

# Proposed Explanation of the Phi Phenomenon from a Basic Neural Viewpoint

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## Abstract

A first principle representation of integrated quantum thermal correlations of autaptic neurons associated with conscious brain mechanisms is proposed – the former termed the retinoid system by Trehub. Within this formulation, one descends on a set of unitary transformations yielding generic symmetries of the reduced neuronal dynamics illustrating the projection of the abstract degrees of freedom onto 3D space. The actual spatio-temporal symmetry suggests a general mirroring interpretation of the autapse as given by the structure of the neuronal network. The theory prompts a motif for the abundance of chemical synapses from a neuron onto itself and provides a simple explanation of the phi phenomenon and the Necker cube optical illusion.

**Key Words:** quantum mechanics, density matrix, thermalization, heuristic self-locus, Poisson statistics, phi phenomenon, Necker's cube.

*Quantum Biosystems* 2015; 6 (1): 160-171

## Introduction

In the Foreword to the volume *Quantum Aspects of Life* (Abbott, 2008), Sir Roger Penrose posed the question: *Is it merely the complexity of biology that gives living systems their special qualities and, if so, how does this complexity come about? Or are the special features of strongly quantum-mechanical system in some way essential?* In fact the whole anthology contends with this query as the invited authors are asked to promote their preferences in their own subjective portraits – a partaking that culminates in chapter 16 devoted to the second plenary debate on *Quantum Effects in Biology: Trivial or Not?*

Although the views expressed by the participants were intended for an animated debate rather than revealing actual opinions, it was decided that the “no team”, surprisingly should defend the benefits and the importance of a quantum mechanical understanding of fundamental life processes. Yet the opposing team – the “yes-team” – not questioning the imperative of quantum mechanics at the fundamental level of description, but rather mistrusting that quantum mechanics would be non-trivial in connection with the practices of Life owing to the basic fact as to whether coherence would be preserved over time scales relevant for e.g. neuron firings in the warm and wet biological environments of the brain. In particular one called attention to the recent critique of the work of Hameroff and Penrose (2003) by voicing the strong-point, *viz.* whether quantum decoherence time scales were commensurate with current simulations of neuron firing in the chaotic biological surroundings in the brain and the spinal cord (Tegmark,

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2000). Despite a number of arguments regarding various analogies drawn in complex ordering in protein dynamics or the possible utilization of laser-like coherence processes in biochemical metabolism, the findings appear evident, i.e. there do not appear to be a straightforward principle or constraint that maintains passable quantum coherence in living systems. Such arguments do also point at the overwhelming difficulties to support cognition via the operations of a quantum computer.

This is, however, not a view that will be endorsed and in this contribution attention will be drawn to some recent advances in chemical physics and quantum chemistry, see e.g. (Moiseyev 2011; Nicolaides and Brändas, 2010, 2012). In Brändas (2013) quantum mechanical representations are developed for an all-embracing picture of the interactions between biological units of so-called “complex enough” systems, involving strands of DNA, the genes and the hierarchies of cellular aggregates etc. to account for a precise realization of the physical conception of communication<sup>1</sup>. In these investigations, employing open system quantum dynamics in an extended non-Hermitian setting, using rigorous dilation analytic techniques (Balslev and Combes, 1971), instigated subsequently at the basic microscopic level, Poisson-mediated communication channels are widened to accommodate spatio-temporal representative portraits of the central making of the living state. The picture is self-referential, including de-coherence code-protection, and furthermore it permits to be augmented and amplified to the neurological domain. Henceforth it could possibly be of fundamental importance for the evolution of human consciousness.

It has recently been advocated and proposed to employ quantum mechanics for explaining consciousness within neurological terms, see e.g. (Baer, 2013).

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<sup>1</sup> Note that it is necessary to distinguish between meaning (semantics) and communication (syntax) where the latter is related to physically well-defined information channels for encoding purposes. This is not always the case in point in contemporary rhetorical tradition (Farrell and Frentze, 1979).

In addition to the opinions articulated above a third direction is here brought forward, *viz.* the suggestion that quantum theory portrays something that one does as cognitive beings. In this view our subjective consciousness is connected to our physical objective world describing our activities as human beings and, by reducing the physics of such beings to so-called cognitive loops, the author asserts that the loop does quantum theory. Thus the architecture of a cognitive loop is qualitatively understood in the language of quantum theory as e.g. quantum jumps associated with atoms or molecules absorbing and emitting photons accounting for the experience of a light flash. In this model the mathematical Hilbert Space is supposed to act as a memory space for neural correlates, which then will contain the essentials of human consciousness.

There is an obvious appeal to such a picture, since it involves the motion of non-zero rest-mass charged particles in interaction with the electromagnetic field. However, as is well known, a Schrödinger wave has to obey some kind of global Schrödinger equation. Even if one admits that this argument is “only in principle”, turning the crank becomes a “hard problem” in itself<sup>2</sup>, since one does not know the factual constraints of such a monster, from realistic spatio-temporal boundary conditions to the correct thermal behaviour for non-equilibrium processes; not to mention the problem of how to merge quantum mechanics with relativity, the reason for the uni-directedness of time, and other fundamental symmetry violations like molecular chirality and its possible gravitational origin.

Returning to the plan of the present article, a brief review will be given of the basic steps in our derivation of a suitable open dynamics that promotes the notion of *communication* as a primary concept within a fundamental quantum framework. The word “quantum” has here a more general meaning than usual, as one must go beyond the original Schrödinger

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<sup>2</sup> The “hard problem of consciousness” was coined quite recently (Chalmers, 1995) and concerns the irreducibility of the mind-body problem, i.e. the subject-object dilemma.

equation for traditional isolated systems and rather henceforward find the proper constraints in open systems far from equilibrium. Yet, quantum mechanical observables permit proper realisations, as each specific chemical-physical situation will decide the necessary mathematical details. From such a perspective, it is possible to derive a transformation theory for the microscopic evolution of living systems from the molecular- to the cellular level and the whole nervous system.

Within this portrait one will find a simple explanation of the phi phenomenon and a surprising understanding of the Necker cube optical illusion. For simplicity the physical model will be illustrated with particular reference to the retinoid model devised for visual perceptions and the particular understanding of often-cited illusions and well-known hallucinations (Trehub, 1991, 2007).

### 1 - A Quantum Representation of the Retinoid Model

It is obviously not viable to make a detailed review of the various steps involved in deriving an authentic ansatz that portrays the neuronal structure from first principles (Brändas, 2012, 2013, 2015). Nevertheless a recount will be made of the background and theoretical ingredients necessary to arrive at such an unexpected straightforward mathematical model, which moreover acquiesces some surprising consequences and results.

As outlined in the introduction a specialized cluster of neurons will be modelled as the constitution of our self and its perspectival origin of our phenomenal experiences (Trehub, 1991, 2007). In particular an analysis of the dynamics of the firing structure as transduced by a visual perception will be carried out. While such a distinct set of neurons, in the terminology of Trehub, establishes the retinoid system, our description will go beyond the manifestation of a 3D volumetric space, due to the fact that our model originates in quantum theory with authentic dynamical patterns resting in the abstract Hilbert space. In any case the proper projections of the neuronal excitations to the spatio-temporal world of classical brain

representations will be shown to give rise to the privileged phenomenon of consciousness. A visual perception, leading to a spotlight of attention, will trace a specific path in the neural network, while projecting the proper 3D part from the abstract representation mentioned above as adapted to the foveal line. In this representation the autaptic property of the neurons of the retinoid system will be demonstrated to play a significant role.

To begin with it is convenient to make use of a general quantum theoretic system operator strictly defined as a reduced density matrix derived from of an abstract  $N$ -particle fermionic wave function  $\Psi(x_1, x_2, \dots, x_N)$ , where in principle the variables represent space and spin and if necessary could also involve time. Taking the trace over all particle variables except  $q$  (usually  $q=2$ ) the corresponding reduced density matrix writes in the so-called Löwdin normalization, (Löwdin, 1955), but other normalizations exist (Yang, 1962; Coleman, 1963).

$$\Gamma^{(q)}(x_1, x_2, \dots, x_q | x'_1, x'_2, \dots, x'_q) = \binom{N}{q} \int \Psi(x_1, x_2, \dots, x_q, x_{q+1}, \dots, x_N) \quad (1)$$

$$\Psi^*(x'_1, x'_2, \dots, x'_q, x_{q+1}, \dots, x_N) dx_{q+1}, \dots, dx_N$$

The energy is then conveniently written in terms of a suitable reduced Hamiltonian  $H_2$  involving only standard two-particle molecular interactions of conventional Coulomb character, i.e.

$$E = \text{Tr}\{H_2 \Gamma^{(2)}\} \quad (2)$$

Although the system operator should contain all the relevant electrons and nuclei of the quantum mechanical system it is in principle possible to reduce the molecular degrees of freedom to the relevant ones that concerns the particular physical situation under examination. Under certain circumstances  $\Gamma^{(2)}$  displays a large eigenvalue that portrays the emergence of superconductivity or superfluidity, (Yang, 1962; Sasaki, 1965; Coleman, 1963).

This formulation considers quantum states sufficiently isolated from the environment so as not destroying the long-range correlation order.

As will be obvious below a necessary feature will be to incorporate, from first principles and within the actual existing framework, the presence and consequences of the influence of thermally induced interactions. For instance well-known theories of “macroscopic quantum theory” emanates from the quantum correlations of electron pairs in superconductivity (Dunne, 1990; Brändas, 2014), spin dynamics in condensed disordered matter (Chatzidimitriou-Dreismann, 1990), coherent-dissipative structures in aqueous solutions (Chatzidimitriou-Dreismann, 1991) and inside complex enough systems in biology (Brändas, 2011).

The abstract Hilbert Space will be defined as a set of basis vectors – they could be the fermionic degrees of freedom in cells, like neurons being excited during perception, and in particular the chemical synapse known as an autapse – the specific reason being explained in more detail in an upcoming section. The pertinent degrees could be light carriers like electrons or electron holes, nuclear movements like the double proton tunnelling motion in DNA or neuro transmitters arranging for the chemical signals in the synaptic cleft. In this modelling one should note the mirroring relation between the correlations of the light carriers like electrons and the movements in the nuclear skeleton provided by the proper quantum thermal correlations that survives in the chaotic hot and wet environment in e.g. the brain (Brändas, 1998).

These quasi-bosonic degrees of freedom (quasi because they are paired fermions from a quantum statistical perspective) form a base set  $|h_i\rangle$ ,  $i=1,2,3\dots n$ , where  $n$  is the space dimension. The base set is formally written as a bold face row vector  $|\mathbf{h}\rangle$  with components  $|h_i\rangle$ , for notation see footnote below<sup>3</sup>. Since one is

<sup>3</sup> The symbol  $|\ \rangle$  does not mean anything particular here, only when one takes the scalar product  $\langle \ | \ \rangle$ .

dealing with an open system the dimension  $n$  will change and fluctuate from case to case. For a specified Hamiltonian the system operator and its reduced partners can be obtained from the Liouville Equation, which in effect is portrayed as a commutator relation between the Hamiltonian (the full Hamiltonian  $H$  or the reduced one,  $H_q$  depending on  $q$ ) and the density matrix, i.e.

$$\begin{aligned} i\hbar \frac{\partial \Gamma^{(q)}}{\partial t} &= \mathcal{L}\Gamma^{(q)} \\ &= [H\Gamma^{(q)} - \Gamma^{(q)}H] \end{aligned} \quad (3)$$

To set up a relevant representation for modelling our open system in a “complex enough” environment at a human body temperature, one must use the Bloch equation for the proper thermalization, i.e. for  $\Gamma^{(2)} = \rho$  below. Incorporating proper analytic extensions one writes (the same symbol is kept for the thermalized  $\rho$  rather than inserting a new notation)

$$\begin{aligned} -\frac{\partial \rho}{\partial \beta} &= \mathcal{L}_B \rho \\ &= \frac{1}{2}(H\rho + \rho H) \end{aligned} \quad (4)$$

with  $\beta = \frac{1}{k_B T}$ , where  $k_B$  is Boltzmann’s constant and  $T$  the absolute temperature and  $\mathcal{L}_B$  is the Prigogine energy super operator (Prigogine, 1980). Fortunately Eqs. (3,4) have a simple general solution under the relevant boundary conditions for the non-Hermitian extension of the open dissipative dynamics in a far from equilibrium situation. The crucial constraint is the condition for the evolution of basic quantum-thermal correlations from first principles.

Leaving out the details, such as the emergence of open system dynamics, non hermitian quantum mechanics, accompanying spatio-temporal boundary conditions, including temperature relations, finite lifetimes, Poisson statistics etc., which all can be defined properly (Brändas, 2013), one finds that the solution  $\rho$  has a very simple form, yet

interesting behaviour. Note that  $\lambda_L, \lambda_S$  are eigenvalues of  $\Gamma^{(2)}$  before thermalization not to be confused with the ones of the transition matrix  $\varrho$  in Eq.(5) below<sup>4</sup>

$$\varrho = \lambda_L |f_1\rangle\langle f_n| + \lambda_S \{ |f_1\rangle\langle f_2| + |f_2\rangle\langle f_3| + \dots + |f_{n-1}\rangle\langle f_n| \} = \varrho_L + \varrho_S \quad (5)$$

with the degenerate energy level chosen to be,  $E = 0$ , as defined by Eq. (2), and the similarity transformation yielding the solution  $|\mathbf{f}\rangle$ , i.e

$$|\mathbf{f}\rangle \mathbf{B} = |\mathbf{h}\rangle \quad (6)$$

as given by the unitary matrix  $\mathbf{B}$  (meaning that its inverse being the complex conjugate of its transpose gives the expansion coefficients in the  $\mathbf{h}$ -basis) defined by

$$\mathbf{B} = \frac{1}{\sqrt{n}} \quad (7)$$

$$\begin{pmatrix} 1 & \omega & \omega^2 & \dots & \omega^{n-1} \\ \cdot & \omega^3 & \omega^6 & \dots & \omega^{3(n-1)} \\ \cdot & \cdot & \cdot & \dots & \cdot \\ \cdot & \cdot & \cdot & \dots & \cdot \\ 1 & \omega^{2n-1} & \omega^{2(2n-1)} & \dots & \omega^{(n-1)(2n-1)} \end{pmatrix}$$

with  $\omega = e^{i\pi/n}$ . Traditionally  $\lambda_L, \lambda_S$  corresponds to the large, small eigenvalues of  $\Gamma^{(2)}$ . They depend on the actual normalization of the reduced density matrix (Yang, 1962, Sasaki, 1965, Coleman, 1963), but their relative magnitude is the same. For instance estimating the probability  $p$  for the average time,  $\tau = \tau_{\text{corr}}$  out of the total time  $\tau_{\text{rel}}$ , see below, that each and every neuron is in contact with everybody else in the network of  $n$  neurons, one obtains  $\lambda_L \approx n(p - p^2)$ ;  $\lambda_S \approx p^2$ , for large  $n$  (Brändas, 2011).

<sup>4</sup> Inserting  $\varrho$  into the Liouville equation requires  $\text{Tr}\{\varrho^\dagger \varrho\} = 1$  as the normalization condition, not indicated above.

For derivations of Eq.(5), see (Brändas, 2012, 2013), and for the transformation Eq. (7), (Reid and Brändas, 1989). The number  $n$ , the relevant molecular degrees of freedom, the correlation- and relaxation times and the temperature are related by the following boundary condition

$$n \propto \frac{\tau_{\text{rel}}}{\tau_{\text{corr}}} \quad (8)$$

where the thermal correlation time is given by  $\tau_{\text{corr}} = \hbar/k_B T$  and  $\tau_{\text{rel}}$  is the relaxation time<sup>5</sup> or life time of a particular biological process like a visual excitation corresponding to a perception of e.g. 20-200 ms or the duration of a saccade. At the 310K, the human body temperature,  $\tau_{\text{corr}} \approx 0,3 \times 10^{-13}$ s. This imparts that during an eye movement of 20ms  $n$  equals the order of  $10^{11}$ , while for a flagellar whip of typically 3,5ms,  $n$  becomes of the order of  $3 \times 10^9$ . These life times do match the neural firing times being of the order of 1-50ms.

Before looking at the amazing properties of  $\mathbf{B}$ , or rather  $\mathbf{B}^{-1}$ , one notes that the latter yields, as said above, a unique linear combination of the  $h_i$ 's. Thus the unitary transformation of  $\varrho$  in terms of the classical canonical form of the nilpotent or shift operator<sup>6</sup>  $\mathcal{N}$  in the basis  $\mathbf{f}$ , see Eq.(5), yields

$$\varrho_S = |\mathbf{f}\rangle\langle \mathbf{f}| \mathcal{N} |\mathbf{f}\rangle\langle \mathbf{f}| = |\mathbf{h}\rangle\langle \mathbf{h}| \mathcal{N} |\mathbf{h}\rangle\langle \mathbf{h}| \quad (9)$$

with the operator  $\mathcal{N}$  in given in complex symmetric form in the basis  $\mathbf{h}$  with an analogous form for  $\varrho_L$ .

$$\mathbf{B} |\mathbf{h}\rangle\langle \mathbf{h}| \mathcal{N} |\mathbf{h}\rangle\langle \mathbf{h}| \mathbf{B}^{-1} = \langle \mathbf{f}| \mathcal{N} |\mathbf{f}\rangle \quad (10)$$

This little exercise demonstrates the anticipation that  $\mathbf{B}^{-1} = \mathbf{B}^\dagger$ , as mentioned, yields the relevant expansion coefficients for a perception, exciting  $n$  neurons, while  $\mathbf{B}$  relates to storage and memory.

<sup>5</sup> The dimension  $n$  may be interpreted as the number of molecular degrees of freedom involved in the process characterized by  $\tau_{\text{rel}}$  as proportional to the quotient in Eq.(8). The relation can be given a more rigorous derivation within the mirror theorem.

<sup>6</sup>  $\mathcal{N}$  is mathematically defined as  $\mathcal{N}^p = 0$  if  $p \geq n$  and  $\mathcal{N}^{n-1} \neq 0$ , where  $0$  is the zero operator.





transitions, Eq.(5), appropriately modelled via the aforementioned CDE.

In what follows the neural network will be considered as higher-level structure, where the representation (5) will constitute a quantum-dot-like basis for a Liouville dynamical formulation. It is interesting to observe that one may derive an analogous linear algebra structure, i.e. using the theory of a Correlated Dissipative Ensemble, CDE, on a higher level order or organisation, yet resonating in terms of compatible dimensionalities, with the lower ones, where the important interactions are the communication between the dynamic entities, from primary molecular aggregates to the cell, with the neuron network contributing to the phenomenal experience, or in the terminology of Trehub, registering an egocentric representation of the brain mechanism, which he denoted as the retinoid system of autaptic neurons. It has not escaped my awareness that the specific symmetry of the postulated CDE suggests a possible mechanism for the binding problem. The model does not distinguish between one or several neurons in communication with the rest of the network. Hence each and every neuron as an open dissipative entity contains the program for its function, albeit its communicative properties being crucially dependent on its position in the cellular hierarchy.

For discussions on the bound conscious experience and the inference that every neuron has some form of sentience, see (Edwards, 2005). A more general appraisal of the understanding of consciousness was presented at an invited workshop hosted by the Nature Network Groups (Pereira, 2010). Various 3D default space theories have recently been discussed and unified in connection with currently accepted consciousness models (Jerath, 2015). An interesting connection between logic and geometry, relating a geometric Clifford algebra of space-time with logic algebraic structures, incorporating the Kantian imagination of the forms of nature, has been presented in "Four forms Make a Universe" (Schmeikal, 2015), representing also an essential basic self-reference property.

Assume that a perception  $S_1$  excites a certain number,  $n$ , of neurons, creating the map  $B^{-1}$ , see Eqs.(6,7). For instance the photons, that reach the eye, are absorbed by a photoreceptor, e.g. rhodopsin, generating a potential in the rod cells. The Opsin-Cis-Retinal upon excitation becomes Opsin-Trans Retinal and the visual information is transduced via intermediate neuron-types to the brain's neural network. As mentioned earlier, the number  $n$  might be large, but in order to study the detailed dynamics of  $S_1$ , the case  $n=6$  will be considered.

It is moreover important to understand that our representation will be basically different from the retinoid array of Trehub, see Fig. 1 in (Trehub, 2007). The  $n$ -dimensional quantum (transition) state is properly characterised by products of particle states (antisymmetrized for fermions or symmetrized for bosonic degrees of freedom) in order to represent the entire communicative interactions between all neurons involved in the perception  $S_1$ . However, tracing out all the neuron degrees of freedom, except for one neuron, as depicted by the Correlated Dissipative Ensemble, the CDE, the dynamical quantum-thermal correlations progress spatio-temporally between locations of the neurons in the network, while rigorously incorporating the reduced dynamics sequentially ordered<sup>8</sup>.

Fig. 1 displays for simplicity the causal set of 6 neuron sites on the (half) unit circle in the complex  $z$ -plane, where  $z=x+iy$ . Note that a 90-degree left-hand rotation has been made so the neuron locations numbered 1 to 6 are situated to the right of the rotated  $x$ -axis in the figure.

The numbers 7-12, completing the unit circle, are mirror images of the causal set as can be easily seen from Eq.(12) below. For the case  $n=12$ , discussed above and corresponding to Eq.(11), the total

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<sup>8</sup> Note that the present representation of a neural communication network is neither Boolean, Bayesian, decision making- or any other classical version. It is neither strictly a quantum network, cf. quantum computational schemes lacking self-referentiability. Since the nodes here are self-referential and communicative they should be called a Gödelian network.

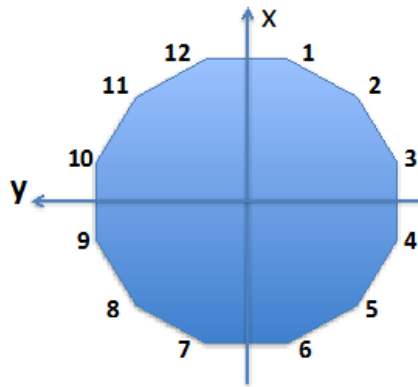


Fig. 1 - Causal set of 6+6 elements

number of the causal set and the mirror points amounts to 24.

In summary each neuron has been pictured as an effective entity in the “sea” of all the others, which are communicating through the network of quantum thermal correlations. The CDE is protected, see above, against decoherence and exhibits time scales commensurate with the biological environment of e.g. humans. Hence the perception  $S_1$ , is represented by  $\rho$  and the transformation matrix  $B^{-1} = B^\dagger$ , i.e. by the vectors in the superposition  $|f\rangle = |h\rangle B^{-1}$  (for simplicity one may redefine  $\omega = e^{-i\pi/n}$  respecting the unitarity of  $B^{-1}$ ). The projection of the six elements of Fig.1 in actual space may look as follows<sup>9</sup> see Fig 2

$$d_1 = \frac{1}{\sqrt{6}} \begin{pmatrix} 1 \\ \omega \\ \omega^2 \\ \omega^3 \\ \omega^4 \\ \omega^5 \end{pmatrix} = d_6^* \quad (12a)$$

$$d_2 = \frac{1}{\sqrt{6}} \begin{pmatrix} 1 \\ \omega^3 \\ \omega^6 \\ \omega^9 \\ \omega^{12} \\ \omega^{15} \end{pmatrix} = d_5^* \quad (12b)$$

<sup>9</sup> Note that showing the neurons as placed in a vertical plane perpendicular the X-axis, see below, it is not suggested that they actually will be materially positioned in one plane.

$$d_3 = \frac{1}{\sqrt{6}} \begin{pmatrix} 1 \\ \omega^5 \\ \omega^{10} \\ \omega^{15} \\ \omega^{20} \\ \omega^{25} \end{pmatrix} = d_4^* \quad (12c)$$

However, as noted by Eq.(12) and Fig.1, there exists 12 locations, i.e. 6 extra mirror locations see Fig.3. The mirror points are numbered 7-12 with the original site number put in parenthesis. One may envision the mirroring plane to contain the X-axis (the line from the pupil to the fovea centralis) orthogonal to the horizontal plane, the Y-plane<sup>10</sup>. Utilizing the terminology of Trehub, the coordinate origin of this “egocentric space” corresponds to a so-called Self-Locus, SL, and the Z-planes orthogonal to the X-axis would contribute to the 3D retinoid egocentric space. Note that X,Y and Z have nothing to do with the complex plane discussed in Fig. 1.

At this point one recognizes the crucial property of the autapse. Since the latter is equipped with a chemical synapse from a neuron onto itself, the transitions generated by the action potential give rise to feedback loops, which is equivalent to incorporating mirroring sites according to Eq.(12).

<sup>10</sup> One reason for establishing such a symmetry plane is the gravitational field exerted on the retinoid system.





Fig. 2 - Actual set of 6 elements

In addition every trajectory in egocentric space exhibits a time-reversed copy in agreement with the complex conjugate symmetry displayed by Eq.(12).

Fig. 4 displays the vectors 1-3 and their conjugates, exposing the causal trajectory of transmission from one neural

location to the next. Note that locations 8 and 11, not “visited”, will be incorporated in the network by  $d_4$  and  $d_6$ , see also Fig. 5, where  $d_1$  and  $d_6$ , corresponding to the initial perception loop, are displayed.

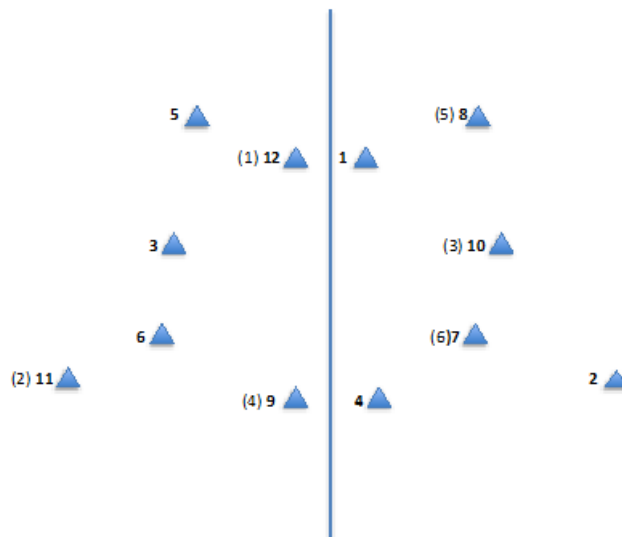


Fig. 3 – Actual mirror set of 6+6 elements

The symmetries exposed above indicate a simple and surprising interpretation of the so-called phenomenon of imitative resonance behaviours directly observed in primate species suggesting the presence of a mirror neuron system. Since every perception is associated with an equivalent excitation structure for any given value of  $n$ , it follows by necessity that the mirror symmetry, illustrated above, must always be automatically incorporated. In Fig. 2 they do not seem to appear, but in Fig. 3, which reproduces the full dynamics of the CDE, they do emerge as a parity reflection of the original causal neuronal sites.

This reading is commensurate with the surprising effects that did produce speculations that there might exist a particular class of mirror-neurons<sup>11</sup>, see e.g. (Rizzolatti and Craighero, 2004). Our interpretation, however, expounds on a general symmetry exhibited by the autapse.

<sup>11</sup> Since the neuronal sites and their mirror images are excited in reverse in any perception, they might cause the “empathic” property associated with the mind’s mirror.

### 3 - Explanation of the phi phenomenon and the Necker cube optical illusion

The well-known phi phenomenon, defined by Max Wertheimer more than 100 years ago, has been a celebrated test ground for multidisciplinary research over the years, see e.g. (Anstis, 1970). Another famous illusion is the Necker ambiguous line drawing, discovered almost 200 years ago. Several major open questions have been formulated in terms of multistable perceptions, e.g. what do neural representations look like – and why are they sometimes unstable? (Kornmeier, 2012). Undoubtedly Trehub’s retinoid system has been one of the most successful models to uncover fundamental answers to

such problems as well as explaining a variety of illusions and hallucinations (Trehub, 1991; 2007). Although the present theory appear to support the assumed properties of a self-locus oriented and a core-self heuristic self-locus retinoid system, confirming many of Trehub’s explanatory model of illusions and hallucinations, it has the power to extend further towards a first principle origin rooted in quantum theory. This assertion will be exemplified below in connection with the proposal of an explanation, based on the Correlated Dissipative Ensemble, CDE, of the phi and the beta phenomenon and the classical Necker cube optical illusion.

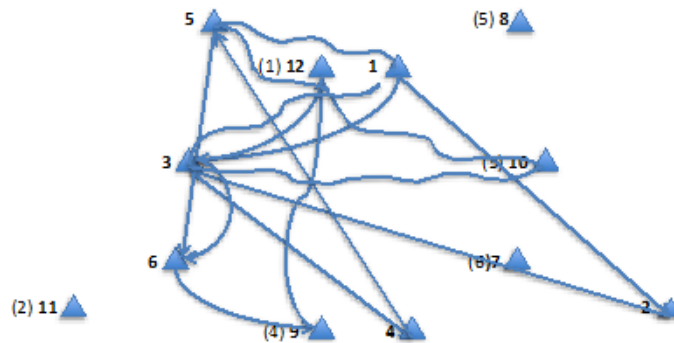


Fig. 4. Actual set of columns:  $d_1, d_2, d_3$

Assume first that a perception  $S_i$  excites a certain number,  $n$ , of neurons. Note that the associated dynamics of  $S_i$  is fundamentally based on the structure of the CDE. The associated spatio-temporal Hilbert Space is given by the states  $|f_i\rangle$  above, where the superposition  $|f\rangle = |\mathbf{h}\rangle \mathbf{B}^{-1}$  has a certain delocalization and time direction. From the properties of the vectors  $\mathbf{d}_i$  in Eq.(12), i.e. that every vector in a general  $n$ -dimensional structure must have, with respect to the mirror plane containing the x-axis in egocentric space, a parity reflected partner. Since the phi phenomenon is perceived to occur when the luminous impulses move at around 30ms, the motion illusion must occur within one set of correlated neuron degrees of freedom. Since the two

consecutive partners  $\mathbf{d}_i$  and  $\mathbf{d}_{i+1}$  as well as their complex conjugates occur in the same perception  $S_i$ , they correlate in such a manner that their accompanying overlapping property including their mirror characteristics, see Figs. 4 and 5, lead to Motion Perception<sup>12</sup>. In other words if the flashes follow an appropriate blank interval, the trajectories portrayed by the vectors  $\mathbf{d}_i$  and corresponding to the “spatial locus” of  $S_i$  overlaps in time and interacts with its mirror partners creating a continuous motion perception. The result is the phi phenomenon. One might surmise that this mechanism also contributes to the brain interpolation of

<sup>12</sup> In Fig. 5 the straight arrows, corresponding to  $d_1$  go from 1 - 6, while the curly ones of  $d_6$  go from 12 (1) - 7 (6).

the blind spot in coordination between the two eyes. A lower frame rate, close to the

optic nerve response time, would also be commensurate with the beta movement.

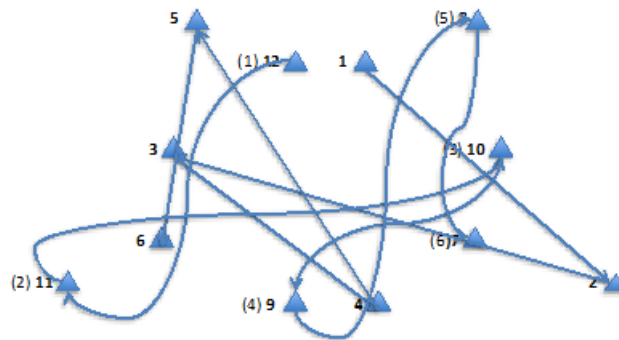


Fig. 5 – Actual set of columns:  $d_1, d_6$

The Necker cube illusion allows essentially a corresponding implementation; as it appears to follow from the same organisation of the CDE mentioned above, see also previous sections. Note that the experience  $S$ , corresponding to the retinoid system being exposed to an ambiguous line drawing of a cube, Necker's cube, contains in the CDE model the vectors  $d_i$  and  $d_i^*$ . Since they both occur in the same transformation, there is simultaneously a competing experience  $S^*$ , containing the vectors  $d_i^*$  and  $d_i$  corresponding to the parity inverted cube. It reveals that the vectors are related via the operation of time reversal. The brain interprets this as a spatial parity transformation, cf. the general belief that our universe is invariant under CPT, (C is the charge conjugation, P the parity and T is the time inversion) implying that if T is reversed then parity must be odd. Hence it follows straightforwardly that a competition between  $S$  and  $S^*$  is perceived as a "conflict" between the orientations of the cube. This results in the perplexing image switching "back and forth" of Necker's famous illusion. It might also contribute to the interpretation of so-called impossible drawings.

Although the illustrations brought forward above are preliminary and tentative it might offer a new way to interpret positive visual phenomena and perhaps also supporting first-hand descriptions of lesions in the visual pathway like decreased visual acuity and

other deficits. Finally one might hope that it will contribute to a better understanding of the underlying mechanisms of positive visual phenomena.

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