A new quantum theoretical framework for parapsychology

Chris Clarke
School of Mathematics,
University of Southampton,
Southampton, United Kingdom,
SO17 1BJ
cclarke@scispirit.com

September 5, 2007

Abstract

An account is given of a recent proposal to complete modern quantum theory by adding a characterisation of consciousness. The resulting theory is applied to give mechanisms for typical parapsychological phenomena, and ways of testing it are discussed.

1 Introduction

A succession of writers (see Radin, 2006, for a popular survey) have associated parapsychological phenomena and quantum theory, their core motivation perhaps being the strong but imprecise feeling that, in Radin's words, "Experiments have demonstrated that the worldview implied by classical physics is wrong . . . in just the right way to support the reality of psi." Until recently it has been hard to turn this feeling into a firm, testable link between physics and parapsychology. Now, however, this possibility is offered by radically new approaches to quantum theory stemming from cosmology (Hartle, 1991; Page, 2001) and the influence on consciousness studies of the work of Chalmers (1995) and Hameroff and Penrose (1996).

Prior to these developments, most quantum theories of psi had been phrased in terms of substance dualism, involving an interaction between mind and matter which either causes and directs a collapse of the quantum state (e.g. Walker, 2000) or determines the nature of an (effective) "measurement" performed by the mind on the brain (Stapp, 2005). The background and motivation for this paper, on the other hand, is an approach inspired by a dual aspect philosophy, in which awareness/consciousness is an aspect of particular quantum systems (Clarke, 2007a)—although from a formal point of view the theory could equally well be formulated in terms of substance dualism. On this view, consciousness does not perform a measurement, which is a purely physical process, but it determines the nature of the universe *that we are aware of*. This produces a testable theory, in which there are far fewer unknown quantities than in a substance dualist theory where the nature of mind in itself remains a largely unknown area.

This paper also adopts a different approach to entanglement than that of Radin (2006). He writes that "Quantum entanglement as presently understood in elementary atomic systems is, by itself, insufficient to explain psi. But the ontological parallels implied by entanglement are so compelling that I believe they'd be foolish to ignore." While agreeing with the first sentence, I would qualify the second. Entanglement usually takes place indiscriminately with the whole of the environment and thus obscures quantum information rather than transmitting it. On the approach here, the explanations of many forms of psi do not use entanglement directly. Instead, they draw on Zeno-like effects (see section 2.4 below) paralleling those of (Stapp, 2005) but here arising from very different philosophical and physical perspectives.

The interpretation of quantum theory used here (Hartle, 1991; Clarke, 2007a,b) is based on the the use of "histories" (defined in section 2.3 below). The approach developed makes no alteration to the dynamics of physical events (the Hamiltonian). It adds to the quantum formalism only ingredients that are needed anyway in order to make most current versions of this interpretation complete. The theory has no free parameters still to be determined, though some structural aspects of its implementation need to be refined by further physical and parapsychological investigation. It is a theory which can stand in its own right as a likely implementation of requirements that have already been accepted in mainstream physics (Page, 2001). I will demonstrate that a theory of this form provides testable explanations for typical psi phenomena.

The account is in three parts. Section 2 describes in outline the historical background and quantum mechanical formalism to be used, section 3 presents mechanisms for typical parapsychological phenomena in terms of this formalism, and section 4 outlines some salient aspects of possible future parapsychological experiments to test these ideas.

2 Theoretical Context

2.1 Background to Quantum Theory

The theory involved here, which I will term "Algebra specification by consciousness" or ASBC, in based on our current understanding of quantum theory. As the enormous progress made in this area over the last 20 years is still little known outside specialist journals, I will summarise this first.

Quantum theory in its early days was characterised by the notion of the "collapse of the state" (or, in older writing, of the wave-function) which was supposed to be initiated by the process of observation. Precisely what characterised an "observation", and how it actually was responsible for the collapse, remained contentious, accounts including the intervention of human consciousness (from Wigner onwards) or the addition an extra physical layer of hidden variables (Bub and others). Groundwork for a different approach was laid by the first fully developed theory that dispensed with collapse: the relative state formalism of Everett (1957). This was assumed in subsequent work, but on its own it did not pinpoint which states could be regarded as classical and which quantum. A decisive step was taken by Daneri et al. (1962) who argued that distinctively quantum effects relied on the relative phases of quantum states (in the sense of the *phase* of a complex number), and showed that this phase information was lost in the course of the macroscopic amplification of a state, resulting in an essentially classical situation but without the invoking of "collapse". This loss of phase information became known as "decoherence" and formed the basis of the modern full theory of the

way in which classical behaviour emerges from a quantum world (Giulini et al., 1996) without the need to invoke collapse.

In parallel with this, the growth of quantum cosmology raised more acutely the need for a theory of the emergence of a classical world, for which a different approach was chosen based on "histories" (Hartle, 1991), developed in section 2.3 below. The two approaches of decoherence and histories are complementary, in that decoherence theory characterises the physical mechanism through which a given subsystem can behave classically, while the histories formalism describes how a sequence (or a space-time network) of such subsystems can build a probabilistic structure, and shows how decoherence enters into this to produce consistent probabilities. Both systems are incomplete, however, in that they only demonstrate that quantum theory is *consistent* with a classical structure without examining whether such a structure *necessarily* emerges, or whether the structure is in any sense unique. A key negative result here was that of Dowker and Kent (1996) showing that the requirement of classical logic did *not* single out a unique framework.

A further strand in the argument was added by Penrose (2004). Working from a picture that included the collapse of the state, he pointed out that general relativity (which must be included in any subsequent general theory, although it is still far from clear how this might be done) implied that not all quantum states could be superposed, and hence gave a criterion for when the quantum state had to collapse as a result of gravitational effects. This criterion can be translated into the language of the histories interpretation (Clarke, 2007a), without the need for state collapse, where it does much to reduce the arbitrariness of the choice of subsystems that is required in the histories and decoherence approaches.

The theories presented so far, while demonstrating the consistency of quantum theory with a classical world, are incomplete in that they still do not explain the necessity of a classical world. For this two further elements are needed: a physical characterisation of what systems have consciousness, and a means of overcoming the problems raised by Dowker and Kent (1996) without interfering with the basic (rigorously tested) dynamics of quantum theory. The first of these, the criterion for consciousness, has been highlighted but not solved by Page (2001), and it is recognised that the solution must necessarily be to some extent speculative in the current nascent state of consciousness research. A possible solution has been proposed by Donald (1990, 1995), but it does not match well with the data from biology and consciousness studies. I have explored a proposal of Ho (1998), based on observations of microorganisms, that systems with consciousness are *extensively coherent* systems (see subsection 2.3, 3c, below). Such a system is by definition one where any two of its parts are maximally entangled, but it is effectively unentangled with systems outside itself. The virtue of this definitions is that, being at a very basic level, it does not insert "by hand" factors such as memory, carbon-based life and so on which are likely to be explained by evolutionary theory; that is, it does not presuppose the details of established biology.

The second of the elements that must be specified in order to make the classical world a consequence of scientific theory, and to answer the challenge of Dowker and Kent (1996) just described, concerns the structure of propositions. In order to understand this, we need to note first that quantum theory tends to be expressed using two alternative languages: based either on logical concepts, or on concepts from linear algebra. In the language of logic, a *proposition* is a statement that can turn out to be either true or false; and ascertaining this could be regarded either as a measurement or as an act of consciousness. In linear algebra language, on the other hand, a proposition is represented by a projection of the space of quantum states into itself, and the

proposition is true if this projection leaves the current state unchanged, and false if it projects the current state to the zero vector in state space. In either case, a collection of propositions together with the usual logical connectives OR, AND and NOT, is called an *Algebra*, and a *Boolean Algebra* if these connectives satisfy the rules of classical logic. The second element needed for completing quantum theory is then a process that selects either a Boolean algebra of projections, or a subset of such an algebra, over each extensively coherent (and so conscious) subsystem. Following the proposal of Stapp (2005), we suppose that it is an act of *consciousness* that singles out a Boolean algebra σ or a subset ς of one, as described in the next section. I will refer to the propositions in the selected (subset of a) Boolean algebra as being *asserted* by this dynamic of consciousness.

2.2 Consciousness

My consciousness of the world is not a pure receptivity of raw data: in addition there is an active side, in that data is inevitably *construed* (Kelley, 1955) into rocks, people, stars etc.; and this not just by verbal association, but be a preverbal processing into significant elements (Teasdale and Barnard, 1993). Though many details of this process are still to be filled in, we can suppose that it takes place through a sequence of stages of neural processing which in its initial stages is well approximated by a description using classical mechanics. In the final stages that manifest to consciousness, however, it is fruitful for both physics and psychology to conjecture that the process is quantum mechanical in the sense that non-commuting propositions (see Note 2 at the end) play an essential role.

As shown by Kelley (1955), the process of construal is fluid and constantly developing: with each moment of perception there is scope for a new construction, a new "framework of meaning", so to speak. This capacity constitutes the active aspect of consciousness through which it can affect the behaviour of the organism. In terms of the dual aspect approach to consciousness adopted here, the mental aspect of construal has as its physical correlate the selection of a particular subset of a Boolean algebra of propositions on the quantum of state of the final stage of processing.

In contrast to the dominant Copenhagen interpretation, which in some versions regards consciousness as the essential part of the process of observation, in the histories version of quantum theory the process of coming to consciousness, involving construal as just described, is quite distinct from *measurement*. The latter is a conventional physical process in which a microscopic state (the system) is coupled to a macroscopic state (the apparatus) so as to form a record. By contrast *consciousness* is a process independent from the ordinary dynamics of physics, operating entirely within the conscious system. The operation of consciousness is partly controlled by the effective state of the system (see Note 2 at the end) which brings into play the effect of information processing in the organism; but its details, which Penrose has argued are non-algorithmic, will require extensive future research.

Because measurement and consciousness have quite different origins, their structures are different. In a measurement the macroscopic state has a very short decoherence time as a result of interaction with the environment, which enables it to form a record. It produces a mixed state on restriction back to the microscopic system, but (since we are not assuming a mechanism for collapsing the state) it does not perform a selection of one particular outcome. In particular, this means that when the quantity being measured is binary (a proposition having the values TRUE or FALSE) the operation of negation operates in the usual way, so that finding not-A to be TRUE is equivalent to

finding A to be FALSE.

Consciousness reflects a very different logic, which arises from the peculiarities of our mental make-up. Though we identify the "I" with our inner verbal dialogue, it is becoming increasingly clear from experiments in cognitive psychology (Teasdale and Barnard, 1993; Barnard, 2004), now recently reinforced by neuropsychology (Dosenbach et al., 2007), that our mind is constituted by at least two distinct but closely interacting systems. It is not necessarily the case that all of these systems are aware in the sense used here; but it does seem from the data of meditative self-reflection (e.g. Sogyal Rinpoche, 2002) that the core of consciousness lies in a non-verbal system which, because of our self-identification with language, we (paradoxically) usually refer to as "unconscious". The non-standard logic of this area was first developed by Ignacio Matte Blanco (Matte Blanco, 1998) and subsequently clarified by Bomford (2005). Its significant points are that it does not possess the standard negation operation, and that it has a structure analogous to, but distinct from, quantum logic (Clarke, 2006), which makes it ideally suited to complementing quantum logic. Because of its non-standard logic there is *no* requirement that when A is in the set ς of asserted propositions, not-A need also be there. Thus ς need not be a full Boolean algebra. This will have crucial implications for parapsychology later. Though the principles that have just been specified above are rather general, they are already sufficiently precise as to give quite a clear idea of the general form of the theory. In particular, it will turn out that the general structure to be outlined will place strong constraints on what psi can or cannot do, making it more testable than conventional dualistic approaches to quantum theory.

It should be born in mind throughout that in the dual aspect approach taken here (which stems from the work of Spinoza — see Note 1 at the end of this paper), mental aspects such as consciousness and physical aspects such as extensive coherence (item 3c, section 2.3 below) have evolved together and are complementary views into the same reality. Extensive coherence does not "cause" consciousness, nor vice versa.

2.3 Quantum Histories

The notion of a history was first formulated by Griffiths (1984) and then transferred to a global context by Hartle (1991). The evolution of the idea can be characterised as a series of reformulations of quantum theory:

- from *probabilities for outcomes of a single measurement* (original quantum theory); to
- *correlations between outcomes of successive measurements*; to
- *probabilities for sequences of measurements* (original history interpretation); to
- *probabilities for an array of measurements in space-time* (Hartle's "generalised quantum theory"); to
- *probabilities for an array of moments of consciousness in space-time* (ASBC).

I will first give (in outline) the definition of how a history represents "an array . . . in spacetime", closely following (Hartle, 1991), and then indicate briefly how probabilities are linked into this. Fuller details are in (Clarke, 2007a).

1. **Loci**. The basic elements that form the basis for a history, termed *loci*, are specifications of a particular subsystem of the universe over a particular region of

space and time-interval—i.e. over a particular space-time region U. An example of a locus drawn from Hameroff and Penrose's theory of consciousness (Hameroff and Penrose, 1996) might be as follows. U would be the union of regions $U_1, \ldots, U_n$ each corresponding to one of a collection of cells (not necessarily connected) making up an organ or organs in the brain, all considered over a (variable) interval of time, and the subsystem associated with consciousness is described by a quantum space $\mathcal{H}$ of states of the conformational structure of the microtubules in the cells of U, together with a complementary space $\mathcal{H}'$ describing all the other degrees of physical freedom over U.

So formally,

(a) a *locus* consist of a triple $(U, \mathcal{H}', \mathcal{H})$, where U is a space-time set and $\mathcal{H}$ and $\mathcal{H}'$ are Hilbert spaces associated with U. The total quantum Hilbert space $\mathcal{H}_0$ over U can be represented as a subspace of $\mathcal{H}' \otimes \mathcal{H}$.

(b) It is also maximal in its extent in time while having the property that all events in U are determined by data at a single moment of time (a property known as global hyperbolicity).

Property 1b results in a time extent that in the centre of the region is of the order of magnitude of the time taken for light to cross the region, reducing to zero at the edges. This is the closest one can get in modern physics to an "instantaneous moment", since the latter cannot be defined in relativity theory.

2. **The consciousness** of a locus, which subjectively corresponds to the condition of extensive coherence (see 3c below), results in there being specified ("asserted") at each locus a particular subset ς of a Boolean algebra σ of propositions (i.e. projections) on $\mathcal{H}$. As described above, ς will in general not be full algebra).

3. **A history** consists of a set $(P_1, \mathfrak{L}_1), (P_2, \mathfrak{L}_2), \ldots$ of pairs in which

   (a) $\mathfrak{L}_1, \mathfrak{L}_2, \ldots$ are loci which are partially ordered with regard to their mutual causal relations (given any two $\mathfrak{L}_1$ and $\mathfrak{L}_2$ either $\mathfrak{L}_1$ is causally[1] prior to $\mathfrak{L}_2$, or vice versa, or they are entirely space-like related to each other), and

   (b) $P_1, P_2, \ldots$ are propositions from the sets ς associated with the respective loci.

   (c) Moreover it is required that each locus in a history is a region such that any two spatially defined non-overlapping parts making up the whole are fully entangled with one another. (See Clarke (2007a). This property is called *extensive coherence*.) Each locus is also maximal—as large spatially as it can be—while still exhibiting extensive coherence.

   Property 3c implements the criterion for subsystems that are aware. The propositions $P_1, P_2, \ldots$ appearing in a history will be referred to as *realised* at their associated loci. The combination of a realised proposition and its locus is interpreted as a *moment of consciousness* (Page, 2001).

Probabilities (or, more precisely, "weights" that can be interpreted as probabilities when the logic of the propositions in the history is classical) are then attached to histories by means of a function $p((P_1, \mathfrak{L}_1), \ldots, (P_n, \mathfrak{L}_n); \rho)$ (see equation (2) in Note 2)

[1] Note that "causal" is used here in the sense of relativity theory, as asserting the existence of a time-like or light-like connection between events, and not in the philosophical sense of causation considered later.

which associates a real number between 0 and 1 with each history, and where ρ is the initial state of the universe. In cases where the histories satisfy a classical logic (as can be shown to be usually the case) the values of this function reproduce exactly the probabilities for ordinary quantum theory. This function, discussed in more detail in Note 2, is a special case of the *decoherence functional* in conventional history theory (modified to this relativistic setting), which packages together the time evolution of quantum theory, its probability interpretation, and the criteria for there being a classical logic.

2.4 Zeno effects

Henry Stapp (Stapp, 2005) introduced a concept similar to ASBC (in a dualistic context) and emphasised the importance of the Zeno effect in understanding how consciousness acted in the world, rather than being a mere epiphenomenon. The conventional Zeno effect, which has now been well studied experimentally (Sudbery, 2002) refers to the situation where an unstable state is prevented from decaying by being observed continuously (an example of "a watched pot never boils"). It can easily be shown that if τ is the normal half-life for the decay of a state, and the state is observed at time intervals δt where thisis significantly less than τ then the half-life is extended to a time of order $\tau^2/\delta t$. In Stapp's dualistic setting, mind observes the brain in this way and thereby maintains preferred brain states that would otherwise be transitory. A similar process can occur in the ASBC approach, but by the inclusion of a succession of projections in a history with the minimum spacing allowed by Penrose's criterion; i.e. δt is now the Penrose time for the physical structure described by $\mathcal{H}$.

The question for parapsychology is, can the observed data from parapsychology experiments be explained by some such mechanism as this, involving applying Zeno-like observations or acts of consciousness to the entangled brain states of their subjects? If the Zeno process takes place by observations (Stapp) or by repeated moments of consciousness but using a full Boolean algebra of propositions, then it is hard to produce a plausible explanation of psi. If the minds of two subjects are entangled in a way that is implicitly (i.e. unconsciously) "known" to them, and they then observe/are aware of their own states and announce the results, then, with or without resorting to Zeno techniques, there will be an interesting correlation between what they say (see section 3.3.1 below). This is, however, not the protocol of a parapsychology experiment, in which typically the content of the consciousness of one subject is controlled by an input from an external random number generator—a completely different situation. The only way round this might be to use a "moving Zeno process" in which the Boolean algebra describing the observation is continuously rotated by the brain so that the projections initially describing A and not-A can be interchanged, the process being steered so as to produce the required final result. While this is theoretically possible, in the light of the argument in section 2.2, it seems much more likely that the mind uses consciousness with an incomplete set ς, and it is this option that I explore below.

If we allow ς to be less than a full algebra, generating the algebra σ, there are then two variants on the Zeno effect, which I will call *forcing* and *entrainment*.

1. Forcing is achieved by consciousness asserting, at a sequence of loci with time-spacing δt, a set ς which includes a projection P but not its negation not-P. This can be done, even when the quantum state in $\mathcal{H}$ is initially not in P, but merely has a non-zero component in P. With the conventional Zeno effect, as it occurs in laboratory observations, the first application of P could either produce the realisation of P or not-P, and subsequent applications would maintain it. In

ASBC, if not-P is not in ς then not-P will not be realised, the corresponding state will not be included in the history, and the moments of consciousness will continue until eventually either P is realised or the probability of P is reduced to nearly zero through interaction with external systems.

2. Entrainment is the result of including in a history a realised projection onto a state that is entangled with a particular state in the environment.

   Suppose that the apparent state α associated with a locus $\mathfrak{L}$ can be decomposed as

$$\alpha = \sum_i a_i \phi_i \otimes \epsilon_i \tag{1}$$

   with $\phi_i \in \mathcal{H}_1$ and $\epsilon_i \in \mathcal{H}_2 \otimes \mathcal{E}_U$ where $\mathcal{E}_U$ (the environment of U) consists of the states outside U. The states ϕ_i are a basis for $\mathcal{H}_0$ lying in the atomic elements of σ. A moment of consciousness realised at $\mathfrak{L}$ can produce an apparent state (equation (3) of Note 2) of the form

$$\alpha_k = \sum_{i \in s_k} a_i \phi_i \otimes \epsilon_i$$

   where all the ϕ_i for $i \in s_k$ are a basis for a single element A_k of ς (Clarke, 2007a).

   This new apparent state will then be effective in determining the states at all subsequent loci. In other words, the local moment of consciousness entrains all aspects of the environment that are entangled with it into the subsequent manifest universe, which emerges as a result of the joint interaction with the initial state of the universe through of the whole network of living systems. Consciousness, though it acts on the ϕ_i, necessarily restricts also the ϵ_i.

It will be clear that the conjunction of forcing and entrainment enables a living system to exercise a determining influence on the whole of the subsequent manifestation of the universe. Repeated inclusion in the history of a projection on a state in $\mathcal{H}$ that is entangled with an environmental state will in principle eventually bring about the manifestation of that environmental state unless this is countered by the competing effect of other organisms. In the next section I will describe how this can appear as phenomena such as psychokinesis and telepathy.

3 Prototypic examples from parapsychology

In this section I will briefly describe the application of ASBC to examples representative of some main experimental categories in parapsychology, after which I will discuss how the theoretical insight afforded by the theory here can open up new lines of enquiry for examining both quantum theory and its parapsychological effects.

3.1 Psycho-kinesis

As an example here I will use Peoc'h's chick experiment (Peoc'h, 1988). Although it has been criticised (Johnson, 1989) and the criticism has been countered by Peoc'h (and the controversy has continued since), I will be using it here as an illustrative example of the sort of effect that is to be expected under the present theory rather than as evidence for the validity of PK.

The report concerns a batch of chicks who were hatched in the presence of a "robot": a cylindrical device which moved in a straight line punctuated by random changes in direction, under the control of a random number generator. The chicks imprinted on the robot, so that when free they would follow it around. For the experimental sessions they were confined in a cage which was placed on a randomly chosen side of a compound in which the robot moved (see figure 1). The experimenter reported that, on a statistically significant proportion of occasions, the robot's movements were mainly confined to a region close to the side of the compound where the chicks were installed. Moreover (Fenwick, 1996) he further claimed that the same results were obtained when the robot was controlled not by a direct connection with a random generator, but with a signal that had been pre-recorded on a floppy disc 6 months earlier!

[Insert figure 1 around here]

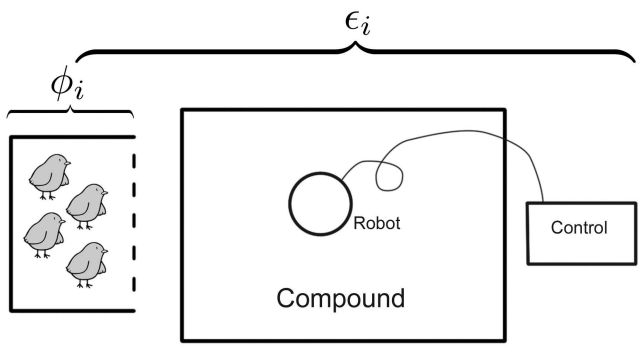

Figure 1. Schematic diagram of Peoc'h's chick experiment. ϕ_i and ϵ_i, corresponding to equation (1) above, indicate respectively the states of the conscious system of the chicks and of the environment together with the other systems of the chicks.

A complicating factor in analysing this experiment is the multiplicity of organisms involved: do we regard the chicks as independent organisms each engaging with the robot, or could their brains, through a mutual entanglement of their states, become jointly coherent, as a single organism? Is the experimenter Peoc'h watching the experiment and also exercising his own influence (raising the intriguing possibility that the chicks might in fact be irrelevant to the effect)? The ASBC formalism is explicitly designed to accommodate such simultaneous loci of consciousness; but for simplicity let us here think in terms of only a single organism, the joint-chicks.

We have here the conjunction of forcing and entrainment described in the previous section. Taking the later variation described by Fenwick, let us suppose they are based on a random number generator controlled by a quantum mechanical effect such as nuclear decay. (Alternative mechanisms are discussed in section 4 below.) The output of this generator is recorded as low intensity variations in the magnetisation of the floppy disk, which has been safely locked up so that no living system has become aware of these data prior to the experiment. The apparent state prior to the chicks experiment will then include a superposition of states $\sum_i a_i \psi_i$, each component of which describes a position and velocity of the robot, together with a corresponding matching set of data on the floppy disk.

The chicks visually observe the robot and thereby entangle their (joint) brain-state with this external superposition (see equation (1) above and figure 1). As a result

of their imprinting the chicks devote a major part of their conscious process to the assertion of a projection of their joint state onto a state where they perceive the robot to be nearer to them than some critical comfort distance.

Forcing and entrainment then restrict the subsequent apparent state to a superposition containing only positions less than this distance. The subsequent operations of Peoc'h, acting at a causally succeeding locus, further reduce this superposition to a particular sequence of positions and a particular (necessarily consistent) content of the disk.

This example demonstrates that the ASBC framework give a very natural account of the process. Without such a framework, it would seem that the chicks had somehow exercised psychokinesis retroactively on the detailed mechanics of the random number generator, defying both the laws of physics and the intellectual power of chicks. With this framework, it is apparent that all they were doing was concentrating hard on their "mother" and wanting it to be near. We can also note that most of the foregoing analysis can be applied, *mutatis mutandis*, to many other standard (and more replicable) psychokinesis protocols, though for most of these the strength of the effect is much lower than that reported by Peoc'h.

3.2 Target guessing

[Insert figure 2 around here]

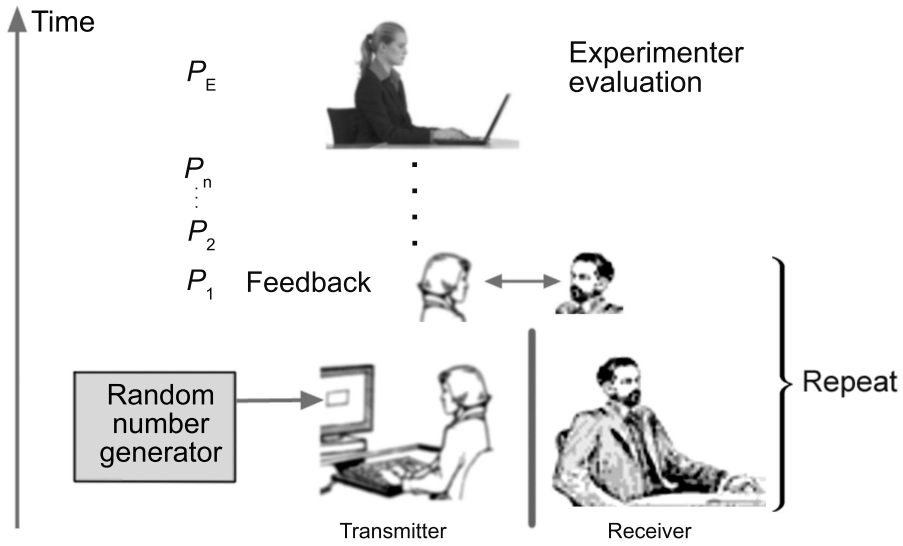

Figure 2. Schematic depiction of a typical target-guessing experiment. P_1, P_2 etc. indicate propositions asserted by the receiver or the experimenter at successive moments of consciousness (loci).

Figure 2 depicts in broad outline a protocol for a variety of parapsychological experiments. Many variation can be made: the random number generator controlling the process could act on many principles, feedback could be immediate after each "guess", or be given after the whole session, or be omitted, the "transmitter" person could be omitted for pure clairvoyance, and so on. I shall assume that there is at least one instance of feedback in each session. In broadest terms, however, the basic structure

remains similar to Peoc'h's experiment in involving a random number generator whose influence is subsequently entangled with consciousness; but we now have an explicit succession of moments of consciousness linked to the outcome, making it appropriate to describe the process in terms of a history. The process could thus be described as involving a sequence $\{P_i \mid i = 1, 2, \ldots, n\}$ (with at least one member) of propositions at moments of consciousness (loci) by the "receiver", and at least one proposition P_E at a moment of consciousness by the experimenter. For example, the proposition P_E in the set ς_E being asserted by the experimenter might be the occurrence of a statistical significance of better than 1%. The probability of some or all of these propositions being satisfied is then given by a function of the form of equation (2) in Note 2 which links all the propositions. Because of the entanglement of the effective state at the locus of P_i with the receiver's memory state, the entanglement of the effective state at P_E with the final record of the whole series, and the causal connections between the these and the individual random number generator states, there will be a positive correlation between the probabilities of each of the P_i and P_E.

Two effects arise from this positive correlation. (a) The individual probabilities of the P_i are enhanced by the effectiveness of the assertion of the set containing P_E by the experimenter, producing an "experimenter effect". (b) The probabilities of each of the P_i (success in individual sessions) will be enhanced by the feedback. Both of these effects might be regarded as a form of retroactive causation, in the sense of causation that operated in a direction opposite to the usual arrow of time (Reichenbach, 2003). This would, however, be a misleading way to think about it. The arrow of time enters into the histories interpretation through the time-displacement maps Λ in equation (2). These represent normal dynamical causation with is made unidirectional by thermodynamic effects that are ultimately traceable to the expansion of the universe. The correlation between the different Ps is of a logical nature: as described in Note 2 it is identical to the correlation existing between logically connected propositions asserted a single moment of time but is in itself independent of time. This non-causal correlation is analogous to Jung's concept of synchronicity. On this viewpoint there is, because of the time-independence of this structure, no essential difference between precognition and telepathy.

3.3 Spontaneous psi

I will examine here two general types of spontaneous occurrence, the first suggesting a different sort of mechanism from the forgoing cases and the second suggesting an instance of the previous mechanisms.

3.3.1 Empathic telepathy

By this title I mean the spontaneous occurrence of apparently paranormal communication between two connected individuals. This is a large category, and I will examine only the phenomena exemplified by the "but *I* was just about to phone *you*!" syndrome, when a particular idea or image occurs to two individuals, well known to each other, at the same time. This case differs from target-guessing in that the random number generator is replaced by a second organism, so that both organisms select the apparent state as part of the history before there is any comparison between them. An explanation through forcing, applied to a state which is not yet selected, is therefore ruled out.

This sort of occurrence seems to be most frequently reported among pairs of organisms, hereafter referred to as Alice and Bill, who have close and sympathetic rela-

tionships. In that case we could postulate what might be called a common or shared (component of) mind. By this I mean that there exists a locus $\mathfrak{L}_{AB} = (U, \mathcal{H}', \mathcal{H})$ in which U consists of two disconnected parts U_A and U_B, one in the brain of Alice and one in the brain of Bill.[2]. By definition of extensive coherence (item 3c, subsection 2.3), the states over these two components will be highly entangled. In particular, if we denote states that correspond to particular ideas over U_A by $\alpha_A^1, \alpha_A^2, \ldots$ and similarly for B, where the superscripts label the same idea for A and B, then we can expect the occurrence of states of the form $\sum_i a_i \alpha_A^i \otimes \alpha_B^i$, If in addition we suppose that the occurrence of a situation where communication is appropriate results in the repeated assertion within $\mathfrak{L}_{AB}$ of a projection on states of this form, then forcing will take place as in the previous example, and the result will be a raised probability of Alice and Bill entertaining the same ideas at a given time.

This example is of particular theoretical interest, because, unlike the mechanisms just described for parapsychology experiments, it involves the entanglement of minds discussed by Radin (2006) (section 1) – or more precisely, the entanglement of two parts of a system that is being maintained in a state of extensive coherence as a result of being a mind. This maintenance has to be achieved by the repeated assertion of propositions that project onto particular entangled states of the two parts, which is part of the *conatus* (Note 1) that characterises minds. Since entanglement is by definition between states that are not time-related, it brings in a condition of simultaneity, which again distinguishes it from the previously discussed effects.

A further distinction from the previous cases is that the underlying mechanism here could give rise to a distance effect. This is because of condition 1b in section 2.3, which implies that the temporal extent of a locus is (approximately) the light-crossing time od its spatial extent. Each component of the joint mind would thus have to maintain its quantum phase, through internal shielding against decoherence, for up to 40msec in the case of long-distance telepathy on earth – a very severe constraint. The mechanism just described is also the most likely candidate for the possible correlation (Grinberg-Zylberbaum et al., 1994; Sabell et al., 2001) of EEG records between distant subjects, where time-synchronisation is a vital aspect.

3.3.2 Spontaneous precognition

This case is of interest because it appears to combine the time independence of subsection 3.2 with the spontaneous empathic connection of 3.3.1 above. It seems to be of widespread occurrence, and happens to be a phenomenon that I have found striking in my personal experience in the form of precognitive dreams that I have either reported to others or recorded in my journal at the time of their occurrence. I will therefore take precognitive dreams as a particular example of spontaneous precognition in what follows.

When a later experiences matches salient points of an earlier dream, this is felt to be remarkable because the subject thinks that such a match would be "extremely improbable by chance". If one were to try to make quantitative this subjective impression (and the area is notoriously difficult to analyse statistically), one might suppose that both our dreams and our experiences of events combine a number of elements whose possible range, though large, is finite, so that one could, at least very roughly, assign

[2]Hitherto I have allowed a tacit assumption that within a human being there exists a unique physical system that carries a coherent state, and that this constitutes "the" consciousness of the person. There is, however, significant evidence that this is not so (Teasdale and Barnard, 1993; Douglas-Klotz, 2001; Lockwood, 1989)

probabilities to particular combinations. For instance, one dream of mine contained the following elements: a book bound in a distinctive yellow ochre colour without other ornament, a Catholic mass and myself weeping, together with other elements strongly correlated with the Catholic mass element. These elements were all fairly rare in my experience, and there seemed only weak correlations between them, so that the dream itself appeared curious enough to be noted. When, a couple of weeks later, an event occurred that combined all these elements at the same moment of time, then *if the dream and the event were uncorrelated* the occurrence of both would seem very unlikely indeed, and this in turn might suggest that was in fact some causal mechanism operating which did correlate the dream and the subsequent event.

Setting aside the question of whether the statistical guesses just made are in fact reliable (something that in this particular case could indeed by seriously challenged) we can examine the light shed on this by the present theory. First, entanglement between the consciousness of the dream and the consciousness of the later event are ruled out: events that are related by separation in time are not in quantum theory regarded as constituting a single compound event, so that entanglement is only definable between events that not separated in time. Second, the theory as at present articulated deals only with moments of consciousness and not with the concept of an enduring self or soul; so that from the point of view of the mental aspect of the world no significance attaches to two experiences belonging to the same person. (The theory thus differs significantly from the ideas of, for example, Sheldrake (1988).) There is thus no basis for the physical connection between the two loci that characterised the previous case of sub-subsection 3.3.1.

On the other hand, part of the mechanism of the target guessing protocol in subsection 3.2 matches well with what is happening with the dream. The delight and fascination that I feel when a dream is verified is similar to that which I experience when a scientific prediction is verified, and in both the case of the experimenter in a target-guessing experiment and the case of my experience of significant events in daily life it could be said that a pre-conscious or unconscious assertion of a desire for a meaningful outcome (i.e. a "proposition") was satisfied. In both cases the two moments of consciousness are in fact correlated by virtue of their entanglement with contemporary records and memory traces. History theory does give a mechanism that connects them, although it is not strictly speaking a causal mechanism.

4 Experimentally testing algebra selection

Untestable theories are not worth the name, and one impetus behind the present work is to open up a theoretical area that will enable one to formulate possible areas for testing more precisely. Caution is, however, called for in this particular domain, because of the way in which the effects operate at the human level, all participants necessarily being involved, including the experimenter, in a strongly interlinked way. The distinctive features of this theory (presented here as a summary of what has gone before), which make it particulary open to refutation are as follows.

1. No physical forces other than those of conventional physics are being introduced.

2. Reality is jointly determined by all conscious organisms, within the constraints imposed by the probabilities of conventional quantum mechanics, by their asserting sets of propositions dependent on their effective quantum state, with a frequency of assertion limited by the Penrose time τ_P.

3. Conscious organisms are identifiable as all systems that are extensively coherent (any two parts are entangled and the system is spatially maximal with respect to this property).

Aspects of this, particularly regarding point 3 and the Penrose time, are testable by physical or neurophysiological means, but I shall focus here on parapsychological tests. I have already described (section 3.3.1 above) an area where there might be an observable distance effect, though that was not in a very reproducible area of parapsychology. Here I explore another line of inquiry suggested by the dominant role of the experimenter effect in these experiments, which stands in contrast to their usual analysis in terms of the transmission of information from one place/person to another. It is a prediction of this theory that an experimenter who is strongly motivated to obtain a particular result will consistently achieve that result more readily than an experimenter motivated to obtain the reverse result, even when their protocols are exactly identical. This possibility, which has often been reported in parapsychology and cited as evidence against all parapsychological effects, deserves careful investigation as means for distinguishing the mechanism presented here from information-passing mechanisms for parapsychology.

The mechanism involved in psi effects is, as we have seen, different in the randomised trials required for experimentation and spontaneous phenomena. Thus the nature of randomisation is a key factor in this approach. The previous examples have been phrased in terms of randomisation using a "quantum event" such as radioactive decay. This is sometimes contrasted with a "classical event" such as the generation of a large integer by an iterative process seeded by the clock time. This assumed distinction between quantum and classical randomness was taken for granted until the development of decoherence theory in the late 1970s. Before then, it was supposed that quantum mechanics took place only among microscopic objects (or arrays of such objects between which an unusual coherence had been established) and that there was an unambiguous distinction between the quantum world and the classical world, with the collapse of the quantum state mediating between the two. Quantum randomness was an inherent aspect of collapse, whereas classical randomness was a result of our ignorance of the exact initial state of the process giving rise to it. As described in subsection 2.1, this position was replaced by the current picture of decoherence and histories.

Within this new picture, a "classical" uncertainty is one deriving from a process, such as tossing a coin, whose physics can be accurately described without reference to quantum mechanics. The initial conditions of any such process, however, stem from unmeasurably tiny fluctuations in the conditions of the whole environment within which the process takes place, fluctuations that are part of a causal chain that stretches back to the earliest phases of the universe when it was a homogeneous quantum entity. In this sense, all uncertainty is of quantum origin, and in the ASBC approach it is explicitly represented as such. The important distinction in that theory is not between classical and quantum uncertainty, but between situations that are still malleable and open to influence through consciousness, and those that have entered consciousness and become public. Here "public" means that the consequences of the situation have significantly impinged on the consciousness of a wide range of disinterested organisms, or have made multiple stored impressions on a single organism. For example, in the Peoc'h experiment involving pre-recording data that controlled the robot, the data was still malleable and subject to influence by the chicks or the experimenter because it had been "locked up" in low-energy imprints on a magnetic disc. Even if it

had been printed, as a long list of binary digits, say, and disseminated in a scientific journal it might still have been malleable, because the information that could have been extracted from it into the consciousness of any reader would still have left more than enough freedom for there to have been a wide range of quantum states available for a behaviour of the robot that would yield a positive result.

Is it possible to arrange randomisation in terms of data this is public in all its details, particularly in view of the potentiality of the experimenter to capitalise effortlessly on any lacunae in the prior determination of the data, while still carrying out a well controlled experiment? It could be that the answer is no, on two very general grounds. First, the establishment of a correlation between events at different times independently of causation has many similarities with the so-called "time machine effects" that can arise in some cosmological models. Such models can regularly produce events which, when judged by the standards of ordinary cosmology, are wildly improbable (Clarke, 1977). Secondly, any protocol for an experiment must be based in some way on a suggestion or decision by some human being (such as myself in writing this article). That person may well have some particular interest, positively or negatively, in parapsychology, so that they will be likely to assert the corresponding proposition when they come to view the results of the experiment and will thereby, by interacting with the quantum factors that swayed their original decision on a particular protocol, influence the outcome of the experiment in line with their own preference. The methodology thus has to be indirect: different forms of quasi-randomisations could be used, together with different inclinations of experimenters, to determine whether the results are consistent or inconsistent with the predictions of this theory. As an example of a public quasi-randomisation, one could generate a sequence of digits by applying an algorithm to the text of a specified book (the algorithm designed to remove as far as possible the strong non-randomness of letters in a book) starting at the first occurrence of the eighteenth noun in the leader of a specified newspaper on a specified date. If this procedure consistently nullified the results of experiments with the general structure of those in subsections 3.1 and 3.2, irrespective of the views of the experimenter, then this could be construed as evidence against point 2 above, which is an essential part of the whole theory.

Notes

1. **The influence of Spinoza.** A further strand of thinking in determining the nature and role of consciousness stems from the philosophy of Spinoza. On the one hand he has been the central source for dual aspect ideas, rather than dualism, which have entered neuropsychology and consciousness studies through the influence of Spinoza on Antonio Damasio (2003); on the other hand Spinoza defined the modern concept of *conatus* (de Spinoza, 1925, Ethices p.102) through which an organism expresses its definitive goal of the maintenance of its own essential being, and which was developed in the pan-psychist picture of Mathews (2003). In this sense the inner activity of consciousness, represented through ς, is not just a disinterested observation of whether A or not-A is the case (so that both of these must be included in a Boolean algebra), but is rather an inner urge that some particular As might be the case. The linking of this theory with panpsychism is further supported by a second influence on it: the work of (Ho, 1998) who argues with considerable evidence that living systems are characterised by internal coherence, expressed in the definition of extensive coherence used here.

Spinoza's approach also puts in a different the light the association of a physical characteristic, extensive coherence, with a the mental characteristic of consciousness, which might otherwise seem odd. It is not that extensive coherence *causes* consciousness. Rather, the basic entity is the organism which develops, in interaction with other organisms, both the internal aspect of consciousness and the external aspect of coherence which implements it.

2. **Consciousness and the quantum state.** This Note contains more technical material of interest to those wanting to relate this approach to traditional quantum theory. The latter describes phenomena as arising from the conjunction of an observation and and the (quantum) state of the observed system. There is a tendency to regard observations and states as a 'real' physical entities; but at the same time it is recognised that they can also be regarded as merely mathematical constructs for analysing the results of laboratory physics. At this mathematical level several different equivalent *representations* of observations and states are possible. In particular, the Shrödinger representation uses a fixed (time-independent) mathematical operator to represent each given measurement (such as position, momentum and so on) with time-varying elements of an abstract space to represent states; whereas at the other extreme in the Heisenberg representation the state is time-independent and each measurement is represented by a time-varying operator.

   Using these two representations gives an easy way to understand the first stages in the evolution of the histories interpretation from traditional quantum theory to histories described at the start of 2. In conventional quantum theory there is a function – call it ϖ – that gives the probability $\varpi(A;\rho)$ of finding the proposition A true in the (mixed) state ρ (explicitly $\varpi(A,\rho) := \mathrm{Tr} A\rho A^\dagger$). If two proposition P and Q belong to a Boolean algebra , then P AND Q is the same as Q AND P; as projection operators $PQ = QP$, and the probability of both being true in the state ρ is $\varpi(PQ;\rho)$. Such propositions are said to *commute*. If we now extend this to a sequence $P_1, P_2, \ldots, P_n$ of projection operators performed at different increasing times, then in the Heisenberg representation the formula for the probability of their all being true simply generalises to $\varpi(P_n P_{n-1} \ldots P_1;\rho)$. This would clearly seem to be also the most natural form for the corresponding quantity (denoted by p above) in the case of moments of consciousness. When rewritten in terms of the more usual Schrödinger representation, and making allowance for the finite time taken by each moment of consciousness, it becomes

$$p(P_1, P_2, \ldots, P_n;\rho) = \varpi(\Lambda_n(P_n)\Lambda_{n-1}(P_{n-1})\ldots\Lambda_1(P_1);\rho) \qquad (2)$$

   where the function Λ describes a time evolution from one moment of consciousness to the next, followed by an averaging over the duration of the succeeding proposition. If we want to retrieve from this the older picture of the "collapse of the state" then we can regard the successive states

$$\rho_k := \Lambda_k(P_k)\ldots\Lambda_1(P_1)\rho\Lambda_1(P_1)^\dagger\ldots\Lambda_k(P_k)^\dagger) \qquad (3)$$

   as k increases from 1 to n as successive "collapses" of an initial state as a result of a succession of moments of consciousness, but this is not necessarily helpful. Formally, however is is sometimes useful to refer to the state ρ_k as the *apparent state* of the universe at U_k. The organism is aware of the restriction of this state to its locus, which I refer to a the *effective state*.

We see from this that the quantum state is given a much reduced role in history theory. The decoherence functional (closely analogous to p above) involves the initial state of the universe, but this is regarded as essentially fixed by some such criterion as the Hartle-Hawking "no boundary condition" (Hartle and Hawking, 1983).

References

Philip J. Barnard. Bridging between basic theory and clinical practice. *Behaviour Research and Therapy*, 42:977–1000, 2004.

Rodney Bomford. Ignacio Matte Blanco and the logic of God. In Chris J. S. Clarke, editor, *Ways of knowing: Science and mysticism today*, pages 129–142. Imprint Academic, 2005.

David J. Chalmers. Facing up to the problem of consciousness. *J. Cons. Studies*, 2: 200–19, 1995.

Chris J. S. Clarke. On the nature of bilogic: the work of Ignacio Matte Blanco. Website page, 2006.

Chris J. S. Clarke. The role of quantum physics in the theory of subjective consciousness. *Mind and Body*, 5:45–81, 2007a.

Chris J. S. Clarke. Generalised histories and decoherence: an outline for a large-scale quantum theory. *Submitted*, 2007b. See http://www.scispirit.com/physics5.pdf.

Chris J. S. Clarke. Time in general relativity. In J S Earman, C N Glymour, and Stachel J J, editors, *Foundations of Space-time theories*, pages 94–108. University of Minnesota Press, 1977.

Antonio Damasio. *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*. Harcourt, 2003.

A. Daneri, A. Loinger, and G.M. Prosperi. Quantum theory of measurement and ergodicity requirements. *Nuclear Physics*, 33:297–319, 1962.

Benedict de Spinoza. *Spinoza opera; im Auftrag der Heidelberger Akademie der Wissenschaften*. Carl Winters, Heidelberg, 1925. Edited by Carl Gebhardt.

Matthew J. Donald. Quantum theory and the brain. *Proceedings of the Royal Society (London) Series A*, 427:43–93, 1990.

Matthew J. Donald. A mathematical characterization of the physical structure of observers. *Foundations of Physics*, 25:529–571, 1995.

Nico U. F. Dosenbach, Damien A. Fair, Francis M. Miezin, Alexander L. Cohen, Kristin K. Wenger, Ronny A. T. Dosenbach, Michael D. Fox, Abraham Z. Snyder, Justin L. Vincent, Marcus E. Raichle, Bradley L. Schlaggar, and Steven E. Petersen. Distinct brain networks for adaptive and stable task control in humans. *Proc. Nat. Acad. Sci. USA*, 104:11073–11078, 2007.

Neil Douglas-Klotz. *The Hidden Gospel: Decoding the Message of the Aramaic Jesus*. Quest Books, 2001.

Fay Dowker and Andrew Kent. On the consistent histories approach to quantum mechanics. *J. Stat. Phys.*, 82:1575, 1996.

H. Everett. 'Relative State' formulation of quantum mechanics. *Rev. Mod. Phys.*, 29: 454, 1957.

P. Fenwick. Chickens dont lie. *Network: the Scientific and Medical Network Revue*, (62):12–13, 1996.

D. Giulini, E. Joos, C. Kiefer, J. Kupsch, I.-O. Stamatescu, and H. D. Zeh. *Decoherence and the appearance of a classical world*. Springer-Verlag, Berlin and Heidelberg, 1996.

R. Griffiths. Consistent histories and the interpretation of quantum mechanics. *J. Stat. Phys.*, 36:219–272, 1984.

J. Grinberg-Zylberbaum, M. Delaflor, L. Attie, and A. Goswami. The Einstein-Podolsky-Rosen paradox in the brain: the transferred potential. *Physics Essays*, 7:422–427, 1994.

Stuart Hameroff and Roger Penrose. Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness? In S.R. Hameroff, A.W. Kaszniak, and A.C. Scott, editors, *Toward a Science of Consciousness – The First Tucson Discussions and Debates*, pages 507–540. MIT Press, 1996.

James Hartle. The quantum mechanics of cosmology. In S. Coleman, P. Hartle, T. Piran, and S. Weinberg, editors, *Quantum cosmology and baby universes*. World Scientific, 1991.

James Hartle and Stephen Hawking. Wave function of the universe. *Physical Review D*, 28:2960–2975, 1983.

Mae-Wan Ho. *The Rainbow and the Worm*. World Scientific, Singapore, 1998.

M. H. Johnson. Imprinting and anpsi: An attempt to replicate Peoc'h. *Journal of the Society for Psychical Research*, 55:417–419, 1989.

George Kelley. *The psychology of personal constructs. Vol. I, II*. Norton, New York, 1955. 2nd printing: 1991, Routledge, London, New York.

Michael Lockwood. *Mind, Brain and the Quantum*. Blackwell, 1989.

Freya Mathews. *For Love of Matter: a contemporary panpsychism*. State University of New York Press, 2003.

Ignacio Matte Blanco. *The Unconscious as infinite sets: an essay in bi-logic*. H. Karnac, 1998.

D.N. Page. Mindless sensationalism: A quantum framework for consciousness. In Q Smith and A. Jokic, editors, *Consciousness: New Philosophical Essays*. Oxford University Press, Oxford, 2001.

Roger Penrose. *The Road to Reality: a Complete Guide to the Laws of the Universe*. Jonathan Cape, 2004.

R. Peoc'h. Chicken imprinting and the tychoscope: An anpsi experiment. *Journal of the Society for Psychical Research*, 55:1–9, 1988.

Dean Radin. *Entangled Minds*. Pocket Books, 2006.

Hans Reichenbach. *The Direction of Time*. Dover, 2003.

A. Sabell, C. Clarke, and P. Fenwick. Inter-subject EEG correlations at a distance - the transferred potential. In C.S. Alvardo, editor, *Proceedings of the 44th Annual Convention of the Parapsychological Association*, page 419. 2001.

Rupert Sheldrake. *The presence of the past*. Collins, 1988.

Sogyal Rinpoche. *The Tibetan book of living and dying*. Random House, second edition, 2002.

Henry O. Stapp. Quantum interactive dualism: An alternative to materialism. *J. Consc. Studies*, 12:43–58, 2005.

Tony Sudbery. Diese verdammte Quantenspringerei. *Stud. Hist. Phil. Mod. Phys.*, 33: 387–411, 2002.

John D. Teasdale and Philip J. Barnard. *Affect, Cognition, and Change: Re-Modelling Depressive Thought*. Erlbaum, Hove, UK, 1993.

Evan Harris Walker. *The physics of consciousness*. Perseus Books, Cambridge, Massachusetts, 2000.