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Creative Choice

How the Mind could Causally Affect the Brain

Abstract: *In this paper a new interactionistic model of mental causation is developed. By analysing the results of physics and neuroscience it is shown that the macroscopic cerebral activity and the resulting behavioural output is not strictly determined. This opens up the possibility that a non-physical mind can influence which of the physically allowed brain states is realised. Most models of mental causation postulate that there are coherent quantum states in the brain which could be influenced by a local mind-brain interaction. Due to environmental decoherence, however, it is questionable whether coherent quantum states can exist in the warm and wet brain. The here presented 'creative choice theory' solves the problem of environmental decoherence by including the environment. The whole universe is considered as a quantum system that is in superposition of alternative realities. It is then assumed that a universal mind collapses the universal wave-function whilst individual minds (as part of the universal mind) interact with individual brains. This leads to a holistic model of reality that could also provide an explanation for ESP-phenomena and mystical experiences.*

1. Introduction

How could the mind causally affect the brain? Many philosophers and scientists have pondered this question, but so far a satisfying answer has not been found. During the last decades, materialistic or physicalistic theories dominated the debate, whilst interactionist dualism, which assumes the existence of a non-physical mental causation,

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has been more and more considered as outdated. Physicalists often justify their rejection of dualism with the principle of causal closure, which states that no physical event has a cause outside the physical domain. This ‘principle’, however, is a mere postulate and not a scientifically proven fact. It is reasonable to consider the laws of physics before arriving at such fundamental statements about reality.

The most fundamental physical laws, the laws of quantum theory, are not strictly determined, which means that the future of a physical system is not necessarily determined by its past. As I will show in section 2 and 3, this is especially true for the brain: Indeterministic quantum events give rise to indeterminate thermal and chemical fluctuations which leads to indeterminate neural noise and thereby to indeterministic processes within the neural network of the brain. At any moment the brain could take on many different states and only one of these possibilities is observed or experienced. Thus, we cannot rule out that a non-physical mind influences which one of the possible brain states is realised. It is the aim of this paper to develop a model that explains how such a mind-brain interaction could look like.

Taking into consideration the results of section 3, thermal interactions are a major source of indeterminacy within the brain. This has important consequences since thermal interactions are also the main cause of environmental decoherence. Decoherence poses a serious challenge for any model of mental causation. Most of these models assume that there are coherent quantum states in the brain which could be influenced by the mind (Eccles, 1994; Penrose, 1994; Stapp, 2005; Clarke, 2007). Due to the effectiveness of decoherence, however, it is not very likely that such quantum states (which could be influenced by Penrose’s ‘gravitational induced collapse’ or by Stapp’s ‘quantum Zeno effect’) can exist in the warm and wet brain. Furthermore, none of the models mentioned above exploits (or can exploit) the macroscopic indeterminacy generated by thermal fluctuations (see section 4 for more details). Since thermal fluctuations are probably the main source of variability within the brain this is a major disadvantage of these models.

The creative choice theory developed in section 5 solves the problem of decoherence in a simple way. We may consider the whole universe as a single quantum system that is in superposition of alternative realities. These superpositions cannot be destroyed by environmental decoherence, since the universe as a whole has no environment. I will then adopt Squires (1991) suggestion that a universal mind or consciousness experiences only one of the many possible realities. I will also assume that the universal mind can to some degree influence which possibility is realised. Our individual minds would be part of the universal mind and therefore participate in the process of choice. Instead of influencing particular quantum states within the brain the mind would 'choose' between alternative macroscopic realities. Such a model would be consistent with decoherence theory and would exploit all sources of indeterminism within the brain.

In the last sections of this paper the creative choice model will be further elaborated. In section 6 I will explore the possible relationship between the individual mind and brain and the causal role of consciousness. As will be shown in Section 7, nonlinear neuronal processes could serve as fine-tuned sources of indeterminism thus providing an interface for a coherent mind-brain interaction. Finally, in section 8 I will apply the model to non-local phenomena that cannot be explained by conventional theories and are therefore usually ignored by mainstream science.

2. Quantum Theory

In any system at a temperature above zero Kelvin there are constant movements on the micro physical level called thermal fluctuations. Actually, the temperature of a system can be defined as the average energy per degree of freedom of all the particles in the system. In water, for example, the thermal energy is stored in the movements and in the internal vibrations of the water molecules.

In order to illustrate the implications of quantum theory on many particle systems and thermal fluctuations, I will use a simple example. Consider a gas in a glass container. In order to make the thermal movements visible, we add some dust particles to the gas. Due to constant collisions with the gas molecules, the particles perform random movements (called Brownian motion) that we can observe with the naked eye. In classical mechanics, we can imagine the molecules as little balls that randomly move around, bump into each other, against the walls and against the dust particles. This classical model of thermal movements is a chaotic system that is highly sensitive to small perturbations. A tiny displacement of a single molecule will soon alter the overall behaviour of the system, including the movements of the dust particles.

In quantum theory, the exact position and momentum of each molecule is uncertain due to the Heisenberg principle, and collisions between molecules are indeterministic quantum events (Child, 1996). To show how this affects our example, I will use a little mathematics. In quantum theory, molecules are described by wave functions. These functions tend to be quite complicated, so in physics we use symbols as shortcuts. Let us denote the wave function of an individual molecule by $|M\rangle$. We assume that initially all molecules of the system are in a defined state, and that the states stay unchanged until two molecules interact with each other. (For simplicity, we ignore interactions with the wall and the dust particles.) Then the initial state of the system can be written as a product of N individual molecule states:[1]

$$|S_{initial}\rangle = |M1\rangle|M2\rangle|M3\rangle|M4\rangle\ldots|MN\rangle$$

Let us say that $|M1\rangle$ and $|M2\rangle$ are the first molecules to bump into each other. The collision can affect their vibrational, rotational and translational degrees of freedom in many ways. Quantum theory tells us that after their interaction the two molecules are in a superposition of all these possibilities. For simplicity, we consider only two of these many possible resulting states. Then, through the interaction, the product $|M1\rangle|M2\rangle$ develops into $\alpha_1|M1_1\rangle|M2_1\rangle+\alpha_2|M1_2\rangle|M2_2\rangle$. The small indices stand for the two different results of the interaction. The parameters α_1 and α_2 obey the normalisation rule $|\alpha_1|^2+|\alpha_2|^2=1$. The squares $|\alpha_i|^2$ yield the probability to find the molecules in the corresponding state. The states of the other molecules are not changed by the interaction. So, through the collision of $|M1\rangle$ and $|M2\rangle$ the initial state of our system develops into:

$$|S_{one}\rangle = \left(\alpha_1|M1_1\rangle|M2_1\rangle+\alpha_2|M1_2\rangle|M2_2\rangle\right)|M3\rangle|M4\rangle\ldots|MN\rangle$$

$$= \alpha_1|M1_1\rangle|M2_1\rangle|M3\rangle|M4\rangle\ldots|MN\rangle + \alpha_2|M1_2\rangle|M2_2\rangle|M3\rangle|M4\rangle\ldots|MN\rangle$$

$$= \alpha_1|S_1\rangle+\alpha_2|S_2\rangle \text{ where } |S_1\rangle=|M1_1\rangle|M2_1\rangle|M3\rangle|M4\rangle\ldots|MN\rangle,$$

$$|S_2\rangle= |M1_2\rangle|M2_2\rangle|M3\rangle|M4\rangle\ldots|MN\rangle.$$

The last expression shows that after one molecule-to-molecule interaction, the whole system is in a superposition of two states $|S_1\rangle$and $|S_2\rangle$. Of course, soon new collisions will happen. After one more interaction we get:

$$|S_{two}\rangle = \alpha_{11}|S_{11}\rangle+\alpha_{12}|S_{12}\rangle + \alpha_{21}|S_{21}\rangle+\alpha_{22}|S_{22}\rangle,$$

and after many interactions (using new consecutive indices):

$$|S_{many}\rangle = \beta_1|s_1\rangle+\beta_2|s_2\rangle+\beta_3|s_3\rangle+\ldots+ \beta_K|s_K\rangle.$$

[1] For a short introduction into quantum formalism see for example Ismael (2000).

$|S_{many}\rangle$ contains a vast number of states, all describing different thermal movements. In principle, we may include the dust particles in our quantum mechanic description. Then, $|S_{many}\rangle$ would also contain many different movements of visible particles. We could simulate these movements on a computer which would yield a vast number of possible trajectories for each dust particle.

Obviously, here we have run into a problem, because when we observe the glass, we can see the dust particles moving on perfectly classical trajectories. We do not see the many possibilities that quantum theory predicts. Basically we are in the same situation as in the famous Schrödinger's cat experiment. Quantum theory tells us that the cat in the box is in superposition of being dead or alive. But when we open the box we find the animal either dead or alive. In this thought experiment, a single quantum event might or might not trigger the death of the cat. In our example, a vast number of quantum events leads to a vast number of possible outcomes. For this reason quantum mechanics, although being a very elegant and highly confirmed theory, needs an interpretation.

The Copenhagen or standard interpretation of quantum theory assumes that somewhere during the chain of events that lead to an observation, the wave function of the regarded system is collapsed. The state is reduced to the one observed (see Faye, 2008, for a review). But where exactly would this happen in our example? During molecule-to-molecule interactions? When molecules collide with macroscopic dust particles? Or when an outside observer watches the movements of the particles? Quantum theory does not answer this question and so far the wave function collapse can not be observed directly.

Another way of framing the problem is to acknowledge that when two molecules interact, their resulting states get entangled with each other. Two states are called 'entangled' if their common state is not a product of individual states, which means that there is no individual state that can be attributed to each particle. In our above example, we see that after the first interaction of two particles $|M1\rangle$ and $|M2\rangle$, the resulting state $(\alpha_1|M1_1\rangle|M2_1\rangle+\alpha_2|M1_2\rangle|M2_2\rangle)$ is a sum of two products that cannot be written as a product of individual states. A measurement performed on one entangled particle influences the outcome of measurements performed on the other particle, even when there is a large distance between the two. Bell (1964) has shown that these non-local correlations between entangled particles (that have been well confirmed experimentally)[2] can not be explained by any theory of local hidden variables. For this reason, quantum theory is said to be 'non-local' and the wave function collapse cannot be a local process. Since, in our gas example, interactions happen all the time, in principle all molecules get entangled with each other. Therefore the system as a whole is in a superposition of many states and we can not attribute individual states to the individual molecules.

In small systems, like single electrons atoms or molecules, we can observe interference of superimposed states (like in the double slit experiment). Also, small quantum systems can tunnel from one state to another. In macroscopic systems like the one in our example, such genuine quantum effects are never observed. The dust particles do not suddenly tunnel from one position to another, rather they move on classical trajectories. This phenomenon can be explained by the 'decoherence theory' (see Zurek, 2003, and section 4 below). In systems with many degrees of freedom, superimposed states quickly decohere, so that the probability for interference or tunnelling is quickly reduced to zero.[3]

For this reason, simply by watching the dust particles in our example it would be impossible to tell that we are looking at a quantum system. Physics, however, tells us that this system obeys the rules of quantum theory and that we are looking at one of many possibilities.

3. Indeterminism In Biological Systems

Thermal fluctuations occur at the micro-physical level, where the laws of quantum theory apply, and are therefore undetermined. In the macroscopic world, the effects of these fluctuations are so small that they can often be neglected. Therefore, macroscopic systems can usually be described very well by classical physics. A good example is a computer. Computers are built solely of solid material, and due to the digitalisation the computational processes are very stable against thermal fluctuations. For this reason, digital computers are very reliable and highly deterministic.

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[2] Correlations between entangled particles that violate *Bells inequality* and thereby confirm the predictions quantum theory have been proven in several experiments (see for example Freedman 1972; Aspect 1982).

[3] Decoherence occurs when molecules or dust particles, being in superposition of alternative states, interact with other particles or photons and thereby become more and more entangled with their environment (which includes the whole gas system, glass container, etc.) Through this process pure quantum superpositions are quickly destroyed, and any macroscopic interference or tunneling phenomena become highly improbable. In a real gas, decoherence will occur extremely fast.

In order to survive, living systems have to preserve information and manage complex metabolic processes in a wet and warm environment. This is established by the double helix (which is a kind of digital information storage), genetic transcription, and many regulative mechanisms that keep cells in a stable state. However, in most biological processes we find some variability or noise, usually due to thermal and chemical fluctuations. Thus quantum indeterminacy will have an effect on living systems. Each thermal interaction, each transition between vibrational states of any molecule, each forming or breaking of a chemical bond, is an indeterministic quantum process. The movements of macro molecules are thermally driven Brownian motions. Although the resulting fluctuations are to certain degree 'washed out' at the cellular level, they have macroscopic effects which cannot be completely neglected.

Consider neural noise. A single neuron shows different responses to repeated presentations of a specific input signal (Schmitt, 1970; Stein, 2005). There are several sources of noise acting within the neurons and it is easy to link them to the underlying molecular and chemical fluctuations. Here, I will focus on two important and well studied examples: ion conductance and synaptic release noise.

The fluctuations of *membrane ion channels* between the open and closed states are thermally driven and therefore in a way amplify these thermal fluctuations (see DeFelice, 1981, for a review). Since ion channels regulate the transmembrane voltage gradient, their fluctuations influence the firing behaviour of the neurons. *Chemical synapses* are not deterministic switches that convert incoming action potentials into the release of fixed packets of neurotransmitters. Instead, they release the transmitter in a probabilistic manner and often at a low rate even spontaneously (see Koch, 1999, for a review). Synaptic release noise is caused by molecular events that occur when the action potential invades the synaptic bouton. The firing probability is modulated by the history of firing of both the pre- and the postsynaptic neuron. We can assume that depending on these modulations and on the strength of the incoming potential, the situation at the synaptic cleft becomes more or less unstable and a release happens spontaneously due to thermal and chemical fluctuations. Since the underlying fluctuations are indeterminate, we can conclude that the resulting neural noise is also indeterminate.

The neural network of the brain is organised in such a way that a large number of neurons participate in performing a given task. So, to a certain degree fluctuations of individual neurons are washed out. The more neurons and synaptic connections participate in a process, the more stable the process becomes. So, when I decide to go to the fridge to get bottle of coke, I usually will manage to do so. Of course, unexpected things may happen. The bottle might slip from my hand and break on the floor. Or, while walking to the fridge I might remember that I have forgotten to make an important phone call and go to the telephone first. Human behaviour is never completely reliable. When I perform a certain task several times, like for example playing a new and difficult piano tune, at the beginning there will be a great variation in the quality of the performance. If I keep practising, the synaptic connections in my brain will be modified in such a way that a correct and good playing gets more and more probable.

But we all know that even in everyday actions that we practised for years, we tend to make mistakes from time to time. We also know that this is more likely to happen when we are excited, very tired or intoxicated. In such moments, the firing probabilities of certain neurons are altered (due to various chemical processes), so a normally reliable programme might become more or less unstable. When you drink enough alcohol, it becomes difficult even to talk or to walk. So noise can certainly lead to variations and disturbances of otherwise reliable programmes. But this might not be the only effect noise has on the brain.

Within the brain, millions of neurons are coupled in various ways. Model studies using non-linear differential equations to simulate neuronal processes show that even in small systems consisting of a few coupled neurons the electronic currents can be very complex and often show chaotic patterns (Borisyuk, 1995). And there is growing evidence that non-linear processes and chaos play an important role on all levels of organisation within the brain (see Korn, 2003 for a review). These processes are coupled with neural noise which makes the brain a stochastic dynamical system. The effect that noise has on non linear or chaotic systems is by no means trivial. Noise can act as a driving factor that influences the dynamics drastically (Lindner, 2004). Depending on the strength of the noise (in comparison to other parameters), noise can in some cases stabilise nonlinear processes and lead to a regular periodic behaviour. However, since nonlinear systems can be very sensitive to small perturbations, in many cases different noise patterns will lead to variations in the overall dynamics, which means that nonlinear processes will often amplify the indeterminacy of neural noise.

Noise and variability is found at all levels in the nervous system up to the firing activity at the scale of the whole brain, as can be seen in EEG-recordings and behavioural output (Swain, 2006). Since the macroscopic variability is not insulated from the indeterminism of neural noise, we can conclude that the cerebral activity is at all levels to a certain degree indeterminate.

Now let us look again at human behaviour. There are many situations where we cannot rely on learned patterns, where we have to make decisions or have to find creative solutions in a complex environment. Even behavioural patterns that we have practised for years are to a certain degree unstable. So we can assume that in more complex or new situations our behaviour is even less determinate.

To illustrate this, let us look at simple thought experiment. A person called Jack has a green and a red button in front of him. We tell Jack that as soon as the bell rings he can press one of the two buttons and depending on the choice he will either get 1000 dollars or nothing. Of course we will not tell Jack which button wins. At this point it is important to differentiate between macroscopic and microphysical cerebral processes. A macro-process can be defined by measurable macroscopic criteria, like for example by the behavioural output it produces. A micro-process would describe the exact dynamics of all the microphysical particles in the brain. (Analogously, I will speak of macro-states and micro-states.) Due to the vast number of degrees of freedom within the brain, we can assume that each discernible macro-process can be realised by a vast number of different micro processes.

Let us say at the time t1, when the experiment begins and Jack has understood the task, his brain is in a defined micro state b1. At any moment, a vast number of quantum events happen, so at the time t2, when the bell rings, the brain will be in a superposition of many of possible micro-states b2. Depending on which of these possibilities is realised, Jack will press the red or the green button. One set of possible b2's will lead to the result red, while another set of states will lead to green. (For simplicity, we ignore the possibility that Jack might do something completely unexpected.) Only if all possible states b2 to a given b1 led to the same macroscopic result, could we say that the outcome of the decision was strictly determined. This would require that the macro process that leads to the observed result is stable against all underlying fluctuations. Since both results are in principle possible and the firing behaviour of each individual neuron is to a certain degree undetermined, this is very unlikely, especially for longer decision times.

What about real life decisions? Of course all I have learned, all the memories engrained in my brain, will have an influence on whether I take this job or marry this woman, etc. But we all know situations in which the pro and contra arguments stand equally against each other and where it is very difficult to decide. Our mind tends to be very busy in such situations. We might be scared to make a mistake, so stress hormones are produced, which changes the firing probabilities of certain neurons. It is extremely improbable that the process that leads to the outcome of such a decision is strictly determined.

Thus we can conclude that generally our behaviour is not strictly determined by the brain and the underlying natural laws. Practically this could mean that in one possible reality I get 1000 dollars, in the other one I get nothing. In one possible reality I marry this woman, while in an other reality I might marry someone else.

4. Decoherence and Mental Causation

As we have seen in the last two sections, indeterminism is not limited to the micro physical realm. The physical laws do not predict the future in a precise way. They provide us with a pool of possibilities instead. This of course raises the question of how one of these possibilities becomes the manifest and essentially classical reality that we experience. As Zurek (2003) points out, this question is partly answered by decoherence theory:

> During the past two decades it has become increasingly clear that many (perhaps all) of the symptoms of classicality can be induced in quantum systems by their environment.

Let me summarise the main results of this theory. In quantum theory all superpositions of states are also valid quantum states. In the case of Schrödinger's cat this means that the superposition 'cat dead + cat alive' would be a legal quantum state. This egalitarian principle of superposition is valid for isolated systems. However, different quantum states react differently to interactions with the environment. Such interactions are in effect measurement processes through which the environment monitors the state of the system. During this process only a particular set of states can be 'observed'. These so-called pointer states are stable in spite of the environment, while phase relations between their superpositions quickly decohere. The process which singles out the pointer states is called environmentally induces superselection or 'einselection'. The state 'cat dead' and the state 'cat alive' would be einselected pointer states, while the non-localised state 'cat dead + cat alive' will never be observed.

What does this mean for the brain and a possible mental causation? Membrane ion channels for example, are open systems that constantly interact with their wet environment. The indeterminate thermal interactions can flip the channel from the open to the closed state and vice versa. The same thermal interactions also act as measurement processes that continuously monitor the state of the channel. The resulting decoherence will immediately destroy all superpositions and the ion channel can only take on the pointer states: 'channel open' or 'channel closed'. The state of the channel will be entangled with the state of its environment, different pointer states are correlated with different environmental states. In order to control the state of the ion channel a possible mental causation would also have to control the state of the environment. The same will apply for the states of a chemical synapse: 'firing' or 'not firing'.

When two water molecules interact with each other, the different possible results of the interaction will interact differently with other molecules which then interact with other particles and so forth. Thus, the result of a single thermal interaction will quickly influence the thermal fluctuations in the whole brain, thereby influencing the states of many ion channels and synapses. The macroscopic indeterminacy described in section 3 is the sum effect of billions of such quantum events happening within and around the brain. It is hard to see how this indeterminacy could be controlled by a local mind-brain interaction.

For this reason, most models of mental causation postulate that quantum processes occur at higher levels of organisation within the brain. Eccles suggested that the vesicle release of chemical synapses could be a quantum tunnelling process, while Penrose proposed that cellular microtubules could act as quantum computers which would influence the firing probability of neurons. It is then assumed that the indeterminacy of these 'quantum processes' is independent from environmental fluctuations and could therefore be controlled by a local mind-brain interaction. This, however, would require that synapses or microtubules can maintain coherence over times relevant for neuronal processing, which is not very likely (Tegmark, 2000; Litt, 2006).

The model of Stapp (2005) is based on the idea that the mind as a non-physical observer is free to choose which observable it measures and how often such a measurement is performed. A rapid sequence of measurements could influence certain structures within the brain via the so called 'quantum Zeno effect'. However, any larger structure within the brain is thermally interacting with the surrounding brain fluid. The mind can only measure what is already constantly measured by the physical environment. Due to the resulting decoherence, the quantum Zeno effect most likely will not work. Stapp (2005) does not mention the problem of decoherence and he does not explain which biological structures could be influenced by the quantum Zeno effect and how this would affect the firing behaviour of neurons. In its current state his model is rather vague. Clarke (2007) tries to fill this gap by combining Stapp's and Penrose's approaches. However, this does not completely solve the decoherence problem. In addition to that, there is no evidence that cellular microtubules can influence synaptic firing in any significant way (Litt, 2006). So none of the above models seems to be consistent with decoherence. And even if the suggested mechanisms worked, the resulting mental influence would probably be small in comparison to the variability caused by thermal fluctuations. It is not very likely that such a weak mental causation could control non-linear neuronal processes that are highly sensitive to small perturbations. For all these reasons, it makes sense to look for an alternative approach that does not rely on the existence of coherent quantum states.

5. Creative Choice

As we have seen in section 2, the movements of dust particles performing Brownian motions are indeterminate although decoherence immediately removes all quantum effects. The same will apply for the brain. Even if all superpositions immediately decohere, neuronal processes will nevertheless be indeterminate. Decoherence theory explains why in the macro-realm only classical states and trajectories can be observed. However, it does not explain why a particular pointer state (like for example 'cat dead' or 'channel open') is realised and not another one. This leads us to the many world interpretation of quantum theory which was first suggested by Everett (1957). In this view the whole universe is considered as a quantum system. Due to quantum interactions, the physical reality branches at any moment into many parallel universes or worlds. Different pointer states belong to different branches of the universal wave function and are therefore realised in different 'Everett worlds'. In one world Schrödinger's cat is dead and in another one it is still alive. In one world a particular synapse fires in another one it does not fire. In one world I move my right arm in another one the left.

Everett considers the many worlds as real, in an ontological sense. However, it is not necessary to adopt this assumption. Following Squires (1991) I will consider the many worlds as possibilities or, as Popper (1977) described it, as 'propensities'. I will assume that a single universal mind experiences only one of the many possible realities. In terms of the Copenhagen Interpretation this would mean: A single universal mind collapses the universal wave-function. In this picture there is no local wave-function collapse and no artificial distinction between classical and quantum systems. There is only the universal wave function and a universal mind that moves along one of the many branches of this function. I will also assume that the universal mind can, to a certain degree, 'choose' which branch is realised. These are the basic assumptions of the creative choice theory. The model would allow the mind to influence the physical reality in a creative way by choosing between macroscopic alternatives.

The universal approach solves the problem of decoherence but it does not explain the relationship between individual minds and brains. The state of my mind depends strongly on the state of my brain and of course I can only move my own arm and not the arm of somebody else. So how could individual minds influence individual brains, as our experience seems to suggest?

At this point it is again crucial to distinguish between microscopic and macroscopic brain-states. Macroscopic brain-states (as defined in section 3) are in principle pointer states, however, they describe a higher level of organisation than the pointer-states of individual ion channels or synapses. Two micro-states are equivalent and realise the same macro-state if they give rise to the same inner experience and the same behavioural output.

Due to thermal interactions, our bodies and brains are entangled with their environment (and thereby in principle with the whole universe). This means that different possible micro-states of the brain are correlated with different environmental states. When two people Jack and Jill, say, are standing next to each other, then each possible micro-state of Jack's brain will be correlated with a particular micro-state of Jill's brain. However, since each macro-state can be realised by a vast number of different micro-states, entanglement will not lead to correlations between macro-states of Jack's and Jill's brains. The laws of physics assign a probability to each potential macro-state. Each possible process in my brain, each experience I could make, will occur with a certain physical probability. The individual mind cannot simply realise a particular micro-brain-state without influencing the state of the environment. Therefore, I suggest that the mental causation increases the occurrence probability of macroscopic brain states by increasing the probability of all micro-states that realise this macro-state. A mental impulse to lift my arm would increase the probability of all possible realities or universal states giving rise to the action 'lifting of my arm'. With this approach, Jack's decision to move his right arm will not interfere with Jill's decision to move her left arm. The two mental choices together will increase the probability of all possible worlds in which Jack moves his right and Jill moves her left arm.

Thereby we have to postulate that individual minds can easily manipulate their own bodies, but they have little or no influence on the macroscopic indeterminism in their environment. We cannot easily influence random generators or other people, although the indeterminism of these 'systems' can affect our brain-states via sensory input. Individual minds can only influence the indeterminacy that has its origin in their brains while the indeterminacy of the environment belongs to the realm of the universal mind. This 'special relationship' between individual minds and brains is another fundamental assumption of the creative choice theory.

The above model includes that possible macroscopic brain states that already have a high physical probability, would need a weaker mental influence than less probable brain states in order to become real. It is important to note that the physical probabilities of brain states will always depend on the situation, i.e. on the history of the brain, the sensory input, etc. If the different possible micro-brain-states (in a given situation) have more or less the same probability, the most probable macro-state will be the one that can be realised by most micro-states. This probabilistic approach to mental causation has the advantage that the physical probabilities would still have a meaning. For example, a physical addiction like smoking would be a strong physical propensity being more or less hard-wired in the brain. Therefore a strong mental intention would be needed to stop smoking. A week intention will not suffice to overrule a strong physical propensity.

In this picture two different kinds of causes exist: the parts (the elementary particles) and their interactions causally affect the whole by determining the possibilities. The whole (the mind) affects the parts by influencing which possibility is realised. So we have upwards and downwards causation. In a probabilistic way, these two directions of causation would determine how our reality proceeds.

A possible objection against this model would be that it violates the statistical laws of quantum theory. Here it should be noted that the physical laws have been developed to understand the dynamics of physical fields and particles. They have been tested on non-living systems in the absence of any significant mental causation. It would be surprising if the same natural laws that describe non-living systems could also explain the interactions between the mind and the physical brain. We can expect that an extension of physics and new natural laws are necessary to understand these interactions.

6. Brain, Mind and Consciousness

In the following section I would like to differentiate between mind and consciousness. I will consider the (individual) mind as a field that dynamically interacts with the brain. Brain states give rise to corresponding mental states, whilst the state of the mental field influences which of the possible brain states is realised. By consciousness I mean subjective awareness or subjective experience. To be conscious of something means to experience something. We do not directly experience that our minds choose between alternative brain states. For example, I do not experience that the intention to move my arm leads to the activation of a particular area within the motor cortex. This means, the mind brain interaction suggested here happens partly unconsciously. However, we will usually experience the results of the interaction.

The distinction between mind and consciousness is important because if mental field and consciousness were the same thing everything that would be unconscious would have to be physical and would therefore be determined by the brain. We do not know, however, whether Freud's unconsciousness or Jung's collective unconsciousness completely reside in the physical brain, or if the unconsciousness at least partly belongs to the mental realm. So, I will treat brain, mind and consciousness as different aspects of a complex body-mind system. The dynamic interaction between mental field and brain gives rise to a conscious experience.

A strong sensory input affects all possible realities, which will lead to a corresponding sensory perception. However the creation of a sensory experience is an active process that involves pattern recognition, binding of different sensory modalities, filtering of information, etc. The mental field could orchestrate this process by choosing corresponding brain states and thereby for example, determining the focus of consciousness. A person with brain damage cannot have certain experiences because the functional basis is missing within the brain. When I take LSD the physical probabilities in my brain will be drastically altered. But whether I have a horror trip or dwell in the bliss of a mystical experience might be decided in the mental realm and not in the brain.

In situations where fast reactions are needed, the brain might act automatically with little mental control involved. However, under normal circumstances the brain might switch between more deterministic and indeterministic processes. In the latter case, the brain would work as a chance generator or a generator of possibilities. We can assume that in many situations there is a large set of more or less probable possibilities that could be realised by the body-mind system. The body-mind system will already know some of these possibilities from experience. When the body is thirsty, the brain will remember that in such a situation it is possible to make a cup of tea, get water from the tap or fetch a bottle from the fridge. These options will arise in the conscious mind, which will evaluate the situation. Depending on the resulting mental influence and on the strength of the physical propensities, the body-mind system would realise one of the possible options. Of course there are situations where none of the known options seems appropriate. Then, the body-mind would switch to a more creative mode and actively search for new possibilities. We can assume that creative cognitive processes arise from a complex mind–brain interaction which is highly indeterminate on the physical level. In moments of inspiration, new ideas may suddenly arise within our mind and we are usually not conscious of the process that generated the idea. Therefore it makes sense to assume that the conscious experience is only the tip of the iceberg, and that creative processes happen at least to some extent unconsciously. However, consciousness seems to be essential for making reasonable decisions and for detecting and realising new possibilities.

In the creative choice model, probable neuronal processes can be more easily realised through mental influence than less probable processes. From this perspective, it is interesting that some of our actions need more conscious attention than others. Consciousness is, for example, needed when we learn new things. Learning to drive a car needs a lot of conscious attention, whereas an experienced driver shifts gears and stops at traffic lights while being deeply immersed in a conversation. Consciousness is also needed when we perform actions that are difficult or at the limits of our capacities. An athlete, who has practised his movements for years, will be highly concentrated during a competition in order to mobilise all of his resources. A measure of how conscious we are would be how intensely we experience the action we perform. There is, of course, no objective measure for this, but we can assume that a rally driver during a race has a more intense experience of driving, than a clerk driving home from his office, still thinking about his work.

When I perform an action I can succeed by achieving the desired result, or I can fail. So, to each action we can assign a physical success probability resulting from the statistical laws of physics. Well practised actions will have a higher success probability than newly learned actions because through practise the neural connections are modified in such a way that the actions become more stable. Performing crude movements has a higher success probability than performing precise movements because the latter ones are more sensitive to fluctuations. A simple task has a higher success probability than a complex task, etc. Performing new or difficult actions with a low physical success probability requires a lot of consciousness, while easy and well practised actions work more or less automatically. On the other hand, from the perspective of creative choice, performing an action with a low probability needs a strong mental influence. This leads us to the assumption that an intense conscious experience increases the effectiveness of the mental causation. The more conscious we are, the more effectively we can influence the physical reality. This idea can be more fully illustrated through the following examples:

- Conscious attention is necessary whenever we perform new tasks, when we have to evaluate complex situations and when cognitive processing and creativity is involved.
- To perform an action where a high level of precision is required, you have to concentrate, even if you have practised the action for years. A mountain climber, a martial artist, a pianist in concert or an actor on stage – they all will be highly alert and present because mental causation (amplified by conscious attention) might push their brains and bodies to the limit of what is physically possible.
- The best way to overcome a bad habit or an inappropriate behavioural pattern (being more or less hard-wired in the brain) is to become conscious of what one is actually doing. When you watch yourself acting in an inappropriate or automatic way, you have the chance to consciously intervene and to choose a better option. (Of course, when the habit is a strong physical propensity this will not always work.)
- A not too drunken man can still act like a sober person if he concentrates enough. So, consciousness can to a certain degree compensate the effects of alcohol.
- The assumption that an intense conscious experience enhances mental causation would also explain the evolutionary advantage of emotions. The arousal of anger or fear leads to an intense experience which would help animals to fight or flee more effectively. (Of course an angry person can also effectively do

harmful things. A higher level of consciousness will be necessary to integrate such ‘inappropriate behaviour’.)

Since we cannot calculate exact physical probabilities, it will be impossible to prove in a strict sense that actions with lower physical probabilities need a stronger conscious attention. But the qualitative arguments presented here certainly point in this direction. So, creative choice would explain in a plausible way why some of our actions require more consciousness than others. I do not say, of course, that there are no other possible explanations. However, from the perspective of physicalism it is in principle difficult to explain why consciousness is necessary for any of our actions, since in a causally closed physical reality it should make no difference to the brain, whether or not it gives rise to a conscious experience.

At this point, I would like to say a few words to the Libet (1983) experiment which is often invoked as an argument against free will. In the experiment, the tested people were asked to either move the right or left hand. It was shown that the decision which hand is moved is initiated by the brain about 350 msec before the people were actually conscious of having decided. This implies that the decision is unconsciously prepared, but it does not imply that the measured cerebral activity (and the resulting decision) is determined. Thus, it is possible that an unconscious mental causation influences the decision making process whereas the result of the decision becomes conscious only after a short delay.

Actually it is not such a surprising result, that we often decide for unconscious reasons. Often, after having made a decision, we can not tell why we have chosen a certain option and not another one. We have simply trusted our intuition which operates unconsciously. However, even an intuitive decision is to some extend a conscious process. In order to decide, first of all I have to be conscious of wanting to make a decision. I should also be conscious of the possible options and reasons that speak for or against the different options. Then I might consciously relax, focus on the issue at hand and wait for an intuitive answer to appear within the conscious mind. A heightened conscious awareness might improve our intuitive abilities by increasing the effectiveness of the mental causation.

7. Nonlinear Neuronal Dynamics

The mind-brain interaction described above will only work if the brain provides the right balance between determined and undetermined processes. A driver can only navigate his car when the steering wheel and the brakes work in a reliable way. The example of the drunken man demonstrates well what happens when usually reliable processes become unstable. A recent paper suggests that the brain uses nonlinear neuronal processes to fine-tune the balance between determined and undetermined behaviour. 'Instead of random noise', Maye (2008) finds 'a fractal order (...) in the temporal structure of spontaneous flight manoeuvres in tethered Drosophila fruit flies. Drosophila can produce these patterns endogenously, without any external cues.' A thorough mathematical analysis of the data shows that 'the fly's behaviour is controlled by brain circuits which operate as a nonlinear system with unstable dynamics far from equilibrium.' Such brain circuits are to a large extent deterministic. However, since unstable nonlinear circuits are highly sensitive to initial conditions and coupled with indeterminate noise (which is always present in neuronal processes) they produce a variability which is fundamentally undetermined. This means that even the small brain of a fruit fly can generate a truly spontaneous behaviour.

Fruit flies can perform flight manoeuvres with minute precision and for example land on the rim of the teacup. In other situations their flight patterns show a high degree of randomness that would not allow them to land on food or to avoid obstacles. Maye concludes from this and the above experiment, that the brain might use nonlinear processes to control the degree of variability it produces: 'Brains indeed do throw the dice — but by refuting the notion of stochasticity our results imply that they have exquisite control over when, where and how the dice are thrown.'

From the perspective of creative choice, the above model would provide a perfect interface for mental causation. In the complex human brain a vast number of more or less determined processes would work simultaneously on different hierarchical levels. The mind would control the brain by taking advantage of the variability that the brain produces. Nonlinear neuronal circuits that are neither completely determined nor completely indeterminate might provide the physiological basis for human cognition and creativity. Noise-induced transitions between coexisting attractors could for example be used to implement indeterminate decision making processes. Analogous to a roulette table or a lottery machine, the brain would generate alternative physical possibilities with reliable and adaptable probabilities.

Nonlinear processes are ubiquitous on all levels of organisation within the brain (Ashwin, 2005). It is assumed that the benefits of these processes for the nervous system lie in their wide range of behaviour and their aptitude to quickly react to changing conditions (Korn, 2003). Given that nonlinear processes are often highly unpredictable, it is still unclear how the brain can take advantage of these benefits in a coherent way. The usual answer given to this question is that a self-organisation process somehow controls the complex (and highly spatially distributed) nonlinear dynamics of the brain.

In the creative choice model, the mind would be the self that organises by increasing the occurrence probability of physical realities in which appropriate patterns of noise operate the cerebral dynamic in a meaningful way. It would be interesting to perform experiments and model studies from this perspective.

8. Non-Local Phenomena

So far we considered only individual minds and brains. However our physical bodies are part of a continuum — they are part of the physical world which can be considered as one universal quantum system. It might well be that also our minds are not completely isolated entities. Usually, we experience ourselves as separate from the world we perceive. Through meditational practice, however, the feeling of separation can more and more dissolve, so that the mediator experiences oneness with the whole universe. This sense of cosmic unity can be experienced during deep meditation, with measurable correlates in the brain (Newberg, 2004). Long-term meditation can also lead to permanent trait changes, where the perceived lack of separation is present even when the person is not meditating. The sense of a separate self diminishes, whilst conscious awareness increases and expands (Austin, 2000). In the creative choice model this would mean that there is no fixed barrier between the personal mind and a possible universal mind. Through mediation, the focus of consciousness would expand more and more from the personal to the universal mind.

The creative choice model would also allow the existence of 'strong intersubjectivity' as it is for example described by de Quincey (2000):

> This is the most radical meaning (of intersubjectivity), and the one that poses the greatest challenge to philosophy of mind. According to this 'stronger' meaning, intersubjectivity is truly a process of co-creativity, where relationship is ontologically primary. (…) 'True intersubjectivity' is unmediated communication or co-creative sharing of presence — it is direct subject-to-subject or 'I-to-I' communion.

Creative choice could explain this deeper meaning of intersubjectivity in the following way: In moments of intimacy, the individual mental fields together form a relationship field which then creates a common experience. The conscious focus does not rest solely on the individual mind but it includes the other person. So, to a certain degree we can experience each other from within and feel directly what the other feels.

The only way to prove the existence of such non-physical connections would be to prove correlations between people that are not physically interacting with each other. Examples of experiments that try to accomplish this are classical ESP experiments. Two popular examples are the Ganzfeld study and Sheldrakes eye-staring experiment. In the Ganzfeld-experiment, a receiver-person is put in an especially relaxed state induced by sensory deprivation and has to guess which of four pictures a sender in a separate room has been looking at (see Palmer, 2003 for a review). In the eye-staring experiment, the target person tries to detect whether or not somebody is staring at him or her from behind (Sheldrake, 2005). Both experiments show small but significant ESP effects.

There is still a controversy whether such significant positive results are credible, mainly for two reasons. First, the observed phenomena cannot be explained by conventional scientific theories and therefore many scientists do not believe that positive results are possible. Second, the measured effects are usually small and not very reliable and can therefore easily be questioned.

Here, the idea of a relationship field might offer helpful explanations. The tested people and the experimenters form a relationship during the experiments, so we cannot exclude the possibility that the personality and the beliefs of the experimenters affect the outcome of the result. Non-local connections would be something we have to allow by expanding the focus of consciousness. Laboratory testing might create some tension in many people, with the effect that they emotionally close down and become less sensitive. Thus, the overall atmosphere in which the experiments are performed, and whether or not the tested people feel comfortable, might be crucial.

There is also an obvious explanation why the observed effects are small. If it is in principle possible to sense what another person feels or thinks, there must exist an unconscious filter that keeps us from being flooded with information. Otherwise, we would turn crazy as soon as we walked through a crowd of people. Many anecdotal accounts of ESP Phenomena describe situations where the picked up information is emotionally relevant for the people involved. A mother might feel when her child is in danger. An empathetic therapist might intuitively know things about his client that he actually cannot know. It is impossible or at least very difficult to simulate emotional relevance in a standardised test situation. Thus ESP effects found in an experimental situation might be much smaller then ESP effects that occur in real life.

Even if the existence of only small ESP effects was confirmed by further experiments, this would show that non-physical interactions between individuals are possible. Such results would also speak for the existence of a non-physical causation and therefore support the creative choice theory.

9. Conclusion

In the here presented model, physics, as we know it, would not describe our reality completely. The physical reality as a whole branches at any moment into multiple possibilities. Another level of existence could influence which of the many branches is eventually realised.

The dynamics of physical fields and particles can be modelled by mathematical equations. It might well be that the here proposed mental fields and their non-local causal effects can not be described in mathematical terms. However, these fields might follow certain laws and principles that can be investigated scientifically. The creative choice theory describes how mental fields could causally effect the physical bodies they are attached to. The model is compatible with the latest results of physics including decoherence theory. It is also compatible with the results of neuroscience. No so far unknown biological mechanisms (like templates of action that are held in place by the quantum Zeno effect [Stapp, 2005] or cellular microtubules that influence synaptic firing [Penrose, 1994; Clarke, 2007]) are needed to understand the mind brain interaction. Creative choice could explain many phenomena in a plausible way and makes predictions that at least in principle could be tested experimentally. Especially nonlinear neuronal dynamics and ESP phenomena would be interesting fields of research from this perspective.

In the creative choice model mystical states might be direct experiences of deeper levels of reality rather than mere illusions generated by cerebral activity. Thus creative choice could provide a link between the natural sciences and the experiential knowledge of mystical wisdom traditions. Here of course, more work will have to be done and a comparison of the creative choice theory with Buddhist philosophy, transpersonal psychology, etc. would be of interest.

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References

Ashwin, P. & Timme, M. (2005), ‘Nonlinear dynamics: when instability makes sense’, *Nature,* **436**, pp. 36–37.

Aspect, A. et al (1982), ‘Experimental Realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: A New Violation of Bell’s Inequalities’, *Phys. Rev. Lett.*, **49**, pp. 91-94.

Bell, John S. (1964), ‘On the Einstein–Podolsky–Rosen-Paradox’, *Physics*, **1**, pp. 195–200.

Borisyuk, G.N., Borisyuk, R.M., Khibnik, A.I., Roose, D. (1995), ‘Dynamics and bifurcations of two coupled neural oscillators with different connection types’, *Bull. Math. Biol.*, **57**, pp. 809–40.

Child, M. (1996), *Molecular Collision Theory* (Dover Publications).

Clarke, C. (2007), ‘The role of quantum physics in the theory of subjective consciousness’, *Mind and Body*, **5**, pp. 45–81.

DeFelice, L. (1981), *Introduction to Membrane Noise* (Plenum, New York).

de Quincey, C. (2000), ‘The Promise of Integralism, A Critical Appreciation of Ken Wilber’s Integral Psychology’, *Journal of Consciousness Studies*, **7**, No. 11/12.

Eccles, J.C. (1994), *How the Self Controls Its Brain* (Berlin: Springer).

Everett, H. (1957), ‘Relative State Formulation of Quantum Mechanics’, *Reviews of Modern Physics*, **29**, pp. 454-62.

Faye, J. (2008), ‘Copenhagen Interpretation of Quantum Mechanics’, *The Stanford Encyclopedia of Philosophy* (Spring 2008 Edition), Edward N. Zalta (ed.), URL = http://plato.stanford.edu/archives/spr2008/entries/qm-copenhagen/.

Freedman, S.J., Clauser, J.F. (1972), ‘Experimental test of local hidden-variable theories’, *Phys. Rev. Lett.*, **28**, pp. 938-41.

Ismael, J. (2000), ‘Quantum Mechanics’, *The Stanford Encyclopedia of Philosophy* (Spring 2008 Edition), Edward N. Zalta (ed.), URL = http://plato.stanford.edu/archives/spr2008/entries/qm/.

Koch, C. (1999), *Biophysics of Computation* (Oxford University Press, New York).

Korn, H., Faure, P. (2003), ‘Is there chaos in the brain? II. Experimental evidence and related models’, *C. R. Biologies,* **326**, pp. 787–840.

Libet, B., Gleason, C. A., Wright, E. W., Pearl, D. K. (1983), ‘Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act’, *Brain*, **106**, pp. 623–42.

Lindner, B. Garcia-Ojalvo, j., Neiman, A., Schimansky-Geier, L. (2004), ‘Effects of noise in excitable systems’, *Phys. Rep.*, 392, pp. 321–424.

Litt A., Eliasmith, C., Frederick, W., Kroon, F.W, Weinstein, S., Thagard, P. (2006), ‘Is the Brain a Quantum Computer?’, *Cognitive Science*, **30**, pp. 593–603.

Maye, A., Hsieh, C-h., Sugihara, G., Brembs, B. (2007), ‘Order in spontaneous behavior’, *PLoS ONE*, **2**(5): e443. doi:10.1371/journal.pone.0000443.
Palmer, J. (2003), ‘ESP in the Ganzfeld. Analysis of a Debate’, *Journal of Consciousness Studies*, **10** (6–7), pp. 51–68.
Penrose, R. (1994), *Shadows of the Mind* (Oxford: Oxford University Press).
Popper, K. & Eccles, J. (1977), *The Self and Its Brain* (New York: Springer Verlag).
Sheldrake, R. (2005), ‘Special Issue: Sheldrake and his critics: the sense of being stared at’, *Journal of Consciousness Studies*, **12** (6), pp. 1–126.
Schmitt, F. (1970), *The Neuroscience. Second study program* (The Rockefeller University Press, New York).
Squires, E. J. (1991), ‘One mind or many? A note on the Everett interpretation of quantum theory’, *Synthese*, **89**, pp. 283–6.
Stapp, H. (2005), ‘Quantum interactive dualism: An alternative to materialism’, *Journal of Consciousness Studies*, **12** (11), pp. 43–58.
Stein, R.B., Gosen, E.R., Jones, K.E. (2005), ‘Neuronal variability: noise or part of the signal?’, *Nat. Rev. Neurosci.*, **6**, pp. 389–97.
Swain, P., Longtin, A. (2006), ‘Noise in genetic and neural networks’, *Chaos (special issue)*, **16**, 026101, URL=http://link.aip.org/link/?CHAOEH/16/026101/1.
Tegmark, M. (2000), ‘The importance of quantum decoherence in brain processes’, *Physical Reviews* E, **61**, pp. 4194–206.
Zurek, W. H. (2003), ‘Decoherence, einselection, and the quantum origins of the classical’, *Rev. Mod. Phys.*, **75**, pp. 715–75.

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