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ORIGINAL PAPER

Observations on entanglement, non-locality and ultra-high dilutions

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Introduction: **Fundamental research into the scientific basis of the manufacture of ultra-high dilutions and their working in applications has evolved over the past twenty years since our last critical analysis of the field was published in 1994 [1]. New contenders from the realm of physics (entanglement, non-locality) have entered the scene. The vast majority within the community of the application of ultra-high dilutions are not physicists. This paper attempts to elucidate the concepts of entanglement, non-locality and their application in ultra-high dilution research (UHD).**
Method: **A selected study on the activity of fundamental research into UHD is performed to gain insight into trends of development activity of fundamental research in this area. In an attempt to nurture further development of theoretical models in fundamental research in UHD, an attempt is made to made recent theoretical concepts more accessible to the larger community including practitioners, policy makers and beneficiaries of UHD.**
Results: **Fundamental research in UHD had a period of prolific activity and recognition at the turn of the millennium until about ten years ago. Since then, research output as well as its recognition receded sharply suggesting that a period of reflection and consolidation may be in progress.**
Conclusion: **The study and the knowledge gained from more recent theoretical models in UHD and entanglement suggest that there may be some benefit in stocktaking of what we really know about the fundamental workings of UHD as well as identifying or developing models that include measurable predictors that go beyond metaphorical descriptors.** *Homeopathy* (2015) **104**, 316–321.

Keywords: Entanglement; Non-locality; Ultra high dilution

Introduction

Following our seminal overview of scientific research into ultra-high dilutions almost twenty years ago[1,2] (Endler, Schulte 1994; Schulte, Endler 1998), a flurry of enthusiasm emerged with the aim to increase the standard of research into homeopathy. Since then, the international journal *Homeopathy*, the Journal of the British Faculty of Homeopathy, has elevated its reputation to that of a widely indexed research journal (CINAHL, MEDLINE®, EMBASE, Excerpta Medica, Scopus).

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The scientific rigor behind research into ultra-high dilutions gained considerable momentum resulting in a renaissance in peer-reviewed publications in *Homeopathy* and a wider appreciation of the field within the scientific community in general. By the turn of the millennium curious mainstream researchers diverted some time of their state-of-the-art laboratory equipment to have a closer look at theories and claims about the working of homeopathic dilutions.

At the same time veterans in the field of homeopathy research enjoyed the challenge of the new scientific rigor and scientific peer-review. By 2003 the SNIP index, a measure of how widely articles in *Homeopathy* are read and cited by the larger scientific community, went above 1.0 (Figure 1). This is a major achievement for any newly indexed scientific journal. During that time the number of research articles per year increased from only a handful in 1998 to over 40 in 2002. While the quantity of research

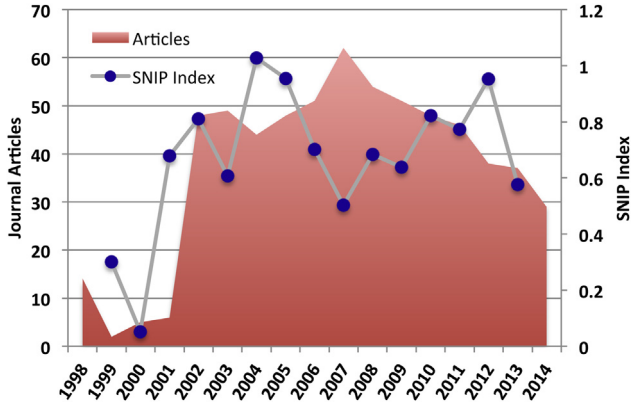

Figure 1 Yearly record of articles published in *Homeopathy* and respective Source Normalized Impact per Paper index. Source: SNIP Index.

increased over that period of time, the quality of research lifted the relevance of the publications from an SNIP index of less than 0.1 in 1998 up to an index of 1.03 in 2002. At that level of quantity and quality, with some strategic planning, fundamental research into ultra-high dilutions was ready to be taken onto a mainstream research funding track. The public perceptions changed though, and with it the perception within the small community of researchers concerning themselves with the fundamental workings of homeopathy.

The astute reader might ask, what has this all to do with entanglement and non-locality? The answer is to some extend reflected in the development of research in the years following 2004. The recognition and relevance of scientific papers in *Homeopathy* dropped dramatically to an SNIP index of 0.5 in while the number of research articles grew to a staggering 62 per year in 2007 and the amount of uncited papers started to move above 50%.[3] Homeopathy, traditionally a practice oriented research field is dominated by provings and clinical case studies whereas fundamental research into the physics of the workings of UHD takes but a small part in the overall research efforts. Consequently, reports on fundamental research into UHD followed the general trend in publications. A more quantitative discourse on fundamental experimental work is presented elsewhere in this special issue.

Nevertheless, authors with interest in the theoretical part of fundamental research became quite prolific with their publication effort and gained some visibility, yet had only a limited contribution to field, guidance as to how theories and findings may be verified. Some research was found to be based on own assumptions made in prior work, which were not or could not be tested; an approach similar to the research we saw during the lead up to our work in 1994. Self- and round-robin citations enjoyed a new revival while the occasional curious newcomer quietly withdrew from field.

In our overview of the field in 1994 we also took note of that theoretical models on the working of ultra-high dilutions in homeopathy were presented in rather obfuscating ways, which at the time we attributed primarily to a limited understanding of the underlying physics. As a consequence of such obfuscation, very few clinical researchers and practitioners working in the area of ultra-high dilution could follow the papers or make sense of the presented physics or verify its validity. However, a perception of model validity appeared through a process of extensive self-citation in follow up publications as well as cross-referencing with a few other like-minded authors in a prolific merry-go-around of co-supporting publications; without validating underlying fundamental assumptions or detailing their limitations. A clear signal for professional researchers to keep a certain distance from the field. A lack of model predictions or measurable evidence was not seen to undermine the believe in a particular theoretical model. Consequently, practitioners and the casual UHD researcher found it difficult to assess the applicability of these new theories and to what practical innovations they might lead in the understanding of the working of ultra-high dilutions in homeopathy and how this might help the approaches taken in their daily consultations with patients. At the other end were the manufacturers of homeopathic remedies who appeared to be content with their products, with only limited interest to understand more in order to improve their remedies; something very unlike the conventional pharmaceutical industry or manufacturing industry that appears to be always striving for a better understanding of their processes and products.

Some new theoretical models in ultra-high dilution research emerged over these years driven by new developments at the frontline of theoretical and tightly related experimental work done by well-established research teams. The theories are very complex and accompanying experiments delicate to conduct. The following of this paper attempts to shed some light into newly hopeful contenders in the search for a verifiable theory of UHD, namely quantum entanglements and non-locality.

Entanglement

The entanglement we wish to elucidate here is the entanglement of quantum objects found in the theory of quantum mechanics and its subsequent application to the macroscopic realm of ultra-high dilutions. Later, we'll broaden this narrow view and place it into a more applicable macroscopic scenario.

Quantum mechanics is concerned with making precise predictions about quantum mechanical objects such as small molecules, atoms, electrons, photons and other objects interacting at atomic scale. Quantum mechanics is one of the most successful theories in physics; it can predict interactions at atomic level with unmatched accuracy. The mathematical framework surrounding quantum mechanics is based on describing quantum mechanical objects in terms of their states, or more precisely, vectors representing their states. Each element of a vector describes a single physical property of the object under investigation (atom, molecule, etc.). A vector is an array of elements, each describing an independent (often called "orthogonal") physical property of the object. For instance, the motion