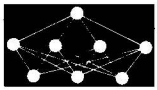

COHERENCE IN LIVING BIOLOGICAL SYSTEMS

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Abstract: Coherence in water and living biological systems is considered experimentally and in relation to its possible involvement in neural networks as well as its clinical implications for electrical hypersensitivity and the mechanisms of homoeopathy.

Key words: *Coherence, biological system, clinical implications, hypersensitivity, homoeopathy*

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1. Theoretical Introduction

The general concept of coherence originally came from optical interference experiments. Ordinary light sources will only give interference over a spatial domain of a few metres since the wave train of coherent oscillations from a radiating atom only lasts for about 10 nanoseconds during which there can be phase coherence and interference between radiation arriving from the same source by different routes. Radiation from some technological sources such as lasers and microwave and other electromagnetic oscillators can on the other hand be extremely coherent and interference is then possible over great distances.

Biological evolution took place in an environment in which coherent systems were free from electromagnetic interference. The only radiation sources having greater coherence than sunlight were the diurnal geophysical fluctuations of the electromagnetic and geomagnetic fields, and other fluctuations associated with the regular periodicity of the planetary system and nature makes use of these signals to monitor the environment.

Fröhlich [1] considered three kinds of coherent excitations in the context of theoretical physics and biology;

(a) excitations of a single mode of vibration, which requires an energy supply above a certain threshold rate;

(b) excitation of a metastable highly polar (ferroelectric) state, which requires a single supply of energy above a critical value;

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(c) excitation of limit cycles or Lotka-Volterra oscillations in complex systems.

A high degree of spatial and temporal coherence is essential for the long-range interactions required for the development and functional control of biological systems. Coherence in time must at least to some extent encompass the life-span of the organism.

Del Giudice and Preparata and co-workers [2-3] have investigated the Quantum Electro Dynamics (QED) of systems of Condensed Matter Physics and in particular, discussed the dynamics of the rotational levels of water molecules. For this, QED requires the solution of the Schrodinger equation coupled with the Maxwell Equations and leads to a model of liquid water resembling condensed vapour rather than molten ice consisting of two distinct interspersed phases; an incoherent phase comprising water molecules in the molecular ground state packed into the spaces between clusters, about 75 nm in size, of water molecules which act coherently towards a large classical electromagnetic field and are stable against thermal agitation through an energy gap of 12.06 eV. This model accounts for the anomalies in the physical properties of water and in general can provide a theoretical foundation to the "flickering" H-bonded network of water molecules envisaged by Linus Pauling.

2. Clinical Effects of Coherence

Since 1982, when Dr. Jean Monro wrote to me asking whether I could do anything to help with her electrically sensitive allergy patients I have been cooperating with her at the Breakspear Hospital in England, and also with Professor W.J. Rea at the Environmental Health Center, Dallas, Texas U.S.A. and Dr. K-P. Runow at the Institut für Umweltmedizin, Emstal, Germany.

Initially, we tested these patients with coherent alternating magnetic fields in a chemical and particulate clean environment, at strengths (of the order of 30 nT in the ELF) typical of those to be found in the environment and over frequencies ranging from millihertz to gigahertz. We observed the various patients' reactions and noted their reported symptoms. These turned out to be the same as the symptoms produced by chemical, food, or inhalant challenges and were characteristic of the individual patient rather than some particular electrical frequency. We sought those frequencies which appeared to be therapeutic in that when they were present in the environment, the patients' symptoms disappeared.

However there were difficulties; many patients would have severe reactions (best avoided if at all possible) at particular coherent frequencies to which they happened to be sensitive, while others would have delayed reactions that came on hours or days later. A technique was needed that was not restricted to those patients who were not very ill, or to those who reacted to an electrical challenge within seconds. To be able to help these other patients, I borrowed from the techniques of radiesthesia.

Some patients do not have a body field strong enough to be detected. In this case, there is usually one or more coherent frequency in the theta (4-7 Hz) or delta (below 4 Hz) brain-wave region which will re-establish a "normal" body field pattern when the patient is exposed to this.

3. Water Memory

As a result of clinical necessity, I found that water is capable of retaining the frequency of an alternating magnetic field in a form which can be used clinically like a homoeopathic remedy [4, 5]. This came about when Dr. Monro and I first encountered a patient who needed a therapeutic frequency in the microwave region and it was not practicable to supply the patient with a microwave oscillator. However, we remembered that Samuel Hahnemann had successfully potentised "electricitas", "magnetis" and we found that we could likewise potentise all the frequencies that we needed into water or saline [5].

Subsequent work on the memory properties of water has given the specific threshold conditions for potentising electromagnetic frequencies into water. For example,for a tube of water placed inside a solenoidal coil, the threshold for the alternating magnetic field is 7.6 μT (rms) if the axis of the solenoid is North-South. Succussing the tube against a wooden surface near and external to the solenoid imprints the water at a thousandth of that field.

Any wire carrying an electric current generates a magnetic field (B) as closed loops of magnetic flux (ϕ) in the space around the wire and at right angles to the direction of the current (i). There must also be a magnetic vector potential (A) which can influence the wave functions of electrons. Actually, the square of the magnetic vector potential is more likely to be involved both from theoretical considerations (Del Giudice, Personal Communication) and the observation that reversal of a toroid does not alter the effect. A solenoid will generate both B and A components, a toroid contains the B component within the coil but generates an A component in the surrounding space. A Möbius loop cancels out both the B and A components.

Water can be potentized with a frequency using a solenoid as remarked above, but it can also be potentised with a toroid. In this case it is necessary either to use succussion with a threshold A of 20 pWb/m (rms), this was given by a current of only 1 μA (rms) in the toroidal coil used. Alternatively, the alternating magnetic vector potential (A) combined with a steady magnetic field (B) will potentize water with thresholds for A = 180 nWb/m (rms) and for B = 1 mT from a permanent magnet, or B = 10 μT (rms) from a coil supplied at any frequency not greater than that of A.

The conclusion from this is that the frequency information is carried on the magnetic vector potential while the magnetic field or the shock wave generated by succussion performs a function equivalent to that of formatting a computer disc. Water could not be potentized using an alternating electric field so that it is unlikely that the dA/dt term is involved, rather it is likely to be the magnetic vector potential (A) term in the wave equation of the electron [6] implying a quantum basis for water memory.

The threshold for the writer to be able to detect a frequency in water excited using a toroid fed from an oscillator set to that particular frequency is A = 17 nWb/m (rms).

The size of the container in which the water is potentised affects the outcome. Potentising water in glass tubes, there is a discontinuity at a tube diameter of 2.5 mm. The writer interprets this as corresponding to the transition from three-

dimensional coherence to a one-dimensional coherence in tubes smaller than 2.5 mm diameter.

Potentising water between parallel glass plates results in the same discontinuity between 1.5 mm and 1.25 mm plate separations, in this case probably representing the transition from a three-dimensional to a two-dimensional coherence.

With both these experiments, there was a peak in the current necessary for potentisation in 2.5 mm diameter tubes. This almost completely disappeared when the experiment was repeated using water that had been de-aerated by boiling. If this length of 2.5 mm represents a half-wavelength mode of resonance, then in free space it would correspond to 5 mm or a frequency of 60 GHz. However, this calculation is only valid if one may use the free-space wavelength for this resonance in water; that is, one must ignore the dielectric constant and refractive index and assume that the resonance is entirely within coherent water.

If such a thing is actually taking place, then there ought to be a similar effect at the hydrogen (proton) resonance at 21 cm (1.42 GHz). Such an effect was confirmed using water in a closed tube length 10.5 cm, or in an open tube 21 cm in length. With these, was not possible to potentise the water at the maximum current available from the solenoid although, it would potentize an open water column 19.8 cm or less, and 22.5 cm or greater.

4. Measurement of Water Frequencies

On retirement, the writer measured the frequencies of the entire stock of chemicals in his laboratory (through their glass or plastic containers) before they had to be disposed of. However, the only general conclusions that could be drawn from this were that the elements all have a single frequency and simple compounds like sodium chloride have three frequencies. There does not seem to be any correlation between the frequencies measured and the chemical structure, although there might be some with the ionic radius.

What is probably being measured here is the structure of a surface layer of absorbed water. When the aliphatic series of hydrocarbons was measured, the frequencies commenced at 0.54 Hz and terminated at 20 Hz for pentane, 50 Hz for hexane and 130 Hz for decane respectively. However, if the hydrocarbon was dried by prolonged shaking with silica gel, no frequencies at all were detected. The critical amount of water to restore the detectability of these frequencies was estimated by admitting a known volume of air of known humidity at about 14 ppm.

5. Coherent Frequencies in Living Cells

Apparatus devised for dielectrophoresis experiments on yeast cells was also suitable for determining whether the voltage steps in the current-voltage characteristics previously obtained with lysozyme solutions could be obtained with yeast cells [7]. Such voltage steps were eventually obtained for a few minutes around the time of cytokinesis. The smaller of the steps detected corresponded to frequencies of about 7–8 MHz and larger ones to 50–80 MHz on the basis of the Josephson conversion factor 500 MHz/μV [8].

The experimental arrangement for detecting these emissions was found to require the electrodes to be mounted on a microscope slide with a gap length of about 1 μm set using a mica sliver as spacer during mounting, the yeast cells were about 5 μm in diameter. A drop of a suspension of synchronously dividing yeast cells in deionized water or isotonic sucrose was placed on the slide and subjected to dielectrophoresis to draw cells into the electrode gap region. The slide was then placed inside a dark shielding box and connected to the input of a spectrum analyser within an electrically screened laboratory. The minimum permissible shunt resistance was greater than 10 Mohms and the maximum permissible shunt capacitance was less than 100 pF as determined by loading the input until the emissions ceased.

About 4 hours after starting the cell culture dividing, corresponding to the end of one mean generation time at the laboratory temperature, the radio-frequency emission might be observed for a few minutes. The spectral bandwidth was about 2 MHz when the signal first appeared in the instrument noise. Its magnitude rose to a few tenths of a microvolt and the bandwidth narrowed rapidly over the next minute or so. The narrowest bandwidth recorded was about 50 Hz. Emissions appeared to occur simultaneously around 1 MHz, 7–9 MHz and 50–80 MHz. Professor Sydney Webb has shown that a frequency of 8 MHz can be calculated from the rate constant for ATP hydrolysis.

If this narrowest bandwidth is determined by statistical fluctuations in the numbers of coherent photons at 8.5 MHz, it should be about 70 Hz and this is within the present experimental accuracy with which the bandwidth could be determined from the photograph of the spectrum displayed on the analyser. For random 8.5 MHz photons this bandwidth would be about 60 kHz [7].

At the time that this work was done (1983), we thought that the micron electrode spacing was needed to ensure that the electrode gap came within the Helmholtz diffusion layers. Recent work suggests that the electrodes were defining a resonant length for coherence waves. In normal saline at the velocity measured for these waves (3.13 m/s), 8.5 MHz resonances would occur at gap lengths which were integer multiples of 0.74 μm.

The electrodes with which we were successful in detecting the emissions were ground and polished steel points (78 rpm gramophone needles). These would permit a whole series of possible resonances like those in Newton's Rings over a wide range of frequencies. The use of evaporated metal film or etched tungsten point electrodes did not result in the detection of any coherent radio-frequency emissions. From the velocities discussed below and listed in Tab. 1., the refractive index for coherence waves passing from normal saline to steel is 3.5 giving beam convergence within the electrode and enhancing the angle of collection to the glancing angle within the saline.

These experiments represented in all probability the first direct evidence of coherent radio-frequency radiation from living cells. Popp has investigated the optical biophoton emission from living cells [9] and with Li shown that a hyperbolic relaxation of the biophoton count-rate is a sufficient condition for coherence in the optical radiation from living systems [10].

Medium	Velocity (metres/sec.)
Tinned-Copper	4.0
Gold	3.4
N-saline	3.1
VOLVIC water	2.6
Silver	1.5
Steel	0.90
Brass	0.81
Molybdenum	0.50
Glass	0.42
Solder (bar)	0.40
Tungsten	0.36
Aluminium	0.25
Air	0.05
Wood, cork, plastic – no propagation	

Tab. 1. *Propagation velocity of coherence or Wust Waves from a frequency of 1 kHz imprinted into VOLVIC (mineral) water.*

The radiesthesia technique used for determining the frequencies of the laboratory chemicals was applicable to the measurement of frequencies in live cell cultures. In the laboratory of Dr. F-A. Popp in Kaiserslautern, the writer has measured the frequencies in "Acetabularia". In this case it was possible to measure both a number of cells and a single filamentary cell many centimetres long. The results showed that there was a whole spectrum of frequencies from below 1 Hz to above 100 MHz, characterized by regular jumps in frequency by a few percent every few minutes to give a cyclical pattern of frequencies which repeated approximately every hour. If the oscillator was left on a stimulatory frequency continuously between measurements, the frequency jump-rate increased to several times a minute. If the oscillator was left on a depressive frequency, all frequency jumping ceased completely. Similar results were obtained with suspensions of T-lymphocytes in cooperation with Dr. B. Griffiths at the Environmental Health Center, Dallas.

The origin of the acupuncture meridians [11] can be interpreted through coherence in the embryological development. It is only at this stage that the undifferentiated cells are in close enough contact to be able to establish a bio-communication network through cell-to-cell links. This might arise through a phase-coherence of currents circulating around the membranes of adjacent cells. The known processes of human embryology show that the human zygote begins a series of rapid cell divisions or cleavage with the absence of cell growth and which ends in the formation of a hollow sphere of cells, the blastocyst, within which various areas can be referred to as presumptive organ regions and by which time some cell differentiation has probably already taken place. This stage is succeeded by the gastrula stage during which there are morphogenetic movements of these presumptive organs bringing them into the correct respective positions from which they undergo their subse-

quent normal development. This results in the establishment of three primary germ-cell layers, two of which develop to form the Yin and Yang organs while the third develops to form the epidermis, ear and pituitary. Thus, in the pre-somite stage of the embryo the individual cells are in close physical proximity, sufficient to initiate channels of coherence which could persist as the organism develops to maturity and provide the acupuncture meridians connecting the peripheral points to the target organs.

6. Surrogate Patient Testing

The measurement techniques described above provide a way of detecting those frequencies which need stimulation in patients too ill or sensitive to be tested in the controlled electrical environment. The patient is given a glass tube containing some water that is tolerated and either holds it for a short while, or succusses the base of the tube on a wooden surface. The water then acquires a memory of the patients body frequencies and these can be measured.

This technique can also be applied to making medication and foods tolerated. In Dallas, we found that some patients cannot tolerate intravenous medication or nutrition because of electrical bio-information imprinted into it at some stage since it had been sterilised. If the substances can be heated above 70 °C , this will erase the electrical imprint. If not, the sterile ampoule can be immersed in water imprinted with patient's neutralizing frequencies for 12 hours without loss of sterility, after which it may become tolerated by the hypersensitive patient.

7. Nature of Bio-Information in Water

Frequency bio-information is coherent and since water is a liquid this bio-information must exist as time domain coherence. The obvious time event which happens in water is the re-arrangement of the hydrogen-bonding 10^{11} times per second. Del Guidice et al. [4, 5] have considered this problem at a more fundamental level through quantum field theory applied to the radiation interactions in water which can give a coherence that persists long enough for the electrostatic atomic attractions to become effective. Then, domains of coherence can exist permanently in the ground energy state unless the coherence is broken by strong external fields. Communication between the coherence domains can be through the Josephson effect since this is available as a consequence of the coherence [6] and would provide a basis for the construction of a neural-network for bio-communication.

In earlier work, Del Giudice and co-workers considered the radiation exchange at the 50 cm^{-1} water resonance and arrived at dimensions for the coherence domains of the order of 100 μm.Their recent theoretical developments [3] show that the oscillations between the ground state and the 12.06 eV excited state in the ultraviolet are more fundamental. This gives rise to domains of coherence of size 75 nm within which the water molecules interact coherently. The interstices are filled with incoherent (gas-phase-like) water molecules in the molecular ground state.

The frequency information imprinted into water will propagate along a copper wire which may be either dipped into the water or wrapped around the outside

of a glass container. The signal does not couple through the plastic covering of insulated wire. Two wires give the same effect as a single wire and there is no differential signal from different parts of the water. This explains why it is only necessary for the beaker or matrix used with electroacupuncture apparatus to have a single lead for the connection. No grounding lead is required because the signal propagating is one of coherence, it is not the modulation of a circulating current.

This bio-information signal passes through carbon and wirewound resistors, capacitors and inductances. It is blocked if a permanent magnet is brought near the conducting path; the critical magnetic field strength for this is 250 μT. It will pass through a semiconductor junction from from p-type to n-type but not from n-type to p-type. It propagates with amplification through an n-p-n bipolar transistor and an n-channel FET with appropriate bias voltages. It is not propagated through a p-n-p transistor nor a p-channel FET. This implies that the signal involves the coherence of electrons and not of semiconductor "holes" and that it has a range greater than the thickness of a base or gate region.

Coherence wave resonances were measured on a parallel wire transmission line terminated in a sliding short-circuit and connected in series with a lead from a brass beaker containing a glass tube of frequency imprinted water. The signal from the water only propagated when the length of the line from the open end to the sliding short-circuit was zero, or an integer multiple of 3.175 cm and it was independent of the frequency imprinted into the water memory from 0.1 Hz to at least 100 kHz. For a stationary wave on a transmission line, the nodes should repeat every half-wavelength. Since the velocity of propagation on the line is most unlikely to be greater than the free-space velocity of electromagnetic radiation, the frequency involved must be less than about 5 GHz if a classical electromagnetic field is involved. However, subsequent experiments showed that water could be imprinted with frequencies from 8 GHz to 12.5 GHz which is inconsistent with the involvement of a classical electromagnetic field.

Since the water signals are switched by an n-channel FET, it was possible to repeat the experiments of Dr. Wust [12] who, in 1934, measured propagation velocities of the order of metres per second for what must now be called Wust Waves. Using FET's to switch the signals in what is in effect the Fizeau method for the velocity of light, the velocity of the signals from imprinted water were measured. The velocity of the signals imprinted into "Volvic" mineral water was 4 m/s along a 1 metre length of tinned-copper wire, while those from normal-saline had a velocity of 5 m/s. A necessary precaution was to block off alternative signal pathways by placing strong magnets over the wires connecting the FET's to the signal generator. Tab. 1. lists preliminary values for the propagation velocities of Wust waves in a number of substances which were measured as wires or, in the case of liquids in a plastic pipette. The signals did not appear to propagate through wood, cork or plastic. The propagation in air was found by Wust to depend on the presence of oxygen as the result of evacuated bell-jar experiments. The refractive index and the critical angle for these wave can be derived from their respective velocities.

Experiments involving signals on a Lecher Wire system in which the short circuit was replaced by a switched n-channel FET showed that for the signals to be able to propagate between the two wires, the switching frequency had to be less than

about 20 Hz. This is interpreted as meaning that the minimum time required to establish the coherence in tinned-copper wire is about 0.05 s.

8. Conclusions

The purpose of these experiments was to obtain the basic design parameters for apparatus to investigate coherence or Wust waves and to be able to design transducers for water memory signals so that they can be read and processed by conventional electronic circuits. Although these results are interesting in themselves, they need to be validated through independent experimentation. They are detailed here in order to encourage others with the necessary skills to join in so that conclusions may be reached which clearly do not depend on personal factors. Once it is understood how to design a system to convert the coherence signal into temporal fluctuations in voltage and current, objective measurements will become a reality. Such results have been achieved by the writer [4, 13] and others but all necessary and sufficient conditions are not appreciated sufficiently for a system to be engineered.

From this work on bio-information, there are two effects which could be applied to the self-assembly of neural networks. Firstly, chemically assembled coherence between particular molecular species through the strong coupling described by Fröhlich between oscillators (oscillating molecules) of the same frequency, and secondly the Josephson effect coupling between domains of wave function coherence to give an extended coherent system with frequency and voltage interrelated by 500 MHz/μV.

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