

# Are Randomized Controlled Trials (RCTs) Redundant for Testing the Efficacy of Homeopathy? A Critique of RCT Methodology Based on Entanglement Theory

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## ABSTRACT

**Introduction:** Randomized controlled trials (RCTs) have yet to deliver unequivocal results demonstrating the efficacy (or otherwise) of homeopathic remedies and individualized homeopathic prescribing. This could be caused by an implicit assumption inherent in RCT methodology that specific effects of a remedy and any nonspecific effects of consultation are independent of each other. Reported here is a theoretical investigation of the consequences arising from this assumption proving to be false.

**Methods:** A previously developed theoretical model of entanglement in homeopathy between patient, practitioner, and remedy (called PPR entanglement) was used in this investigation.

**Results:** The adherence to RCT methodology could result in such trials completely disrupting the formation or survival of any three-way PPR entangled state.

**Conclusions:** Assuming the PPR entangled state is a necessary condition for therapeutic interaction, alternatives to RCTs are urgently required that can take into account possible entangled specific and nonspecific effects during trials of homeopathy. That RCTs sometimes deliver positive results for the use of homeopathic remedies may be caused by residual entanglement arising from homeopathic remedy manufacture.

## INTRODUCTION

Weatherley-Jones et al.<sup>1</sup> recently highlighted problems of interpreting results from RCTs of homeopathy.<sup>2–10</sup> Specifically, in trials on nonindividualized homeopathic medicines<sup>3,7,8</sup> and individualized prescribing,<sup>2,4–6</sup> it was found that the RCT methodology implicitly assumes that “the healing process during treatment is an *additive effect* [author’s italics] of the natural course of the disease, the nonspecific effects of the therapeutic intervention (e.g., consultation), and the specific effects of the treatment. As a placebo is not considered to have any specific effect, effects seen in a placebo arm of a trial are due to the additive effects of the natural course of the disease, and the non-specific effects of the therapeutic intervention.”<sup>1</sup> Similar doubts

about the appropriateness of applying the RCT methodology to other so-called “complex” interventions (e.g., acupuncture and psychotherapy) have recently been expressed.<sup>11</sup> Weatherley-Jones et al. conclude: “It is not reasonable to assume that the specific effects of homeopathic medicine and the non-specific effects of consultations are independent of each other. . . .”

This conclusion could be interpreted to mean that specific and nonspecific effects of treatment are *entangled* in a sense derived and generalized from<sup>12</sup> from how this term is used in quantum theory<sup>13,14</sup>: ergo, specific and nonspecific effects of the healing process are not simply additive: they are intimately and nonfactorizably correlated with each other.

Therefore, by the very nature of its built-in linear assumptions, the RCT methodology could have the effect

of breaking any entangled state that may arise during homeopathic interventions. Consequently, if patient–practitioner–remedy (PPR) entanglement is a necessary concomitant of such interventions, it follows that the more rigorously the RCT methodology is applied, the less likelihood there is that such trials will consistently demonstrate the efficacy or otherwise of homeopathy (e.g., RCTs of homeopathy do sometimes return positive results<sup>15</sup>). The purpose of this paper is to investigate whether a previously developed algebraic PPR entanglement model<sup>16</sup> is capable of predicting such a possible entanglement breaking effect during RCTs.

## ENTANGLEMENT IN PHYSICS

### *Action at a distance*

Entanglement and nonlocality<sup>17</sup> are concepts derived from conclusions predicted from the behavior of quantum systems.<sup>18</sup> Entanglement has been defined as “the mysterious ability of nature to enforce correlations between separated but entangled parts of a quantum system, even if they are out of speed-of-light contact with each other; and to reach instantaneously across vast spatial distances, or even across time itself, to ensure that the parts of a quantum system are made to match.”<sup>19</sup> In effect this means that a measurement performed on one of the entities comprising an entangled quantum system immediately provides information on its entangled partners, no matter the intervening space or time and *without passage of a signal*.

It was the implied *unsigned instantaneousness* of this correlation (which appears to violate the speed-of-light limit set by relativity theory on the rate of material processes in the universe) that so disturbed Einstein, causing him to dismiss quantum mechanics as an incomplete theory.<sup>20</sup> Subsequently, Bell discovered the conditions, which would allow the notion of entanglement to be tested (called Bell’s inequality),<sup>21</sup> and experimental verification by Aspect et al. followed some 20 years later.<sup>22</sup> These experiments demonstrated conclusively that Einstein was wrong and that entanglement is a fundamental property of the universe.

At the level of atoms and molecules, entanglement is an established scientific fact and is now considered to be a resource<sup>23</sup> of practical value in the development of quantum computing, cryptography, and possible teleportation.<sup>24</sup>

### *Greenberger-Horne-Zeilinger three-way entanglement*

Entangled quantum entities have no individuality: only the entangled group as a whole has a well-defined state. This state derives from the entanglement of their fundamental physical properties (e.g., for particles, their spin; for photons, the direction of their polarization).

In the case of Greenberger-Horne-Zeilinger (GHZ) entanglement<sup>25</sup> among three electrons with spin of  $1/2$  (either

up,  $\uparrow$ ; or down,  $\downarrow$ ), a general pure entangled state of these three quantum particles may be written as the superposition:

$$|\Psi_{\text{gen}}\rangle = a|\uparrow\uparrow\uparrow\rangle + b|\uparrow\uparrow\downarrow\rangle + c|\uparrow\downarrow\uparrow\rangle + d|\downarrow\uparrow\uparrow\rangle + e|\uparrow\downarrow\downarrow\rangle + f|\downarrow\uparrow\downarrow\rangle + g|\downarrow\downarrow\uparrow\rangle + h|\downarrow\downarrow\downarrow\rangle \quad \text{Equation 1}$$

where a, b, c, d, e, f, g, and h are all complex numbers<sup>26</sup> such that the sum of the squares of their real parts;

$$|a|^2 + |b|^2 + |c|^2 + |d|^2 + |e|^2 + |f|^2 + |g|^2 + |h|^2 = 1,$$

$|\uparrow\uparrow\uparrow\rangle$ , represents for example, the state where all three spin- $1/2$  particles’ spins are pointing up. This leads to a total of eight three-particle maximally entangled states called GHZ states: Equation 2:

$\frac{1}{\sqrt{2}}( \uparrow\uparrow\uparrow\rangle \pm  \downarrow\downarrow\downarrow\rangle)$	$\frac{1}{\sqrt{2}}( \uparrow\downarrow\uparrow\rangle \pm  \downarrow\uparrow\downarrow\rangle)$
$\frac{1}{\sqrt{2}}( \uparrow\uparrow\downarrow\rangle \pm  \downarrow\downarrow\uparrow\rangle)$	$\frac{1}{\sqrt{2}}( \downarrow\uparrow\uparrow\rangle \pm  \uparrow\downarrow\downarrow\rangle)$

Equation 2

the first pair (boldface) being, for physical reasons, readily distinguishable from the other six.

## ENTANGLEMENT IN HOMEOPATHY

The principal difficulty that biomedicine has with the claims of homeopathy may be summed up as follows: “How can a remedial substance, diluted and succussed repeatedly, have ANY effect, let alone a therapeutic one, according to the current biochemical and bio-molecular paradigm?”

For this reason, when positive results are claimed for homeopathy, biomedicine generally explains them as placebo responses. If true, this might mean that the placebo response is one of the most important therapeutic agents in existence! But it might also mean that an important element in any therapeutic homeopathic intervention is the nature of the relationship between patient and practitioner: what Weatherley-Jones et al. refer to as the nonspecific effects of therapeutic intervention.<sup>1</sup>

Concerning itself primarily with what it considers to be purely physical (and therefore measurable) reactions and interactions of drug molecules, conventional biomedicine dismisses patient–practitioner interactions as “psychologic,” meaning nonphysical (i.e., essentially unmeasurable), and therefore either beneath its aspirations toward being a “hard” science, or of no importance. Consequently, the effects of homeopathy tend to be labeled as *psychologic* (i.e., non-physical).

Not only does such an attitude betray the innate difficulty that the current biomedical Zeitgeist has in dealing with anything that is perceived to challenge its fundamental opera-

tional paradigm (which is itself predicated on the reductionist philosophy of Newton and Descartes, enshrined in classical physics), it also reveals the extent to which biomedicine is either ignorant of or unaware of the conclusions and predictions of quantum physics—arguably one of the most important branches of modern science. By contrast to the biomolecular explanatory model, quantum physics appears to have no problem in formulating propositions concerning how, for example, the universe could spontaneously appear out of seemingly nothing, viz-a-viz, so-called empty space, via quantum fluctuations.<sup>27</sup>

Thus it would appear that the discourse of quantum physics might be a more appropriate vehicle for discussing the homeopathic process than the classical reductionist paradigm of conventional biomedicine. Before delving further into this, however, a fundamental philosophical difference between the classical and quantum physical descriptions of the world will be considered.

To recapitulate, classical physics enshrines common sense: anything physical is observable. Thus, that which is unobservable must necessarily be considered nonphysical, and therefore beyond the remit of classical physics. Aligning itself with the paradigm of classical physics, conventional biomedicine is therefore reduced to interpreting therapeutic interactions as observable physical processes (e.g., interactions between drug molecules and cellular receptor sites).

Quantum physics, however, explicitly states that (without losing the requirement of empirical evidence for knowledge of physical characteristics) it is possible for physical properties to be unobservable.<sup>27</sup> Thus the measurement of a quantum state returns real numbers (called eigenvalues). Yet the quantum state itself (e.g., its wave function) is described using complex numbers<sup>26</sup> that cannot be homomorphically embedded into real numbers (e.g., in trying to “squeeze” a three-dimensional cube into a two-dimensional plane, some information (e.g., the cube’s three-dimensionality) inevitably is lost). Ultimately this means giving up any notion of knowledge of things “in themselves,” separate from observation of them. In quantum theory the knower and the known are intimately connected.

In the therapeutic context “eigenvalues are analogous to the symptoms of a disease. These are (observed) disturbances of the body which show up and indicate something that does not show up . . . .” In contrast “just as a cold persists even though its (observable) symptoms are suppressed, so a quantum system has a [wave function with a] definite amplitude, even though it has no eigenvalue.”<sup>27</sup> In other words quantum theory supports the notion that just because a thing is not observable, it does not necessarily mean it is not physical. It is for this reason that the discourse of quantum theory<sup>28</sup> is considered appropriate for describing the homeopathic therapeutic process. If all of this seems rather confusing, one should not worry. As Richard Feynman, one of the most famous physicists of the twentieth century once

said, “I think I can safely say that nobody understands quantum mechanics.”<sup>29</sup>

For the notion of entanglement to be useful in any macroscopic context (e.g., homeopathy and complementary and alternative medicine (CAM), then its quite specifically narrow definition used in orthodox quantum theory requires expansion. There are several ways of achieving this, which can be broadly differentiated into *mathematical* and *nonmathematical*. The latter approach<sup>30</sup> is called *emergent entanglement* and assumes that the only form of entanglement is that of orthodox quantum theory. However complex systems consisting of billions of particles can have an emergent property that arises from the system as a whole; and this property can be exploited for various purposes of communication at both intra- and extracellular levels and ultimately at the level of organisms.<sup>28</sup>

The mathematical approach<sup>12,31</sup> is called *generalized entanglement* and is based on a developing metatheoretical context in which orthodox quantum theory is embedded. Called *weak quantum theory* (WQT),<sup>12</sup> it effectively relaxes some of the fundamental axioms of orthodox quantum theory (e.g., the need for Planck’s constant,  $h/2\pi$ ) but retains the algebraic formulation of the latter.<sup>32,\*</sup> Such a formulation predicts the existence of generalized entanglement when certain conditions of complementarity are met. A feature of complementarity in WQT is that it is much more likely to be phenomenologic in nature, as opposed to the ontologic complementarity of orthodox quantum theory.

My approach to entanglement uses the mathematical formalism of orthodox quantum theory but applied in a macroscopic context, combined with the assumptions of WQT.<sup>33</sup> Thus the notions of wave functions and operators are borrowed from orthodox quantum theory but are taken to have a more sophisticated meaning as befits creatures consisting of billions of material particles, emotions, and mind. Unlike orthodox quantum theory, however, relationships between wave functions and operators are also considered to be nonlinear. Interestingly WQT comes to a similar conclusion in that expectation values (i.e., the mean value of a series of determinations of an experimental observable) corresponding to operators are nonlinear, not linear as in ordinary quantum theory. This feature of nonlinearity will become clearer in the next section.

To sum up this section, the algebraic formulation of entanglement in homeopathy might possibly be described in prose as follows: “If our friendship depends on things like space and time, we’ve destroyed our own brotherhood: but overcome space and all we have left is here. Overcome time and all we have left is now. And in the middle of here and now, don’t you think we might see each other once or twice?”<sup>34</sup>

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\*See Reference 32 and references therein.

### *The use of GHZ entanglement as a metaphor for homeopathy*

A description of PPR entanglement in terms of the GHZ state was previously given.<sup>16</sup> Conclusions and equations derived in that and subsequent papers<sup>32</sup> will be used here. Thus, patient (Px), practitioner (Pr), and remedy (Rx) states are each imagined as expressible in terms of wave functions;  $\Psi_{Px}$ ,  $\Psi_{Pr}$ ,  $\Psi_{Rx}$ . Also, although Px, Pr, and Rx can each have a multitude of states, only two for each will be considered. If  $|n\rangle$  denotes a state with wave function  $\Psi_n$ , then in any potentially therapeutic situation Px may be considered in a state of wellness ( $|Px \uparrow\rangle$ ) or unwellness ( $|Px \downarrow\rangle$ ); Pr may be helpful ( $|Pr \uparrow\rangle$ ) or unhelpful ( $|Pr \downarrow\rangle$ ); and the remedy may be curative ( $|Rx \uparrow\rangle$ ) or noncurative ( $|Rx \downarrow\rangle$ ). Using the GHZ formalism, a maximally entangled state between Px, Pr, and Rx may be written as:

$$|\Psi_{PPR}\rangle = \frac{1}{\sqrt{2}}(|Px \uparrow Pr \uparrow Rx \uparrow\rangle \pm |Px \downarrow Pr \downarrow Rx \downarrow\rangle) \quad \text{Equation 3}$$

In orthodox quantum theory, experimental observations are described by operators. There is a connection between wave functions ( $|\Psi\rangle$  and its complex conjugate  $\langle\Psi|$ ), operators ( $\Omega$ , and the observations associated with them), and the outcomes of measurements, leading to an “expectation value” ( $\langle\Omega\rangle$ ). This is the mean value of an observable after a series of experimental observations:

$$\langle\Psi|\Omega|\Psi\rangle = \langle\Omega\rangle \quad \text{Equation 4}$$

A similar equation can be written to describe the outcome of the therapeutic entangled interaction among Px, Pr, and Rx leading to an observed overall change in symptoms,  $\Delta Sx$ <sup>35</sup>:

$$\langle\Psi_{PPR}|\Pi_r|\Psi_{PPR}\rangle = \langle\Delta Sx\rangle \quad \text{Equation 5}$$

where  $|\Psi_{PPR}\rangle$  represents the PPR entangled state wave function,  $\langle\Psi_{PPR}|$  its complex conjugate, and  $\Pi_r$  denotes the “homeopathic operator” (and the “therapeutic state space” created by Pr).

It is worth noting that although equations 4 and 5 look superficially similar, in Equation 4 the self-adjoint operator  $\Omega$  is an entity essentially independent of that which it operates upon (the wave function  $|\Psi\rangle$  and its complex conjugate  $\langle\Psi|$ ). However in Equation 5, the practitioner Pr is functioning both as the homeopathic operator  $\Pi_r$  and as part of the PPR entangled state wave function  $|\Psi_{PPR}\rangle$  (and its complex conjugate,  $\langle\Psi_{PPR}|$ ) that  $\Pi_r$  operates upon. In this sense, the Pr operates to “reflect back” the state of Px and the notion of cure. Thus the homeopathic operator  $\Pi_r$  is an “active mirror.” Pr embodies the homeopathic operator  $\Pi_r$ , which includes “generating” the “state space” in which therapy takes place. In this respect, Equation 5 may be considered nonlinear: Pr maybe thought of as helping to create both the conditions for cure (the home-

opathic operator,  $\Pi_r$ ) and being entangled with the curative PPR state. Thus the function of Pr is helping to create a healing “space” (also denoted by  $\Pi_r$ ) for Px and then appearing and operating within that space as part of the PPR entangled state.

### **ENTANGLEMENT-BREAKING EFFECT OF RCTs**

Weatherley-Jones et al.<sup>1</sup> highlight two types of RCT used to test the efficacy of homeopathy: (1) specific, nonindividualized homeopathic medicines<sup>3,7,8</sup>; and (2) individualized homeopathic prescribing.<sup>2,4-6</sup>

RCTs deemed to be of higher quality tend to show less significant results than those of lesser quality. Weatherley-Jones et al.<sup>1</sup> ask whether this is “because homeopathy is nothing more than a placebo effect or does the evaluation of a homeopathic approach create particular challenges for a placebo-controlled trial?”

#### *RCTs of specific nonindividualized homeopathic medicines*

If a nonindividualized homeopathic medicine is considered as one prescribed with little or no intervention by a practitioner (Pr), then in terms of Equations 3 and 5 this would mean that there would be no opportunity for entanglement with Pr. Thus in Equation 3  $|Pr\rangle$  becomes 0. Equation 3 therefore reduces to:

$$|\Psi_{PPR}\rangle = \frac{1}{\sqrt{2}}(|Px \uparrow .0.Rx \uparrow\rangle \pm |Px \downarrow .0.Rx \downarrow\rangle) = 0 \quad \text{Equation 6}$$

In other words the PPR entangled state and its complex conjugate  $\langle\Psi_{PPR}|$  collapse to zero. However, a further conclusion can be drawn. With no practitioner Pr, then there can be no homeopathic operator/state-space,  $\Pi_r$ , i.e.,  $\Pi_r = 0$ . Substituting into Equation 5 gives:

$$\langle\Psi_{PPR}|\Pi_r|\Psi_{PPR}\rangle = \langle 0|0|0\rangle = \langle\Delta Sx\rangle = 0 \quad \text{Equation 7}$$

(i.e., the expectation value  $\langle DSx\rangle$  also becomes 0, which means that no change in symptoms can be expected). Thus the more rigorously RCT methodology is applied to testing of nonindividualized homeopathic medicines, the more an entanglement model of the homeopathic process predicts how they are unlikely to provide significant results in terms of a therapeutic change in symptoms.

#### *RCTs of individualized homeopathic prescribing*

The entanglement argument here is more subtle. Clearly a practitioner Pr is now involved and may entangle with Px

and Rx, so that initially, at any rate, Equation 3 holds; for example:

$$|\Psi_{PPR}\rangle = \frac{1}{\sqrt{2}} (|P_x \uparrow Pr \uparrow R_x \uparrow\rangle \pm |P_x \downarrow Pr \downarrow R_x \downarrow\rangle)$$

Equation 3

However, under the conditions of the RCT protocol, crucially Pr does not know whether the prescribed remedy is verum or placebo.

It is worth pointing out that there are situations in real homeopathic practice in which a practitioner might *intentionally* give a placebo (e.g., sac. lac.) as a second prescription, for example, when Pr has assessed that the action of a previous remedy is not exhausted yet Px is still experiencing symptoms.<sup>36</sup> It should be emphasized that this is *not* the case in an RCT designed to test individualized homeopathic prescribing, as the *intention* of Pr is to give the prescribed remedy but is uncertain as to whether that intention is met.

How might this affect the therapeutic outcome? Weatherly-Jones et al. state:

The homeopaths had been instructed to conduct their consultations as usual and consider that all patients received real homeopathic treatment, not to think about whether patients were on placebo or real treatment, and to consider that lack of reaction to remedies was due to factors documented in the homeopathic literature. Thus, the reaction of patients to any specific effects of the prescription could affect the homeopath, potentially influencing the nature of the consultation. In this way, the specific effect may impact on the non-specific effect.<sup>1</sup>

Thus to comply with implicit assumptions inherent in the RCT methodology, homeopathic practitioners are expected to engage in a highly questionable (and ultimately confusing) form of self-deception that would be utterly unthinkable in a real therapeutic situation.<sup>37,†</sup>

Thus in light of Pr’s crucial uncertainty over whether Px received verum or placebo Pr cannot “reflect” the entangled state wave function  $|\Psi_{PPR}\rangle$  to give its complex conjugate,  $\langle\Psi_{PPR}|$ , so that  $\Pi_r = 0$ , and  $\langle\Psi_{PPR}| = 0$ , leading algebraically to:

$$\langle\Psi_{PPR}|\Pi_r|\Psi_{PPR}\rangle = \langle 0|0|\Psi_{PPR}\rangle = 0 = \langle\Delta S_x\rangle$$

Equation 8

(i.e., same result as in Equation 7), and the expectation value  $\langle(\Delta S_x)\rangle$  tends to 0, meaning that no change in symptoms

can be expected. Thus the more rigorously individualized homeopathic prescribing is tested via RCTs, the more an entanglement model of the homeopathic process predicts that the RCTs would fail to provide significant results in terms of a therapeutic change in symptoms.

*The RCT as an act of observation*

On the basis of these conclusions it is interesting to consider the RCT methodology as an observational process. Equations 6 and 8 indicate that a possible effect of the RCT methodology is to reduce the PPR entangled state wave function ( $|\Psi_{PPR}\rangle$ ) and its complex conjugate ( $\langle\Psi_{PPR}|$ ), to zero.

In orthodox quantum theory, based on the positivist Copenhagen Interpretation (CI),<sup>38</sup> such a process is deemed to occur as a direct result of the observational process. It is called “the collapse of the wave function.” While unobserved, a particle is considered to exist in an indeterminate state and its evolution in time is expressed by its wave function. However observation causes the wave function to “collapse,” and a particle is observed the complementary position and momentum of which are related via Heisenberg’s Uncertainty Principle. Thus in CI the act of observation in part creates that which is observed. The price of knowledge therefore is the loss of an underlying (ontologic) physical reality.<sup>39‡</sup> It could be argued that by its very nature, the RCT is an observational procedure that can “collapse”  $|\Psi_{PPR}\rangle$  and its complex conjugate  $\langle\Psi_{PPR}|$ , and is having a similar “reality-losing” effect here (i.e., the loss of the homeopathic effect). Thus the PPR entanglement model is implying that the observational stance taken during the RCT trial methodology to the investigation of the efficacy of homeopathy essentially disrupts the very thing that it is trying to observe. This suggests that the application of the RCT methodology to the study of homeopathy is fundamentally flawed, in agreement with the Weatherley-Jones et al.<sup>1</sup> conclusions based on clinical findings.

**CONCLUSIONS**

The purpose of the present paper has been to investigate a theoretical approach to the problem of how specific effects of a remedy and nonspecific effects of consultation are related in RCTs of homeopathy. This investigation was based on a previously developed PPR entanglement model and whether it can determine how the RCT methodology could interfere with entanglement between specific and non-specific effects of therapy.

The starting point for this is that PPR entanglement be considered a necessary condition for therapeutic interaction. Following the algebraic logic of the metaphor reveals that

<sup>†</sup>See Reference 37 and references therein. Note that this situation was referred to recently by Dr. Alex Hankey as “The Maddox Effect” (see Hankey A. A “Maddox Effect”? A reason to adopt time series protocols in tests of homeopathic remedies. This issue, pp 759–761).

<sup>‡</sup>See Reference 39 and references therein.

imposition of the conditions necessary to conduct the RCT methodology either:

- *Impede PPR entanglement* altogether in trials of nonindividualized homeopathic remedies, or
- *Break PPR entanglement* once it is formed in trials of individualized homeopathic prescribing.

This has been compared to an effect of observation in orthodox quantum theory known as “the collapse of the wave function” and is offered as a possible explanation for the failure of RCTs to provide consistently unequivocal evidence for the efficacy (or otherwise) of homeopathy, particularly in tests of individualized prescribing.<sup>21</sup>

However, apart from doubting the wisdom of the involvement of homeopaths in such RCT trials, the question remains as to why some effects are still observed, particularly in trials of nonindividualized homeopathy: according to the argument developed here, there should be none.

There are several ways of addressing this problem. One possibility is that a homeopathic remedy entails the entangled *intention* of those involved in its preparation.<sup>40,41</sup> Without overarching PPR entanglement to “lock” the remedy into “therapeutic coherence,” this residual entanglement might be enough to deliver the relatively small clinical effect sizes that are sometimes observed in RCTs.

A second possibility also suggests a surviving residual entanglement from remedy production but, ironically, as the cause of so-called Memory of Water (MoW) effects.<sup>37</sup> Although still a controversial subject area, the evidence base for MoW is arguably more compelling than for RCTs of nonindividualized homeopathic remedies.<sup>42</sup> Also MoW effects are generally considered to be of light-speed-limited electromagnetic origin. However this does not necessitate abandonment of a nonlocal entanglement argument for one involving local electromagnetic fields.<sup>43</sup>

Earlier work on MoW<sup>44</sup> suggested that homeopathic remedy preparation (involving sequential dilution and succussion) leads to a domain-like ordering of huge numbers of water molecules.<sup>45</sup> This could result in a coherent modulation leading to the formation of an overarching electromagnetic field binding all these molecules together. Thus each domain behaves as a coherent holistic structure, with all its water molecules moving and reacting to external influences in step. In other words, the water molecules entangle with each other, and this entanglement is a necessary prerequisite for an overarching electromagnetic field. Thus there would appear to be different possible levels of entanglement, from the molecular up to the whole being.<sup>46</sup> Consequently although RCTs on nonindividualized homeopathic remedies

rule out the possibility of overarching PPR entanglement, the residual molecular entanglement built into the remedy by the MoW could survive, leading possibly to the observed small effects sometimes observed in homeopathic clinical trials.

In this context it is interesting to consider how these ideas affect another attempt to explain the healing effects of homeopathy and other CAMs, viz-a-viz the biofield hypothesis. This is thought to involve coherent “excitations” that are essentially electromagnetic in origin and therefore limited by the speed of light.<sup>47,48</sup> Thus as living organisms can be considered predominantly constituted of densely packed dielectric or dipolar molecules, they could represent special almost solid-state systems of constantly interacting electric and viscostatic forces.<sup>49-51</sup> Under these circumstances metabolic “pumping” may result in the buildup of coherent modes of vibration similar to the action of lasers.<sup>35</sup> Certainly this could explain the phenomenon of biophoton emission observed from living systems.<sup>52,53</sup> Consequently, over the small distances between individuals in therapeutic and RCT contexts, differentiating between instantaneous entanglement and light-speed-limited electromagnetic effects may well create potentially insurmountable experimental problems, not least because (as has previously been stated) the electromagnetic biofield may be thought of as essentially the result of biomolecular and biophysical coherence/entanglement.<sup>51</sup>

One possible experimental solution might be to divide subjects into two groups and to ensure that one group of subjects were surrounded by the equivalent of a Faraday cage. This would essentially screen out any electromagnetic influences arising from putative biofields. Thus while bearing in mind the possibility that (as mentioned above) separating entanglement from electromagnetic effects may well be impossible, electromagnetic screening could at least help to determine whether they are connected in some way. However this presumed *a priori* relationship between entanglement and biofield leads to the prediction that the arguments presented in this paper are applicable to both hypotheses of healing.

Finally, although there might be a theoretical justification for clinical observations that RCTs of homeopathy are flawed, this merely adds urgency to the search for more relevant and pragmatic methodologies for testing the clinical effectiveness of homeopathy.

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<sup>8</sup>Weingärtner<sup>40</sup> and Walach<sup>31</sup> propose a different version of entanglement, in which the homeopathic effect is a result of the remedy, the whole of its preparation history, and the homeopathic experience.

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