

# **Are Memories Really Stored In The Brain?**

A Quantum Theoretical Non-local Model of Human Memory

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## **ABSTRACT**

The possibility of a radically new mechanism to explain the functioning of human long-term memory is considered.

After reviewing orthodox nodal and connectionist (internal) memory models, an alternative model is proposed. This model assumes at the outset that memories are not stored in the brain at all. Rather it is proposed that the brain operates more like an aerial rather than an internal memory storage device. The model assumes also that decoherence effects do not invalidate a quantum theoretical treatment of the brain subsystems responsible for memory recall and it is shown how memories are recovered atemporally (non locally in time) from at least the past null cone of the recipient.

The cosmological consequences of the atemporal physics underpinning the model are reviewed in terms of the nature and emergence of well defined sub-atomic particles in early times following the big bang. Also it is explained how the model gives a quite natural explanation to certain reported effects such as E.S.P, psychic phenomena and reincarnation experiences.

### **Review of orthodox memory models**

The brain performs many functions and considerable attention has been given recently by physicists to try to understand its functioning, particularly with respect to consciousness[1],[6],[9].

I leave aside the issue of the nature of consciousness in this paper but wish to propose an alternative model to the orthodox view, regarding how long term memory function might work.

The orthodox view usually assumes that memories are retained in some form within the brain. However, the human brain is not a large organ and yet it is clear that it must have a huge storage capacity and enormous capability for data handling.

A crude orthodox model might be that certain cells in the brain (we might call these cells “node cells”) are each responsible for storing a single binary bit, thus n cells would enable at least n bits to be stored. However, according to Vitiello [2], storing and recalling information is a diffuse activity of the brain and information is not necessarily lost even after local parts are destroyed or damaged. Thus it seems natural to suppose instead, that a more dynamical functioning for memory is at work, perhaps based on signals which operate via connections between global, rather than the local parts themselves. Such connectionist models have the added advantage of enabling much greater storage capacities than do the simple cell memory idea. To see why this is so, consider n nodes, each connected to every other node. This would give the number of connections c to be:

$$c = \frac{n(n - 1)}{2}$$

for large n

$$c \propto n^2$$

Moreover, if these n squared connections had “strengths” i.e. ranging from 0--1, when normalised, then the extremes could be used to store bits and partial connections instrumental in associating “weights” to other binary bits or groups of bits.

The collection of all the connections, if they were ordered to form a string could code

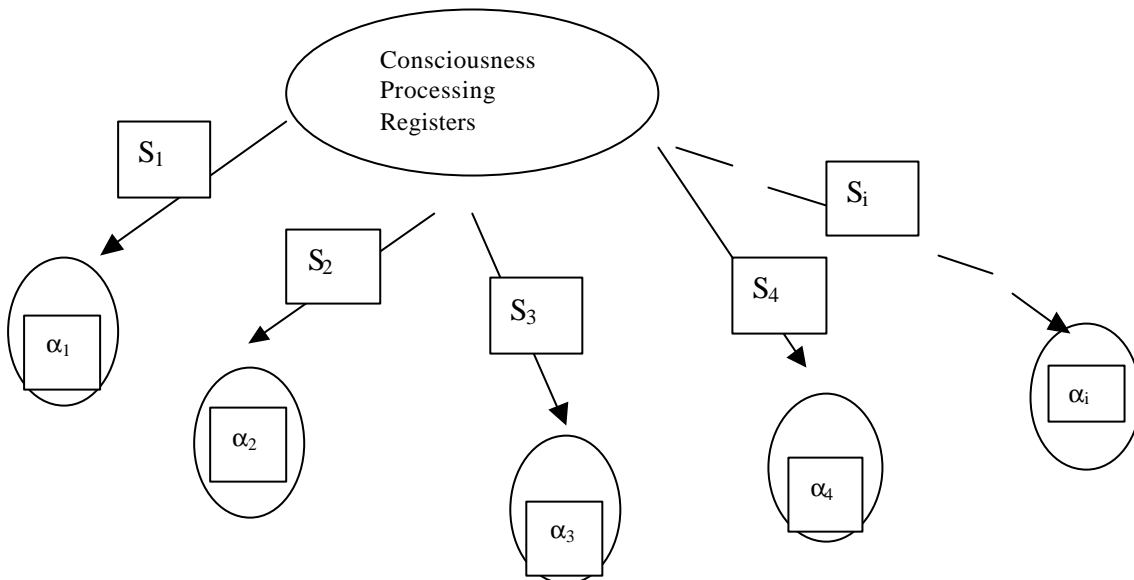
$$2^{n^2}$$

different binary numbers. If a subset of these connection strings were somehow divided up into i equal and ordered substrings, then these strings could each form a basic memory  $\alpha_i$ . These  $\alpha_i$  might then form an orthonormal basis in a vector space of very large dimension. e.g.

$$a_i = \begin{pmatrix} \alpha_{10} \\ \alpha_{01} \\ \alpha_{00} \\ \alpha_{11} \end{pmatrix}, \quad \begin{pmatrix} \alpha_{00} \\ \alpha_{11} \\ \alpha_{10} \\ \alpha_{01} \end{pmatrix}, \quad \dots, \quad \begin{pmatrix} \alpha_{00} \\ \alpha_{01} \\ \alpha_{10} \\ \alpha_{11} \end{pmatrix}$$

Additionally, if the bases were not unique, then the same memory vector could be described in an alternative basis. Thus local damage (to a basis vector) would not stop a complex memory being recovered.

If alternatively, a unique basis system is necessary, then a subset of connections might be utilized, using the “strengths”  $S_i$  ( $0 \leq S_i \leq 1$ )



Thus memories would be represented solely by bases  $a_i$  rather than a vector  $f$ . This can be interpreted as follows:

whilst trying to remember some fact, the brain is in the superposition of states

$$f(t) = \sum_i \hat{a}_i s_i(t) a_i$$

When a memory is “recalled”, then the vector  $f$  would effectively “collapse” from the superposition onto one of the bases (memories). Thus the entire memory system of the person is modeled by a very large dimensional linear vector space operating similarly to Hilbert space vectors in Quantum Mechanics. Indeed the strength coefficients  $S_i(t)$  may well provide probability strengths (amplitudes) which serve to guide the remembering process onto the correct basis vector memory.

Perhaps the semi-dreaming state, where jumbled and paradoxical scenes pass through consciousness, could be described by just such superpositioned vectors  $f$ . The waking state seemingly operates much faster and the  $S_i(t)$  (probability?) distribution function is much sharper. To mirror quantum mechanics, we have:

$$\dot{\mathbf{a}}_i |\mathbf{s}_i(t)|^2 = 1$$

If the brain operates on the basis of quantum mechanical rules, then at the emergent psychological level, we might expect a similar effect to be mirrored. (c.f. also the reference by Stapp [8] who argues that consciousness itself cannot naturally be accommodated or explained by classical mechanics, whereas quantum mechanics can provide such an explanation).

Although an improvement, even the above mentioned connectionist memory model is probably not sufficient for an adequate explanation of possible storage capacity. There are, however some very sophisticated and promising studies on possible memory functioning, which utilize a dissipative quantum field-theoretic approach to memory mechanisms [2]. Importantly, this approach like the crude example given above can account for both the huge storage capacity and the puzzling way in which the brain can retrieve information, sometimes even when damaged. As I have said, local damage does not always result in memory loss e.g. it is the connections (possibly invariant of path) that are essential for storage, rather than the local node or neuron itself. Therefore the connectionist scheme outlined above may, at least appear to be a more appropriate way to try to begin to understand memory function. However, in this communication, I wish to propose a radical alternative to this currently held orthodox view. The motivation for considering such a scheme will, I hope become apparent. In addition however, the model has the capability to explain phenomena such as ESP etc. that have long been considered to be real in spite of the lack of repeatability of experiments which relate to the effects. The interested reader can follow up the question of PSI, as well as gain access to starting literature in Bem and Homerton's article[14].

Essentially the thesis outlined in this paper begins at the outset by assuming that the brain itself does not store (long term) memories at all, but rather retrieves them from an external store. Indeed the implications of such a mechanism, if real, would be far reaching.

If we follow the assumption that the brain itself does not store memories, then it must instead act as some form of aerial, picking up memories previously stored from some source, which is assumed to be a real physical field. (However, such a field may be formally equivalent to some form of atemporal connections in space-time, as will be explained in due course).

The idea that memories are not stored in the brain may well be unorthodox, but many other physical devices operate using processes, which involve information transfer via transmission and reception of external physical fields.

For example, radio and TV signals are transmitted via the electromagnetic field, and these modulated signals are then received, demodulated and amplified, providing adequate recovery of transmitted information.

An even more interesting and illustrative example is the way information is stored on ferromagnetic media. Unlike radio signals, the information in this case is stored

permanently on the said media. Moreover, subsequent reading of the information does not attenuate the original signal. In other words the reading of the signal does not extract energy from the signal itself as in the case of electromagnetic radiation.

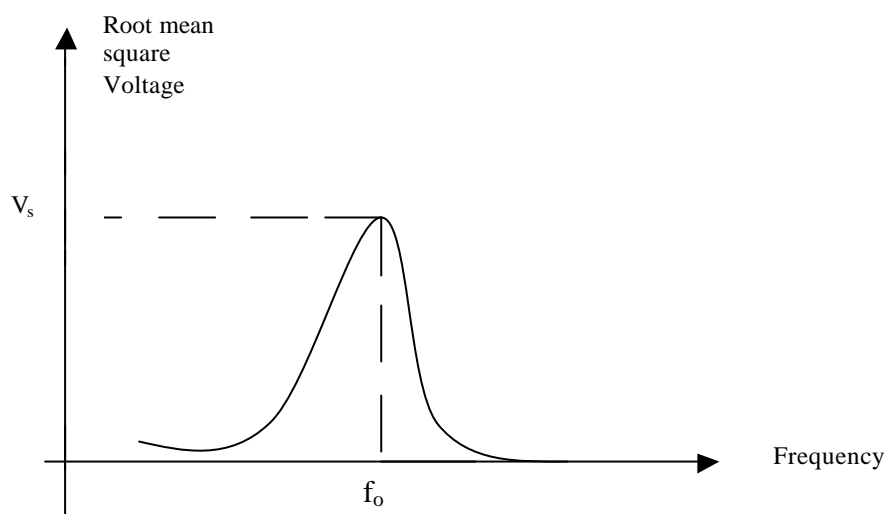
Largely speaking, ferromagnetic behaviour of certain materials ensures that the information storage is, fairly permanent and the energy required to recover the information comes from the movement of the media in the vicinity of coils resulting in electromagnetic induction.

### **In search of a new model**

Stapp [3], and others [7] have pointed out that there are many theoretical reasons for believing that our experiences are correlated to the electromagnetic properties of our brains. He further argues that, since our experiences have a classical character, then the closest connection of quantum mechanics to classical mechanics is via the coherent states of the electromagnetic field. These states are possibly a very robust feature of brain dynamics with respect to perturbations resulting from thermal or other noise [6].

In this work, I will argue from simple quantum theoretical ideas how an alternative memory model might work but at this stage it is sufficient only to suggest a basic mechanism as a starting point for future research. Many workers would argue that a quantum mechanical description of brain functioning is inappropriate because of decoherence effects and therefore classical statistical mechanics is the more relevant starting point. However, Stapp[8] has argued that classical mechanics cannot accommodate consciousness in the same way that quantum mechanics can. Therefore I am not convinced that such decoherence effects would occur in a way which would invalidate such an approach.

I have already given examples of how the transmission and reception of radio waves might be used as an analogy for understanding how the brain may function. Many of us have tried at some stage to tune a radio into a particular station. The radio is capable of being tuned to select signals of a particular frequency. It does this using an aerial together with inductors and capacitors which form a tuned circuit wherein an alternating current will resonate in response to small signals picked up from the background radiation field. Variation of the values of the components (usually plate overlap area of a capacitor) results in a variation of the resonant frequency of the circuit and therefore sensitivity to signals of a chosen frequency. The diagram shows a typical frequency response distribution for a radio set selection circuit.



Here it can be seen how a small signal picked up via the aerial, increases the magnitude of the alternating voltage in the tuned circuit, around its resonant frequency ( $f_0$ ). The signal voltage  $V_s$ , which is usually a number of times larger than the actual incident signal, can now be amplified further. The real value of such tuned circuits is the way in which they allow selectivity to occur. Only signals of frequency equal to or very close to  $f_0$  are picked up. This provides the method of reception of the information which has initially been previously encoded via amplitude modulation onto a carrier signal of frequency ( $f_0$ ).

The analogy here should be clear. If the brain were to operate in a similar way, then it would likewise function as a receiver (and a transmitter!). Signals previously deposited into a background “plastic” field could be recovered. The plasticity of the field being essential since coded signals (memories) written into the field must remain as fixed deformations within it. The example referred to earlier of the storage on magnetic media is useful here because it provides an example of a plastic field effect albeit due to the semi-permanent arrangements of magnetic dipoles.

Both of the above cited analogies are helpful conceptual tools for understanding how such a possible field might operate, but if such a field exists it would have to satisfy some very stringent conditions.

Firstly, like information stored on magnetic media, the storage must be fairly permanent. As already indicated, this requires that the field be a “plastic field”. I define a plastic field (as opposed to an elastic one) to be one which retains distortions (modulated information) in much the same way that a sandy beach retains footprints. A plastic field can however be produced from stationary wave phenomena of a normal elastic field – any fixed waveform profile can be decomposed into a sum of sinusoidal waves.

Secondly, the brain, or rather the particles within it must be able to make imprints on the profile of the plastic field. Some energy would be required to do this, just as some would be needed to read the information from it. In other words, particles would have to

interact with this field but energy must not be directly withdrawn from it during the reading process, otherwise attenuation would occur and paradoxically, remembering would induce forgetting! It is likely that in such a model, as each “read” takes place, a subsequent “write” is induced, thereby modifying and reformulating the original memory. Such a mechanism would better reflect actual memory function whilst accounting for any energy - momentum exchange between particles and field. This is important to bear in mind because the simple model presented later, although not utilizing a field theoretic approach, is formulated in a way which does account for such exchanges, albeit in a rather different way.

Thirdly, this “field” would have to pervade throughout space-time such that, all points of space-time capable of influence i.e. that lie within and on the future null cone of any remembered event, would also have identical informational imprints. This is necessary, because the distortions must not be space dependent. Memory retention is invariant with respect to displacements, acceleration and velocity. Thus the field would be expected to be a function of time only, although new distortions(memories) would propagate out into the future null cone, modifying the existing deformation (by the addition of fourier components) appropriately. Moreover, at all of the space time events in and on the future null cone, the field would have to represent faithfully the profile generated at the remembering event. This would require propagation of the new profile without significant attenuation. The simplest candidate for such a field would be a global scalar field. Global scalar fields are not unknown in physics - the Higgs field [15] being perhaps the most obvious example - but a field which is both global, form invariant and having attenuation free propagating capability would be very unusual. Nevertheless soliton-like behaviour could be a possible mechanism for such propagations.

The complications associated with a field theoretic approach are clearly formidable and seem initially to render the external memory idea to be either at worst physically unrealistic or at best theoretically intractable. However, there are other theoretical as well as experimental [10],[14] reasons for continuing on with the possibility of an externalized form of memory. Of particular interest are non-local effects.

For some time now the very puzzling nature of the non-local EPR like correlations have been under intense theoretical scrutiny by physicists, and it is perhaps in this area that we can find a key to understanding the way an externalized memory (if it exists at all!) might work. The possibilities of such correlations have been suggested by a number of workers (see particularly the short article by Fröhlich in Quantum Implications, Essays in honour of David Bohm. Edited by B J Hiley and F D Peat[4]). In particular, the possibilities of biological utilization of these effects has also been considered by Josephson and co workers[10], who argue for the existence of a mechanism used by organisms whereby use is made of such Bell-like connections. Non locality in space-time necessarily implies some form of intimate connection between events that are separated, not only in space but also in **time**. In the theory of relativity space and time are supposedly placed on roughly the same footing and therefore atemporal (i.e. time like, non locally correlated) events might be expected. Atmanspacher [5] has considered the process of observation in

Quantum Mechanics from an information theoretical point of view. He develops a formalism describing the elementary transfer of one “bit” of information which is produced at a sub-quantal level of physical description which he calls the Sub Quantum Realm (SQR). He suggests that once a single bit has been produced within the SQR, it can be transferred to the ordinary level of quantum description. He concludes that the SQR is intrinsically atemporal and non-local. Thus it may well be that the plastic field discussed earlier, need only serve as a conceptual device rather than a new real physical field. In reality, it may be that atemporal EPR-like access to previous events and to ordinary fields at these events, is what actually serves to pass on the information to future points in space-time. This would explain why no attenuation of the information occurs, just as no primary deterioration of the correlated states occurs in space-like separated pairs of particles in the more familiar EPR experimental effects. In short we remember events by atemporally accessing **our own past world lines!** Note that there should be nothing startling about this idea - we do already access our own world lines quite “naturally” each time we look into a mirror, but access here is obtained by the normal classical electromagnetic field.

All of this raises many deep questions. For example, such an atemporal mechanism would rely on the “block space-time” approach – at least for events in the past light cone of the rememberer (the past would have to exist!). However, I leave aside here all such questions and problems and simply work from a set of basic assumptions, which may well, be invalid. However as a springboard for future research, I make no apology for adopting a somewhat cavalier approach.

### **Atemporal Memory Model**

I begin by stating the assumptions required of such a model and go on to show how a brain (sub)system responsible for memory might be described by a Hamiltonian ( $\mathbf{H}_0$ ) which is varied – and then as a consequence - perturbed (called the process of remembering) in the present by an atemporal potential function piece ( $\mathbf{H}_1$ ) from the past. “Remembering” here means that we re-order our brain subsystems to make the current describing hamiltonian  $\mathbf{H}_0$  for the brain subsystem nearly, if not identical (up to unitary transformations) to some previous hamiltonian  $\mathbf{H}_0'$  of the same sub-system. The set of eigenstates (memories) associated with  $\mathbf{H}_0$  and  $\mathbf{H}_0'$  are then identical. The system is then driven into the particular state (memory), identical to that in the past, and determined from the past by conditions set by the last eigenvector (stationary state) that existed when the hamiltonian was described by  $\mathbf{H}_0'$  (the prime indicates “past”) i.e. the non – simultaneous commutator

$[\mathbf{H}_0, \mathbf{H}_0'] = 0$  at the time of remembering.

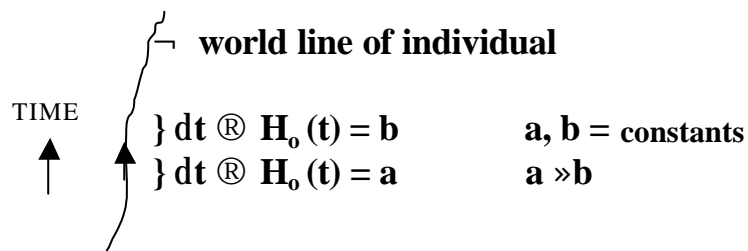


## Assumptions

- (1) The brain can function in a quantum-coherent manner as Stapp and Vitiello have proposed.

There is much debate on this issue and some physicists seem to think that decoherence effects imply that Quantum Mechanics should be exorcised from brain function altogether e.g. classical mechanics electromagnetics, biochemistry, etc. are all that is needed to explain brain function – even including consciousness! Suffice it to say that if it turned out that the (presumably)minute (but hopefully non locally co-operative) sub-systems responsible for memory do not in fact function in a quantum coherent manner - then the theory proposed here would of course be invalidated.

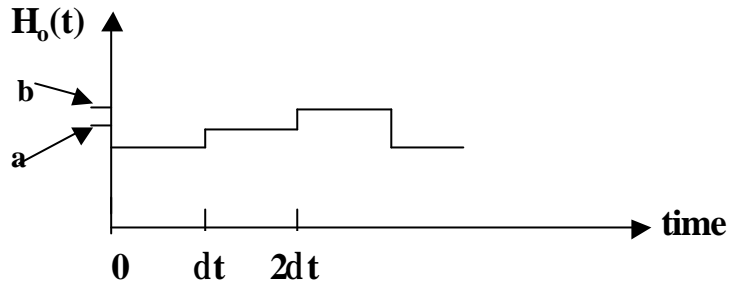
- (2) The hamiltonian  $\mathbf{H}_0$  of the brain subsystem responsible for memories varies in time – because the brain alters it! It does this as part of the natural focusing (à la Josephson[10]) or remembering process. However, I assume that for small periods of time  $d\mathbf{t}$ ,  $\mathbf{H}_0$  remains virtually constant or is at least a normally very slowly changing function of time: see diagrams below - although artificial, this is helpful when considering the model.



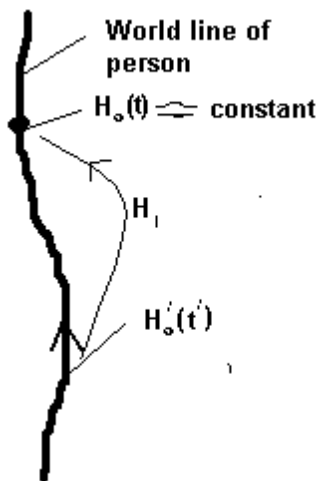
**a** and **b** are measures of energy.

- (3) It is important to understand the status of the sub-system's hamiltonian  $\mathbf{H}_0$ . It is representative of brain sub-system **STRUCTURE**. In particular, the sub-system responsible for memory recovery. It is assumed that the sub-system structure alluded to here includes matter, charge and field distributions – particularly the coherent electromagnetic field modes referred to earlier.

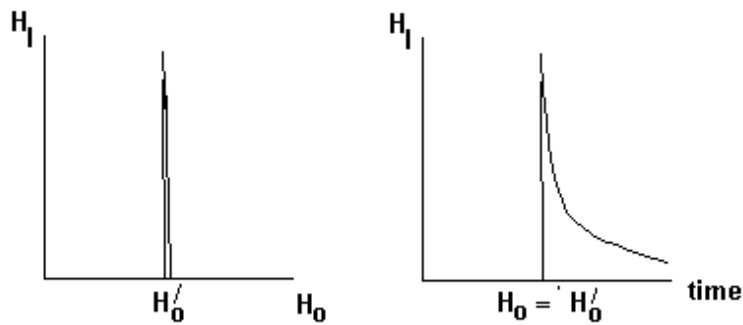
Thus, in this simplified model, during time  $d\mathbf{t}$ ,  $\mathbf{H}_0$  remains constant (= a, say), after which it changes by intended focusing or by default random relaxation to some quiescent arrangement (= b, say).



The idea that a hamiltonian can represent a given system structure and, in particular to be used to describe even identical copies of living systems has been considered by Dyson [11] in his “scaling hypothesis”. Dyson originally studied such system representations to determine whether life could continue indefinitely in flat or expanding universes. Indeed, although it may not be clear initially, the theory developed in this paper would have profound implications for the continuation of life in the universe, irrespective of whether it is open or closed.



(4) If the focusing of  $\mathbf{H}_0$  by the brain results in a hamiltonian  $\mathbf{H} = \mathbf{H}_0 = \mathbf{H}_0'$  where, [up to unitary transformations]  $\mathbf{H}_0'$  describes a past arrangement, then



atemporal connections ( $\mathbf{H}_I$ ) exist (are switched on when  $\mathbf{H}_0 = \mathbf{H}'_0$ ), see diagrams above, such that hamiltonian  $\mathbf{H}_0$  can be perturbed from the past by  $\mathbf{H}_I$ , thus causing transitions between the eigenstates  $\frac{1}{2}h_i >$  of the system's energy eigenbasis.

Note  $\frac{1}{2}h_i >$  is the energy eigenbasis of  $\mathbf{H}_0$  system

$\frac{1}{2}h'_i >$  is the energy eigenbasis of  $\mathbf{H}'_0$  system

(5)  $\frac{1}{2}h'_i >$  corresponds to a particular arrangement of the brain subsystem, which we experience as a 'memory'.

If  $\mathbf{H}_0$  can be varied such that, at some stage the full hamiltonian of the sub-system

$$\mathbf{H} = \mathbf{H}_0 = \mathbf{H}'_0$$

then

$\frac{1}{2}h_i > = \frac{1}{2}h'_i >$  up to a rearrangement of indices.

e.g. at time  $\mathbf{t}$ ,

$$\mathbf{H} = \mathbf{H}_0 + \mathbf{H}_I(\mathbf{t})$$

And  $\mathbf{H}_I(\mathbf{t}) = \text{an atemporal perturbation}$

Note – There is nothing new here (apart from the atemporal perturbation). For example, a simple hydrogen atom in the present has the same Hamiltonian and energy eigenbasis as it had, or indeed any other hydrogen atom had in the past.

(6) For simplicity I restrict the eigenbasis to just 2 discrete eigenstates – not unreasonable for small  $\delta t$ .

\* Define the anti-kronecker delta:

$$d^{mn} = \begin{cases} 1 & \text{for } m = n \\ 0 & \text{for } m \neq n \end{cases}$$

where  $m, n$  can take values 1,2 corresponding to the two eigenstates available during  $\delta t$

\* Define the Inverse commutator for the operators  $A, B$ :

$$d[A, B] = \begin{cases} 1 & \text{for } A, B \text{ commute} \\ 0 & \text{for } (AB - BA) \neq 0 \end{cases}$$

e.g. if  $A, B$  do not commute  $d[A, B] = 0$

Hence for  $H_0 = H_0'$   $d[H_0, H_0'] = 1$

Now define for  $H_0 = H_0'$

$d_{nL} = \langle h_n | h_L' \rangle = \text{either } 1, 0$

e.g.  $d_{nL} = \text{normal kronecker delta} = \begin{cases} 1 & \text{for } n = L \\ 0 & \text{for } n \neq L \end{cases}$

$|h_n\rangle$  is a current state of system with  $H = H_0$

$|h_L'\rangle$  is the LAST state of (the) system with describing hamiltonian  $H_0'$

Again, when  $H_0 = H_0'$  then  $d[H_0, H_0'] = 1$

i.e. the state of the system at the end of  $\delta t$  in some past interval of the person's world line is one of either  $|h_1'\rangle$  or  $|h_2'\rangle$ . Whichever it is, we label this as  $|h_L'\rangle$

(7) The atemporal perturbation  $H_I(t)$  causes transitions of the present state such that the current state is driven into the last state (memory) corresponding to  $|h_L'\rangle$ . I claim that this is how remembering of a past event occurs!

This is less of an assumption than it is a consequence of the mathematical development given later.

(8) Energy exchange Postulate: this is described on Page 15

## Summary of the memory or remembering process

1. The brain “tunes” the subsystem by varying its structure randomly i.e.  $\mathbf{H}_0$  is varied.
2. Whenever the present subsystem structure is identical in form to some past existing structure i.e. when  $\mathbf{H}_0$  corresponds  $\mathbf{H}_0'$ , the system experiences perturbations  $\mathbf{H}_1(t)$  “from the past” which drive the state of  $\mathbf{H}_0$  to the last existing state (memory) that the system, described by  $\mathbf{H}_0'$  had in the past.

Note that the symbol  $\mathbf{H}_0'$ , is used to indicate the variability of  $\mathbf{H}_0$ ,

when  $\mathbf{H}_0 = \mathbf{H}_0'$ , the state of system is driven to  $1/2h'_L>$

3. Note that the brain acts as an aerial here. Any damage to the brain would, of course, spoil reception just as would damaging any aerial.
4. The mathematical approach followed in this work uses the standard approach of time dependent perturbation theory, which can be found in any basic textbook on quantum mechanics. Because I have limited the discussion to the case of just two states for a given time interval  $\delta t$ , means that exact results can be obtained for such a period, as opposed to the usual approximate results of perturbation theory. The basic idea is to calculate the time development of a system described by a time independent hamiltonian  $\mathbf{H}_0$  which is perturbed by a time dependent influence described by  $\mathbf{H}_1(t)$ . The time dependent description of the system obtained is expressed in terms of the eigenstates and eigenvalues of  $\mathbf{H}_0$ .

## THE MODEL

For a perturbed system:

$$\mathbf{H} = \mathbf{H}_0 + \mathbf{H}_1(t)$$

and we have the eigenvalue equation

$$\mathbf{H}_0 1/2h_n> = E_n 1/2h_n>, \quad n = 1,2$$

In the absence of any perturbation, the system would remain in the original eigenstate  $|\frac{1}{2}h_n\rangle$  with eigenvalue  $E_n$  forever!

Suppose though, at  $t = 0$ , the state of the system is

$$|A\rangle = \sum_n \dot{C}_n |h_n\rangle$$

thus the initial state is some linear superposition of the unperturbed energy eigenstates.

Standard perturbation theory gives for  $H_I \neq 0$

$$|A(t)\rangle = \sum_n \dot{C}_n(t) e^{-\frac{2\pi i E_n t}{h}} |h_n\rangle$$

Where  $h = \text{Planck's constant}$ .

Schrödinger's equation gives

$$\frac{i\hbar}{2\pi} \frac{d}{dt} |A(t)\rangle = H |A(t)\rangle = (H_0 + H_I) |A(t)\rangle \quad (1)$$

**The righthand side of (1) gives:**

$$(H_0 + H_I) |A(t)\rangle = \sum_n \dot{C}_n(t) e^{-\frac{2\pi i E_n t}{h}} (E_n + H_I) |h_n\rangle \quad (2)$$

**The left hand side of (1) gives:**

$$(H_0 + H_I) |A(t)\rangle = \sum_n \dot{C}_n \left( \frac{i\hbar}{2\pi} \frac{dC_n(t)}{dt} + C_n(t) E_n \right) e^{-\frac{2\pi i E_n t}{h}} |h_n\rangle \quad (3)$$

Equating the right hand sides of (2) and (3), and then left multiplying by  $\langle h_m |$ , gives, after interchange of  $m$  and  $n$ , the standard result.

$$\frac{i\hbar}{2\pi} \frac{dC_n}{dt} = \sum_m \dot{H}_{nm}(t) e^{iW_{nm}t} C_m(t) \quad (4)$$

where  $\mathbf{H}_{mm}(\mathbf{t}) = \langle h_n^{1/2} \mathbf{H}_I(\mathbf{t})^{1/2} h_m \rangle$

and  $W_{nm} = (E_n - E_m) / (\hbar/2\pi)$

Note again that  $n, m = 1, 2$  only, for simplicity (e.g. only 2 different memory states are accessible for the period  $d\mathbf{t}$  with the system described by  $\mathbf{H}_0$  – one of which may just be no memory at all, a null state perhaps). This restriction is of course, not unreasonable, especially for arbitrarily small intervals  $d\mathbf{t}$ . It is also assumed that the diagonal elements of the perturbing hamiltonian  $\mathbf{H}_{mm}(\mathbf{t})$  are zero – a special but common case.

Final assumption The Energy Exchange Postulate: the atemporal piece  $\mathbf{H}_I$  is a real exchange of energy but it occurs in the present. The nature of  $\mathbf{H}_I$  is determined by some form of coding within the space time itself indicating to the present system how energy exchange with the environment (current) must occur to drive the system into a particular state – namely that which corresponds to one which once existed e.g. there is no actual energy-momentum transferred from past to future. To this end I propose the following for the probability amplitudes of  $|\mathbf{A}(\mathbf{t})\rangle$ :

$$C_n(\mathbf{t}) = \frac{1}{\sqrt{2}} [2(d_{nL} - (-1)^{d_{mL}} e^{-k\mathbf{t} - \ln 2})] \frac{d\mathbf{H}d^{mn}}{2} \quad (5)$$

Where  $k = \text{constant}$  and  $d\mathbf{H} = d[\mathbf{H}_0, \mathbf{H}_0'] = 1$  i.e.  $\mathbf{H}_0 = \mathbf{H}_0'$

$n$  can take values = 1, 2 and  $m = \begin{cases} 1 & \text{when } n = 2 \\ 2 & \text{when } n = 1 \end{cases}$

The anti- Kronecker term is included for later convenience.

Now consider the case  $L = 1$  ( $L$  stands for “Last”)  
i.e. a (last) past eigenstate was  $\frac{1}{2}h'_i \rangle = \frac{1}{2}h'_1 \rangle = \frac{1}{2}h'_L \rangle$

For the two cases  $n = 1$  and,  $n = 2$  with  $d\mathbf{H} = 1$ , and  $d^{mn} = 1$

$$|C_1|^2 = (d_{1L} - (-1)^{d_{2L}} E)$$

$$|C_2|^2 = (d_{2L} - (-1)^{d_{1L}} E)$$

Where, for later simplicity, the substitution  $\mathbf{E} = \mathbf{e}^{-kt - \ln 2}$  has been made.

Note that for either case  $\mathbf{L} = 1$  or  $\mathbf{L} = 2$ , that we have

$$|\mathbf{C}_1|^2 + |\mathbf{C}_2|^2 = 1 \quad \text{as required for normalised probability amplitudes.}$$

Also even if  $\mathbf{H}_0$  is **not** equal to  $\mathbf{H}_0'$  then  $d\mathbf{H} = \mathbf{0}$  and  $\mathbf{C}_1 = \mathbf{C}_2 = \frac{1}{\sqrt{2}}$  as required.

Equation (5) becomes for  $n = 1, m = 2$ :

$$\mathbf{C}_1 = \frac{1}{\sqrt{2}} [2(d_{1L} - (-1)^{d_{2L}} \mathbf{E})] \frac{d\mathbf{H} d^{mn}}{2}$$

$$\backslash \frac{d\mathbf{C}_1}{dt} = \frac{d\mathbf{H} d^{mn}}{\sqrt{2}} \frac{\mathbf{kE}(-1)^{d_{2L}}}{[2(d_{1L} - (-1)^{d_{2L}} \mathbf{E})]^{1 - \frac{d\mathbf{H} d^{mn}}{2}}} \quad (6)$$

But from equation (4)

$$\frac{i\hbar}{2p} \frac{d\mathbf{C}_1}{dt} = \dot{\mathbf{a}}_m \mathbf{H}_{1m} e^{i\omega_{1m}t} \mathbf{C}_m$$

$$= \mathbf{H}_{12} e^{i\omega_{12}t} \mathbf{C}_2 \quad (7)$$

since  $n = 1$  implies  $m = 2$  i.e.  $\mathbf{H}_{11} = \mathbf{H}_{22} = \mathbf{0}$



Equation (6) implies

$$\begin{aligned} \backslash \frac{ih}{2p} \frac{dC_1}{dt} &= \frac{dH d^{mn}}{\sqrt{2}} \frac{ih}{2p} \frac{kE(-1)^{d_{2L}}}{[2(d_{1L} - (-1)^{d_{2L}} E)]^{\{1 - \frac{dH d^{mn}}{2}\}}} \\ &= H_{12} C_2 e^{iw_{12}t} \quad \text{from equation(7)} \end{aligned}$$

$$\text{or } \frac{dH d^{mn} kE(-1)^{d_{2L}} ih}{2p[2(d_{1L} - (-1)^{d_{2L}} E)]^{\{1 - \frac{dH d^{mn}}{2}\}}} = H_{12} e^{iw_{12}t} [2(d_{2L} - (-1)^{d_{1L}} E)]^{\frac{dH d^{mn}}{2}}$$

\

$$H_{12} = \frac{dH d^{mn} kE(-1)^{d_{2L}} i h e^{-iw_{12}t}}{2p[2(d_{1L} - (-1)^{d_{2L}} E)]^{\{1 - \frac{dH d^{mn}}{2}\}} [2(d_{2L} - (-1)^{d_{1L}} E)]^{\frac{dH d^{mn}}{2}}}$$

or generally

$$H_{nm} = \frac{ih dH d^{mn} kE(-1)^{d_{mL}} e^{-iw_{mn}t}}{2p[2(d_{nL} - (-1)^{d_{mL}} E)]^{\{1 - \frac{dH d^{mn}}{2}\}} [2(d_{mL} - (-1)^{d_{nL}} E)]^{\frac{dH d^{mn}}{2}}}$$

NOTE that for  $n = m$ ,  $H_{nm} = 0$  as required

since  $m = n \Rightarrow d^{mn} = 0$

We can re - write the earlier equation for  $H_{nm}$  as

$$H_{nm} = i e^{-i\omega_{nm}t} X_{nm} \quad (8)$$

$$\text{where } X_{nm} = \frac{\hbar}{2p} \frac{dH d^{mn} k (-1)^{d_{mL}} E}{[2(d_{nL} - (-1)^{d_{mL}} E)]^{\frac{1}{2}} [2(d_{mL} - (-1)^{d_{nL}} E)]^{\frac{1}{2}}}$$

and in particular,

$$H_{12} = i e^{-i\omega_{12}t} X_{12}$$

thus for a given value of  $L$  ( $= 1$  or  $2$ )

$$X_{21} = - X_{12}$$

$$\backslash \quad H_{21} = - i e^{i\omega_{12}t} X_{12}$$

and

\  $H_I$  is Hermitian

$$H_I = \begin{pmatrix} \text{æ } 0 & H_{12} \ddot{0} \\ \text{ç } H_{21} & 0 \ddot{0} \end{pmatrix} = \begin{pmatrix} \text{æ } 0 & H_{12} \ddot{0} \\ \text{ç } H_{12}^* & 0 \ddot{0} \end{pmatrix} \quad (9)$$

Suppose now that  $L = 1$  i.e. the last eigenstate was  $|h'_L\rangle = |h'_1\rangle$

then  $n = 1$ ,  $m = 2$  and

$$H_{12} = \frac{\hbar k}{4p} e^{-i\omega_{12}t} \sqrt{\frac{E}{1-E}}$$

Now we see that since  $E = e^{-(kt + \ln 2)}$  (chosen for convenience), that when  $t = 0$

$$\sqrt{\frac{E}{1-E}} = 1$$

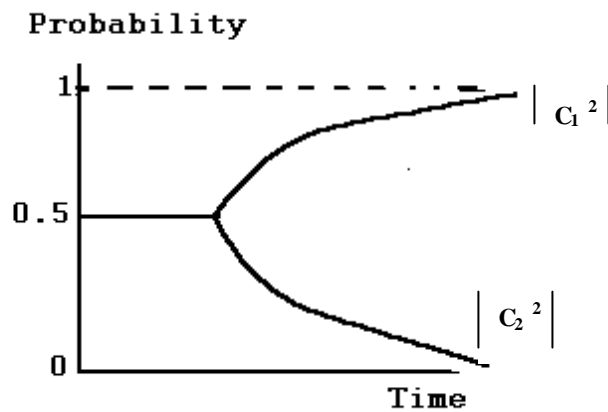
Thus for  $L = 1$ ,  $dH = 1$ ,  $d^{mn} = 1$ , and  $m = 2$ ,  $n = 1$

$$\text{Equation (5) } \Rightarrow C_1 = \frac{1}{\sqrt{2}} [2(1 - e^{-(kt + \ln 2)})]^{\frac{1}{2}}$$

$$|C_1| = (1 - e^{-kt - \ln 2})^{\frac{1}{2}},$$

and

$$|C_1|^2 = 1 - e^{-kt - \ln 2}, |C_2|^2 = e^{-kt - \ln 2} \quad (10)$$



Thus equation (10) implies that if  $L = 1$  and  $\mathbf{H} = \mathbf{H}_0 + \mathbf{H}_1$  then, the probability that the system will be found in the same state (memory) as it was in the past approaches unity with time (i.e. we are successful in trying to remember something by the method of variation of  $\mathbf{H}_0$ ). This happens when the state is driven by the atemporal  $\mathbf{H}_1$  piece to the correct memory.

A general expression for  $\mathbf{H}$  would be:

$$\mathbf{H} = \mathbf{H}_0 + d[\mathbf{H}_0, \mathbf{H}_0'] \mathbf{H}_1 \quad (11)$$

and when the brain can randomly tune, or change  $\mathbf{H}_0$  (implied by  $\mathbf{H}_0'$  symbol), then when  $\mathbf{H}_0 = \mathbf{H}_0'$  the atemporal  $\mathbf{H}_1$  piece is “switched on” ( $d[\mathbf{H}_0, \mathbf{H}_0'] = 1$ ) driving the memory to be the same as when the brain was last in that state ( $L = 1$  here).

Perhaps so-called mediums and clairvoyants etc. have a more able tuning capability than most, i.e. they learn to make

**H<sub>0</sub>**   »   **H<sub>0</sub>'**           for certain brain sub-systems, hence gaining some (?) access  
**them**       **subject**       to their (subject's) memories or world lines.

Also consider those people who, by the same method or by random genetic capability, find that at times they can make

**H<sub>0</sub>**   »   **H<sub>0</sub>'**  
**them**       **some person in the past now long dead.**

This would mean that the people have some atemporal access to memories of **other people**, not only from other places, but also from other times. This might also explain reincarnation type experiences.

Note that there are many so called “identical systems” e.g. electrons, hydrogen atoms etc. Therefore my suspicion would be that  $k \mu \frac{1}{N!}$ , where **N** = the number of identical systems.

This would make the time constant in equation (10) very long, therefore making the chance of (say), **all** hydrogen atoms in the universe ending up in the same state, very remote. However, in the very early universe, before particles of any particular mass or structure/charge were born, the story would have been very different. As soon as massive sub-atomic particles began to appear from the vacuum, the space-time would be coded by their hamiltonians and therefore further particle creations would become ever more limited to a given set of particle types. The same driving mechanism would apply! Perhaps this would explain the clearly well defined - but unexplained particle types e.g. electrons, protons etc. that we observe today. In a modern particle accelerator, collisions respect the conservation of mass-energy. However, why the mass energy distributions come out in well-defined values for the particular particles is not known. Perhaps then, the reason why say a proton arises out of such a collision is simply because, for a given range of energies the collision “remembers” similar collisions from the past. Coded in the space-time now is the data which drives the results of such collisions to produce the results they do. Moreover, how do fundamental particles “know” how to retain their existence or alternatively to decay after specific lifetimes? Perhaps things actually are as they are because they were as they were e.g. atemporality preserves past behaviour. This atemporal memory process could of course be extended to any “system”. However, being essentially a quantum effect, decoherence of complex classical systems would eventually limit the atemporal connections sufficiently for the world, at a macroscopic level, to manifest the effect in any striking way other than those suggested in this paper.

## Conclusions

In the model proposed in this paper, brain subsystems responsible for memory are described by the full hamiltonian

$$\mathbf{H} = \mathbf{H}_0 + d[\mathbf{H}_0, \mathbf{H}_0'] \mathbf{H}_I$$

The arrow indicates the brain's ability to vary its biochemical structure and  $\mathbf{H}_0$  describes the biochemical structures associated with remembering.

When the brain tries to remember something, it begins to change its biochemical structure. At this stage

$$\mathbf{H} = \mathbf{H}_0, \text{ i.e. } d[\mathbf{H}_0, \mathbf{H}_0'] = 0$$

because  $\mathbf{H}_0$  does not yet correspond with any past state of the brain  $\mathbf{H}_0'$  which once existed.

However, when  $\mathbf{H}_0 = \mathbf{H}_0'$ , then  $d[\mathbf{H}_0, \mathbf{H}_0'] = 1$  and the perturbation  $\mathbf{H}_I$  is "switched on". This atemporal perturbation drives the common eigenstates of the  $\mathbf{H}_0$  and  $\mathbf{H}_0'$ , to yield a single state (memory) coincident with the last state (memory) held by the brain when its appropriate subsystem was described by  $\mathbf{H}_0'$  e.g. remembering has occurred.

The energy exchange postulate ensures that energy and momentum are not passed forward from the past into the future – rather the space-time is somehow coded to indicate how energy exchange with the environment must occur to achieve memory recall.

However strange this may seem, no one as yet seems to know for sure whether the structure of space-time has anything to do with the way the mind works. Indeed we are back in the old story of reconciling quantum mechanics and general relativity. Many would argue that gravitational effects are irrelevant for explanations of both consciousness or memory since electric fields at brain level are so large compared to gravitational fields that there can really be no significant influence at this level. However Penrose [12], does argue convincingly that gravitational physics is important, if not a key component of consciousness. Indeed he considers that consciousness operates at the very level where general relativity and quantum mechanics find their interface with one another. Certainly the non-linear, general relativistic treatment of the interaction of colliding waves - whether electromagnetic, mixtures of electromagnetic and gravitational or entirely gravitational - has been shown to have significant effects on the development of the space-time following a collision. What is important is that the subsequent effects of these collisions can build up in magnitude, in spite of the minuteness of the original wave profiles. Indeed, under specific conditions of symmetry, minute interactions can even develop into real space-time singularities [13]. Thus it may be that the geometry of

space-time is just the factor, which makes all the difference to how human beings can be both conscious and able to codify and retrieve data.

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