.
  - FBD aims to show that branch counting (which violates branching indifference) is the only rational rule for assigning credences in a branching multiverse.
    - Primary reason: "By setting her credences as per BC, an agent is weighing the lives of each of the post-branching people equally. This is rationally compelling because each of them is as her as any of the others." (p13).
  - But how can BC be rational if (according to the Everettians) there is no branch count?

FDB's concern

- "If you are a contented Everettian, I implore you to be honest, be naïve, hear it afresh:
  - 'There are multiple branches, yet there is no such thing as the number of branches'.
- Even if you've numbed your ears, doesn't this still sound wrong?" (p18).

- The problem is:
  - Doesn't the claim that there are multiple branches *commit one* to there being a number of them?

Branch indeterminacy

- Metaphysical:
  - The number of branches is *indeterminate*.
    - There is no matter of fact about how many there are: the ontology does not entail any given branch number.
- Epistemological:
  - The number of branches is *indeterminable*.
    - It's ongoing, it's physically impossible to know how many, the number is potentially infinite.
- FDB will argue that:
  - The metaphysical claim is untenable
  - The epistemological claim is not useful for the DW-proof.

Metaphysical: indeterminate branch

- FDB (p22) quotes his article referee:
  - "The number of branches depends on the choice of coarse-graining and basis. Nobody makes this choice, of course; the branch count is simply not well-defined, and this is perfectly compatible with there being branches. Compare: The number of bays and inlets on the English coastline is ill-defined, but there are bays and inlets (Or: the number of clouds in the sky is…)"
- FDB replies:
  - The very notion of an inlet or bay is not well-defined. But once it is, the number of such things is not indeterminate.
  - If you have a geographical hypothesis about the bays and inlets on the English coastline (e.g. there are fewer than 10 years ago) it is you who owes me the definition. And wrt that definition, the number is not indeterminate.
  - Likewise: when Everettians claim there are multiple future branches, there is (must be) an implicit definition of the branches.

Epistemological: indeterminable

- "Quite generally, the world is a complicated place and in any actual decision-making situation

- "That the contingencies of a situation are such that one cannot abide by the strategy does not show that the strategy is irrational."
- "If we could ascertain the numbers, then it would be rational to base one's credences on those numbers. It is not the case that if we cannot ascertain those numbers, then branch counting is irrational. Rather, if we cannot ascertain those numbers, then it is not possible to act rationally!"
  - But could we recourse to the Born rule?
    - FDB: "If QM weight as per the Born rule is a proxy for branch numbers, then it would be rational to set one's degrees of belief to those weights, given the lack of epistemic access to the number of branches." (p.24) But this is not plausible.

Recourse to "no worse off" strategy?

- In the spirit of Papineau's defence Greaves (p126) writes:
  - "Even if the naïve counting measure were coherent, though, the objection would remain a curious one: it presupposes a dubious application of the principle of indifference (and might just as well be levelled against a single-universe collapse interpretation, in which all outcomes are "equally possible".

- Is there any reason, specific to collapse theories, for why collapse theories are not committed to branch counting?