Interactive Destiny

Andrew Soltau

Abstract: Mitra demonstrates that specific memory erasure causes the observer to be in a different sector of the multiverse, one with a different destiny: events in the future, remote to any possible influence of the observer, having radically different probabilities. The concept only applies to an observer defined by a structure of information, so cannot apply to a human observer as usually defined, as the physical body. However, Everett defines the functional identity of the observer as the contents of the memory, a structure of information. Only such an identity encounters the appearance of collapse. Thus, any observer encountering change of this nature is necessarily of this type, and in principle Mitra's effect would apply.

Alteration to the quantum state of the physical environment effective for the observer merely by deletion of a record of observation would seem to require that the universe is primarily an information system, and that physical reality is secondary to the information defining it. This, however, is only the case with respect to the collapse dynamics. The universe is first and foremost a physical reality, as generally understood, defined by the quantum state, with the concomitant linear dynamics. Thus, at any given moment, the effective physical environment of the observer is a Newtonian, relativistic, physical domain, probabilistically defined throughout four-dimensional space-time by the linear dynamics of the quantum state of the environment effective for that observer: here the quantum mechanical frame of reference. With regard to the collapse dynamics, such a domain is of a first, primitive, logical type, while collapse, the change of the quantum mechanical frame of reference, is of a different, second logical type. As Everett makes clear, collapse is a purely subjective phenomenon, and as Tegmark explains, it exists only on the inside view of the quantum mechanical frame of reference. In this regard, and here only, the information process of the collapse dynamics, the establishment of new correlations with the physical environment, is primary, and, in a sense, 'overrules' the linear dynamics of the physical environment.

1 Introduction

Mitra shows that eliminating key records of correlations from the memory of an observer alters the sector of the multiverse that observer is in (2009). As Tegmark states, this is unlikely to apply to: “... beings like us with warm, wet brains where quantum superpositions get rapidly destroyed." (Chown, 2009). However, for observers defined solely as a structure of information, Mitra's startling dictum must hold. In Everett's 'Relative State' Formulation of Quantum Mechanics (1957) the functional identity of an observer is the record of observations, a structure of information. In this case the principle Mitra explains applies to us directly.

As shown in The World Hologram (Soltau, 2010b), not only is this record of observations the record of correlations established with the environment, it is the sole definition of the determinacy of the effective physical environment of this observer. Naturally enough, in such a context, if correlations are eliminated, by deleting the memory defining them, the observer is no longer correlated with those aspects of the physical environment. In this way, therefore, the observer can interact with, and deliberately alter, the apparently immutable future of the reality, the destiny, even with regard to remote events which the observer could not possibly influence directly. An obvious difficulty with this idea is that the observer, structure of information or not, is part of a physical reality, and one cannot see how physical reality can change in this manner. This, however, is the same problem as that at the crux of comprehending quantum mechanics as formulated by Everett.

Everett's formulation has eluded satisfactory explanation for over 50 years, but becomes straightforward in the light of the quantum concept of time, and Tegmark's inside and outside views of a quantum mechanical frame of reference. Deutsch, describing the quantum concept of time (1997, pp. 258-287), explains that the universe can be understood as a multiverse of moments or 'snapshots', each one a specific version of the physical space-time environment. Each is defined by a specific quantum state, thus each moment, here the quantum mechanical frame of reference, is a Newtonian, relativistic, physical domain, probabilistically defined throughout four-dimensional space-time, by the linear dynamics of that quantum state. The appearance of collapse Everett describes is the transition from one such quantum mechanical frame of reference to another. Each such moment is described by a specific quantum state, and thus defines a specific linear dynamics. The collapse dynamics is the change from one quantum state to another, the transition from one moment to another in the quantum concept of time. As Everett explains, this is a purely subjective phenomenon: there is only the appearance of collapse.

Assuming a single world containing many observers, it is a great puzzle how quantum mechanics seems to assign different quantum states to the worlds of Wigner and his friend in Wigner's well-known thought experiment (1961). When reality is understood to be defined on a per-observer basis, as Rovelli (1996) considers inevitable, this is simply a basic aspect of the nature of reality. Everett's formulation is of this nature. While he defines a unitary no-collapse universe, which obviously contains all possible observers, each functional identity of an observer is in a unique and idiosyncratic version of the effective physical environment, here the quantum mechanical frame of reference: hence many worlds. Each such world also fits the Copenhagen interpretation, albeit on a per-observer basis: reality cannot be assigned to the unobserved. [1]

1 One world many observers is a tacit understanding underlying the Copenhagen interpretation, but the

There is no change to physical reality as an observation is made, as Everett describes:

> *... it is not so much the system which is affected by an observation as the observer, who becomes correlated to the system*. (1973, p. 116; his italics)

Without question, observation is a passive act, changing only the observer, as the observer acquires a new correlation with the environment. The result of this acquisition, however, is a process operational at a different logical level to the linear dynamics of the physical environment. The appearance of collapse he describes is the transition from one moment, in the quantum concept of time, to another. Effectively there is collapse, the change of the quantum state. As Tegmark (1997, 1998) explains, this is a purely 'subjective' phenomenon, meaning it occurs only on the inside view of the effective quantum mechanical environment of the observer, here the quantum mechanical frame of reference. On the outside view, there is no collapse. This is the subject of The Quantum Mechanical Frame of Reference (Soltau, 2010a). As Everett explains, objectively, on the outside view, all possible observations are made, resulting in all possible versions of the observer making an observation. Subjectively, however, on the inside view, each such version of the observer exists in a specific and idiosyncratic version of the effective physical environment: the 'relative state', the quantum mechanical frame of reference.

The formulation of an observation in the neural network of the observer is clearly a physical event, but results in a change of the effective physical environment of the observer. As the functional identity of this observer changes, this observer is defined as existing in a different version of the physical environment, a different quantum mechanical frame of reference. In Mitra's terms, this change alters the sector of the multiverse in which this observer is instantiated. Thus this process of information, a change in the record of correlations with the effective physical environment, the collapse dynamics, operates 'outside' of the linear dynamics. Similarly, the elimination of a record of observation from memory is clearly a physical act, but the consequence is identical in nature to that of making an observation. Given Everett's formulation, this is simply the 'undoing' of the making of an observation. The record of correlations with the physical environment is altered, and the observer is thereby defined as being in a different version of the physical environment, a different sector of the multiverse: a different quantum mechanical frame of reference. Both observation as defined by Everett, and the undoing of an observation described by Mitra, are processes of information. Both are caused by changes in the physical environment defining the structure of information defining the correlations record of the observer, but resulting in the change of the of the version of the physical environment effective for that observer, the quantum mechanical frame of reference.

If the record of ensuing catastrophe deliberately deleted from the observer's memory is reinstated, the observer is back in the sector of the multiverse in which it started. Equally, the same record of observations added, despite not having been previously deleted, must also necessarily cause the same effect. Thus, potentially, a scientific basis is provided for the effectiveness of deliberately engineered observations, which otherwise can only be rationally viewed as entirely ineffectual, except as psychological exercises. Bizarrely, although solely on the inside view, in the subjective environment of the observer, prayer and spells should work. This is used to illustrate the differences between the effective domains of Tegmark's outside and inside views of a quantum system, Change of the quantum state occurs only in the latter.

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stated principles are a precise fit to the per-observer reality defined, in slightly different forms, by Everett and Rovelli.

2 The Observer's Reality

Everett defines the functional identity as the state of the memory, in turn defined as the record of sensory observations and machine state: the latter being sensory observations of the internal state of the body-mind.[2] It is with regard to this identity that there is the appearance of collapse:

> Judged by the state of the memory in almost all of the observer states, the probabilistic conclusion of the usual "external observation" formulation of quantum theory are valid. (1957, p. 462)

It is only with respect to this identity that there is the appearance of collapse, and thus the apparent enactment of the standard von Neumann-Dirac formulation (1955). As he states:

> ... we were able to show that all phenomena will *seem* to follow the predictions of this scheme to any observer. (1973, p. 110)

If an observer is encountering the appearance of collapse, specific change of the quantum state of the physical environment, this is the only possible identity of the observer. To all other identities, all possible quantum mechanical futures are realised, hence the measurement problem. As Greaves states:

> The quantum measurement problem is very simple: under the assumption that our measurement apparatus is in principle describable by quantum mechanics, the collapse postulate contradicts the unitary dynamics. (2004, p. 1)

The unitary dynamics applies not only to every possible kind of measurement apparatus, but also to the human body-mind. Only at the level of sensory experience, defined by a structure of information, is there a specific and idiosyncratic outcome to each observation. It is this experiential level of reality that Everett defines and addresses. At this level, observation is an information process: the addition of the record of an observation to the functional identity of the observer. As a unique, singular and idiosyncratic process, this does indeed contradict the unitary dynamics. This, however, is 'outside' the unitary dynamics: the quantum jump is the transition from one quantum mechanical frame of reference, with one specific linear dynamics, to another. This is the change of the linear dynamics, a process of different logical type to the linear dynamics.[3] Furthermore, it is one that can only be engaged in by an observer defined as a structure of information. All physical objects, including the body-minds of observers, follow solely the unitary linear dynamics, with all possible versions of events being enacted.

Naturally, the structure of information defining the sensory experience of the observer at each moment is instantiated in a specific physical structure. However, given multiple realisability of such an observer, in an Everettian no-collapse universe, the determinacy of the effective physical environment of this observer is defined by, and only by, the record of observations made by this observer, here the world hologram.[4] Thus the moment, or snapshot, the quantum mechanical frame of reference, Everett's relative state, is defined solely by the record of observations made by this observer. Inevitably, as each observation is made, the observer is thereby in a different moment or snapshot, a different quantum mechanical frame of reference. This transition is

2 This is described in detail in The World Hologram (Soltau, 2010b).
3 This is described in detail in Logical Types in Quantum Mechanics (Soltau, 2010c).
4 This is described in detail in The Quantum Mechanical Frame of Reference (Soltau, 2010a)

'outside' the linear dynamics, despite the fact that the linear dynamics is what gives rise to it. This is the exercise of 'quantum time': a sequence of moments, snapshots, quantum mechanical frames of reference, in the quantum concept of time. This transition is of different logical type, in Russell's (1908) terminology, to the linear dynamics of the physical environment. It is to the linear dynamics as acceleration is to velocity.

While the logical form of these concepts is straightforward, the identity of the observer portrayed seems to bear little relation to the observer as usually understood, as the physical body-mind. However, while the record of observations does not define the accustomed identity of the human observer, it precisely defines a phenomenon intensely familiar to all human observers: it is the known world. This is the virtual reality each observer formulates to represent the real physical environment, as Deutsch explains (1997, p. 120). The structure of information which Everett defines as the functional identity of the observer is the experiential reality of the observer, here the world hologram. The functional identity Everett defines is therefore utterly familiar to the human observer: this is the subjective reality the observer experiences at all times, the known world. However, this structure of information is also the record of correlations with the effective physical environment. Given multiple realisability of this structure of information, this, and this alone, defines the determinacy of the effective physical environment of the observer, which is otherwise indeterminate. Thus the known world is effectively 'the real world'.

This structure of information is Tegmark's 'inside view' of the world defined by a specific quantum state: the quantum mechanical frame of reference. As he states:

> Here one choice of outside view is that of a Hilbert space where a wave function evolves deterministically, whereas the inside view is that of a world where things happen seemingly at random, with probability distributions that can be computed to great accuracy from the wave function. It took over 30 years from the birth of quantum mechanics until Everett showed how the inside view could be related with this outside view. (1998, p. 10)

Everett shows how, on observation, there is the appearance of collapse on the inside view, while the outside view is a superposition:

> ... each element of the resulting superposition describes an observer who perceived a definite and generally different result, and to whom it appears that the object-system state has been transformed into the corresponding eigenstate. (1973, p. 10)

Each different eigenstate exists in a different quantum mechanical frame of reference, each one the discrete and idiosyncratic world of that specific version of the observer. It is only on the inside view that these slightly different quantum mechanical frames of reference, each defined by a different record of observations, exist as separate and singular entities. On the outside view, the outcome is a superposition, decohering subsequently to a mixture:

> It is then an inescapable consequence that after the interaction has taken place there will not, generally, exist a single observer state. There will, however, be a superposition ... each element of which contains a definite observer state and a corresponding system state. (1973, p. 10)

This is the quantum mechanical frame of reference of an external observer, in the position of Wigner to Wigner's friend. Objectively, on this outside view, there is no collapse. The

phenomenon exists only on the inside view, at the experiential level of reality, defined by the record of observations. The outside view is the same thing as the world of the observer as a physical entity in the unitary linear dynamics. The inside view is the same thing as the observer as an experiential reality: the record of observations, the world hologram, with the avatar self identity figure, that which the observer is familiar with as 'me', at the centre.

3 The Quantum Mechanical Frame of Reference

Deutsch defines the no-collapse universe as a multiverse of 'snapshots', each one a specific version of the physical space-time environment. As he explains;

> The snapshots which we call 'other times in our universe' are distinguished from 'other universes' only from our perspective, and only in that they are closely related to ours by the laws of physics. (1997, p. 278)

In other words, there is an array of all possible snapshots, each one a block universe, a four-dimensional moment, and certain special cases of such moments are possible pasts and possible futures of our current snapshot, our universe at the present moment. This is to emphasise his previous statement “Other times are just special cases of other universes.” (p. 278) of which he says “This is the distinctive core of the quantum concept of time.” (p. 278).[5]

In the context of the standard view of the universe, this concept is incompatible with relativity, because for a universe with many observers, there many different definitions of simultaneity. As Deutsch states, of observers moving at different velocities:

> ... each perceive spacetime as being sliced up in a different way into ‘moments’. … That is, *they do not agree about which events should appear in the same snapshot*.” (1997, 268; emphasis added)

However, not only is Everett's formulation a precise description of the quantum concept of time, in the context he defines, it is entirely compatible with relativity, as the frame of reference is always that of a specific individual observer.

On the inside view, with each observation, each measurement of the state of the physical environment, the correlations record changes. Thus effectively the quantum state of the physical environment changes, but the environment itself does not change This is the transition from one snapshot in the quantum concept of time to another. This is simply the change to the quantum mechanical frame of reference. This change, the collapse dynamics, is of different logical type to the linear dynamics, being the change to the linear dynamics. It is to the linear dynamics as acceleration is to velocity: the differential, but with respect to 'quantum time'. The linear dynamics is the dynamics of a specific version of the physical environment, defined by a specific quantum state: here the quantum mechanical frame of reference. The collapse dynamics is the change to the quantum mechanical frame of reference, with the concomitant change to the linear dynamics. This is the relationship between the two dynamics fundamental to quantum theory.

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5 He goes on to say “This understanding first emerged from early research on quantum gravity in the 1960s, in particular from the work of Bryce DeWitt, but to the best of my knowledge it was not stated in general terms until 1983, by Don Page and William Wooters.” (1997, p. 278).

Collapse has eluded comprehension, despite decades of expert, sustained attention. On the view presented here, its nature has been invisible because this is a process of a different logical type to the linear dynamics, one which does not perfectly supervene on any physical process. If the collapse dynamics is understood as something 'outside' of the linear dynamics, quantum mechanics holds no puzzles or mysteries. The collapse dynamics is the change, from one quantum mechanical frame of reference, a specific version of the physical environment, defined by a specific quantum state, to another. This change, the collapse dynamics, the exercise of the quantum concept of time, is to the linear dynamics as the iteration of the frames of a movie is to the frames.[6] In such a context, Everett's formulation is straightforward. On observation, the quantum mechanical frame of reference is changed, but this is a purely subjective phenomenon, meaning it happens only on the inside view. Nothing changes except the quantum mechanical frame of reference effective for this observer. There is only the appearance of collapse.

Oddly, the change of the quantum mechanical frame of reference on the inside view is 'outside' the time evolution of the linear dynamics, as will be further illustrated in the following sections. In an environment of this nature, the making of an observation can be effectively 'undone', as Mitra (2009) demonstrates. Given Everett's definition of the functional identity of the observer, and the multiple realisability of this identity, this phenomenon is self-evident. On deletion of the record of an observation, the observer is defined as being in the version of the physical environment where that observation has not occurred, and those events have not determinately taken place. As Mitra states, the observer is thereby in a different quantum mechanical frame of reference:

> ... memory erasure can cause one to end up in a different sector of the multiverse (2009, p. 1)

As with the making of an observation, this is a purely subjective, inside view, phenomenon. This is a second logical type operation, in a per-observer transtemporal reality. On the outside view, the observer may have deleted some memory, but still exists in the same version of physical reality. Objectively, if a catastrophe is imminent, it naturally remains so nonetheless.

4 The Inside and Outside Views

The paradox of Wigner's friend is only a paradox when we assume that all observers in communication with each other must necessarily exist in identically the same reality, which Rovelli states is specifically at odds with experimental physics:

> … the notion of a universal description of the state of the world, shared by all observers, is a concept which is physically untenable, on experimental ground. (1996, p. 7)

Rovelli proposes that correlations are the only determinant of the effective physical environment of the observer, and from this premise demonstrates a simple derivation of the formalism of quantum mechanics. Similarly, Everett's formulation inherently defines the effective physical environment of the functional identity of the observer as one in which only the sensory observations made by that observer define the determinacy of the effective physical environment

6 This is described in detail in Logical Types in Quantum Mechanics (Soltau, 2010c).

of that observer. Thus it is the record of observations, the world hologram, the subjective reality known by the observer, and this alone, which defines the determinacy of the quantum mechanical frame of reference of the observer. In such a formulation, Wigner's friend and Schrödinger's cat present no problems or paradoxes, but are simply inevitable aspects of the multiple-observer system, in which the effective physical reality is defined on a per-observer basis. By the same token, since the frame of reference is always that of a specific observer, there is no conflict between the quantum concept of time and relativity.

Everett's formulation hinges on the distinction between the outside and inside views of the quantum mechanical frame of reference. As Tegmark states:

> Everett's brilliant insight was that the MWI *does* explain why we perceive randomness even though the Schrödinger equation itself is completely causal. To avoid linguistic confusion, it is crucial that we distinguish between
>
> - the outside view of the world (the way a mathematician thinks of it, i.e., as an evolving wavefunction), and
> - the inside view, the way it is perceived from the subjective ... perspective of an observer in it.
>
> (1997, p. 2; his italics)

The difference between the outside and inside views is readily demonstrated. The time evolution of the quantum mechanical frame of reference is different viewed objectively, outside, and subjectively, inside, as in the case of Wigner's friend. As stated by Laudisa & Rovelli:

> ... a variable (of a system S) can have a well determined value q for one observer (O) and at the same time fail to have a determined value for another observer (O'). (2005)

To illustrate this, Barrett's classic example (1998) is examined from both perspectives. When an observer (O), here Wigner's friend, goes to measure the x-spin of a physical system S that begins in a superposition of x-spin eigenstates, the initial condition of the physical system to be measured is indeterminate:

$$|\text{“ready”}\rangle_O \, (\alpha \, |\text{x-spin up}\rangle_S + \beta \, |\text{x-spin down}\rangle_S \,)$$

Wigner's friend performs the experiment. Objectively, in Wigner's (O' above) quantum mechanical frame of reference, no collapse has occurred. This is the time evolution of the overall linear dynamics in the the objective view of the quantum mechanical frame of reference:

$$\alpha \, |\text{“spin up”}\rangle_O \;\; |\text{x-spin up}\rangle_S + \beta \, |\text{“spin down”}\rangle_O \;\; |\text{x-spin down}\rangle_S$$

Subjectively, however, meaning from the perspective of the experimenter, Wigner's friend, a specific observation has just taken place. This provides exactly the outcome predicted by the standard von Neumann-Dirac collapse formulation, which is that the quantum-mechanical state of the system will collapse either to:

$$|\text{“spin up”}\rangle_O \;\; |\text{x-spin up}\rangle_S \quad \text{or to} \quad |\text{“spin down”}\rangle_O \;\; |\text{x-spin down}\rangle_S$$

which, subjectively, is exactly what happens. Subjectively, meaning simply on the inside view, in the quantum mechanical frame of reference of the functional identity of the observer, one or

the other happens, as the observer defined by the correlations record fissions. As the correlations record fissions, so too does the quantum mechanical frame of reference.

The same expression can be used to represent the individual observer-environment system as a whole, the quantum mechanical frame of reference. Multiple realisability means that the effective physical environment of the functional identity of the observer in Everett is indeterminate except where defined by the record of observations. It is a simultaneity of all versions of the physical environment instantiating this observer, this world hologram. The record of observations is the record of observables defining the set of commuting operators which define the determinacy of the observed system, and all else is indeterminate. Initially, the quantum mechanical frame of reference of the observer is the superimposed sum of two slightly different quantum states:

$$|\text{“ready”}\rangle_O \, (\alpha \, |\text{x-spin up}\rangle_S + \beta \, |\text{x-spin down}\rangle_S \,)$$

The quantum states x-spin up and x-spin down are two different versions of the effective physical environment, defining two quantum mechanical frames of reference in which everything except the x-spin to be measured is identically the same. Objectively, this system evolves according to the linear dynamics:

$$\alpha \, |\text{“spin up reality”}\rangle_O \;\; |\text{x-spin up}\rangle_S + \beta \, |\text{“spin down reality”}\rangle_O \;\; |\text{x-spin down}\rangle_S$$

On the outside view, objectively, in Wigner's perspective, no collapse has occurred. In Wigner's quantum mechanical frame of reference, the outcome of the experiment is a simultaneity of both possibilities:

> ... each element of which contains a definite observer state and a corresponding system state. (Everett, 1973, p. 10)

For each version of Wigner's friend there is a determinate x-spin result. In Wigner's perspective, however, the outcome is a simultaneity of outcomes, observer states, and system states. Thus his quantum mechanical frame of reference is indeterminate with regard to x-spin, and the state of the friend. Subjectively, however, meaning on the inside view, from the perspective of Wigner's friend, a specific observation has just taken place. Thus there are now two, different correlations records. As the correlations record fissions, so too does the quantum mechanical frame of reference. The result is two parallel realities:

$$|\text{“spin up reality”}\rangle_O \, |\text{x-spin up}\rangle_S \quad \text{and} \quad |\text{“spin down reality”}\rangle_O \, |\text{x-spin down}\rangle_S$$

As a result, each of the new versions of the experimenter is now in a different, specific, version of the physical environment, a different quantum mechanical frame of reference. On the inside view, collapse has occurred. Both observer and environment are changed. Two slightly different versions of the observer are now defined as existing in two slightly different versions of the physical environment, different quantum mechanical frames of reference, in each of which a specific version of the observation has just taken place.

Everett addresses the obvious potential confusion between these inside and outside views:

> At this point we encounter a language difficulty. Whereas before the observation we had a single observer state afterwards there were a number of different states for the observer, all occurring in a superposition. Each of these separate states is a state for an observer, so that we can speak of the different observers On the other hand, the

> same physical system described by the different states. is involved, and from this viewpoint it is the same observer, which is in different states for different elements of the superposition (i.e., has had different experiences in the separate elements of the superposition). In this situation we shall use the singular when we wish to emphasize that a single physical system is involved, and the plural when we wish to emphasize the different experiences for the separate elements of the superposition. (e.g., "The observer performs an observation of the quantity A, after which each of the observers of the resulting superposition has perceived an eigenvalue.") (1973, p. 68, footnote)

Thus Everett defines 'observer' as denoting the outside view and 'observers' as denoting the inside view. What he does not emphasise is that, '… the different experiences for the separate elements of the superposition' form the basis of different experiential realities, and that each experiential reality is determinate solely where defined by the record of observations, the functional identity. Thus it is not just that there are multiple experiential realities, inside views, existing within the context of the one objective physical reality, the outside view. Each experiential reality is the sole determinant of the effective physical reality, the quantum mechanical frame of reference, for that version of the functional identity of the observer. Naturally, the overarching objective physical reality is the no-collapse universe of the unitary linear dynamics. Thus the basic premise of the many-minds type of interpretation is essentially correct: it is solely the experiential definition of reality that defines the effective physical environments of observers.[7] Once such an experiential reality is equated with the determinacy of the effective physical environment defined by the correlations record, Everett's formulation is self-explanatory.

5 Undoing Observations

According to Everett's formulation, when Wigner's friend makes an observation, on the inside view, he thereby exists in a different version of the physical environment: one in which this observation has determinately taken place. For each version of the observer, as Everett states, on observation:

> … the observer-system state describes the observer as definitely *perceiving that particular system state*. This correlation is what allows one to maintain the interpretation that a measurement has been performed. (1957, p. 459; his italics)

On the outside view, objectively, this is only one aspect of the simultaneous exercise of all possible outcomes. On the outside view, it is also an irreversible process. Objectively, nothing can possibly put the observer back in a different version of the environment to the one established by observations. However, as Mitra demonstrates, if the record of observation can be deliberately deleted, the observer is thereby in a different sector of the multiverse, one in which this observation has not been determinately made, and thus the events previously observed are,

7 The implications are certainly remarkable. As Donald states, given a reality defined solely by observations: "… physical constants would not have precise values in "our worlds". … Only the finite amount of information which determines one's structure as observer would determine the "world" in which one lives." (1997).

subsequently, not determinately the case. This process is an 'undo' of the observation. This can only apply to an observer defined as a structure of information. Mitra defines the observer in terms of states of consciousness, thus addressing the same experiential reality as Everett:

> In this article we will take the view that whatever the exact quantum mechanical state vector is, the possible states the observer's consciousness can be in, can be identified with some classically describable macrostates of the observer. We will consider the additional information needed to specify the exact quantum state of the observer as part of the rest of the universe. (2009, p. 2)

For a motive he considers the observer seeing the news of the unavoidable, impending arrival of a hitherto highly improbable global catastrophe. He posits a machine intelligence, so that the observer can delete the record of this observation from memory. In such a situation, the version of the observer which made that observation becomes, once again, the version of the observer that did not. This does not mean that time runs backwards or that any physical property of the environment changes. It means simply that the observer is now defined slightly differently: as existing in a different sector of the multiverse, one in which this specific observation has not been determinately made, and, subsequently, the events previously observed are no longer determinately the case.

Before the observation is initially made, the environment of the functional identity of the observer is the simultaneity of two, different, quantum mechanical frames of reference:

$$|\text{“get news”}\rangle_O \, (\alpha \, |\text{catastrophe}\rangle_S + \beta \, |\text{no-catastrophe}\rangle_S \,)$$

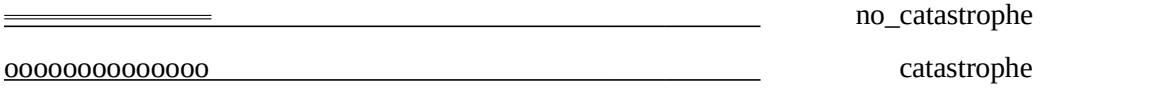
where 'catastrophe' and 'no-catastrophe' are two different versions of the effective physical environment. Objectively, on the outside view, the system evolves to:

$$\alpha \, |\text{“no news”}\rangle_O \;\; |\text{no\_catastrophe}\rangle_S + \beta \, |\text{“bad news”}\rangle_O \;\; |\text{catastrophe}\rangle_S$$

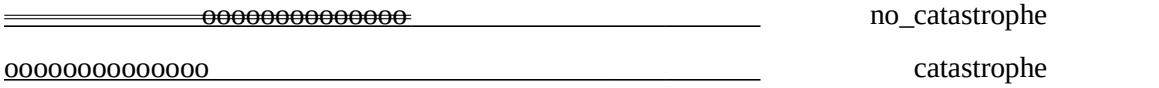
As regards Wigner's position, the external observer who has not observed the news, the quantum mechanical frame of reference is effectively unchanged: the external observer, for whom the news is still unknown, exists in a quantum mechanical frame of reference in which both catastrophe and no-catastrophe are possible realities. On the inside view, however, as regards the position of Wigner's friend, the system has evolved to:

$$|\text{“no news”}\rangle_O \;\; |\text{no\_catastrophe}\rangle_S \quad \text{or to} \quad |\text{“bad news”}\rangle_O \;\; |\text{catastrophe}\rangle_S$$

There are two parallel realities, catastrophe and no-catastrophe, and on the inside view the different versions of the observer are now determinately defined as existing in one or the other.



If the observer in the catastrophe timeline deletes this observation from memory, he thus becomes the observer $|\text{“no news”}\rangle_O$ instantiated in the $|\text{no\_catastrophe}\rangle_S$ quantum mechanical frame of reference. He is instantly defined as existing in the timeline of the $|\text{no\_catastrophe}\rangle_S$ linear dynamics. In effect this is an undo of the making of the observation.



This is oversimplified[8] but the key point is that effectively, the two dynamics, linear and collapse, operate in different domains. The domain of the collapse dynamics, the change to the correlations record of the observer, is effectively orthogonal to the domain of the linear dynamics, the time evolution of the matter and energy of the four-dimensional space-time physical environment along the linear time dimension of space-time. [9] The quantum jump is the jump to a parallel reality, a different version of the determinacy of the physical reality. As Everett states:

> The "quantum- jumps" exist in our theory as relative phenomena (i.e., the states of an object-system relative to chosen observer states show this effect), while the absolute states change quite continuously. (1973, p. 115)

6 The 'is_fake' Marker

The destiny is the determinate future, which in a quantum mechanical world is probabilistic. By deleting memory, the observer is directly interacting with the probabilistic definition of the quantum mechanical frame of reference, the destiny. The processes Mitra defines cannot apply to a human observer as usually defined, as physical body-mind. However, Everett defines the functional identity of the observer as the state of the memory, in turn defined as the record of sensory observations and machine state. It is only with regard to such an identity that there is the appearance of collapse, and the cyclical sequence of the standard von Neumann-Dirac formulation. The observer that finds himself in a reality exercising the dynamics of this formulation is thus necessarily of this nature. As Everett demonstrates, it is only at the experiential level that there is the appearance of collapse. With regard to all physical objects, including the body-mind of the observer, all possible variations of the time evolution of the unitary linear dynamics are exercised.

Human observers cannot deliberately delete a record of observation from memory, since memory is redundantly distributed in the neural network. However, the fascinating question is raised of the effectiveness of deliberately adding realistic observations. If the observer that deletes a record reinstates it, it is back where it started. Moreover, if an observer in the no_catastrophe time-line were to add this record to memory, it would thereby be in exactly the same unfortunate position, even if it did not initially exist there and deliberately delete an observation. If deliberate deletion of an observation from memory changes the sector of the multiverse in which the observer is instantiated, so must deliberate addition of an observation. Unlike an AI, a human observer cannot directly interfere with memory in such a straightforward manner. We can no more artificially add an observation directly to memory than delete one from memory. On the other hand, imagination can be used to generate imaginary scenes.

Naturally, these visualisations are observations. In the healthy individual it is clear that such experiences are made-up. Since this is not the case in the extreme case of hallucinations, where there is no such awareness, it is clearly possible to have internally generated observations which

8 The intervening period would have to be defined. However, if the AI adds by *replacement*, over-writing the record by that of a bland intervening period, the simple example presented is effected.

9 There is an immediate question as to 'what' is transferred. This is the subject of Logical Types in Quantum Mechanics (Soltau, 2010c)

are taken to be naturally occurring. In principle, visualisation is not a different kind of thing to the addition of the observation to the AI's memory: it is simply an observation. The key difference is that it is accompanied by the record of having instigated the observation. This means that this observer is instantiated in, and only in, versions of the physical reality where both are the case: the observation was made and recorded, as was the record of having instigated this process. In other words, the observer exists in versions of the physical environment where this observation was a visualisation. The record of instigation is effectively an is_fake marker with regard to the internally instigated observation. If the AI in Mitra's example were to deliberately delete such a record of instigation, it would be as if the observation had been natural, provided the observation is physically possible.

As with the deletion of any observation, this procedure is easy enough for the AI, but impossible for a human observer. However, if the observer can induce the observation to occur without the is_fake marker, a similar situation is produced to that of the AI which eliminates such a marker. In the human observer, repetition induces automaticity, thus any repeatedly generated stimulus tends to recur spontaneously. The spontaneously occurring recurrence would not be accompanied by the is_fake marker. If this recurrence is gratifying, it will tend to be reinforced, thus the observation continues to be made, without the is_fake marker. As the record of any instigation of this process recedes and fades, the contents of the visualisation is repeatedly observed and recorded, and further reinforced. One could argue that, to the degree that the original is_fake marker fades from memory, the observer is thereby increasingly defined as existing in the version of the effective physical environment in which the observation recalled is natural. This would provide a rationale for the effectiveness of prayer and spells: spelling out the desired observation in five sensory specifics in the imagination.

Suppose the observer visualises the good news of a great success inevitable in the future :

$$|\text{“get news”}\rangle_O \, (\alpha \, |\text{success}\rangle_S + \beta \, |\text{no-success}\rangle_S \,)$$

The observer state “good news” is a state of making a clear construction of the observations of events concomitant with the desired outcome taking place, accompanied by the record of deliberate instigation of this formulation. The state 'success' is a quantum mechanical frame of reference, a version of the effective physical environment in which the events visualised determinately take place. This has no effect on the quantum state of the environment. If α is small compared to β, it remains so, aside from ordinary results from improved motivation on the part of the observer. These do not form part of this dynamics.

Objectively, when the observer discovers the true status of the state of affairs, this evolves into

$$\alpha \, |\text{“good news”}\rangle_O \, |\text{success}\rangle_S + \beta \, |\text{“bad news”}\rangle_O \, \, |\text{no-success}\rangle_S$$

subjectively,

$$|\text{“good news”}\rangle_O \, |\text{success}\rangle_S \quad \text{and} \quad |\text{“bad news”}\rangle_O \, \, |\text{no-success}\rangle_S$$

If this discovery does not take place for some time, and in the meantime, a deliberate formulation in the imagination becomes a self-reinforcing habit, the same observation is repeatedly made, without the accompanying is_fake observation being made. Thus the observation is reinforced in the neural system, while the is_fake observation fades with time evolution of the system. The determinacy of the effective physical environment is defined solely by the record of observations,

the world hologram. It thus becomes more and more the case that the observer is determinately defined as existing in versions of the universe where the observer has made observations concomitant with the enactment of the objectives of the visualisation. However improbable the success of which the news is visualised, if the is_fake marker is dissolved, the observer is defined as having determinately made that observation, and thus existing in the sector of the multiverse where these events have determinately taken place. The observer becomes the observer $|\text{“good news”}\rangle_O$ instantiated in the quantum mechanical frame of reference $|\text{success}\rangle_S$.

7 Conclusion

As Barbour (1999), Deutsch (1997) and Woodward (1996) demonstrate, the quantum universe is static: every possible space-time configuration of matter and energy exists timelessly, 'already'. Each configuration, or moment, each one a snapshot of the state of the physical universe, simply exists. This is at odds with the subjective experience of observers. Subjectively the universe changes all the time. Everett (1957) demonstrates that the appearance of collapse is a purely subjective phenomenon, meaning it exists only on the inside view of the quantum state, as described by Tegmark (1997, 1998). On the inside view, however, change is effected. The making of an observation, the addition to memory of the five-sensory structure of information representing the observation of the physical environment and the internal state, alters the sector of the multiverse the observer is in. This is the appearance of collapse described by Everett. Although solely on the inside view, the making of each observation effects the change of the definition of the quantum state of the physical environment effective for this observer, and the collapse dynamics is exercised. Moreover as a singular, specific, idiosyncratic dynamical change to the effective physical environment, it applies only to the functional identity he defines: the state of the memory, defined in turn as the record of sensory observations and machine state. Given that we encounter the appearance of collapse, and a determinate reality, at every moment, we can only be observers of this nature.

The collapse dynamics is of different logical type to the linear dynamics. The linear dynamics is the dynamics of the time evolution of a specific quantum state. The collapse dynamics is the change of the quantum state, with the resulting change in the linear dynamics. This is the time evolution of the quantum state to a different quantum state, effective in the quantum concept of time. It is of different logical type to the linear dynamics, the time evolution of the quantum state effective in the linear time dimension of space-time: the time evolution of the disposition of matter and energy in the four-dimensional space-time universe, within the context of a single, specific quantum state. It is to the linear dynamics as velocity is to position. With respect to the linear dynamics, the collapse dynamics is a second, derivative, logical type phenomenon, a ;quantum time' phenomenon. In this kind of context, Everett's logic is straightforward. The making of each observation is the transition, on the inside view, to a different effective quantum state, a different 'relative state', a different quantum mechanical frame of reference. As a result, a different version of the functional identity of the observer exists in a different version of the physical environment, one in which this observation has been determinately made. These transitions come about as a result of the formulation of observations in the progression of the linear dynamics, but are nonetheless 'outside of' or meta to the linear dynamics.

The four-dimensional space-time universe is the domain of Newtonian mechanics, Einstein's relativity, and the linear dynamics. This is the quantum mechanical frame of reference, of the first, primitive, logical type. The sequence of quantum mechanical frames of reference, the collapse dynamics, is of a different, second logical type. An observation is determinately made only at this level, at the logical level of the collapse dynamics, which exists only at the experiential level of reality Everett defines. This is the inside view, the view of the specific 'relative state', the quantum mechanical frame of reference of the observer. It is only at this experiential level, as defined by Everett, that there can be any change of the quantum state. This is the transition from one snapshot of the universe, one moment, to another. Within each moment, the linear dynamics progresses until another observation is made, whereupon there is another collapse, another quantum jump, to a different moment, a different quantum mechanical frame of reference. Thus, subjectively, on the inside view, the cyclical dynamics of the standard von Neumann-Dirac formulation of quantum mechanics is encountered by the observer.

With regard to the dynamics of collapse, second logical level dynamics, the universe has the same logical structure as a movie: a sequence of frames. At each moment the quantum mechanical frame of reference defines the disposition of matter and energy in the four-dimensional, space-time matrix of the universe. From the perspective of the functional identity of the observer as defined in Everett's formulation, the quantum mechanical frame of reference is idiosyncratic to the individual observer: it is determinate only where observed by this observer.

With each observation, the quantum mechanical frame of reference fissions, resulting in multiple, per-observer, Copenhagen interpretation type realities, many worlds. As Everett states:

> ... with each succeeding observation (or interaction), the observer state "branches" into a number of different states. (1957, p. 459)

Thus the unitary universe / multiverse system gives rise to branching, per-observer, transtemporal physical realities, each branch being an instance of the effective physical reality of a specific version of the observer, a specific quantum mechanical frame of reference. Thus each version of the observer lives in a personal, physical, parallel reality.

In this kind of reality, the determinacy of the effective physical reality is defined by, and solely by, the record of observations Everett defines as the functional identity, the record of correlations with the physical environment. Hence each such reality is of the nature defined by the Copenhagen interpretation: reality cannot be assigned to the unobserved. Since the observer herself defines the determinacy of the quantum mechanical frame of reference, to change this record of observations is to change the quantum mechanical frame of reference, the sector of the multiverse in which this observer is defined as existing. In this context, the level of information is 'prior' to the level of the physical, because it is the correlations record that defines the determinacy of the effective physical environment, the quantum mechanical frame of reference.[10]

In this context, the undoing of an observation, and the concomitant change to the quantum state of the effective physical environment, is automatically a possibility. Mitra demonstrates the quantum mechanics of 'undoing' an observation, for an observer in a position to carry out this interesting procedure. He posits a high functioning machine intelligence capable of performing

10 As Zeilinger notes, " ... while in a classical world view, reality is a concept prior to and independent of observation with all its properties, in the emerging view of quantum mechanics, the notions of reality and information are on an equal footing" (1999, p. 642)

precisely this operation. As he shows, by deleting the record of an observation, such an observer is thereby present in a different sector of the multiverse. The reality of the future events it wished to avoid is now only a background probability, and the destiny of this sector of the multiverse is very much more the one it wanted. Interaction with the destiny has been effected. Naturally, this is a purely subjective phenomenon, and a second logical type phenomenon, a 'quantum time' phenomenon. These are not physical processes in the ordinary sense of the word, in that these are not processes in the time evolution of the physical in the linear dynamics defined by a specific quantum state. Each is the transition to a different effective quantum state of the physical environment: the observer is instantiated in a different sector of the multiverse.

By the same token, if the memory were to be reinstated, the observer would be back where it started. Adding observations deliberately is in principle as efficacious as deliberate deletion: not because this process gives rise to quantum correlations, but simply because the definition of the observer is changed to that of the observer instantiated in a slightly different simultaneity of snapshots. In each such snapshot, a correlation exists between the observer and the aspect of the physical environment defined as determinate by that observation. Thus the observer is defined as existing in a different sector of the multiverse, with a different destiny. Again, this is an operation of the second logical type. Mitra demonstrates this kind of effect for a specific type of observer, one defined solely by a structure of information. Additionally, there seems to be a strong logical case for such a phenomenon in the reality of human observers, given an identity of the type Everett defines. If these principles hold, habituated 'fake' observations would tend to affect the probabilistic future of the effective physical reality for this observer. Although logical, this seems so bizarre that it could be well considered the Schrödinger's cat of the no-collapse universe.

Somewhat perversely, this fascinating phenomenon would be quite impossible to measure, by definition. There could be no evidence that there was an influence. Once the observer in Mitra's example has made a transition to a new sector of the multiverse, there can be no evidence of this operation having been carried out, and how effective if therefore was. As Mitra states:

> Assuming the validity of the MWI, we are forced to accept that by resetting the memory to a previous state, the reason why the memory was reset is no longer determined. (2009, p. 4)

It appears that any second logical type level phenomenon is entirely untestable, and non-falsifiable: the operation is only successful to the extent there is no evidence. It is an alteration to the observations record which is only effective if there is consequently no record of the alteration. The undoing of the effect of an observation, for instance, is only effective to the degree there is no record of that undoing. Any record or evidence would be an is_fake marker. This is, therefore, a purely philosophical proposition. This is of course a more than adequate reason for these concepts not to have come to light previously in the field of physics. Nonetheless, the properties of the reality experienced which hinge on it are perhaps as significant as can be imagined. If the collapse dynamics discovered in the mechanics of quantum theory is, as Everett proposes, purely subjective, it is on a per-observer basis. By the same token, however, the observer is of such significance in her reality that not only observations of real events, but even visualisations of possible events, would tend to influence the probabilistic future of the reality of this observer, the destiny. It seems a fruitful area of investigation.

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