

The Cat oRules

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The oRules of state reduction are applied to the Schrödinger cat experiment. It is shown that these rules can unambiguously describe the conscious state of the cat, as well as an outside observer at any time during the experiment. Two versions of the experiment are considered. In version I, the conscious cat is made unconscious by a mechanism that is triggered by a radioactive decay. In version II, the sleeping cat is made conscious by an alarm clock that is triggered by a radioactive decay.

Introduction

Four rules called the *oRules* are given in previous papers [1, 2]. These rules are said to govern the process of stochastic choice and state reduction in an *ontological model* of a quantum mechanical system, and describe how the consciousness awareness of an observer changes during this process. In the present paper, these rules are applied to the case of Schrödinger's cat.

An early version of the *oRules* appears in another paper where they are simply called *The Rules* [3]. This early version is also applied to the Schrödinger cat [4]. The present paper is a new portrayal of ref. 4 that uses a better representation of continuous change, plus the more recent version of the rules, attended by a discussion that brings the text up to date.

In ref. 1, an interaction is studied that involves a particle passing over a detector with some probability of capture. A conscious observer witnesses the detector at various times during the interaction. It is found that if the observer observes the detector during a particle capture, a new state of consciousness accompanies the associated state reduction.

That is, when the oRules are applied in the cases investigated in ref. 1, consciousness is found to switch from one state to another on the occasion of a stochastic choice.

There are four separate oRules (1-4). The first refers to the *probability current* J that flows into a state. The current J is defined to be the time rate of change of the square modulus.

oRule (1): *For any subsystem of n components in a system having a total square modulus equal to s , the probability per unit time of a stochastic choice of one of those components at time t is given by $(\sum_n J_n)/s$, where the net probability current J_n going into the n^{th} component at that time is positive.*

The *ready brain state* referred to in the next oRule is defined as one that is **not conscious**, but is physiologically capable of becoming conscious if it is stochastically chosen. The *active brain state* referred to below is one that is either conscious or ready. Ready brain states are underlined in this treatment whereas conscious brain states are not. This switches the convention adopted in ref. 3.

oRule (2): *If an interaction produces new components that are discontinuous with the initial state or with each other, then all of the active brain states in the new components will be ready brain states.*

(see ref. 1 for an elaboration of “discontinuous” and “initial state”)

oRule (3): *If a component containing ready brain states is stochastically chosen, then those states will become conscious brain states, and all other components in the superposition will be immediately reduced to zero.*

(see ref. 1 for a discussion of “immediately”)

oRule (4): *If a component in a superposition is entangled with a ready brain state, then that component can only receive probability current.*

The purpose of the present paper is to apply these rules to two versions of the Schrödinger cat experiment. Version I is a somewhat modified formulation of that famous puzzle. That usually involves a cat being placed on two components of a quantum mechanical superposition, where it is alive on one component and dead on the other. This distinction is ambiguous because an alive cat can be unconscious, in which case it is every bit as inert as a dead cat. The distinction used here is that the cat is conscious on one component of the superposition, and unconscious on the other. In version II, the cat begins in an unconscious state, and is aroused to a conscious state.

The Apparatus

We first look at the apparatus that is used in the Schrödinger cat experiment *without* a cat or an external observer being present. The oRules applied to the apparatus by itself gives an unaccustomed glimpse of the quantum mechanical behavior of a macroscopic thing. This happens because state reduction, under the oRules, can only occur when there is an observer present. So we will see what a functioning macroscopic object looks like when it carries out a routine without the benefit of a ‘collapse’ of the state anywhere along the way.

The apparatus will consist of a radioactive source and a detector that is denoted by either d_0 or d_1 , where the first means that the detector has not yet captured the decay particle and the second means that it has. The detector output will be connected to a mechanical device that carries out a certain task, such as a hammer falling on a container that then releases an anesthetic gas. This device will be denoted by $M(\alpha, t)$, where α indicates the extent to which the task has been completed, and t is the time. The component $d_0M(\alpha_0, t)$ indicates that the source has not yet decayed at time t and that the mechanical device is still in its initial position given by α_0 . The component $d_1M(\alpha_1, t)$ indicates that the decay has already occurred by the time t , and that the mechanical device has advanced to a position given by α_1 . Let i_0 be an indicator that tells us that M has not completed its task, and i_1 tells us that it has. Then $d_1M(\alpha_1, t)i_0$ means that the device has not completed its task at time t . When $\alpha = \alpha_f$ we will say that the device M has fully run its course, so $d_1M(\alpha_f, t)i_1$ means that the source has decayed, and that the mechanical

device has completed its task at time t as indicated by α_f and by the indicator i_1 . We also suppose that the source is exposed to the detector for a time that is limited to the half-life of a single emission. At that time a clock will shut off the detector, so it will remain in the state d_0 if there has not yet been a particle capture.

The system at $t_0 = 0$ is then $\Phi(t_0) = d_0M(\alpha_0, t_0)i_0$, and in time becomes

$$\Phi(t \geq t_0) = d_0M(\alpha_0, t)i_0 + d_1M(\alpha, t)i_0 \rightarrow d_1M(\alpha_f, t)i_1 \quad (1)$$

where all but the first component are zero at t_0 , and where $\alpha_0 \leq \alpha < \alpha_f$. The arrow represents a continuous-classical progression from the second to the third term in eq. 1, so these two terms are really a single component seen at two different times. A plus sign always represents a discontinuous change (here between d_0 and d_1), and an arrow always represents a continuous change.

A spread of alphas at a given time represents a possible uncertainty in the state of the mechanical device at that moment. Although the device is macroscopic, there is a quantum mechanical uncertainty as to when it begins its operation. The function $M(\alpha, t)$ is therefore a pulse that represents that uncertainty moving along the α axis. Although the second and third terms in eq. 1 are a single component, the width of this component (in α) allows both of these terms to be simultaneously non-zero in that equation. In consequence, as time progresses, the second term in eq. 1 and then the third will gain amplitude, but the third cannot do that until after a time T that corresponds to the time it takes for the mechanical device to complete its task.

Since we arranged to have the first component decrease for a time equal to the half-life of a single emission, its square modulus will stabilize to a constant value of 0.5 at that time, assuming that eq. 1 is normalized. After that, no new current will flow into the second component, so the amplitude of $d_1M(\alpha, t)i_0$ will fall back to zero as the pulse $M(\alpha, t)$ runs out along α . When $M(\alpha, t)$ finally goes to zero, the last term $d_1M(\alpha_f, t)i_1$ will reach its maximum value. In the end, the first component and the last term (representing the final form of the second component) will survive, each with a square modulus equal to 0.5.

Add an Observer

Before inflicting this apparatus on a cat, we will see how the oRules work when an outside observer witnesses the apparatus in operation – i.e., after the primary interaction has begun. In that case, eq. 1 becomes

$$\Phi(t \geq t_0) = [d_0M(\alpha_0, t)i_0 + d_1M(\alpha, t)i_0 \rightarrow d_1M(\alpha_f, t)i_1] \otimes X \quad (2)$$

where X is the unknown brain state of the observer prior to the physiological interaction.

Let the observer look at the detector at some time t_{look} , giving

$$\begin{aligned} \Phi(t \geq t_{\text{look}} > t_0) &= d_0M(\alpha_0, t)i_0 \otimes X \rightarrow d_0M'(\alpha_0, t)I_0B^b \\ &+ d_1M(\alpha, t)i_0 \otimes X \rightarrow d_1M'(\alpha, t)I_0B^b \\ &\rightarrow d_1M(\alpha_f, t)i_1 \otimes X \rightarrow d_1M'(\alpha_f, t)I_1B^b \end{aligned}$$

where the physiological process represented by the arrows is a continuous and classical progression leading from independence to entanglement. The arrows carry i into I and $\otimes X$ into B^b . The indicator I includes the bare device i plus the low-level physiology of the observer. The brain state B is only the higher level processes of the brain that directly involve consciousness (i.e., not image processing). The state B^b is called a *brink state* because it is an inactive state (i.e., not yet conscious or ready) that is on the brink of becoming active. This progression is classical to the extent that it ignores the quantum uncertainties that are internal to the apparatus and the physiology of the observer¹.

During this process the observer will be unable to distinguish between the two detector states d_0 and d_1 , which is why his brain is called inactive in the above equation. However, at some moment t_{ob} (i.e., the moment of observation) the observer will resolve the difference between these states, and when that happens a continuous ‘classical’ evolution will no longer be possible. Let this happen with the appearance of the brink state B^b . At this point the solution will branch “quantum mechanically” into additional components, with oRule (2) requiring the introduction of ready brain states \underline{B}_0 and \underline{B}_1 .

$$\begin{aligned} \Phi(t \geq t_{\text{ob}} > t_{\text{look}} > t_0) &= d_0M'(\alpha_0, t)I_0B^b + d_1M'(\alpha, t)I_0B^b \rightarrow d_1M'(\alpha_f, t)I_1B^b \\ &+ d_0M''(\alpha_0, t)I_0\underline{B}_0 (+) d_1M''(\alpha, t)I_0\underline{B}_0 (\rightarrow) d_1M''(\alpha_f, t)I_1\underline{B}_1 \end{aligned} \quad (3)$$

¹ The “decision” of the observer to look at the detector is assumed to be deterministically internal in an *ontological* model like this one (see ref. 1). In this respect, any ontological model is like classical physics.

where \underline{B}_0 and \underline{B}_1 are ready brain states that interact with I_0 and I_1 respectively². Probability current in eq. 3 flows vertically into the second row from components in the first row, beginning at the time t_{ob} . This current represents the physiological interaction that follows the active engagement of the observer. Horizontal current will flow in the first row during the primary interaction, but not in the second row because of oRule (4) which says that the ready brain state \underline{B}_0 cannot transmit current to the ready brain state \underline{B}_1 , or to itself. Forbidden current flow is indicated by the parenthesis around the plus sign and the arrow in the second row of eq. 3.

The first oRule requires that the time integrated current flowing into the second row of eq. 3 must equal 1.0. So one of the recipient terms must be eventually chosen.

If the observation occurs after time T , then current will have gone into the last (sixth) term $d_1M''(\alpha_f, t)I_1\underline{B}_1$ in eq. 3. If that term happens to be stochastically chosen at a time t_{sc6} , then the ready state \underline{B}_1 will become conscious, and following oRule (3) the state of the system will be

$$\Phi(t \geq t_{sc6} > t_{ob}) = d_1M(\alpha_f, t_{sc6})I_1B_1$$

This will complete the interaction. It corresponds to the observer coming on board when the mechanical device has already finished its task. The un-underlined state B_1 is a brain state of the observer that is conscious of the indicator I_1 (and possibly the detector d_1).

If the fifth term in eq. 3 is stochastically chosen at t_{sc5} , then

$$\Phi(t \geq t_{sc5} > t_{ob}) = d_1M(\alpha, t)I_0B_0 \rightarrow d_1M(\alpha_f, t)I_1B_1$$

beginning at time t_{sc5} before the final time t_f . So the final state is

$$\Phi(t \geq t_f > t_{sc5} > t_{ob}) = d_1M(\alpha_f, t)I_1B_1 \quad (4)$$

Another possibility is that there will be a stochastic hit on the fourth term $d_0M''(\alpha_0, t)I_0\underline{B}_0$ in eq. 3 at a time t_{sc4} . This reduces the state of the system to

$$\Phi(t = t_{sc4} > t_{ob}) = d_0M(\alpha_0, t)I_0B_0$$

which will continue to evolve under the primary interaction giving

² \underline{B}_0 is a ready state in the fifth/sixth term of eq. 3 because that component is discontinuous with the initial component. \underline{B}_0 is a ready state in the fourth term because is discontinuous with the fifth/sixth term as per oRule (2). Each passage from B^b to \underline{B}_0 in this equation occurs at the same time, so if the observer looks at the apparatus after the primary interaction has begun, both the fourth and the fifth/sixth terms in eq. 3 will be simultaneously non-zero.

$$\Phi(t \geq t_{sc4} > t_{ob}) = d_0 M(\alpha_0, t) I_0 B_0 + d_1 M'(\alpha_0, t) I_0 \underline{B}_0 \quad (5)$$

where the second component is zero at t_{sc4} and increases in time. This component will not be succeeded by another value of α in the continuum that normally follows $d_1 M'(\alpha, t) I_0 \underline{B}_0$ because oRule (4) will not allow a self-generating succession of ready brain states. That is, no transition is allowed *from* the second component in eq. 5 because it contains the ready brain state \underline{B}_0 . Consequently, the component α_0 *cannot be skipped over* as the mechanical device begins its operation.

The second component in eq. 5 may now be stochastically chosen at time t_{sc42} , such that $t_{sc42} > t_{sc4}$. In that case the system will again be reduced, giving

$$\Phi(t = t_{sc42} > t_{sc4} > t_{ob}) = d_1 M(\alpha_0, t) I_0 B_0$$

From this point on, the observer will track the classical behavior of the mechanical device as happened following eq. 4, beginning in this case with α_0 and ending with α_f in $d_1 M(\alpha_f, t) I_1 B_1$.

The primary (horizontal) current will cut off at $t_{1/2}$. If that happens after the fourth term in eq. 3 has been stochastically chosen at t_{sc4} , and before eq. 5 has run its course, then it (eq. 5) will become time independent.

$$\Phi(t \geq t_{1/2} > t_{sc4} > t_{ob}) = d_0 M(\alpha_0, t_{1/2}) I_0 B_0 + d_1 M'(\alpha_0, t_{1/2}) I_0 \underline{B}_0 \quad (6)$$

The existence of this superposition is like similar cases in the previous paper (ref. 1) where a component containing as ready brain state no longer takes in probability current. We call that component a *phantom* because it serves no further purpose (see discussion in ref. 1). This designation applies to the second component in eq. 6, so we choose to redefine the system by dropping this component (again see ref. 1). Equation 6 therefore corresponds to the observer (in the first component) finding the detector in the state d_0 and the indicator in I_0 with the clock run out.

If the cut-off occurs after the fifth term in eq. 3 has been stochastic chosen, it (the fifth term) will continue to run its classical course to the sixth term like eq. 4, ending with the observer being aware that the mechanical device has completed its task.

And finally, if the cut-off at $t_{1/2}$ occurs before there has been a stochastic hit of any kind, then the second and third terms of eq. 3 will go to zero as current is drained from them into the fifth and sixth terms. This may give rise to a stochastic hit on one of these terms, reducing the state to either the fifth term that subsequently evolves into the sixth term, or it will reduce to the sixth term directly.

Otherwise, without such a stochastic hit, the component that is the fifth and sixth terms will become a phantom after receiving this current. However, physiological (vertical) current will continue to flow after $t_{1/2}$ from the first component to the fourth term $d_0 M''(\alpha_0, t) I_0 \underline{B}_0$ in eq. 3. This will lead to a hit on the fourth term at some time t_{sc43} giving

$$\Phi(t \geq t_{sc43} > t_{1/2} > t_{ob}) = d_0 M(\alpha_0, t_{sc43}) I_0 \underline{B}_0 \quad (7)$$

This again corresponds to the observer finding the detector in detector state d_0 with the clock run out.

Since the clock limiting the detector is set equal to the half-life of a single emission, there is a 50% chance that the system will terminate in the original state. Otherwise, there is a 50% chance that the mechanical device will go to the end.

Version 1 with no Outside Observer

We now replace the indicator in eq. 1 with cat brain states. The first of these is C_0 , the brain state of the cat when it is conscious of the variable α_0 . This is the state of the cat before a stochastic hit. It is now required that all lower physiological operations of the observer's brain are included in the mechanical device. Before a stochastic choice occurs, the system is given by

$$\Phi(t \geq t_0) = d_0 M(\alpha_0, t) C_0 + d_1 M'(\alpha_0, t) \underline{C}_0 \quad (8)$$

where the second component is initially zero and increases in time. The time dependence of M and M' reflects only the change of square modulus that results from the flow of current from the first to the second component. The ready state in eq. 8 is not conscious; and in any case, it poses no paradox of the kind generally associated with the cat. The fourth rule again insures that there cannot be a stochastic choice of alphas higher than α_0 , so again, α_0 cannot be passed over.

If there is a stochastic hit at time t_{sc} , eq. 8 will become

$$\Phi(t_f \geq t \geq t_{sc} > t_0) = d_1 M(\alpha_0, t_{sc}) C_0 \rightarrow d_1 M(\alpha, t) C_\alpha \rightarrow d_1 M(\alpha_f, t_f) U \quad (9)$$

where U is the unconscious state of the cat, and C_α is the brain state of the cat when it is conscious of the variable α . Again, $\alpha_0 \leq \alpha < \alpha_f$. The two different brain states in this equation do not result in a paradox because they occur at different times. The three terms in eq. 9 represent one component at three different times. Time dependence in M and M' therefore refers to that evolution and not to a change of square modulus. Also in this case, $M(\alpha, t)$ is not a pulse of quantum mechanical uncertainties as it is in eq. 1, for the process in eq. 9 is initiated by a sharply defined stochastic hit. So α has a sharply defined and classically determined value at any time t . The arrows in eq. 9 carry t classically and continuously from t_{sc} to t_f , as α_0 goes to α_f and C_0 goes to U . The final state of the cat is therefore

$$\Phi(t \geq t_f) = d_1 M(\alpha_f, t_f) U \quad (10)$$

If, on the other hand, primary current stops flowing at the half-life time $t_{1/2}$ before a stochastic hit, then the second component in eq. 8 will stabilize in place giving the time independent equation

$$\Phi(t \geq t_{1/2} > t_0) = d_0 M(\alpha_0, t_{1/2}) C_0 + d_1 M'(\alpha_0, t_{1/2}) \underline{C}_0 \quad (11)$$

where both components have come to a square modulus equal to 0.5, assuming that the equation is initially normalized. The cat in eq. 11 remains conscious of α_0 , so it has escaped being put to sleep.

There is a 0.5 probability that eq. 10 will be the final state, and a 0.5 probability that eq. 11 will be the final state. This confirms our expectations.

Version I with Outside Observer

Imagine that an outside observer looks in on the cat during these proceedings to see how it is doing. This observer is initially in the wings represented by $\otimes X$ as in eq. 2. The physiological interaction applied to eq. 8 is then

$$\begin{aligned} \Phi(t > t_{\text{ob}} \geq t_{\text{look}} > t_0) &= d_0 M(\alpha_0, t_{\text{look}}) C_0 \otimes X \rightarrow d_0 M(\alpha_0, t_{\text{ob}}) C_0 B^{\text{b}} \rightarrow d_0 M(\alpha_0, t) C_0 B_0 \quad (12) \\ &+ d_1 M'(\alpha_0, t_{\text{look}}) \underline{C}_0 \otimes X \rightarrow d_1 M'(\alpha_0, t_{\text{ob}}) \underline{C}_0 B^{\text{b}} \rightarrow d_1 M'(\alpha_0, t) \underline{C}_0 \underline{B}_0 \end{aligned}$$

where again B^{b} is the brink state of the observer, and \underline{B}_0 is the ready brain state of the observer when he is aware of the cat being conscious of α_0 . The first row of this equation is a single component that evolves continuously and classically as represented by the arrow. It carries $\otimes X$ into B_0 by a process that leads from independence to entanglement³. The mechanical device associated with B^{b} after time t_{ob} now includes the lower level physiology of both the cat and the outside observer.

The primary interaction is still active during this time, and this gives rise to a vertical current going from the first to the second row in eq. 12. The second row is therefore a continuum of terms that are created parallel to the first row at each moment of time. So after t_{ob} , vertical current flows only into the final component in the second row of eq. 12. Terms prior the last one no longer have current flowing into them from above, and since there is no horizontal current among these ready states, they become phantoms as soon as they are created. Therefore, when the interaction is complete eq. 12 is

$$\Phi(t > t_{\text{ob}}) = d_0 M(\alpha_0, t) C_0 B_0 + d_1 M'(\alpha_0, t) \underline{C}_0 \underline{B}_0 \quad (13)$$

where $d_1 M'(\alpha_0, t) \underline{C}_0 \underline{B}_0$ is initially zero and increases in time. This equation is identical with eq. 8 with the addition of the observer. From this point on the options work out the same as they do in the previous section, except for the addition of the observer.

If there is a stochastic hit between times t_{look} and t_{ob} in eq. 12, then the corresponding ready state in the second row will be stochastically chosen, and the subsequent continuous process will lead to the final state $d_1 M'(\alpha_r, t_r) U B_U$, where B_U is the brain state of the observer when he is aware of the unconscious cat.

³ The realized state B_0 in the first row is the result of a continuous evolution arising from the physiological interaction. The ready state \underline{B}_0 in the second row is the result of the discontinuous evolution arising from the primary interaction – i.e., the sixth term is discontinuous with the initial state.

Version II with no Outside Observer

In the second version of the Schrödinger cat experiment, the cat is initially unconscious, and is awakened by an alarm that is set off by the capture of a radioactive decay. The mechanical device $M(\alpha, t)$ is now an alarm clock, where α represents the clock's successive stages – from its initial response (to radioactivity) to the ring. As before, the alarm will go off only 50% of the time. The equation of state is

$$\Phi(t \geq t_0) = d_0M(\alpha_0, t)U + d_1M(\alpha, t)U \rightarrow d_1M(\alpha_f, t)\underline{C} \quad (14)$$

where U is the initial unconscious state of the cat, \underline{C} is the cat's final (and still unconscious) ready brain state, and the second and third terms (of the second component) are initially equal to zero and increase in time. Again, there may be a time delay T before the third term containing the ready brain state of the cat can accumulate value after t_0 . We assume eq. 14 to be normalized.

When current does flow into the third term it might be stochastically chosen at time t_{sc} . If that happens the system will become

$$\Phi(t \geq t_{sc} > t_f > t_0) = d_1M(\alpha_f, t_{sc})C \quad (15)$$

This will terminate the interaction. It corresponds to the cat finding himself aroused by the alarm 50% of the time.

Only the third term in eq. 14 contains a ready brain state, so only it can be stochastically chosen in a way that leads to an oRule (3) reduction. If there is no stochastic choice, then the square modulus of the first component of eq. 14 will fall to a value of 0.5. The second term will initially rise to some positive value and fall again to zero, and the third term will rise to a square modulus of 0.5. In the final state of the system, the square moduli of the first and the third terms will be equal to 0.5, and the second will be zero. Therefore, at and after t_f when the alarm mechanism has run its course, the system will end its evolution with two time independent components

$$\Phi(t \geq t_f) = d_0M(\alpha_0)U + d_1M(\alpha_f)\underline{C}$$

which will appear 50% of the time. The cat is not conscious in either one of them. Redefining the system by dropping the second component gives

$$\Phi(t \geq t_f) = d_0M(\alpha_0)U$$

Version II with Outside Observer

If the outside observer interacts with the cat & apparatus after there has been a stochastic choice leading to eq. 15, then following a separate physiological interaction, the conscious observer will be on board with the conscious cat. The two of them will experience an amended version of eq. 15 given by

$$\Phi(t \geq t_{ob} > t_{sc} > t_f > t_0) = D_1 M(\alpha_f) C B_{fC} \quad (16)$$

where B_{fC} is the observer's state of awareness of the variable α_f and the conscious cat C.

Now imagine that the outside observer enters the picture before the stochastic choice that leads to eq. 15, assuming that the primary interaction has already begun. Equation 14 will be

$$\begin{aligned} \Phi(t \geq t_{ob}) = & d_0 M(\alpha_0, t) U B^b + d_1 M(\alpha, t) U B^b \rightarrow d_1 M(\alpha_f, t) \underline{C} B^b \\ & + d_0 M'(\alpha_0, t) U \underline{B}_{0U} (+) d_1 M'(\alpha, t) U \underline{B}_{\alpha U} \end{aligned} \quad (17)$$

where \underline{B}_{0U} (or $\underline{B}_{\alpha U}$) is the observer's ready state of awareness of the variable α_0 (or α) and the unconscious cat. The fourth oRule blocks the appearance of a sixth term. The ready components in the second row are equal to zero at t_{ob} and increase in time⁴. The appearance of the observer leads to a stochastic hit on one of these components.

If $d_0 M'(\alpha_0, t) U \underline{B}_{0U}$ is chosen at time t_{sc4} , then eq. 17 reduces to

$$\Phi(t \geq t_{sc4} > t_{ob}) = d_0 M(\alpha_0, t) U B_{0U} + d_1 M'(\alpha_0, t) U \underline{B}_{0U} \quad (18)$$

where the second component is zero at t_{sc4} and increases in time. This component cannot advance further than α_0 because of oRule (4). Another stochastic hit at t_{sc42} will give

$$\Phi(t \geq t_{sc42} > t_{sc4} > t_{ob}) = d_1 M(\alpha_0, t) U B_{0U} \rightarrow d_1 M(\alpha_f, t) C B_{fC}$$

resulting in

$$\Phi(t \geq t_f > t_{sc42} > t_{sc4} > t_{ob}) = d_1 M(\alpha_f, t_{sc42}) C B_{fC} \quad (19)$$

If $d_1 M'(\alpha, t) U \underline{B}_{\alpha U}$ in eq. 17 is chosen at time t_{sc5} , then it reduces to

$$\Phi(t \geq t_{sc5} > t_{ob}) = d_1 M(\alpha, t) U B_{\alpha U} \rightarrow d_1 M(\alpha_f, t) C B_{fC}$$

resulting in

$$\Phi(t \geq t_f > t_{sc5} > t_{ob}) = d_1 M(\alpha_f, t_{sc5}) C B_{fC} \quad (20)$$

⁴ Again, $\underline{B}_{\alpha U}$ is a ready state because it is discontinuous with the initial state, and \underline{B}_{0U} is a ready state because it is discontinuous with $\underline{B}_{\alpha U}$.

If there is a stochastic hit on the third term in eq. 17 at t_{sc3} , it will evolve continuously to become

$$\Phi(t \geq t_{sc3} > t_f > t_{ob}) = d_1 M(\alpha_f, t_{sc3}) C B_{fC} \quad (21)$$

In either case, the final state in eqs. 19, 20 or 21 is the same as eq. 15 except that the external observer is now on board.

Version II with a Natural Wake-Up

Even if the alarm does not go off, the cat will wake up naturally by virtue of its own internal alarm clock. The internal alarm can be represented by a classical mechanical device that operates at the same time as the external alarm. The interaction is assumed to run parallel to eq. 14, and is given by

$$\Phi(t \geq t_0) = N(t_0)U \rightarrow N(t)U \rightarrow N(t_{ff})C \quad (22)$$

where $N(t)$ is the internal mechanism and t_{ff} is the final time of its internal development. Taking the product of eqs. 14 and 22 at t_0 gives

$$\Phi(t = t_0) = d_0 M(\alpha_0, t) N(t) U$$

After which the state becomes the subsequent product

$$\Phi(t \geq t_0) = [d_0 M(\alpha_0, t) U + d_1 M(\alpha, t) U \rightarrow d_1 M(\alpha_f, t) \underline{C}] [N(t_0) U \rightarrow N(t) U \rightarrow N(t_{ff}) C]$$

where the cross product suggests a conflict between C and U states. To resolve this, we follow two possible scenarios. The first assumes that the stochastic choice and external decay occurs before the internal decay, and the second assumes that the internal decay occurs before the stochastic choice and external decay. The first of these gives

$$\Phi(t \geq t_0) = [d_0 M(\alpha_0, t) U + d_1 M(\alpha, t) U \rightarrow d_1 M(\alpha_f, t) \underline{C}] [N(t_0) \rightarrow N(t)]$$

resulting in

$$\begin{aligned} \Phi(t \geq t_{ff} > t_f > t_{sc} > t_0) &= d_1 M(\alpha_f, t_f) [N(t_0) \rightarrow N(t) \rightarrow N(t_{ff})] C \\ &= d_1 M(\alpha_f, t_f) N(t_{ff}) C \end{aligned} \quad (23)$$

The second scenario is

$$\Phi(t \geq t_0) = [N(t_0) U \rightarrow N(t) U \rightarrow N(t_{ff}) C] [d_0 M(\alpha_0, t) + d_1 M(\alpha, t)]$$

After t_{ff} this becomes

$$\Phi(t \geq t_{ff} > t_0) = N(t_{ff}) [d_0 M(\alpha_0, t) + d_1 M(\alpha, t) \rightarrow d_1 M(\alpha_f, t)] C$$

And after t_f

$$\Phi(t \geq t_f > t_{ff} > t_0) = d_1 N(t_{ff}) M(\alpha_f, t_f) C \quad (24)$$

Both of these scenarios lead to the same conscious state in eqs. 23 and 24.

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