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Abstract

As a therapeutic intervention, homeopathy is the target of increased scepticism because in the main, its remedies are diluted and succussed (potentized) out of material existence. This puts homeopathy seemingly at odds with the paradigm of conventional science, in particular, that atoms and molecules are the fundamental building blocks of all matter. Accordingly, homeopathy cannot work, so that any reported beneficial effects must, at best, be due to the placebo effect. The purpose of this article is to challenge that conclusion and to suggest that there may well be conventional science-based explanations of how homeopathy could be possible.

Homeopathy's key principles are first described. Then the double-blind randomized controlled trial (RCT), the chief means by which homeopathic remedies and prescribing are tested, is shown to be based on a linear reductionism that is too blunt an instrument with which to test the efficacy of complex interventions such as homeopathy.

The memory of water hypothesis, as a mechanism for how potentized remedies might work, is reviewed, along with some evidence for its existence. A possible rationale for the water memory effect is proposed in terms of a dynamic 'ordering' of water's constantly switching network of intermolecular hydrogen bonds, induced by the manufacturing process of homeopathic remedies. This could lead to a long-range molecular 'coherence' between trillions of mobile water molecules.

However, the water memory effect is an essentially pharmacological explanation of homeopathy's putative efficacy. It is pointed out that healing also entails an interaction between consenting beings. From this point of view, an explanation of any therapeutic procedure should include an attempt to describe the nature of the patient–practitioner interaction. From this perspective, a quantum theoretical treatment of the therapeutic process, involving a form of macro-entanglement between patient, practitioner and remedy (PPR), is advanced as another possible explanation of the homeopathy's efficacy. This shows that the reason double-blind RCTs deliver at best only equivocal results on homeopathy's efficacy is because it effectively breaks the PPR entangled state. A comparison is made between the entanglement-breaking effect of double-blind RCTs and the wave-function 'collapsing' effect of observation in orthodox quantum theory.

The article concludes by suggesting that the memory of water and PPR entanglement are not competing but most likely complementary hypotheses, and that both are probably required in order to provide a complete description of the homeopathic process. While awaiting experimental evidence of these hypotheses, it is suggested that observations of clinical outcomes would be superior to RCTs for further testing homeopathy's efficacy.

INTRODUCTION

Of all complementary and alternative medical (CAM) therapies, homeopathy is arguably the most controversial, and certainly the one most likely to attract opprobrium from CAM's detractors. How, they ask, can a potentized homeopathic remedy, containing nothing of the original substance, exert any effect, let alone a therapeutic one? This article is an attempt to provide possible answers to that question.

What is homeopathy?

Homeopathy's system of therapeutics was developed by Samuel Hahnemann during the late 18th and early 19th centuries. Its principles[1] differ from conventional medicine in several key respects, the most notable being:

- The Principle of Similars: remedies are prescribed for a sick person, which in healthy individuals produce similar symptoms to that of the sickness. Experimenting on himself, Hahnemann discovered that Cinchona bark (at the time, used in the

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treatment of malaria) produced in him a similar feverish condition. The principle of similars goes back through Paracelsus in the 16th century, to the classical Greek physician Hippocrates.[2] It leads to a method for the discovery of remedies called provings: substances are tested on healthy volunteers and the symptoms they exhibit collected, systematically collated, and eventually matched during homeopathic case-taking, to the totality of symptoms brought by a patient.[3] The homeopathic materia medica now contains well over 5000 remedies of plant, animal, mineral and disease origins.

- The Vital Force: again an idea revived from ancient sources whose nearest modern equivalent is the homeostatic immune system. However, the Vital Force's remit[1] is thought to extend holistically beyond the physical, into the realms of the mental and emotional. It is seen as that which attempts to harmonize the whole person on all levels of their being. Thus 'dis-ease' is considered more in terms of symptom expression by a disharmonized susceptible Vital Force, than invasion by pathogens or organic malfunction. The goal of homeopathic treatment therefore is to bolster the Vital Force, so it throws off the dis-ease. This leads to the notion of a dis-ease 'hierarchy' that may well consider disturbance on the mental and emotional planes to be of greater profundity than physical pathology.[4]
- Potentization: the most controversial of Hahnemann's claims and the one unique to homeopathy. Remedies are considered of greater potency the more they are succussed, that is, serially diluted *and* violently agitated (there is an inverse relationship between remedy potency and actual physical concentration of the remedial substance). This is important as without succussion, mere dilution is not considered sufficient to potentize a remedy. It is said Hahnemann discovered potentization by chance, but he certainly diluted his remedies (some of which are highly poisonous in material doses) in order to reduce their toxicity. Many homeopathic remedies are potentized to a degree where no molecules of the original substance remain.[5]

Homeopathy's provenance

Although philosophically homeopathy is bound to be at odds with the more empirical tenets of orthodox medicine (for example, the idea of an all-pervading Vital Force is considered these days quaintly atavistic), it is this last potentization principle that is so contentious for homeopathy's detractors. Homeopathy must at worst be cynical quackery and/or shared delusion; at best, an exercise in 'the placebo effect'; as if the latter were something of little value.

Much effort has been expended in recent years grappling with the practical, scientific and philosophical issues raised by the principle of potentization.[6] So, in the light of our modern understanding concerning the fundamental atomic and molecular constituents of matter, how indeed could homeopathy be possible? But before continuing, it is worth considering how and why homeopathy has managed to survive for so long, while appearing to cock a snook at orthodox medicine and latterly, the contemporary molecular-based biomedical paradigm.

In one shape or form, atomic theory has been around for about 2500 years. Originally propounded by the ancient Greek philosophers Leucippus and Democritus, atomic theory's full development did not occur until well into the 19th century. It was only finally accepted by mainstream science early in the 20th century when Avogadro's Number (the number of atoms or molecules contained within the mass of a substance in grams, equivalent to its atomic or molecular weight – a staggering 6×10^{23}, that is 6 hundred thousand million, million, million) was confirmed experimentally by, among others, Albert Einstein.[7,8] There is now no area of science free of the atomic/molecular paradigm, and medicine is increasingly seen as having a fundamental biochemical basis.

However, homeopathy was being practised and developed by Hahnemann and his colleagues prior to Avogadro and the early chemists and physicists making their atomic and molecular discoveries, and certainly long before the general acceptance of atomic theory. It also achieved notable clinical successes in some of the epidemics which swept Europe and America (for example, cholera, yellow fever, typhoid, and so forth) during the 19th century, despite scurrilous attempts to cover this up.[2] The orthodox physicians and apothecaries of the time were more concerned with the possible threat to their livelihoods posed by homeopathy, than its seeming contradiction of yet-to-be-agreed basic scientific principles. Thus homeopathy was able to establish a sizeable therapeutic foothold; rivalling the orthodox medicine of the time.

Subsequent scientific advances throughout the 19th and 20th centuries improved orthodox medicine's safety record. The germ theory of disease (an idea Hahnemann alluded to in his writings, long before Lister, Koch and Pasteur)[1] and the later success of antibiotics during and after the Second World War, ensured the clinical advantage swung back in favour of orthodox medicine. More recently, the development of molecular bio-medicine (the discovery of the biochemical principles involved in disease processes, for example, sickle-cell anaemia)[9] and so-called* evidence-based medicine with its randomized placebo-controlled trials,[10] have led to some only too willing to proclaim that homeopathy is as good as dead.[11–13] However, reports of homeopathy's demise may well be premature.

DOES HOMEOPATHY 'WORK'?

This is the $64,000 question. First, it is worth reminding ourselves that there is a real human dimension to healing. It could be argued that this has been removed from conventional medicine, with its emphasis on mechanistic principles, such as diagnostics, surgical procedures, and the never-ending search for 'magic-bullet' drugs.

This is not to decry development and use of high-tech appurtenances to the physician's skill, as anyone who has survived serious trauma as a result of swift accident and emergency intervention will gratefully testify. But in attempting to treat chronic illness, conventional medicine faces a difficult task when its main surgical and pharmaceutical options have been exhausted.

Homeopathy does not 'compete' in this arena. Two hundred years ago, even Hahnemann acknowledged that sometimes conventional medical intervention might be a necessary pre-requisite before homeopathy could be effective.[1] Many with

chronic and acute conditions continue to turn to homeopathy for support. It has even been used to support patients until the paramedics arrive. Interestingly, homeopathy's greatest successes are claimed to be with animals and young children. So should homeopathy be considered complementary, as well as an alternative to conventional medicine, and continued to be offered on the NHS? That depends on whether it can be shown that it 'works'. Herein lies a dilemma, for conventional medicine as well as homeopathy.

The trials of homeopathy

There is increased demand for a scientific evidence base to underpin the claims of any therapeutic procedure. The 'gold standard' used in clinical research is the double-blind randomized controlled trial (RCT). In its simplest form, the RCT tests a drug blind against a placebo, and the observed differences are used to establish the drug's efficacy. Thus, in recent years, homeopathic remedies have been subjected to rigorous double-blind RCTs as if they can be treated in exactly the same way as conventional drugs.[14–16] Detailed discussions of these trials have been reported elsewhere, so I will confine myself to general comments on the results.

First, for remedies that are supposed to contain little or no molecules of the substances they were originally made from, a significantly large number of these trials and meta-analyses have delivered positive results.[17–19] Second, because according to homeopathy's detractors, 'Homeopathy shouldn't work, therefore it cannot!', such positive results generally lead to an outcry that the trials were not rigorous enough and that further testing is necessary. Conversely, when trials return negative responses, then detractors breathe a sigh of relief, and proclaim that it is time homeopathy was dead and buried.[11–13] In this respect, homeopathic remedies arguably are subjected to even greater scrutiny than the conventional drugs for which the double-blind RCT was originally designed. Considering the number of double-blind RCT-tested conventional drugs that have subsequently had to be withdrawn from clinical use (because of the appearance of dangerous side-effects, for example, Vioxx), homeopathy's detractors could well be accused of a little bias.

Third, it is interesting that trials so far have delivered such equivocal results: some in favour of homeopathy; while others against. If homeopathy really was that impossible, surely negative trial results would be the norm? And it is useless to argue that those who achieve positive results are poor scientists or more biased towards homeopathy, than those who do not.[10] In this regard, one has to seriously question the objectivity and motivation of a recent meta-analysis published in *The Lancet*[11] (which received a high-profile airing in the world's press). This paper claims to have garnered data from well over a hundred trials and previous meta-analyses, yet selectively made use of the only eight which happened to show that homeopathy was no better than placebo. As for the meta-analysis itself, this has recently received short shrift for its biased methodology by some high-profile scientists.[20] Clearly the double-blind RCT trial procedure is an emotive issue. However, the main message, I believe, is that the data from double-blind RCTs of homeopathic remedies so far do not fully support or totally deny the thesis that homeopathy 'works'.

This is compounded by results from double-blind RCTs of individualized homeopathic prescribing.[21] Here, neither patient nor homeopath know if the prescribed remedy is verum or placebo. These trials show that homeopathy's effectiveness can sometimes be no better than placebo.[21] We shall see later why such a result should not be at all surprising. However, the fact that homeopathy (or indeed any therapeutic procedure, including conventional medicine) *is never practised according to RCTs' double-blind strictures*, should make us wonder why observations of clinical outcomes are not more systematically employed as a better test of real-life therapeutic efficacy.

'If gold rust, what shall iron do?' Deconstructing the double-blind RCT

Does the double-blind RCT really provide a relevant set of protocols with which to investigate homeopathy or indeed any CAM therapy?[10] This question becomes increasingly urgent and relevant when one takes careful account of an implicit assumption lying buried in the heart of the double-blind RCT philosophy: *that the efficacy of a drug or therapy can be treated separately from the context in which it is given*.[22] Driven by this essentially positivist assumption, researchers consider drug/therapy efficacy and context merely as separate and additive, as opposed to fundamentally complex, entangled and interactive. It is then but a simple series of arithmetical steps to arrive at a figure for the efficacy of the drug/therapy over placebo. Thus, Weatherley-Jones *et al.*[22] have pointed out that during a double-blind RCT of any drug/procedure:

1 The healing process during treatment is considered to be a purely *additive* effect of:
   a the natural course of the disease;
   b the non-specific contextual effects of the intervention (e.g. consultation);
   c the specific effects of the intervention.
2 Placebo is not considered to have any specific effects, so that those seen in the placebo arm of the trial are due only to the *additive* effect of:
   a the natural course of the disease;
   b the non-specific contextual effects of the intervention.

Ergo, to arrive at the specific effects of the intervention, one merely takes the summed total additive effects of B away from those of A, that is, $(1 + 2 + 3) - (1 + 2) = 3$.

This might all seem perfectly reasonable when dealing with conventional pharmaceuticals. After all they have known, measurable and reproducible properties (even if as already mentioned, during clinical practice they may subsequently turn out to have previously unknown and potentially dangerous 'side-effects', leading to their withdrawal). But where the double-blind RCT is being used to test the efficacy of a therapy as well, then *the implicit assumption that specific and contextual effects are not interfering or affecting each other, can only at best be a very rough approximation, at worst false.*

To be fair, in conventional circles this has not gone unrecognized[23] so that many CAMs, including acupuncture, touch therapies and homeopathy, have been called 'complex interventions'. However, the 'interference' of contextual effects has even been observed in double-blind RCTs on conventional medicines, where it has been shown that drug presentation to the patient (in terms of the shape and/or colour of a

particular pill) can affect its efficacy.[24] Clearly, therefore, the positivist thinking behind the double-blind RCT is incapable of properly accounting for and including contextual effects of therapy, particularly in complex interventions. For homeopathy, this means that it is not possible to separate the supposed clinical effects of a remedy from the contextual effects of the homeopathic interview. In fact, it can be shown[25] using an algebraic algorithm (based on an assumption of 'macro-entanglement' occurring between patient, practitioner and remedy – called PPR entanglement),[26] that any attempt to 'get at' the effects of the homeopathic remedy, separate from the entangled context in which it is prescribed, is likely to destroy the very therapeutic effect one is trying to investigate. It is rather similar to Admiral Lord Nelson who, at the Battle of Copenhagen, put his telescope to his blind eye and said, 'I see no signal!' Thus, it is not surprising if double-blind RCTs of homeopathic prescribing[21] show no effects greater than placebo, or that double-blind RCTs of homeopathic remedies are so equivocal. We shall return to this point later.

HOW COULD HOMEOPATHY WORK?

In a sense, it would be so much more convenient if the positivist thinking behind double-blind RCTs was universally true and had delivered a definite 'no' concerning the efficacy of homeopathy. For if homeopathy really does work, then we are right back where we started, with 'How can (seemingly) "nothing" do something?' It is instructive to consider how this question might arise.

The trouble with science

Despite the triumph of atomic theory, science has yet to become a unified edifice. Theory and practice in one branch of science need not necessarily overlap with and inform other disciplines. This is most apparent when one compares physics with bio-medicine. The theoretical and predictive refinements embodied in modern non-deterministic quantum theory, for example, have little bearing on the day-to-day empirical reductionism that informs most of the chemical and biomedical sciences.

This may seem controversial as in its simplest form, quantum theory appears to confirm the centuries-held belief in the underlying atomic and molecular basis of matter. However, in quantum theory the idea of atoms and molecules is not axiomatic. Certain fundamental approximations have first to be made (for example, the Born–Oppenheimer and orbital approximations) before atoms and molecules 'fall-out' of quantum theory.[27] But these atoms and molecules are not the hard, tiny, inert 'billiard balls' as was thought, up until the end of the 19th century. They are nebulous, uncertain, highly active, and with complex ever-changing inner 'structure'. This can lead to some stark contradictions.

Thus, physicists think of objects interacting with each other 'at a distance' via a variety of intervening and intertwining fields (indeed, in its most sophisticated form, quantum field theory predicts that the objects are themselves fields). Although it is accepted that quantized electric fields bind atoms together, bio-molecular scientists still consider that molecules interact mainly via direct physical contact, which in cells is highly organized. Such thinking has difficulty, for example, rationalising the speed with which enzymes specifically recognize and turn over millions of substrate molecules per second, purely via organized collisions. It seems increasingly likely therefore that the meeting of enzyme with substrate molecules could be facilitated by some prior long-range field interaction, possibly mitigated and amplified by solvent water molecules that 'lock' them into each other.[28] This leads to one of the most 'popular' explanations for how, in the absence of the original substance molecules, homeopathic remedies might work.

The 'memory' of water

Without water, life would be impossible. As the Nobel Laureate Albert Szent-Gyorgyi pointed out, 'Water is the mater and the matrix, the mother and the medium of life.'[29] Yet, this common and most vital of fluids is actually not as simple as the formula H_2O might suggest. Unlike the di-hydrides of other Group 16 elements in the Periodic Table (sulphur, selenium, tellurium and polonium), H_2O is not a highly toxic, inflammable and evil-smelling gas. The fact that water is a clear, tasteless, odourless, life-giving and sustaining liquid is due to residual electrical forces called hydrogen bonds, which originate deep within the electronic properties of the oxygen atom. It is these hydrogen bonds that at room temperature loosely bind individual water molecules into large rapidly changing dynamic 'structures'.[29] And it is these fleeting water 'structures' that in turn fundamentally influence and mediate the interactions between chemical and biochemical entities.

To adopt a theatrical metaphor, if nucleic acids, proteins, carbohydrates, lipids and hormones and so forth, are the principal 'actors' in the unfolding biochemical drama that is life at the molecular level, then water provides the stage, scenery, theatre, and ultimate direction to that drama. From this perspective, it could well be that too much emphasis has been placed on bio-molecules at the expense of the solvent in which they perform.

Thus, each type of bio-molecule, because of its individual pattern of electrically charged and neutral atomic constituents, will have associated with it an ever-changing 'halo' of interconnected water molecules.[28] At the charged sites on the bio-molecule, water molecules will congregate, while few water molecules gather at the neutral sites. Thus, electric fields generated by bio-molecules will be modified and modulated by their surrounding 'halo' of water molecules, and this influence would be rapidly translated via water's rapidly switching network of interconnecting hydrogen bonds, throughout the whole solvent and received by other bio-molecules.

However, there is so much about this universal fluid that still needs to be discovered, so that even if scientific attention were to shift away from bio-molecules to their aqueous medium, the experimental and theoretical problems could be enormous. For example, within a single microscopic cell, there are huge differences in the water content and properties of its various parts, from the jelly-like consistency of the cytoplasm, to the more fluid content of vacuoles. Modelling such diversity is likely to be a computational nightmare.[29] However, the structure of water itself is being modelled, and shows that it can form dynamic (short-term) hydrogen-bonded coherent molecular 'structures' similar to icosahedra

(a 3D 20-sided figure) around cavities.[30] From here, it is not so hard to imagine that such fleeting aqueous 'structures' could be the bearers of a 'memory' of things once dissolved but now disappeared. But is there any evidence for this?

In 1988, the late Professor Jacques Benveniste claimed controversially that the protein immunoglobulin E, when diluted and succussed out of existence in the homeopathic manner, could still bring about the decolourization of blue-stained basophils (white blood cells involved in the anti-histamine response).[31] The close attentions of a 'quack-busting' team (led by the then editor of Nature, Sir John Maddox, and which included a magician),[32, 33] plus difficulties in reproducing his experiments by other workers,[34] led to Benveniste being pilloried by the French scientific establishment: he lost his funding and his laboratories. Then, in 2004 and after six painstaking years, a pan-European consortium of five separate laboratories reported on a slightly different version of his original protocol, to obtain results essentially in agreement with Benveniste's.[35] The team, puzzled by their results, have challenged others to reproduce their findings.

Reports in other parts of the mainstream scientific literature, suggest water may indeed have a memorizing capability. For example, Samal and Geckler have shown that molecules of a variety of water-soluble substances (for example, salt, starch, even DNA) tend to clump together as the aqueous solution is diluted, rather than getting further apart, as common sense suggests.[36] They also demonstrated conclusively that the size of these clumps depends on the previous dilution history of the solution – the more dilute the starting solutions, the larger the final molecular 'clumps' – implying that water is again exerting some kind of memory effect, even when molecules of the original substance are still present.

In a completely different field, Rey has obtained thermo-luminescence data from homeopathically prepared ultra-high dilutions of lithium and sodium chloride, which are reproducibly different from pure water diluted with itself.[37] This entails freezing solutions down to 77K (–196°C), and then bombarding the frozen crystal lattice with high-energy ionizing radiation. On slowly warming, energy stored in the lattice from the original radiation is released as a thermo-luminescent glow, whose spectrum, it turns out, is characteristic of how a particular dissolved material has altered the water's pattern of dynamic hydrogen bonding.

Rey found these characteristic spectra remained even when the original material had long been diluted and succussed out of existence. This suggests that the altered pattern of hydrogen bonds survived removal of the original material. An alternative view, however, is that the freezing and warming processes cause water to go through several different crystalline forms which produce grain boundaries with each other. These boundaries might well be sites where tiny amounts of impurities are concentrated, so causing the observed differences in thermo-luminescence spectra.[30] Thus, the jury is still out regarding the value of this technique for physically observing water memory effects. Nevertheless, Rey's work could be the first to experimentally demonstrate a hypothesis about water first put forward by Italian physicists almost 20 years ago.

Using quantum theory, Del Guidice, Preparata and Vitiello predicted that, given a large enough number of water molecules (in the order of 10^{17}, representing a visible macroscopic entity), the sum total of all the hydrogen-bonded interactions between the water molecules leads to a correlated state where they all resonate together, spontaneously organising themselves into a so-called 'coherent domain'.[38] This phenomenon was called 'super-radiance', and the physicists went on to show that such correlated 'coherent domains' could not only be triggered by homeopathy's potentization process (serial dilution and succussion),[39] they would survive removal of all trace of the original dissolved substance. In other words, a possible theoretical mechanism for homeopathic potentization and the water-memory effect could already exist.[40] Thus, the act of homeopathic remedy potentization could be likened to the 'encoding' of the solvent with the remedial substance's 'imprint' in a manner similar to the way a compact disc is formatted. When dropped onto a solid pill or a tablet (consisting of glucose or lactose), the homeopathically potentized remedy's 'memory' could be 'locked' by hydrogen bonding to hydroxyl groups of the solid glucose or lactose substrate.

Finally in this section, there has been extensive work over the years on the effects of potentized substances on living things. In a recent highly significant example, Binder *et al.*[41] repeated earlier observations showing the positive effects of homeopathically potentized arsenic solutions on restoring growth to wheat seedlings previously stunted by sub-lethal doses of arsenic.

HOMEOPATHY 'AT A DISTANCE'

This, however, cannot be the whole story. The memory of water hypothesis, even with evidence and a possible theoretical mechanism in its favour, is a response grounded in the atomic and molecular paradigm of conventional bioscience. There is nothing wrong with that per se, but healing, cure, therapy of any kind also depends on a very human interaction between consenting beings, something ordinary bioscience does not take into account. Thus, the memory of water hypothesis could have the effect of confining attention exclusively to the pharmacological or pseudo-pharmacological effects of the potentized medicine, as if it were the sole agency of cure.

From this perspective, perhaps discussion of how homeopathy might work needs to be less focused in the purely deterministic domain of biomedicine. It might allow development of non-deterministic (non-local) theoretical models that take better account of its experience, while at the same time maintaining sight of the 'local' biomedical aspects of the medicine. This has long been argued for in the larger domain of complementary medicine, especially when considering the underlying meaning and implications of the placebo effect.[42] Here, the complex psychological interaction between patient and practitioner is more thoroughly explored. But as we shall see, theoretical models may be available from within the quantum theory of physics that, with its concepts of non-locality, complementarity and entanglement, may help explain this part of the homeopathic process.

The domains of quantum theory

To most, quantum theory and its implications only apply within the confines of particle physics, not in our macroscopic world. It is true that quantum theory's

non-commuting algebraic language is dominated by an incredibly small number called Planck's constant (6.626×10^{-34} Js), commensurate with observations and measurements of events in the sub-atomic through to the molecular domains. However, it turns out that one of the strangest outcomes of quantum theory – the notion of non-locality or entanglement[7, 8] – need not be size-limited.[43]

Entanglement is said to occur when the parts of a system are holistically matched such that measurement of one part of the system instantaneously (that is, not limited by the speed of light) provides information about other parts, regardless of their separation in space and time. What is important is whether the elements of the system are correlated (that is, act as one indivisible whole), and whether such a system's processes can be described using what is called a 'non-commuting algebra of complementary observables'.

What this somewhat obtuse phrase means is that when two separate operations of observation are performed in a sequential manner, *the overall result depends entirely on the sequence in which they are performed*. This is readily understood when considering a set of operations involved in, for example, cooking. Here the sequence involved in preparing for example a loaf of bread, is exquisitely dependent on performing the set of operations – mixing the ingredients; kneading the dough; allowing the dough to rise; baking the risen dough – in the correct order. For if they are performed in a different order, instead of a tasty warm loaf, one is likely to end up with any number of disagreeable and inedible offerings. Expanding on this concept leads to another key idea from quantum theory, known as *complementarity*.

Thus, a single explanation or model might not be adequate to explain all the different observations that can be made on a quantum system. For example, in order to explain how electrons are diffracted when they strike the atoms in a crystal lattice, it is necessary to assume that each electron behaves as a wave. However, when considering the photoelectric effect and electrons being expelled from a solid when struck by photons of the right energy, it is necessary to assume that the electrons and the photons are behaving as if they are particles. This results in the well-known apparent contradiction of particle-wave duality. The point is, in order to be able to explain the properties of electrons (or photons or any quantum entity) it is necessary to have two different but complementary concepts to explain such quantum phenomena. It is almost as if the answer one obtains on performing the two experiments depends entirely on how the (experimental) question is asked; and *both* are necessary in order to acquire a complete picture of a process or system.

It is generally believed that such peculiar behaviour is limited to the sub-microscopic world of particles, atoms and molecules. However, a more generalized version of quantum theory (which relaxes or weakens several of orthodox quantum theory's axioms, including dependence on Planck's constant) has appeared in recent years, called Weak Quantum Theory (WQT).[44] This explicitly allows quantum theory's application into such macroscopic areas as philosophy, psychology and information dynamics and, by implication, into possible explanations of the dynamics of healing.

Why quantum theory? 'We only see the world we make'

Why go to the trouble of developing quantum theoretical metaphors and models of the homeopathic (or indeed any CAM) process? What is it about quantum theory that could so resonate with homeopathy/CAMs?

Classical physics and quantum physics differ in an important aspect. The former enshrines common sense, for everything considered physical is observable and therefore measurable: this is the leitmotif for all reductionist science and underpins the whole of biomedicine. However, in quantum physics the opposite can also be true: not everything considered physical is observable or measurable. So in quantum physics, there is the concept of the wave function, which is not a directly observable entity as such: only its effects are. A wave function is considered to be a multi-dimensional descriptor of a system's state, whose existence may be inferred from the observable effects it produces in our 'reality'.[45]

The reason for this is not because of any fault in measurement: it depends on the mathematical language we use to describe those measurements. Thus, measurement of a quantum state, as with any experiment, ends up providing real numbers (e.g., 1, 2, –6, e, ½, $\sqrt{2}$, etc). However, the multi-dimensionality of the quantum state can only be fully described using a much larger number set called *complex numbers*. These are irreducible aggregates consisting of a real part and a so-called 'imaginary' part based on $\sqrt{-1}$, *which is something that cannot be described in terms of real numbers*.

Real numbers can be seen as being part of the larger set of complex numbers but not vice versa. Trying to fit a state or a system whose full description requires complex numbers into the real number set is like trying to squeeze a three-dimensional cube into a two-dimensional plane: some information invariably is lost, notably in this case, the cube's three-dimensionality. It is this loss of information in trying to translate the complex number set into the reals that leads to much of what is considered to be 'quantum weirdness'.[45]

Esoteric as this explanation might seem, the consequences of the quantum description of reality for our view of the universe are profound. It means ultimately giving up any notion of knowledge of things 'out there', 'in themselves', separate from our observation of them. There is no escaping it: we have to come to terms with the unsettling fact that in quantum theory, the observer and the observed are intimately and irreducibly connected. 'We only see the world we make.'

Now in homeopathy and CAMs there is the notion of an all-pervading Vital Force (Vf) which strives to hold the whole organism in balance.[1] However, this Vf is not a directly observable entity: like the wave function in quantum theory, it is only observed indirectly through the effects it produces, in this case symptoms. Thus it could be argued that through this descriptive similarity of wave function and Vf, *there is a similarity in discourse between quantum physics and homeopathy/CAMs*. Perhaps quantum theory's language could be used to describe homeopathy.[46]

Heisenberg's uncertainty for homeopaths

There are several different quantum models of the homeopathic process currently in existence for which space limitations unfortunately do not allow detailed consideration.[47] In the one I am developing,[26] the homeopathic process is regarded as a set of non-commuting operations. Here, complementary local

observations (practitioner's observation of the patient) and global observations (practitioner's observation of his/her own inner state, how that might fluctuate during the session, and the state of the patient–practitioner relationship) are made by the practitioner. The ultimate result of this process is the remedy. From this perspective, the patient, the practitioner, and (not withstanding its material provenance) the remedy can be regarded as forming a three-way entangled therapeutic entity, such that attempting to isolate any one of these breaks or 'collapses' the entanglement.[48]

This has provided a rationale for why double-blind RCTs of homeopathy return equivocal results.[25] It suggests that the double-blind RCT is an observational procedure whose effect is to 'collapse' the three-way patient–practitioner–remedy entangled state in much the same way that observation collapses a particle's wave function in the Copenhagen Interpretation of orthodox quantum theory.[49]

Thus, while unobserved, a particle is considered to exist in an indeterminate state, and its evolution in time is expressed as a wave function. Observation, however, causes the wave function to 'collapse' to a particle whose complementary position and momentum are related via Heisenberg's Uncertainty Principle. The profound meaning of this is that *the act of observation in part creates that which is observed*. Or, even more starkly, 'The price of knowledge therefore is the loss of an underlying ontological physical reality'.[50] In a similar way, the double-blind RCT may be considered to 'collapse' the three-way entangled state wave function, leading to the loss of the underlying homeopathic effect. This would be the biomedical equivalent of an Uncertainty Principle.

The fact remains however that sometimes trials of non-individualized homeopathic remedies do return positive results.[14–19] Assuming the same level of competence and objectivity by the experimenters as those who obtain negative results, this could perhaps be explained as some surviving entanglement from production of the remedy, ironically as a result of the water memory effect. The work of del Guidice, Preparata and Vitiello mentioned earlier, suggested the formation of 'coherent domains' within water's dynamic hydrogen-bonded 'structure'.[38] This kind of mass correlation over a huge number of water molecules is highly suggestive of a form of molecular entanglement; the individual water molecules of a coherent domain making up one entangled entity. The tantalizing prospect emerges that there could be several levels of entanglement operating in the homeopathic process: from the molecular (created during production of the homeopathic remedy), right up to that occurring between patient, practitioner and remedy.[51] Consequently, although according to this analysis double-blind RCTs on non-individualized homeopathic remedies rule out the possibility of over-arching three-way PPR entanglement, the residual molecular entanglement built into the remedy via the water memory effect could survive, possibly leading to the small positive effects observed in many homeopathic clinical trials. Thus, in considering how homeopathy might be possible, it will be necessary in my view to take full account of both 'local' memory of water effects and 'non-local' contextual effects.

CONCLUSION

So, is homeopathy possible? Surveying the evidence and the efforts of many competent and open-minded scientists so far, the answer to date is, maybe.[20] There is still much theoretical and experimental work to be done, but the ideas proposed in this article could lead to a testable working theory for the therapeutic process, specifically in homeopathy, and more generally in CAMs. However, progress in this direction tends to be hampered by the difficulty in acquiring the necessary research funds from a largely sceptical and anti-homeopathic (and/or scientistic) funding community. Nevertheless, with both local ('memory of water') and non-local (entanglement) hypotheses in existence, work to begin developing experimental protocols is in progress.

Finally, the question has been raised as to whether homeopathy is best explained by 'water memory' effects or some non-local entanglement, and if so, how might one be able to distinguish between them.[52] In my view it is probably far too early to tell. More importantly, it is much more likely that both hypotheses are complementary and that both are required in order to provide a complete description of the homeopathic therapeutic process.

Meanwhile, perhaps further trials should concentrate more on ways of objectively measuring outcomes[53] from 'real-life' practice, rather than acquiring ever more equivocal data from a clinical trials procedure that is patently unsuited to meaningfully testing homeopathy or any other complex therapeutic intervention.

Note

* I prefixed the term 'evidence-based medicine' with the term 'so-called' because for all its apparently current 'cult' status in conventional medical circles, there are real problems with evidence-based medicine. These include 'its reductionism; its unwitting paternalism; its privileging of restricted kinds of evidence; its dependence on the questionable concept of equipoise; the instability of the "truths" it produces; its capacity to eliminate individuals in favour of categories; its historical arrogance; and its contempt for the wisdom and integrity of our predecessors'.[54]

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