

## EDUCATION AND DEBATE

# Complexity science and homeopathy: a synthetic overview

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**Homeopathy is founded on 'holistic' and 'vitalistic' paradigms, which may be interpreted—at least in part—in terms of a framework provided by the theory of dynamic systems and of complexity. The conceptual models and some experimental findings from complexity science may support the paradoxical claims of similia principle and of dilution/dynamization effects. It is argued that better appreciation of three main properties of complex systems: non-linearity, self-organization, and dynamicity, will not only add to our basic understanding of homeopathic phenomena but also illuminate new directions for experimental investigations and therapeutic settings.** *Homeopathy* (2003) 92, 203–212.

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## Introduction

The homeopathic and scientific medical worlds have developed separately. For example homeopaths, in general, have not perceived the need, in their clinical practice, for evidence provided by clinical trials or by basic research from animal experiments or in vitro laboratory studies. On the other hand, most academic medical scientists show no interest in homeopathic methods of clinical care. However, in recent years there has been an increasing demand both for scientific evidence (in homeopathy) and of a more humanistic/holistic attitude (in conventional medicine). This quotation from last edition of Harrison's Principles of Internal Medicine is worth noting: *'The practice of medicine combines both science and art. (...) One must be able to identify the crucial elements in a complex history and physical examination. The combination of medical knowledge, intuition, and judgment defines the*

*art of medicine, which is as necessary to the practice of medicine as is a sound scientific base'*.<sup>1</sup> There is need of an interface by which those two worlds begin to communicate. A possible framework for such an interface is provided by complexity theory, this may contribute to the development of a new, integrated, concept of disease and therapeutics.

The main principles of homeopathy, the 'similia principle', the 'potency' and the 'holism' may be investigated by different scientific approaches. The role of complexity science is to link these different fields but especially to provide possible explanations of global, systemic phenomena and theories that are associated not with a single mechanism, but with general modifications of the organism during disease and therapy. This concept may appear self-evident, but it actually represents a breakthrough in the history of science.<sup>2–12</sup> As a matter of fact, there is still no agreement on the acceptance of the complexity paradigm, especially in medical sciences.

There are a number of possible definitions of complexity, none is fully satisfactory. A complex adaptive system has been defined as *'a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions changes the*

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context for other agents'.<sup>13</sup> In complex systems we often see the *emergence* of hierarchical network of multiple cross-interacting elements.

Three major properties of complex systems are their non-linearity, their self-organization capability, and their dynamicity. The analysis of some implications of these three properties may illuminate possible links between complexity theory and the principles of homeopathy.<sup>14–17</sup> In fact, the starting point for understanding the action of homeopathic medicines is not the medicine itself, but the body: one only needs to consider the disparate symptoms that are described for each individual medicine in the *materia medica* to realize that homeopathy is based on the implicit metatheoretical assumption that the body is a complex system.<sup>17</sup> Moreover, these theoretical ideas may help to develop working hypotheses, empirical tests and new directions for experimental investigations and therapeutic settings.

There are many implications of complexity science for homeopathy. But complexity theory cannot be seen as a definite scientific 'explanation' of elusive pharmacologic phenomena. Most consideration in this field are still of metaphorical nature, also for conventional medical science, where practical applications of complexity science are still few, compared with the theoretical discussion of the subject. There are a number of topics where homeopathic claims may be investigated using conceptual tools provided by complexity science at various levels (ie organic, cellular, molecular complexity), but we need to make the theory more quantitative and to develop empirical tests in order to test a number of hypotheses that have been developed in this field.

## Non-linearity

A major feature of complex systems is their *non-linearity*. This concept includes the lack of proportional relationship between input and the outcome. This includes chaotic phenomena such as unpredictable behaviour and sensitivity to small perturbations.

Schematically, the following connections between non-linearity and the homeopathic field can be drawn.

### Inverse effects and hormesis

The first connection is established with the well-known phenomenon of *inverse, opposite, or biphasic, effects* of very low doses of drugs. Rather than being an exception, non-linearity between dose and response is the rule in biological systems. The occurrence of dual effects (both stimulatory and inhibitory) caused by the same agent at different doses or different times has been described in various experimental systems and has been often called 'hormoligosis', or 'hormesis'.<sup>18–21</sup> A demonstration of inversion of effects on testing the *in vitro* adhesiveness of leukocytes has been reported previously,<sup>22</sup> where extremely low doses

of bacterial peptides caused inhibitory effects while higher doses caused an activation. This phenomenon is probably due to the dynamics of signal transduction and specifically to a 'gating' effect of cyclic AMP. There are many other models of hormesis, such as those which focus on the protection against cell toxicity by extremely low doses of toxic substances.<sup>18,23,24</sup> These effects conceivably have a mechanistic explanation in the behaviour of heat-shock proteins, ie in molecular system whose activation is responsible for protection of cells from several types of aggression. Whatever the mechanism(s) of these effects at biological and physiopathological level, it is important to say that this kind of inverse effect does not represent 'the' only explanation of homeopathic effects, which may have further and more complex implications at the level of the whole organism.

### Paradoxical and rebound effects

A related topic is so-called '*paradoxical pharmacology*', as regards the *in vivo* effect of medicines: acute and chronic effects of drugs are often opposite effects.<sup>25</sup> This is particularly true for receptor-mediated events. For example, acute agonist exposure can produce activation of receptors and increased signalling, whereas chronic exposure can produce desensitization and decreased signalling. This secondary reaction of the organism to a medicinal stimulus has been observed with hundreds of modern drugs, and is referred to as a rebound effect. In this process, the organism is stimulated to react through a vital (paradoxical, secondary or homeodynamic) reaction, oriented by the primary effect of the drug. Here there is a significant overlap with traditional homeopathic concepts.<sup>26</sup> In fact, these long-term effects should have properties that are similar to the symptoms that is being treated in the short term. If this is the case, we could exploit paradoxical and rebound effects in order to obtain a curative effect.

It has been suggested<sup>27</sup> that modern drugs can be utilized according to the principle of homeopathic cure, employing rebound effect as a curative reaction. It would be possible to compile a *Materia Medica* that would group the symptoms produced by rebound effects of medications in human individuals, utilizing them, a posteriori, following a partial or total similitude, in infinitesimal or substantial doses. It should thus be possible to take advantage of modern pharmacological experimentations either in healthy individuals (phase 1 trials) or in ill people (phase 2–3 trials), thus amplifying the spectrum of homeopathic cure with a wide range of new symptoms and medications.

### Chaos

Another great field of possible studies emerging from non-linearity of complex systems is deterministic *chaos*. Chaos means an apparent disorder (or pseudo-randomness) in space and time (unpredictability),

concealing a deterministic order, with the specific features of sensitivity to initial conditions and presence of multiple equilibria. Chaotic regimes have been found in a number of physiological systems, from heart to brain, this results in enhanced susceptibility to regulation.<sup>3,10,28,29</sup> Torres and his group have done important work on the concept on enhanced susceptibility of biological systems and have shown the feasibility of an approach using physical and mathematical tools to interpret in this way the electrophysiological signals.<sup>15,30</sup> They also pointed out that the susceptibility of a complex system is greatly enhanced near a phase transition, or critical point. In these conditions, adding random energy ('noise'), even a minute perturbation will push the system over the energy barrier. This phenomenon, called stochastic resonance, may be a physical explanation of the effect of succussion during the preparation of homeopathic medicines.<sup>31,32</sup> The same mechanism may operate also in vivo during homeopathic therapy or during proving of the medicine, where stochastic resonance, provided by noise from biochemical reactions, may amplify inside the living organism the effect of small but highly specific information provided by the medicine itself.

This concept of enhanced sensitivity of chaotic systems can be extended to other types of biological regulation: the complex, extremely weak *electromagnetic field* of the organism involves low-frequency electromagnetic signals that may regulate homeostasis in non-linear, non-equilibrium living systems. It has been suggested<sup>33</sup> that rapid signal propagation of electromagnetic fields as well as its long-range properties may account for the rapid and global effects of medical interventions like acupuncture, bioelectromagnetic therapies, and homeopathy.

The work of Bell *et al* represents a contribution to understanding of the implications of chaos theory for homeopathy.<sup>16</sup> In particular, they have suggested that non-linearity and therefore the subtle effects of homeopathy can be assessed through a number of tests, like subjective measures of well-being, creativity, mood, or objective measures like musculoskeletal activity, skin electric conductance, EEG, and so on. Most importantly, they have adapted certain types of computations on time-series data to study non-linearity and signal complexity during homeopathic treatment.

Investigating chaotic dynamics may furnish a more complete and predictive information for characterizing therapeutic effects of various types of periodical stimuli (including physiological stress, acupuncture, electric pacing, psychotherapy, and so on), of pharmacological compounds<sup>34</sup> and of highly diluted homeopathic remedies.<sup>30,35-37</sup>

### Variability and reproducibility

Finally, the presence of chaotic dynamics in complex systems could provide a framework to the well-known

problems of reproducibility of laboratory and clinical experiments in homeopathy. Assuming that the effect of homeopathic high dilutions represent a perturbation of the deterministic chaotic evolution of a target system, it follows that the replicability of every experiments would be affected by extremely small changes of conditions of the experiment itself. This suggestion is in agreement with some experimental findings by different laboratories, where the effect of high dilutions in laboratory has been tested. When the effect has been found, the inhibition curves showed alternating peaks of inhibition, lack of effect or even stimulation on increasing dilutions, but there was little correspondence between different laboratories and in the same laboratory the effect peaks often changed in different experiments. A similar problem has been recently noted by Lorenz and collaborators.<sup>38</sup> They showed that the effect of histamine on basophils is markedly influenced not only by the dilution/potency of histamine, but also by the composition of the diluent. Other replication problems are related to season and to the individual donors blood samples. Of course, we should not attribute all these technical problems to the presence of chaotic dynamics. Other factors may be involved, such as experimental errors or chance variations like in other fields, but this hypothesis deserves further attention.

Further development of basic research is highly desirable and cell- and plant-based bioassays may be suitable tools for this purpose. Botanical bioassays appear suitable for basic experimentation in homeopathy, making it possible to perform a large number of experimental repetitions. Recently, it has been suggested that the variability of the system is the true target of homeopathic treatments and that this assumption could provide a key for interpreting the irreproducibility phenomenon and support a non-reductionistic phenomenological theory of homeopathy.<sup>39,40</sup> It would be interesting to analyse large experimental datasets and time-series with mathematical tools of complexity science in order to distinguish deterministic chaotic phenomena from chance variability.

Non-linear phenomena are also found in chemistry: there are chemical reactions which are capable of self-organization in non-equilibrium states in the course of time. The prototype of these reactions is the one described by Belusov-Zabotinski: in this redox reaction, there is a critical threshold of reagents below which sustained oscillations are observed.<sup>5</sup> The degradation of glucose in an enzymatic reaction involving two enzymes competing for the same substance also shows complex oscillating patterns.<sup>2,41</sup> The amplitude and period of oscillations in these reactions are dependent on the concentration of components and other parameters like temperature, so that extremely small changes in these conditions can lead to an increase in oscillation frequencies and amplitudes or cause them to become chaotic, as described by mathematical models such as the Verhulst function.<sup>2,14</sup>

It is conceivable that these highly non-linear transition phenomena in chemical systems could provide useful tools for exploring 'homeopathic' phenomena, like possible changes of solvent structure due to succussion/dynamization.

The difficult replicability of homeopathic clinical trials is also well known.<sup>42</sup> Recently, Hyland and Lewith<sup>43</sup> tested the effect of homeopathic immunotherapy and compared the changes of symptoms induced by *verum* (the potentized substance to which the patient was allergic) with those of a group which received placebo. Unlike the results of previous investigators,<sup>44</sup> who reported, using slightly different methods, a positive effect in favour of homeopathic immunotherapy, in this case the end-point clinical effects were null. However, the pattern of data indicated that *verum*, compared to placebo, approximates to an oscillation and this difference is statistically significant. According to the authors,<sup>17</sup> such an oscillation is consistent with a complexity theory interpretation of how the body functions as a whole. The significant conclusion is: '*We should consider that homeopathy (and other complementary therapies) are complex interventions and will require a different clinical trial methodology from that currently employed.*'

## Self-organization

One of the merits of complexity science is its ability to explain *self-organisation*, meaning the capacity of some complex systems to generate order from disorder, patterns, coherence, that in dynamic terms (during time) may develop variable oscillations and attractors (the attractor is an equilibrium position of the system, the other states form the basin of attraction and will move towards the attractor over time). A complex system can be composed of only a few elements, but the interaction of components on one scale can lead to complex global behaviour on a larger scale that in general cannot be deduced from knowledge of individual components. These elements, connected by physical forces, in suitable conditions and when they are subject to a flux of energy (heat, light, mechanical agitation, etc), tends spontaneously to organize as a 'structure' (either spatial like a form, or temporal, like a series of events occurring with a given frequency).

This notion of emergent properties of large numbers of interacting parts also allows a reasonable explanation of the Hahnemann's 'vital force' in terms of total activity of all the cells in the body, of complex feedbacks and homeodynamics. It is a crucial aspect of the healing process that billions of cells act in concert to destroy foreign invaders or tumour cells and to re-establish the healthy morphological and functional state. To achieve this coordination, soluble hormones, the nervous system, cell-cell interactions and possibly long-range signals such as electromagnetic signals<sup>45</sup> provide a link between general, systemic,

factors and local factors. The reciprocal influence of systemic and local factors is so important that a psychological stress can be associated with immune suppression and infection while, conversely, an infectious process under a tooth can cause profound psychological depression. Here we can attempt other bridges with the homeopathic field.

## Symptom pattern

The concept of self-organization can be associated with a re-evaluation of the concept of '*symptom pattern*', that is the symptomatology of disease that is not a sum of different symptoms, but a peculiar pattern, where symptoms reflect a profound, dynamic unity. It has been suggested that this complexity can be exploited in observational studies and clinical trials by utilizing complex outcomes like quality of life questionnaires, constitutional type questionnaires, and similar.<sup>46</sup> Here we can remember the homeopathic clinical observational studies from several groups.<sup>47-52</sup> Recognizing that symptoms are the expression of a profound unity and coordination of internal 'vital' reactions should have profound impact on the way by which different symptoms are considered and 'weighed' during homeopathic repertorization. A higher importance should be given to symptom patterns (or syndromes) with respect to the simple sum of single different symptoms.

## Water structure

A second point of contact and of investigation is the emergence of *organized patterns in water* and in condensed matter. Here we can mention the hypothesis of clusters, or clathrates, which deserves further attention by researchers in physics. A plausible hypothesis, backed up by modern quantum mechanical calculations and some experimental data is that molecular memory is an emergent property (in the sense used in complexity theory) of large numbers of molecules all physically interacting with other, via known physical principles.<sup>53-61</sup> An unresolved problem is still that of stability of clusters over thermal fluctuations that should tend to dissipate any emergent structure.

Moreover, these data are in agreement with quantum electrodynamic theories.<sup>62,63</sup> The basic idea of this reconsideration of quantum electrodynamics (QED) in condensed matter, liquid and solid, is that *macroscopic* assemblies of identical *microscopic* systems, below a certain temperature (the critical temperature) and above a particular density (the critical density) behave in a way completely different from an ensemble of microscopic objects kept together by short-range, electrostatic forces, as now currently generally believed. The fundamental new aspect of the theory is that interactions among the microscopical systems (atoms and molecules) are not restricted to the 'nearest neighbours', but extend over 'domains', of the

size of the wavelength of the electromagnetic field that vibrates at the common frequency of matter systems. Such 'coherence domains' represent the fundamental building blocks of condensed matter, inside which matter (atoms, molecules, electrons and nuclei) oscillates in tune (technically: in phase) with a macroscopic (classical) electromagnetic field, much in the same way as it happens in a familiar laser, with the fundamental difference that the coherent electromagnetic radiation is now trapped permanently inside the coherence domains, its function being to hold the system together against the assaults of thermal fluctuations.

A related point is the presence of *fractal* structures in chaotic systems. A fractal is a geometric shape that has symmetry of scale, or self-similarity. This means that it is a shape that one could zoom to infinite magnification and it would still look the same. Computer-generated fractals can create realistic pictures of mountains, coastlines, plants, bronchial tree, etc. We and others have made an intuitive prediction that the phenomenon of increase of 'potency' in serial dilutions may have a physical basis according to the theory of self-similarity and formation of fractal structures in serial dilutions, where serial dilutions are seen as mathematical iteration processes.<sup>14,35,36</sup> Through serial dilutions and succussions, the homeopathic solution could undergo to a process of increasing physical structuring, similar to the geometrically wonderful, branched fractal images. This explanation would be consistent with some findings of experiments where the effect of homeopathic dilutions shows peaks of activity alternating with non-activity. At present, this idea is only speculative, also due to the difficulty in reproducing studies of dynamization, but recent experiments, showing different optical emissions under electromagnetic impulses<sup>64</sup> and characteristic thermoluminescence peaks<sup>65</sup> in homeopathic dilutions, open a new window for the study of this elusive phenomenon.

### Patient-doctor interactions

Finally, we have to consider the great importance that is given by homeopathy to interactions such as those between the patient–doctor–medicine and environment–body–mind. Complexity science may give conceptual tools and methods of analysis for this kind of interactions. Some efforts may have concentrated more on the homeopathic medicine as an entity in itself, others also considered the effect of the medicine on the body. It has also been suggested<sup>66–68</sup> that according to complexity theory the medicine would act in the context of a tripartite relationship with the patient and the practitioner. What may be the physical basis of such an entanglement is still a matter of speculation.

In any case, this point forces us to take into account the 'context' of cure (eg: patient–physician interactions) and therefore to seriously question double blinding for testing homeopathy: this method by definition would disrupt those interactions. This

method can be useful to investigate specific questions in restricted experimental settings, where the object of experimentation is not to prove 'homeopathy' as a global therapeutic approach but only to measure the 'difference of effects between a homeopathic potency and placebo' (as it has been done, for example for dilutions of pollen or dust mite). It is essential to be clear that these two outcomes are not the same thing.

## Dynamicity

A third essential characteristic of complex systems is their *dynamicity*. In fact, complex science is also referred as *dynamic systems theory*. This point emphasizes the capability to change during time, to evolve according to new requirements. This is based on the structural and functional plasticity of living beings, on associative memory and learning. Adaptation capability and evolution includes the importance of individual history, of sensitization/desensitization phenomena that condition the behaviour of cells and organisms. Changes of sensitivity during the transition from health state to disease and during therapy have a major impact in the rational explanation of similia principle. This point has been raised by others.<sup>16,47</sup>

### Dynamic oscillations and attractors

Physiological rhythms are central to life: both regular, and chaotic irregular *oscillations* are often found in complex networks.<sup>69</sup> These may be responsible for properties such as diurnal rhythms of hormone and cytokine levels, febrile cycles in inflammatory or infectious diseases, recurrent illnesses such as juvenile chronic arthritis or depression and psychosis. Temporal organization of biological phenomena is evident in the rhythmic functional modifications of cells, tissues and organs. Physiological variables as disparate as enzyme reactions, neuronal activity, heart rate, respiration, cell division, ovarian cycle, corticosteroid circadian variations, cell calcium oscillations, membrane polarization/depolarization, sleep/waking, oxidative metabolism, actin polymerization, cyclic nucleotide concentration, all undergo time-dependent oscillations and generate spatial patterns (waves). These oscillations and patterns may be considered as dynamic attractors of the involved physiological variables and might function as biological clocks.

Periodical variation of molecular concentrations can be used, by living systems, as means for coding and transmitting information. In other words, signals can be transmitted and perceived not only as variations in the *amplitude* of the intensity of a given phenomenon, but also in the *frequency* with which it occurs. The most familiar example of *frequency-modulated* signal transmission is the action potential in nervous system, but other molecular oscillations such as calcium waves and hormonal changes have been interpreted in this new light.<sup>70</sup>

It could be speculated that oscillating physiological systems and the communications associated with them could be regulated by means of synchronization or tuning, ie by means of a change in frequency imposed by resonant interaction with another oscillator. According to this notion, the homeopathic medicine might act in the patient as an external guide frequency. A potentized homeopathic drug might be regarded as a small amount of matter containing elements oscillating in phase (coherently), capable of communicating these oscillatory frequencies, via a process of resonance, to biological fluids (mostly made up of water), but also to complex 'metastable' structures, subject to non-linear behaviour patterns and capable of oscillating (macromolecules, alpha-helices, membranes, filamentous structures, receptors). There would thus be the possibility of a link between drug frequencies and oscillators present in the living organism perturbed by the disease.<sup>14,37</sup>

### The complexity of diseases

Oscillations of control parameters of physiological systems are the norm in biology and in medicine. If, however, the coordination is lost, ie the *connectivity* of the system as a whole and in relation to the rest of the body, certain subcomponents may oscillate in an excessive, unpredictable and pointless manner, thus generating localized disorders which may be amplified (amplification of fluctuations is a typical behaviour of chaotic systems). Interestingly, after homeopathic treatment, these oscillations may reflect a global perturbation of the organism or of subsystems (eg the immune system) triggered by the medicine.<sup>17</sup> Of course, the follow-up of therapy should take into account these phenomena.

The impact of complex science on the *theory of disease* as proposed by homeopathy is of major interest. Many diseases are multifactorial, self-organizing, dynamic processes that involve the whole individual and its environment.<sup>71,72</sup> These multiple levels of complexity demand new attitudes in medicine, both in 'diagnostics' and in 'therapeutics'. From the standpoint provided by complexity science (and by homeopathy) the 'core' of disease dynamics is situated *not only* at the level of multiple environmental factors or genetic factors involved, but at a more fundamental level, the *systemic information disorder*.

When a biologic system (eg a cell with its receptors) is stressed by excess stimuli it may undergo a functional block, due to downregulation of its sensitivity, shedding of receptors, metabolic exhaustion, and so on. Under such conditions, significant components of the networks are pushed out of regulatory homeodynamics, but in a living complex system, loss of communication means pathology. So, a certain oscillating behaviour or a certain structural modification can become 'fixed' in a pathological attractor simply due to a (even very small) perturbation,

eventually losing the possibility of reversibility. This kind of pathological modification of a dynamic system can be considered a 'erroneous adaptation', where the system finds a fixed point, or a periodically oscillating behaviour outside the normal, range of variation. In a particular sub-set of space-time, ie locally or for a short period, this new attractor may appear as the most convenient in terms of energy expenditure. However, for the system as a whole and for future prospects of development of the system itself, an erroneous adaptation can be highly deleterious.

Here we can see an important contribution of homeopathic tradition, starting from a new, holistic, concept of vital force and its possible dynamic alterations. According to Hahnemann (*Organon*, par. 29) '*every disease (not entirely surgical) consists only in a special, morbid, dynamic alteration of our vital energy*'. Paragraph 86 further states: '*Disease and healing develop only through dynamic influences*'. The author was aware of the existence of pathogens and familiar with the work of his contemporaries, including Sydenham, Jenner, and others (paragraph 38), but he strongly emphasized dynamic factors related to host, environment, and subject.

The 'dynamic alteration of vital energy' can be translated in modern terms as a block of homeodynamics and communication. As previously pointed out by several authors,<sup>7,14,16,73</sup> people with various diseases lose non-linearity, lose complexity in the behaviour of systems and subsystems, such as their adaptability to environmental changes is compromised. A wide-ranging loss of physiological complexity from molecular to cellular, and from tissue to organ levels accompanies ageing and age-related diseases. These changes can be quantified and the results of treatment monitored. It has been suggested that asthma and many other chronic diseases can be treated as 'stuck', semi-stable, states of organism's complex networks, in other words as pathological dynamic attractors.<sup>14,17,74</sup> The underlying pathology remains because the network connectivity is lost and the organism is unable, by itself, to achieve an effective regulatory competence. Possibly, this view of disease complexity is a modern translation of the classic concept of 'miasm' of homeopathic theory.<sup>75</sup>

### The complexity of cure

From this complex concept of disease we can better understand the role of homeopathy and make some general hypotheses about its mechanisms of action. Pharmacodynamics are very tightly associated with non-linear pathophysiological processes, and the implications of this relation demand that a new approach, different from the classic approach, should be adopted in greater extent in pharmacology.<sup>33,76</sup> The therapeutic strategy becomes the cure of the whole system in its dynamicity and complexity, not the modification of a single factor or molecular mechanism.

If the core of pathological dynamics is loss of communication, healing is increase of communication, establishment of connections between different systems, integration of responses. Sometimes, healing requires external perturbations that remove pathological adaptations (attractors). The ‘science’ and ‘art’ of the doctor are to help the natural, but often erroneous healing power by providing a right information for the extremely complex, unique, and open system that is a human being affected by some disturbance of its homeostasis.

The two main goals of homeopathic therapy are the possibility to increase network connectivity or complexity and—in chronic diseases—the attempt to shift a pathological attractor towards the healthy state (ie to ‘unstick’ the attractor). These goals may be pursued using the classical homeopathic method founded by Hahnemann, that now can be better understood and can be implemented with new tools of investigation.

The attempt to increase network connectivity is based on well-known properties of complex systems such as the above-mentioned global dynamics and associative memory. Associative memory and learning are peculiar properties of neural networks and immune networks:<sup>9</sup> when the network is modified by coherent information, it undergoes a series of changes of nodes and connections (pattern imposing, initialization, relaxation), that eventually take the form of an attractor, consisting of a specific configuration of those modifications (‘imprinting’ of the network). This imprinted configuration makes possible the recovery of stored information when a similar (even if not identical) stimulus is imposed on the network. This kind of property may be the basis of homeopathic healing, where ‘pathological’ coherent information (the medicine) is presented to the organism and a coherent response is triggered, which in turn, leads to a relaxation of the system in the form which is memorized as healthy state (‘recovery’). In the absence of such an exogenous coherent information, a ‘chronically pathological’ system could be trapped or stuck in a pathologic attractor, from where it could not be able, by itself, of ‘finding’ the way to a correct series of modifications leading to the healthy state.

The homeopathic cure may be seen also as capability change of attractor.<sup>17,74</sup> This idea is in agreement with an observation by Iris Bell and collaborators:<sup>48</sup> they showed that the homeopathic treatment of chronic disease, as perceived by doctors, includes changes in categories like ‘freedom’ (eg: ‘ability’ to move out of a ‘stuck’ state), ‘adaptiveness’ (eg evolution and flexibility, that is a characteristic of complexity), and ‘coping’ (eg capability of handling the stress). Muscari Tomaioli has used quality of life questionnaires in order to measure the level of ‘vital energy’ as a subjective sensation of patients during homeopathic therapy.<sup>50</sup> These complex categories can now be measured and treated as quantitative variables in

research and clinical follow-up and is exactly here that homeopathy meets science.

A scheme of the main concepts and evidences related to the complexity science and of their possible implications in homeopathy is given in [Table 1](#).

## Key points of a working hypothesis

In summary, the homeopathic approach introduces systemic regulation, in order to recruit the associative memory of network in a way that is coherent with its endogenous healing capability. In order to do this, the medicine should carry a global pattern of information that increase network connectivity at the specific points where it was lost. Considering chronic diseases as new pathologic attractors, the medicine should be able of ‘unsticking’ the system from this attractor, shifting it in opposite direction and ‘catching’ it on the rebound which the network naturally produces in response to any disturbance. A ‘homeopathic’ medicine is the medicine that increases the network connectivity by introducing information perturbing its nodes in a pattern ‘similar’ to the disease, ie according to similarity of symptoms.

The key point emerging from recent developments in complexity science can shape the following working hypothesis:

- Biomedical therapy is conventionally addressed to multiple environmental and genetic factors but this approach often fails to recognize the true complexity of individual diseases. A method to identify specific and individual remedies at the level of *systemic* information disorders is necessary. The simillimum medicine may be perceived by specific centres (or ‘nodes’) of network regulatory systems as a complex information, regarding whole disease dynamics.
- Symptom patterns are external expressions of complex reactions caused by a medicine (in sensitive provers) and by disease (in sick persons): so, the classical ‘similitude of symptoms’—according to which the correct drug may be chosen on the basis of careful analysis of symptoms—may bypass the possible lack of knowledge of molecular details of disease dynamics.
- In acute diseases the simillimum may activate local feedback (eg: histamine or *Apis mellifica* on basophils) but may also reinforce the connectivity of local reactions with systemic, teleonomically oriented, reactions.
- In chronic diseases the simillimum may operate by ‘unblocking’ the pathological attractor and orienting the network towards a pattern that is approximate to healthy homeodynamics.
- The high specificity of action of homeopathic medicine may be due to the sensitization (priming) of involved network nodes and the complexity and coherence of medicine actions at various levels.

**Table 1** Terms of complexity theory and their possible implications in homeopathy

Complexity science concepts and evidence		Possible implications in homeopathy	Possible experimental approaches
Non-linearity	Lack of dose–response proportionality Rebound effects	Inverse effects of low vs high doses Similia principle, primary and secondary drug effects	Hormesis, laboratory studies Animal studies, paradoxical pharmacology in humans
	Chaos, stochastic resonance	Potency, succussion, ultra-low dose effects, oscillation of symptoms	Laboratory studies, electrophysiological tests, computation of time-series and dose–response data
	Information transfer by resonance	Potency	Condensed matter physics, electrophysiological effects of potencies
Self-organization	Complex feedbacks and homeodynamics, networks, emergence	Vital force	Analysis of symptoms as patterns, measurement of quality of life (q.o.l.)
	Water structure and dynamics	Potency, succussion, high-dilution effects	Condensed matter physics
	Fractals	Potency	Condensed matter physics, mathematical models
	Entanglement, context effects	Patient–doctor relationship, modalities of symptoms	Observational studies and clinical trials, quantum physics (?), psychology
Dynamicity	Dynamics of biological sensitivity (priming, desensitization) Physiologic oscillators	Potency, ultra-low dose effects, oscillation of symptoms Change of symptoms, chronobiological effects	Provings, clinical study of individual sensitivity Observational and experimental clinical trials (with suitable methods)
	Dynamic attractors	Miasms, constitutions	Provings, symptoms as patterns
	Disease as loss of connectivity and complexity Cure as increase of complexity and change of attractor	Dynamic alteration of vital energy, emphasis to individual history Holism, similia principle	Symptom patterns, observational and experimental clinical trials Study of adaptivity, coping, ‘freedom’, q.o.l.

- Since ultra-low doses of medicines are used, they touch only nodes having enhanced susceptibility. Possibly, high dilutions/potencies integrate global dynamics also by electromagnetic (or quantum entangled) regulation.
- Various methods, allowing ‘measurement’ of complexity in the organism and its subsystems under the effect of therapy, are now available. These applications may contribute to homeopathic clinical research (by including these parameters in research outcomes) and to basic research (by trying to identify possible action mechanisms of homeopathy inside the body).

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