Varieties of Divergence: A Response to Saunders and Wallace

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ABSTRACT

I continue to maintain that David Lewis's concept of overlapping persons cannot yield pre-measurement uncertainty in the Everett interpretation of quantum mechanics in the way that Simon Saunders and David Wallace originally seemed to suggest. However, I argue that in their reply to me they make it clear that they do not wish to invoke overlap of persons after all. That makes it mysterious why they defended their interpretation of personal overlap in the first place and questionable what role overlap has to play in their proposal. If Everettian branching can be understood to involve the divergence of distinct, non-overlapping worlds a concept of pre-measurement uncertainty is available. That idea was first proposed by David Deutsch but required an *ad hoc* postulate. Saunders has recently suggested that a similar scheme arises naturally out of the physics. If correct, that is important as it offers escape from some bizarre consequences of current alternative ways of understanding probability in the Everett interpretation.

1 Everett and Uncertainty

In conventional stochastic quantum mechanics a given quantum measurement has a range of possible outcomes with associated probabilities and an irreducibly probabilistic process takes place that determines which of the outcomes actually occurs. According to the interpretation which owes its origin to Hugh Everett III [1957] what takes place, roughly speaking, is the splitting of the world into the occurrence of all outcomes, each in a branch with an associated novel physical quantity, sometimes called branch weight or cross-section, which is numerically equal to the stochastic probabilities. On the face of it, it does not look as if an informed subject believing the Everett interpretation prior to making a measurement can be uncertain as to what outcome s/he will observe; s/he will observe all possible outcomes, each in a different branch.

Since quantum-mechanical predictions are typically probabilistic and supporting evidence for those predictions typically takes the form of observations of outcome frequencies over extended experimental runs, it

is not obvious how quantum mechanics is testable on the Everett interpretation. However, much ingenuity has gone into trying to resolve this problem. Proposed solutions fall into two camps, either claiming or denying that a notion of uncertainty is required. This paper addresses a dispute in the former camp.

An issue of this journal contained a proposal by Simon Saunders and David Wallace [2008a] together with my critique of it [2008] and a reply by Saunders and Wallace [2008b]. That proposal claimed to describe a way in which pre-measurement uncertainty is possible on the Everett interpretation. I have since argued [2010] that the status of the interpretation as a scientific theory, preserving the testability of quantum mechanics, does not require pre-measurement uncertainty but does require the possibility of post-measurement, pre-observation uncertainty. The idea that post-measurement uncertainty could have an important role to play was first suggested by Lev Vaidman [1998].

My [2010] argument entailed some bizarre consequences such as the infamous idea that an informed observer believing Everett should expect to always survive a round of so-called quantum Russian roulette where a quantum measurement issues in a branch with substantial cross-section where the downstream observer is instantly killed before having time to observe the outcome[1]. I claimed that such bizarre consequences could only have repercussions for our perception of the human predicament and could not undermine the scientific status of the Everett interpretation. However, if a concept of pre-measurement uncertainty is available the bizarre consequences can be avoided and, given the choice, supporters of the interpretation would surely prefer to do without them. That's why it is important to establish whether pre-measurement uncertainty really is tenable.

2 Against Overlap Again

Saunders' and Wallace's proposal centrally involved a concept of overlapping individuals first introduced by David Lewis [1976]. I shall begin by briefly describing how I originally thought their proposal was supposed to work for a simplified model of Everettian branching before turning my attention to their Reply, which undermines that original reading. I shall then consider the fallout of this *impasse*.

Lewis adopts the so-called worm theory of transtemporal identity which identifies a persisting object with its history, a spacetime world-tube. Suppose that a measuring apparatus is prepared to measure the spin of a particle relative to a chosen direction so that, according to stochastic quantum mechanics, there are two possible outcomes, UP and DOWN. On the simplified Everett picture there are two downstream branches. One where there is ApparatusUP, showing the result UP, one where there is the ApparatusDOWN. If the concept of Lewisian overlap is applied here then both ApparatusUP and ApparatusDOWN are to be identified with their histories and their histories overlap prior to measurement. So ApparatusUP and ApparatusDOWN both exist throughout the whole process. They overlap prior to the measurement and diverge after it, which is to say that before the measurement they have segments of their history, temporal stages, in common.

Likewise there are two observers of the apparatuses, HydraUP and HydraDOWN. Prior to the measurement the observers overlap, they share bodily stages, but they can nonetheless make numerically distinct simultaneous utterances. Thus prior to measurement a single vocal event which sounds like an utterance of 'I am either HydraUP or HydraDOWN but I don't know which' is actually two distinct utterances made separately by

[1] I have also argued that similar bizarre consequences arise for attempts to understand probability in the Everett interpretation which do not invoke uncertainty. See Tappenden [2004].

the two distinct observers. This attribution of utterances to worm-persons departs from Lewis's own preference, as Saunders and Wallace point out ([2008a], pp. 295-296) but I have not taken issue with that. What I have argued ([2008], pp. 309-312) is that even if this utterance attribution is allowed it still does not warrant either observer prior to measurement being able to intelligibly say 'I will see UP or DOWN but I don't know which'. The reason being that neither observer can reliably refer to herself with an utterance of 'I' since any utterance of 'I' by the observers during overlap is manifest as a single vocal event. As I saw it, Saunders and Wallace supplied no reason why HydraUP's pre-measurement utterance of 'I' should refer to herself rather than HydraDOWN so I claimed that they were helping themselves the semantic rule which they stated as:

> *the word 'I' refers to the speaker in any sentence in which it occurs* ([2008a], p. 295, original italics)

I dubbed this rule - I's Right ([2008], p. 309). I argued that it looks innocuous but needs a warrant in contexts of overlap where speakers putatively share one and the same bodily stages. In their Reply, Saunders and Wallace seem to think they had supplied the needed warrant:

> A "world", recall, is for us a four-dimensional non-branching entity realised by the branching structure of the quantum state; any such world is "quasi-classical", isomorphic on sufficiently coarse-grained levels to the familiar world of people and animals, chairs and tables. Tappenden is welcome to tell whatever referential story he likes within that world, and it will go exactly the same way as in the non-branching case. If, for instance, he feels that his using 'I' to refer to himself relies on a causal link between a stage of himself and his utterance, that causal link is available to him - *provided* he is happy with an emergent notion of causation relativised to a world, and with a notion of stage likewise relativised. ([2008b], p. 315, original emphasis)

But there's something seriously wrong here. Of course, if the notion of stage is 'relativised to a world' there is no problem with claiming I's Right. In that case, HydraUP's bodily stages prior to measurement reside in a world of sailing ships and sealing wax and the result UP whilst HydraDOWN's stages reside in a world of cabbages and kings and the result DOWN. *But then HydraUP and HydraDOWN don't overlap prior to measurement*! So why did Saunders and Wallace expend so much effort in their original proposal defending their version of Lewis's overlapping persons?

If the everyday worlds in which HydraUP and HydraDOWN say 'I will see UP or DOWN but I don't know which' do not have the vocal events which instantiate matched utterances in common, if those vocal events are isomorphic but each in a separate, non-overlapping world, then HydraUP's 'I' can refer to her via the vocal event which is a part of a stage of her body and likewise for HydraDOWN. So what role is overlap supposed to play in Saunders' and Wallace's proposal? What's going on?

There's a clue in the following exchange. I wrote:

> prior to measurement HydraUP sees ApparatusUP, the apparatus which is going to display the result UP, and HydraDOWN sees ApparatusDOWN. But not everything in the Hydras' pre-measurement environment inhabits the proposed two worlds. Events and temporal stages of sufficiently short duration are common to both worlds. Thus if HydraUP and HydraDOWN see a lightening flash outside their respective laboratory windows prior to measurement then they both refer to one and the same lightening flash even though they each refer, supposedly, to numerically distinct apparatuses and windows. ([2008], p. 311)

They responded :

> Talk of 'lightening flashes', in particular, will not do : such events are themselves quasiclassical in nature, describable only in decoherent-history terms. (To make this vivid, note that in the time taken by a lightening flash - a process of a few milliseconds - decoherence will produce branching into countless billions of segments of decohering histories, even using quite a coarse-grained notion of individual branches.)
>
> As we noted in our original paper, on our semantics what is common to worlds cannot be captured in ordinary words. In metaphysics or physics, it requires technical language ('temporal parts' ; 'segment of a decoherent history'.) ([2008b], p. 316)

My earlier characterisation of the predicament of HydraUP and HydraDOWN was highly simplified. It is of course quite right to point out that a lightening flash is a thicket of branchings in Everett's multiverse. But so is a vocal event which instantiates an utterance of 'I'. Again, if vocal events are not common to Saunders' and Wallace's decohering worlds there is no problem with personal self-reference and their original discussion of overlapping persons is simply irrelevant. But they do apparently want overlap at a sub-decoherence timescale. What's that about ? How is that serving to sustain non-overlapping coarse-grainedly isomorphic worlds at the scale of lightening flashes and utterances of 'I' ? An explanation seems called for.

Saunders [2010] changes tack. There he suggests that a technique which he calls vector mereology can be used to distinguish worlds at the sub-decoherence timescale so that there is non-commonality of objects all the way up, so to speak, and overlap falls out of the picture. It would not be appropriate to discuss Saunders's new proposal in detail here but before closing I shall say something in general about the use of non-overlapping, diverging worlds to introduce pre-measurement uncertainty to the Everett interpretation.

3 Divergence Without Overlap

The idea that pre-measurement uncertainty is available if Everett branching can be understood in terms of the divergence of a fibre-bundle of parallel worlds was first fielded, so far as I know, by David Deutsch. He wrote :

> In order to solve this problem, I propose a slight change in the Everett interpretation :

Axiom 8. The world consists of continuously infinite-measured set of universes.

> By a 'measured set' I mean a set together with a measure on that set. The interpretation of the state (27) [equation p. 13] will be that the set of universes consists of n_1 disjoint subsets, where the a_1th subset is of measure $|C_{a_1}|^2$. Each of these subsets, which I shall call a *branch*, consists of a continuous infinity of identical universes. During the model measurement, the world has initially only one branch, and is partitioned into n_1 branches. The branches play the same role as individual universes do in Everett's original version, but the probabilistic interpretation is now truly 'built in'. ([1985], p. 20, original italics)

Michael Lockwood adapted this idea to his 'many minds' version of the Everett interpretation ([1989], pp.230-232). Clearly the divergence of universes in this scheme must not arise out of stochastic processes within them. But all the appeal of the Everett interpretation resides in its not going beyond quantum mechanics as is. The addition of a postulate like Deutsch's Axiom 8 is inelegant, to say the least, and never met with much enthusiasm.

If Saunders has indeed found a way to derive a diverging fibre-bundle picture from the physics and nothing but the physics then that is important. It offers the only way currently in prospect of understanding probability in the Everett interpretation which does not bring with it bizarre consequences such as inevitable survival of quantum Russian roulette.

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