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Vibrational Resonance and Cognitive Internalization

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Dedicated to
Erich Jantsch (1929-1980)
Terence McKenna (1946-2000)

Abstract

Continuing in the spirit of earlier works, we propose a mathematical model for the process of internalization of ideas. This entire concept presupposes a paradigm of mind with internal and external regions, which we accept provisionally for the sake of discussion. In short, we envision a physical model comprising several excitable, continuous media in parallel planes, interconnected by a process of resonance of vibrations. The mathematical model for this physical analog is then discretised, and proposed verbatim as a computational model for the mental system. This model is typical of complex dynamical systems, as they have evolved during the last twenty years or so.

CONTENTS

1. Introduction

In July, 1930, Einstein and Tagore met twice in Berlin. This excerpt is taken from the second conversation. [Tagore, 1931, p. 224; Chakravarty, 1961, p. 112]

> EINSTEIN: The problem begins, whether truth is independent of our consciousness.
>
> TAGORE: What we call truth lies in the rational harmony between the subjective and objective aspects of reality, both of which belong to the super-personal man.

In this short paper we construct a mathematical model for Tagore's idea of truth as the rational harmony of two aspects of reality. We translate aspect as field,

and harmony as resonance. That is, reality is imaged as an immaterial, excitable field, capable of maintaining vibratory activity and space-time patterns. Our model of reality is derived from our earlier work on the morphic resonance concept of Rupert Sheldrake. [Sheldrake, 1981] In fact, the views of both Tagore and Sheldrake are informed by ancient Indian roots. The objective aspect or field is the cognitive domain of science, nature, or external reality. The subjective aspect or field is the cognitive domain constructed by an individual being, or internal reality.

To Einstein, the external aspect was true reality. His use of the word consciousness above seems to mean individual (internal) consciousness or awareness, as opposed to the more literal meaning of shared (external) understanding, also known as conscience. To Tagore, the two aspects together comprised true reality: awareness and conscience in harmony. This fundamental disagreement was the topic of the conversation from which the quotation above is taken.

Naturally the question arises: Why, in this postmodern world, would we wish to add new mathematical models to a verbal discussion ongoing for thousands of years? The new mathematics we are now injecting into this long-ongoing dialogue – complex dynamics, chaos theory, fractals, and the like – belongs to both the internal and external aspects of reality. And being new, or newly discovered, it partakes of the evolutionary aspect of reality. It is because of this mathematical evolution, or more properly, the coevolution of mathematics and conscience,

that new models are appropriate. New math, new shared understanding, new individual awareness, new math, etc. This hermeneutical cycle is basic to the evolution of conscience. In science, it is manifest in the concepts which are purely mathematical rather than actually physical, such as the gravitational field of Newton and the electromagnetic field of Maxwell. [Kline, 1985] The wave and heat equations of mathematical physics are derived from these field concepts, and these in turn are the tools of the modern theories of morphogenesis, such as the reaction-diffusion equations of biological morphogenesis, which is such a large part of mathematical biology, following from the works of Rashevsky, Kolmogorov-Piscunin-Pontriagin, and Turing

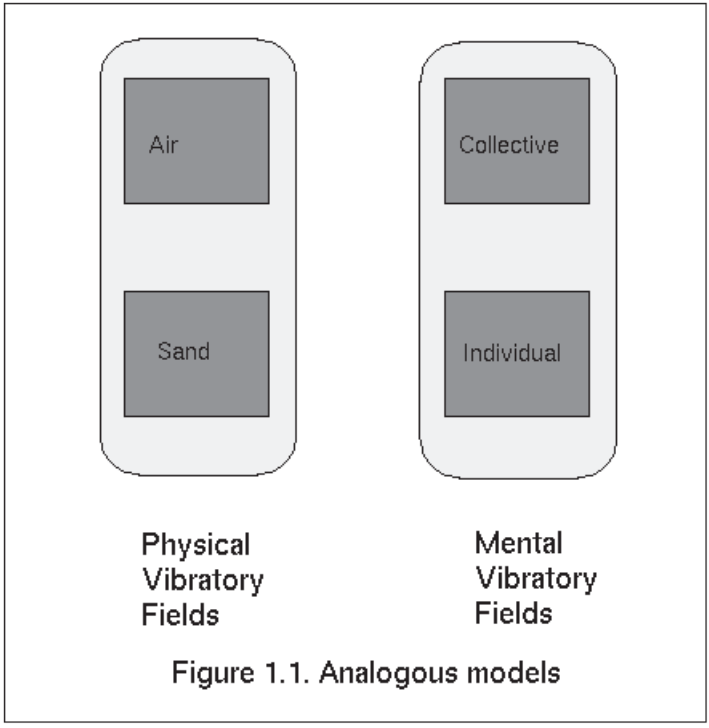

Figure 1.1. Analogous models

Using these tools of mathematical morphogenesis, we go on now to develop a model, for the internalization of a concept from the objective (external) aspect or field of conscience to the individual (internal) field of awareness, or vice versa, by a process of vibrational resonance or harmony. In other words, a model for Tagore's reality. The outline of our presentation is shown in Figure 1.1.

2. An exemplary complex dynamical system from classical physics

Inspired by Benjamin Franklin's invention of the glass harmonium, Ernst Chladni studied the patterns of vibration in glass plates by observing the motion of sand sprinkled on the plate, maintaining its vibration by bowing the edge with a cello bow. With this project, around 1820, he founded acoustics, the branch of physics devoted to the production and transmission of sound. [Abraham, 1988] A similar phenomenon was observed by Michael Faraday in a thin layer of liquid on a vibrating plate. He named these patterns crispations. [Abraham, 1976]

Controversy regarding the mechanism producing these patterns led to experiments in a vacuum, and revealed that grex vortices in the air over the plate, excited by its vibrations, moved the sand. A grex is a toroidal motion, in which the fluid moves downward through the center of the tori, and upwards around the outside. Further experiments using a light powder in place of sand gave further information regarding the vortices in the air. The heavier sand particles are moved by the bottom of the vortices, collecting at the nodes. The lighter powder

particles are lifted over the top of the vortices and deposited at the antinodes. All this is shown in Figure 2.1,

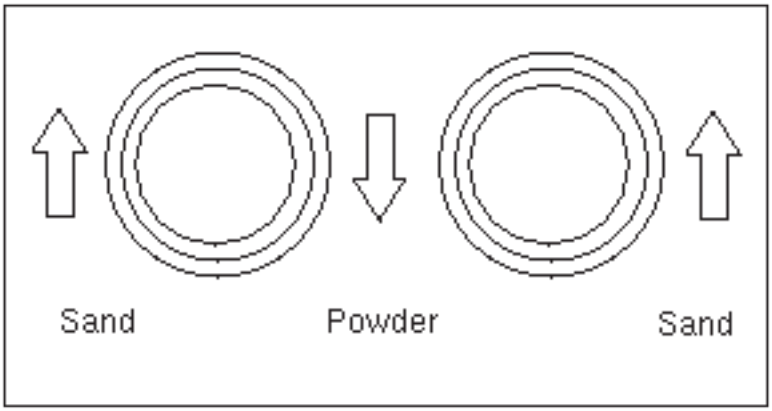

Fig. 2.1. Section of a grex

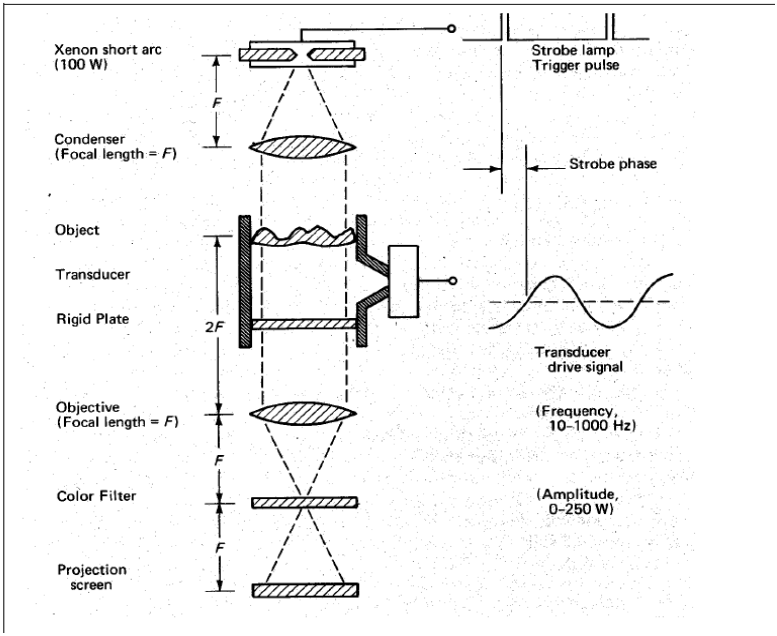

Fig. 2.2. The Jenny macroscope

More recent experiments by Hans Jenny using a mixture of black sand and white powder dramatically demonstrated this filtration by density in the vortices, with the sand moving to the nodes, and the powder to the antinodes. The pattern so produced is highly suggestive of biochemical pattern formations in embryogenesis, and other morphogenetic processes. [Jenny, 1967] An experimental arrangement for the study of Faraday crispations is shown in Figure 2.2. An electrical wave delivered to a transducer (loudspeaker) creates a sound wave in the air beneath a plastic plate, inducing and maintaining a pattern of vibration. This in turn activates a related pattern of vibration in the thin layer of liquid resting on the plate, and thus a pattern of grex vortices in the layer of air over the plate. Air, plastic, liquid, air: four layers of coupled pattern formation processes.

3. An exemplary complex dynamical model from classical mathematics

We begin with a simple dynamical model for a single layer of vibrating media from classical mathematics. That is, a partial differential equation of evolution type for a function which may be regarded as an abstract representation of the instantaneous state of the medium. For example, in the case of a wave equation, the function may represent the displacement of the two- or three-dimensional material from an equilibrium position. Or in the case of a reaction-diffusion equation, the function may represent the concentrations of several chemical reactants. Not wishing to ascend to the level of the symbolic notations of classical mathematics, we may think of the function as a point in an infinite-dimensional geometric space, and the equation of evolution as a vectorfield (or flow) in that space. Thus, our ordinary intuitions from dynamical

systems theory – attractors, basins, bifurcations, and so on – may come into play. In short, our model for a single excited layer is a flow scheme, that is, a continuous dynamical system with control parameters, defined on an abstract space of functions representing the states of the medium – the state space. The meaning of this will be elaborated in a special context in the next section. For the moment, we may simply regard the model, a dynamical scheme, as a black box. A point in this box is a mathematical representation of an instantaneous vibratory state of the medium, another (very thin) box, a layer. The height of the point may be regarded as an index of the possible vibratory states, and the horizontal position an index of the control parameters of the model.

We next consider two layers of vibrating media. For example, a thin, horizontal layer of air, lying upon a thin layer of water. For each layer, we imagine constructed a mathematical model, a dynamical scheme. Visualizing each model as a black box, we thus have two boxes, one above the air. But we further suppose that the two layers are in contact. Thus the motion of the water influences the motion of the air, and vice versa. To represent these mutual influences in our mathematical models we must connect the two black boxes. First, the state of the water affects the control parameters of the air. In the theory of complex dynamical systems, this is called a serial coupling. [Abraham, 1993b] Next, the state of the air affects the control parameters of the water, another serial coupling. Taken together, the two links represent a serial bicoupling, in the language of complex dynamical systems theory.

Our physical experience of vibratory systems in contact, strings of a musical instrument for example, includes the phenomenon of resonance. In this phenomenon, the

vibrations of each string encourages the vibration of the other, if the vibrations are harmoniously related. More generally, we may say that a space-time pattern in one vibratory medium induces a harmonious space-time pattern in another medium. This is, in fact, the situation with the experiments of Chladni and Faraday, in the 19th century, as described above. Specific dynamical schemes have been elaborated for the crispations of Faraday, in particular, and there is a growing literature regarding them in mathematical and scientific journals today. But we will be discussing only the computational form of these models, to which we now turn.

4. The modern computational form of the complex dynamical model

The study of the space-time patterns determined by equations of evolution – such as those of mathematical physics, chemistry, and biology described above – were initially carried out with the methods of classical analysis, the only mathematics known to the early pioneers in this field: Euler, d'Alembert, Fourier, and so on. These methods were very limited, and yielded results only in the hands of the most gifted analysts. They conceived of computational methods also, in which extensive arithmetic done laboriously with paper and pencil gradually revealed some faint image.

A dramatic example of the computational approach, before the advent of computing machines, was provided by Richard Southwell. As part of the war effort in Great Britain during the Second World War, Southwell commanded a troop of arithmetically gifted youth, drafted from universities for this purpose. Following a computational method of his own devising, still used today, Southwell directed the clever kids,

scampering in stocking feet over huge paper carpets, from atop a tall step ladder. Doing arithmetic upon numbers they read from the paper at their feet on small scratch pads in their hands, they would stoop from time to time to write a new result on the large paper carpet, crossing out the previous result.

The computer revolution tipped the scales, giving great advantage to computational methods over the analytical techniques. Not only faster and more general, these new methods could be applied by any computer-literate person. This is the dominant style of applied mathematics today. Applied to our problem of the spaced-time pattern of vibration maintained by an external force acting on an excitable medium, such as an elastic membrane, the Southwell method reduces the membrane to a two-dimensional lattice of identical cells, each described by a small oscillator – for example, a simple pendulum, or a weight hanging from a coil spring. Each such cell is coupled somehow to its four nearest neighbors. Such a mathematical object is called a cellular dynamical system, or cellular dynamaton, or CD for short.

The CD for one membrane, or layer, is visualized on the computer monitor as an apparently continuous image of changing colors. Each pixel (point on the screen) is given a color which is a code for a number. For example, red might denote the displacement of a pendulum to the left by one inch, while blue indicates displacement to the right by one inch. Colors in between may be coded for intermediate positions of the pendulum. One starts with any convenient pattern of colors on the screen. The equation of evolution for the vibrating state of the membrane, interpreted by the Southwell method, then determines, from this initial pattern, a new one.

And repeated application of this method with the new pattern yields still another, and so on. Thus, a moving image is seen on the screen, and after a few iterations of the computational method of Southwell (if all is going according to Hoyle) we are viewing the space-time pattern determined by the equation of evolution chosen at the start of the process.

Finally, this strategy may be applied to the complex system of two coupled membranes. Each membrane is modeled by a CD, and the two CDs are coupled to each other, cell-by-cell, as shown in Figure 4.1.

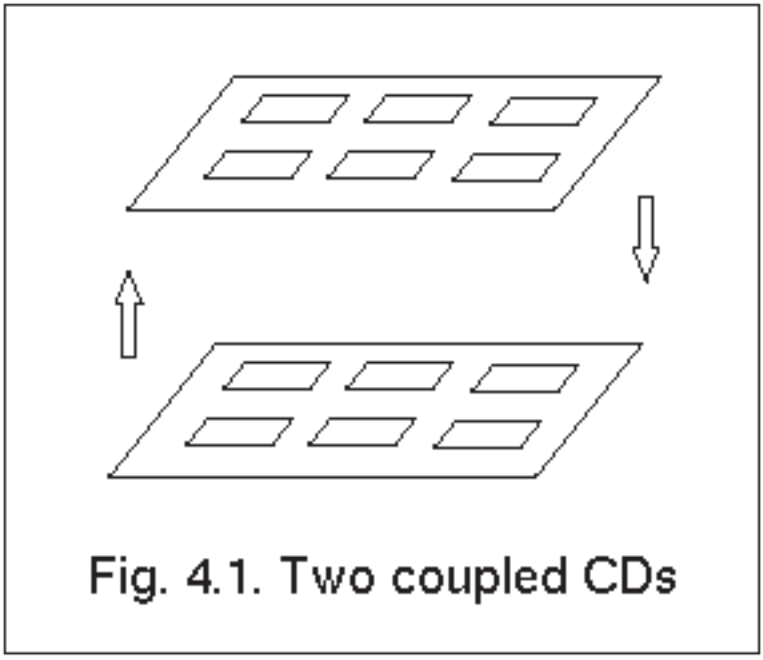

Fig. 4.1. Two coupled CDs

5. Application to conscience

Consciousness is among the vaguest and most important of words, but the conventional meanings fall into two main groups. On the one hand, the Einstein view, it is taken to mean individual awareness – the conscious, inner self. And on the other hand, in the Tagore view, it means an emergent, collective property of whole communities of individuals – schools of fish, herds of cattle, flocks of birds, cultures of humans. Here we mean this latter, literal meaning: shared understanding. This is also called conscience. With this agreed, ™I am conscious∫ would mean that I have an open channel of communication between my individual, internal awareness, and the collective mental field of consciousness, or conscience, of my culture.

Just as the early cartographers made maps of the world by gluing together individual charts brought back by pioneering navigators, shared understanding may have been constructed by convergence, or emergence, of individual understandings. This map of the intellectual world, constantly evolving, becomes stored in libraries and perhaps in an immaterial or mental field of living, collective memory. New individuals – infants, children, young adults, immigrants – are brought into this collective field, or acquire conscience, through an educational process commencing perhaps in conversation with family members or neighbors. There is also evidence that some sort of telepathy, such as morphic resonance, contributes to this induction process. [Sheldrake, 1981; Radin, 1997] Such a resonance process of mental fields, individual and collective, is consistent with the Sanskrit heritage which informed Tagore and Sheldrake. In the Kashmiri Shaivite tradition, a divine oscillation (Spanda) is the driving force which maintains an excited state of vibration in the collective field. [Dyczkowski,

1992] The existence of such fields is, of course, controversial. Even assuming their existence, the idea that information is encoded into the field as a vibratory space-time pattern – like a radio broadcast into the electromagnetic field – is a further flight of fantasy. And yet, this vibration image has been a part of our conscience for thousands of years, due to prophesy, sacred texts, gnostic experiences, and the like. Finally, accepting all this for the sake of discussion, there is the further question: Is the vibrating field evolving, or eternal? We summarize all views in one image in Figure 5.1.

And in Figure 5.2 we see, side-by-side,

- the physical experiment of Chladni, Faraday, Jenny, myself, and others, and
- the vibratory model of conscience

which is the justification for our common mathematical model, based on complex dynamata, for both.

6. Conclusion

How is information, such as Euclid's geometry, encoded into a vibratory field? We have not gone into this question. What we have done is to describe a complex dynamical model for the resonance of two vibrating membranes. What is the use of this? We suggest (based upon extensive personal experience) that experiments with this model, performed with a personal computer, will be highly educational, as well as artistically beautiful. One may gain thus an intuitive understanding of intuitive understanding itself, an interesting self-reflection.

References

- Abraham, Ralph H., Vibrations and the realization of

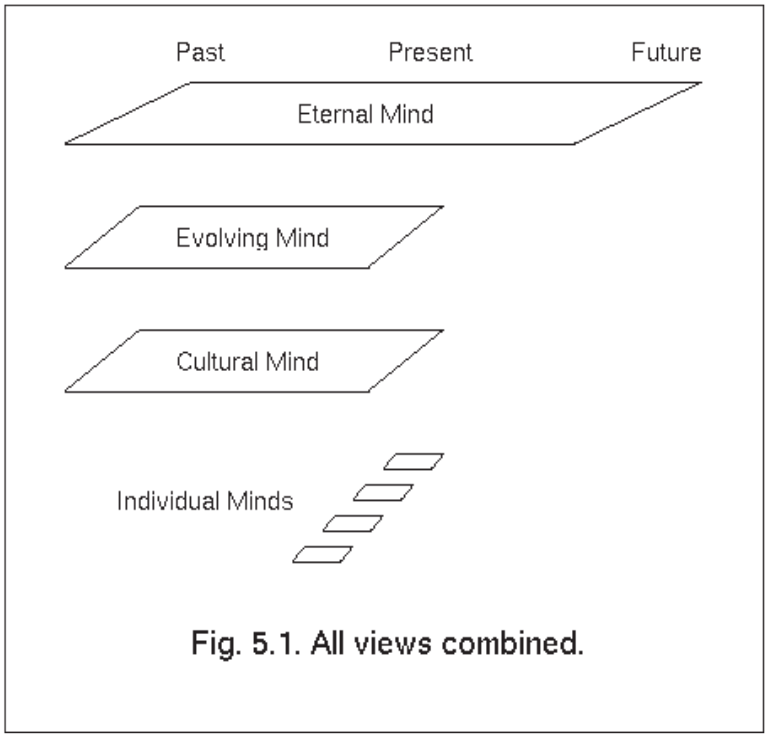

Fig. 5.1. All views combined.

Driver	**Eternal mind**
Plate	**Evolving mind**
Air	**Cultural mind**
Sand	**Individual minds**

Fig. 5.2. Two systems, side-by-side

form, in: Erich Jantsch and Conrad H. Waddington, eds., *Evolution and Consciousness: Human Systems in Transition*, Reading, MA: Addison-Wesley, 1976; pp. 134-149.

- Abraham, Ralph H., The role of math in the evolution of the noosphere, in Erich Jantsch, ed., *The Evolutionary Vision: Toward a Unifying Paradigm of Physical, Biological, and Sociocultural Evolution*, Boulder, CO: Westview, 1981; pp. 153-168.

- Abraham, Ralph H., The macroscopy of resonance, in: *Selected Studies: Physics - Astrophysics, Mathematics, History of Scienc*e, Th. M. Rassias and G. M. Rassias, eds., North-Holland, Amsterdam, 1982, pp. 3-8.

- Abraham, Ralph H., Dynamical models for thought, *J. Social Biol. Structures 8*, 1985, pp. 13-26.

- Abraham, Ralph H., Vibrations in math, music and mysticism, IS Journal 1, 1(0) 7-8 (1986).

- Abraham, Ralph H., Mechanics of resonance, Revision, 10(2): 13-19 (1987).

- Abraham, Ralph H., Visual musical instruments, High Frontiers, Fall, 1988.

- Abraham, Ralph H., Erodynamics and cognitive maps, in: The Evolution of Cognitive Maps:
- New Paradigms for the 21st Century, Ervin Laszlo and Ignazio Masulli, eds., Gordon and Breach, 1993, pp. 255-264.

- Abraham, Ralph H., Cellular dynamata, in: From Topology to Computation: Proceedings of the Smalefest / M.W. Hirsch, J.E. Marsden, M. Shub, eds. New York: Springer-Verlag, 1993.

- Abraham, Ralph H., Human fractals: the arabesque in our mind, Visual Anthropology Review, 9, 1993, pp. 52-55. Reprinted in IS Journal #15/16, Summer 1995, pp. 75-79.

- Abraham, Ralph H., Erodynamics and the dischaotic personality, in: Chaos Theory in Psychology, F. D. Abraham, and A. R. Gilgen, eds., Greenwood, Westport, CN, 1995; pp. 157-167. Reprinted in IS Journal #15/16, Summer 1995, pp. 80 - 85.

- Abraham, Ralph H., Vibrations: communication through a morphic field, Proc. Intl. Conf. Synthesis of Science and Religion, Calcutta, 1996, to appear.

- Chakravarty, Amiya, ed., A Tagore Reader. New York: Macmillan, 1961.

- Dyczkowski, Mark S. G., tr., The Stanzas on Vibration: The Spandakarika with Four Commentaries. Albany, NY: State University of New York Press, 1992.

- Jenny, Hans, Kymatik = Cymatics. Basel: Basilius Presse, 1967.
- Kline, Morris, Mathematics and the Search for Knowledge. New York, NY: Oxford University Press, 1985.

- Radin, Dean I. The Conscious Universe: the Scientific Truth of Psychic Phenomena. New York, N.Y.: HarperEdge, 1997.

- Sheldrake, Rupert, A New Science of Life: the Hypothesis of Formative Causation. London: Blond & Briggs, 1981.

- Tagore, Rabindranath, The Religion of Man: Being the Hibbert Lectures for 1930. London: George Allen and Unwin, 1931.