Brain Information Optimization and Ethical Behavior

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ABSTRACT

Neural networks are tackled through probabilities for neurons to be activated by other neurons. They are represented by doubly stochastic matrices, named brain matrices, the polytope of which is the convex hull of the permutation matrices which are vertices of this Birkhoff polytope. Each permutation matrix enables to identify loops of neurons associated with a given neurotransmitter. The entropy of evolution of one network is defined and a short study of the optimal information transport in this network leads to consider two thresholds that give rise to questioning about the foundations of classical psychoanalysis within the construction of an extended and more realistic matrix of the neural network. A parallel is emphasized between the expansions in permutation matrices of the brain matrix and the quantum measurement theory through the collapse of the wave function. At a higher scale all the neural networks can be integrated in a global model that can be studied on the same ground as individual brain matrices or through specific thresholds in order to define the origins of ethical behaviors as well as what can lead to mental disability.

Key Words: Brain Matrix Expansion, Wave Function Collapse, Neural Loops, Cognitive Optimization, Consciousness, Behavioral Drive, Ethical Decision Making

DOI Number: 10.14704/nq.2018.16.3.1158 **NeuroQuantology 2018; 16(3):12-22**

Introduction

For any researcher consciousness is a permanent questioning of matters and sciences whereas for scholars it is an opportunity to put forward the greatest constructions that their mind can build using the most relevant theories of a given time even founded on thoughts that appeared centuries ago: the Holy Grail being to find the most comprehensive description of the reality that copes with organizing data produced by experiments according to protocols that enhance a part of a scientific truth. The most successful scholar-researcher should be humble in front of this extraordinary complex matter that mind will always be, one step beyond any knowledge or understanding. Looking for how consciousness "works" is almost comparable for an observer to get out of a car he or she is driving in order to study how she is driving. Getting out of the moving car is very physically dangerous and gives no solution for the driver to appreciate his own driving behavior whereas he is no longer "on board". Nevertheless people drive and see others driving and it is the best way – after getting a driving license with pieces of advice – to understand how to use a steering wheel and how to behave in the road traffic. So drivers forget humility and some of them are even proud of driving a car. Whatever the knowledge, based on experimentation or on introspective reflection, on readings or using physical tools, it is important to feel a kind of pride to have it and to adopt a behavior thanks to it.

This paper is written "out of the traffic" with no idea on how to behave as a scholar, certainly because its writer has no idea or is not

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 25 November 2017; **Accepted:** 20 February 2018

a scholar. However it gives a primary image of what consciousness could be. Its formalism is based on a strong mathematical structure and accounts for the underlying chemical properties that animate a neural network.

It also widens a "standalone" view developed in previous works. A speculative one, using also doubly stochastic matrices, sets down the old problems of duality and universality (Chauvet 2016): both mind-body dualism and wave-corpuscle duality are tackled in using the notion of evolution entropy the oscillation of which leads to figure out a multiplicity of universes and the emergence of a kind of spirituality, ethics being a major issue studied through the concepts of a simplified cyclic science – from experimentation to observation and interpretation – compared with other psychological, religious [and so forth] cycles. Another one presents a physical model for the description of evolutionary phenomena (Chauvet 2006), including economic laws (Chauvet 2013) through a translation of the quantum uncertainty of Heisenberg.

Although psychoanalysis principles are not fully accepted among mind specialists, psychiatrists or psychologists, they constitute a source of investigations for the description of the internal world of a body. Whereas early works using the bistochastic model were influenced by the second Freudian topics, the present paper develops the less controversial first one which defines the three levels of relative consciousness, in spite of the superficiality of the distinction between those levels that appear entangled.

This entanglement relies on the analysis of the information transport in a network of neurons, the constraints of which are classical in optimization problems and enable to find a solution of this kind of problem through the use of the entropy of evolution applied to the doubly stochastic matrices decomposition.

The mathematical formalism put forward for the functional mind description bears an analogy with the early developments of quantum physics and is thus connected to the concrete perceptions of the world out of a purely intellectual – psychoanalytic – neural network functioning.

This opening to an outer world leads to the conception of a wider model of interacting uniform neural networks and places ethics as one of the main stakes of the human mind whose equilibrium depends also on the policies which rule the interactions.

The Brain Matrix

Let $\{N_i\}_{1\le i\le n}$ be a set of n neural networks identified by the number N_i of neurons O_j^i that they include. Those networks are represented by their graphs of activation as suggested in the figure 1.

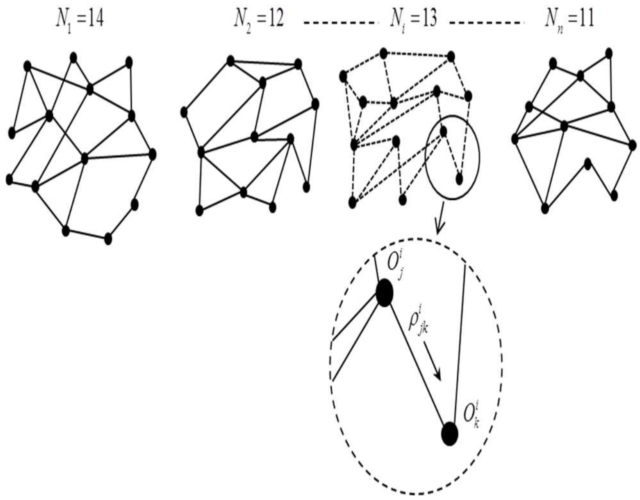

Figure 1. n neural networks N_i

Let B_i be a doubly stochastic matrix, where ρ_{jk}^i is the probability of activation of the neuron O_k^i by the neuron O_j^i of the neural network of N_i neurons:

$$B_i=\left[\rho_{jk}^i\right]_{1\le j,k\le N_i};\forall k\sum_{j=1}^{N_i}\rho_{jk}^i=1,\forall j\sum_{k=1}^{N_i}\rho_{jk}^i=1 \quad (0.1)$$

Such a matrix has already been used and studied (Chauvet 2016) for building a closed simple mind model before relaxing the conditions of bistochasticity in order to account for real mind functioning. The present approach is slightly different and relies on the properties of bistochastic matrices.

According to the theorem of Birkhoff (1946) – von Neumann (1953), the set of $N_i\times N_i$ doubly stochastic matrices forms a convex polytope (Birkhoff polytope) which is the convex hull of the set of $N_i\times N_i$ permutation matrices, and furthermore the vertices of the Birkhoff polytope are the permutation matrices; so B_i can break down into permutation matrices $\pi_{i\alpha}$ (which are also bistochastic):

$$B_i = \sum_{\alpha} C_{i\alpha}\pi_{i\alpha}, C_{i\alpha} \geq 0, \sum_{\alpha} C_{i\alpha} = 1; \\ \pi_{i\alpha} = \left[\rho_{jk}^{i\alpha}\right]_{1\leq j,k\leq N_i}, \rho_{jk}^{i\alpha} = 0 \vee 1 \left(0\ or\ 1\right) \qquad (0.2)$$

Considering for instance that $N_i = 7$, a neuron being represented by O_j^i, a permutation matrix has the following form (each column and each row has only one nonzero element):

$$\begin{array}{c} \\ O_1^i \\ O_2^i \\ O_3^i \\ O_4^i \\ O_5^i \\ O_6^i \\ O_7^i \end{array} \begin{array}{c} \begin{matrix} O_1^i & O_2^i & O_3^i & O_4^i & O_5^i & O_6^i & O_7^i \end{matrix} \\ \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \end{array} \qquad (0.3)$$

It is thus possible to identify cycles in this instance of permutation matrix:

$$\sigma_{i\alpha}^1 : O_1^i \to O_2^i \to O_4^i \to O_3^i \to O_6^i \left(\to O_1^i \ldots\right) \\ \sigma_{i\alpha}^2 : O_5^i \to O_7^i \left(\to O_5^i \ldots\right) \qquad (0.4)$$

So $\pi_{i\alpha}$ has the following properties: it represents the connections that are activated by the neurotransmitter $\nu_{i\alpha}$ of magnitude $C_{i\alpha}$ between the N_i neurons of the network; this permutation matrix breaks down into disjoint support cycles $\sigma_{i\alpha}^l$ which characterize loops of activated neurons and one loop constitutes an elementary function $f_{i\alpha}^l$ performed by the neural network.

$F_{i\alpha}$ is the set (of cardinality $m_{i\alpha}$) of the elementary functions associated with $\pi_{i\alpha}$:

$$F_{i\alpha} \square \left\{f_{i\alpha}^l\right\}_{1\leq l\leq m_{i\alpha}} \qquad (0.5)$$

Within the establishment of a parallel between Birkhoff polytope and the polytope built for structuring the n-tuples of the mixed strategies of non-cooperative games (Nash 1951) and according to previous works (Chauvet 2006 & 2013) $\pi_{i\alpha}$ or $F_{i\alpha}$ can be considered as a pure strategy, a term which appears below, whereas B_i 's are considered as mixed strategies.

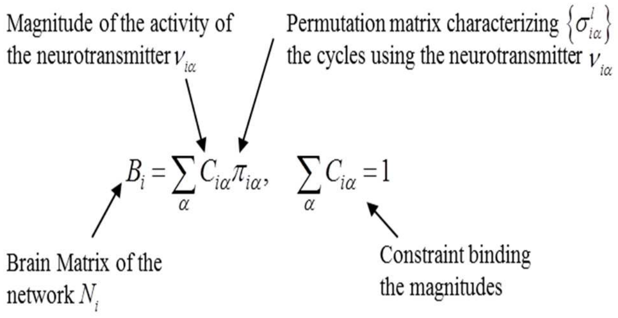

Figure 2. Meaning of the Brain Matrix breakdown

Then the set of the cycles $\sigma_{i\alpha}^l$ of $\pi_{i\alpha}$ is $\Sigma_{i\alpha} = \left\{\sigma_{i\alpha}^l\right\}_{1\leq l\leq m_{i\alpha}}$ and the mapping $\chi_{i\alpha} : \Sigma_{i\alpha} \to F_{i\alpha}$ is a bijection, the cycle $\sigma_{i\alpha}^l$ corresponding to the elementary function $f_{i\alpha}^l$ through $\chi_{i\alpha}$. The length $L_{i\alpha}^l$ of a cycle $\sigma_{i\alpha}^l$ is the number of different neurons activated within the corresponding loop. It is easy to verify that $\sum_{l=1}^{l=m_{i\alpha}} L_{i\alpha}^l = N_i$.

The Brain Matrix B_i, although constrained as being a doubly stochastic matrix, does not show any clear view on the way how neurons are activated, the probability ρ_{jk}^i being rather random, except if B_i is a permutation matrix itself.

So when researchers are looking for evidences that their brain models fit with the chemical and physiological realities, they implicitly use the expansion of Birkhoff – von Neumann in order to put the strain of uncertainty on the biochemical properties of the neurotransmitters that run through the chemical synapses which constitute the majority of the connections between neurons in a human being. Nevertheless, on the one hand, it is important to notice that the Brain Matrix model can also integrate electrical synapses where the neurotransmitter $\nu_{i\alpha}$ is replaced by electricity in the gap junction. On the other hand it is possible to have $\nu_{i\alpha} = \nu_{i\beta}$ (with $\alpha \neq \beta$) in order to account for a first kind of entanglement of neural loops of different sets of cycles: in the frame of a permutation matrix, those cycles have disjoint supports but while considering several permutation matrix corresponding to the same neurotransmitter (or electrical carrier) it is necessary to take into account entangled supports of the cycles using this common neurotransmitter.

Entropy of Evolution and Transport Problem

The Entropy of Evolution

The entropy of evolution (Chauvet 2016) of the neural network N_i can be written:

$$H_i = -\sum_j \sum_k \rho^i_{jk} \ln \rho^i_{jk} \qquad (0.6)$$

The necessary and sufficient condition for H_i to be minimal is: $\rho^i_{jk} = 0 \vee 1, \forall j,k$.

Such condition determines B_i, which is doubly stochastic, as a permutation matrix showing cycles. So when looking for an order in its interaction with its environment and thus through the minimization of its entropy, the corresponding neural network reaches a state characterized by loops of neurons associated with a maximum probability.

Information Optimal Transport Interpretation

Neurons are the carriers of information. From O^i_j to O^i_k, whatever the nature of the information which is transmitted, it can be noted I^i_{jk} (a positive value) and its expected transported amount is then $\rho^i_{jk} I^i_{jk}$ while the cost of the transport is $\ln\left(1/\rho^i_{jk}\right)$: economically, when the transported quantity of matter increases, the carrier is chosen accordingly and generally the cost of shipping per unit of matter decreases; a principle which applies also to the transport of the information. Furthermore, the cost of the transmission of information from one neuron to another is infinite when the connection between those neurons does not exist and when the probability of activation, of the second one by the first one, is null. When the connection is well established, the cost of transmission is insignificant. The total cost of information transport in the neural network N_i is then:

$$G_i = \sum_j \sum_k I^i_{jk} \rho^i_{jk} \ln \frac{1}{\rho^i_{jk}} \qquad (0.7)$$

A sufficient condition for G_i to be at its minimum (null) is $\rho^i_{jk} = 0 \vee 1, \forall j,k$ which, applied to the doubly stochastic matrix B_i, means that the minimum of G_i is reached when the entropy of evolution is minimal, and so that the loop pattern of the neural network N_i is an economic optimization of the network functioning in relation with its environment. Otherwise the optimal transport is a minimum problem (Intriligator 2002) with the following constraints: each neuron O^i_j must transmit more than a^i_j amount of information to the other neurons for being meaningful and each O^i_k must not receive more than b^i_k in order not to be subject to a cognitive overload. Both constraints can be written:

$$\begin{aligned} &\forall j \sum_{k=1}^{N_i} \rho^i_{jk} I^i_{jk} \geq a^i_j, \sum_{k=1}^{N_i} \rho^i_{jk} = 1 \\ &\forall k \sum_{j=1}^{N_i} \rho^i_{jk} I^i_{jk} \leq b^i_k, \sum_{j=1}^{N_i} \rho^i_{jk} = 1 \end{aligned} \qquad (0.8)$$

And the total meaningful amount of transmitted information cannot exceed the maximum cognitive complexity:

$$\begin{aligned} a^i = \sum_{j=1}^{N_i} a^i_j &\leq \sum_{j=1}^{N_i} \left[\sum_{k=1}^{N_i} \rho^i_{jk} I^i_{jk} \right] \\ &= \sum_{k=1}^{N_i} \left[\sum_{j=1}^{N_i} \rho^i_{jk} I^i_{jk} \right] \leq \sum_{k=1}^{N_i} b^i_k = b^i \end{aligned} \qquad (0.9)$$

For all the $\pi_{i\alpha}$'s of the expansion of B_i, the transport problem is solved, knowing obviously that $H_{i\alpha} = G_{i\alpha} = 0$ (with clear notations) and:

$$\begin{aligned} &\forall j \, \exists \kappa_j \in \mathbb{N}^*_{N_i} \sum_{k=1}^{N_i} \rho^{i\alpha}_{jk} I^{i\alpha}_{jk} = I^{i\alpha}_{j\kappa_j} \geq a^{i\alpha}_j \\ &\forall k \, \exists \iota_k \in \mathbb{N}^*_{N_i} \sum_{j=1}^{N_i} \rho^{i\alpha}_{jk} I^{i\alpha}_{jk} = I^{i\alpha}_{\iota_k k} \leq b^{i\alpha}_k \end{aligned} \qquad (0.10)$$

$$a^{i\alpha} = \sum_{j=1}^{N_i} a^{i\alpha}_j \leq \sum_{j=1}^{N_i} I^{i\alpha}_{j\kappa_j} = \sum_{k=1}^{N_i} I^{i\alpha}_{\iota_k k} \leq \sum_{k=1}^{N_i} b^{i\alpha}_k = b^{i\alpha} \qquad (0.11)$$

These exact solutions are used below to build the neural architecture of a second kind of information optimal transport through the minimization of the entropy of evolution.

Superposition Principle and the Extended Brain Matrix

According to the magnitude $C_{i\alpha}$ associated with the neurotransmitter $\nu_{i\alpha}$, the corresponding couple $(\pi_{i\alpha}, F_{i\alpha})$ is expressed as being prominent over other couples of the decomposition of B_i the magnitudes of which are lower than $C_{i\alpha}$; or as being rejected in the background noise made up with the couples of low magnitudes.

Although the notion of threshold might depend on the network of cardinality N_i, on its nature and on the different kinds of neurotransmitters, it seems appropriate to introduce this notion in order to describe the way how neural networks behave.

Let the thresholds be defined as:

$$C_i = \frac{\sum_\alpha C_{i\alpha} b^{i\alpha}}{\sum_\alpha b^{i\alpha}}; \quad U_i = \frac{\sum_\alpha C_{i\alpha} a^{i\alpha}}{\sum_\alpha a^{i\alpha}} \qquad (0.12)$$

Let C_i be the upper threshold above which the expression of $\pi_{i\alpha}$ is high enough to be a conscious behavior of the neural network; and let U_i be the lower threshold below which this expression is kept unconscious.

The first Freudian topics suggests (Bergeret 2012) three states of the psychic apparatus: the unconscious $C_{i\alpha} \le U_i$, the preconscious $U_i \le C_{i\alpha} \le C_i$ and the conscious $C_i \le C_{i\alpha}$.

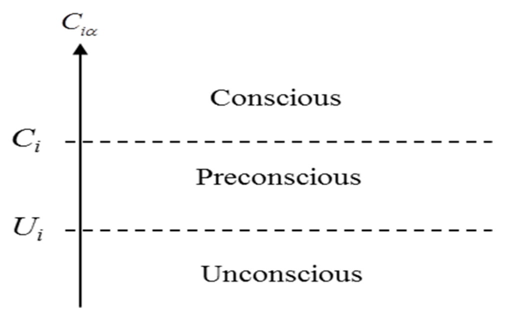

Figure 3. First Freudian Topics

Nevertheless fixing the thresholds U_i and C_i is an artificial means of studying any mind; hence it is probable that those thresholds vary according to the subject or object of an observation and that they also depend on time and maturity or age.

It is important to notice that $C_i = 0 \Rightarrow U_i = 0$ and that $U_i \ge C_i$ is possible.

Consciousness and Cognitive Capacity

The Conscious is made of the couples $(\pi_{i\alpha}, \Sigma_{i\alpha})$ the corresponding magnitudes of which are higher than C_i. At a given time, we consider such couples of the network of N_i neurons. We then build its Extended Brain Matrix (B_i^C) made of the superposition of the cycles from those couples.

Considering the set A_i of all α's such that $C_{i\alpha} \ge C_i$:

$$\Sigma_i^C = \bigcup_{\alpha \in A_i} \Sigma_{i\alpha} = \bigcup_{\alpha \in A_i} \{\sigma_{i\alpha}^l\}_{1 \le l \le m_{i\alpha}} \qquad (0.13)$$

Then $B_i^C = \left[\rho_{jk}^{iC}\right]_{1 \le j,k \le N_i}$ satisfies the following conditions:

$$\begin{cases} \rho_{jk}^{iC} = 1 \vee 0 \\ \sum_{j=1}^{N_i} \rho_{jk}^{iC} = c_k^{iC} \ge 1 \; \forall k \\ \sum_{k=1}^{N_i} \rho_{jk}^{iC} = r_j^{iC} \ge 1 \; \forall j \end{cases} \qquad (0.14)$$

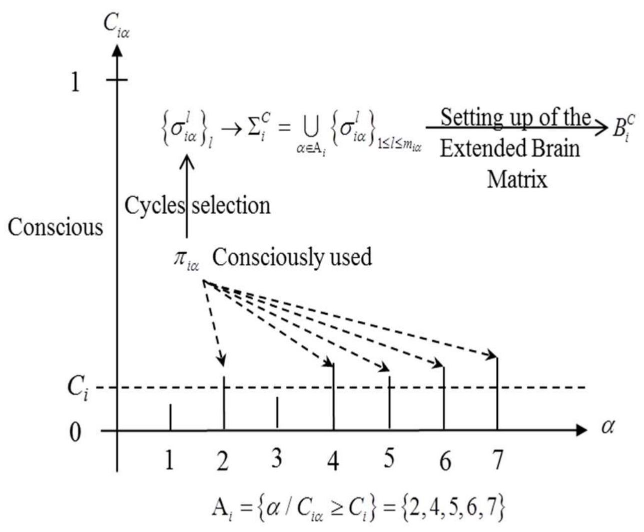

Figure 4. Cycles selection for the setting up of the Extended Brain Matrix

For a complex neural network for which the Brain Matrix is a permutation matrix then

$B_i^C = B_i$ and out of this singularity, $\exists k / c_k^{iC} \geq 2$ and $\exists j / r_j^{iC} \geq 2$, then B_i^C is not doubly stochastic, but the associated entropy of evolution H_i^C and G_i^C are null what characterizes an efficient brain functioning.

When C_i decreases, the neural network accesses a higher degree of consciousness and the corresponding cognitive capacity characterized by the values of c_k^{iC} and r_j^{iC} may increase. So the Conscious is a balance between what is necessary for an operational thinking or for action, and an extra awareness of more information about an environment and its interpretation.

It is important to specify that the cognitive capacity evolves with the creation of new connections between neurons. Following this point of view, it appears also that what seemed artificial in this theory is a characterization of the potential of evolution of a neural network: actually, the fact that the sets of cycles associated with neurotransmitters are coming from permutation matrices implies that each neurotransmitter should be used by all the neurons of the network, what is not verifiable. However neurons can be appealed to develop receptors for different kinds of neurotransmitters while also other nervous cells develop the ability to produce the same kinds of molecules necessary for the creation of new connections. This evolution is not only a matter of chemistry and the new developments are based on the interactions of the network body with its environment and on the genotype of each neuron which is then expressed in the phenotype, the most observable part of the neural system.

Out of the Brain Matrix Framework: Inhibition

There are two kinds of inhibition: the first one applies to functions and is covered by the Extended Brain Matrix principle and the second one is neural, at the neuron level.

On the one hand, the functional inhibition is reached by the Conscious-Preconscious-Unconscious mechanism which selects as Conscious the functions or the sets of cycles corresponding to magnitudes above C_i. The other functions are pushed to the Preconscious or to the Unconscious and they correspond to permutation matrices that are not used consciously, what is equivalent to write that the associated magnitudes are null for the Conscious.

On the other hand, the neural inhibition requires for its description to get out of the Brain Matrix framework and of the double stochasticity of the permutation matrices legacy which implies non-null rows and columns in the Extended Brain Matrix. This second kind of inhibition can be reached while considering that neural loops are not closed and more, that the neurons of one given loop are not all activated. In other terms, for any reason, the real lengths $RL_{i\alpha}^l$'s are shorter than $L_{i\alpha}^l$'s and $\sigma_{i\alpha}^l$'s are split into fragments or simply shortened while functions are redefined.

The exact model of the brain and complexity solving

Whether it is because of an inhibition or because a connection is not already established, the transport problem applied to the brain functioning enables to describe the restrictions in the use of neural loops at the level of the informational layer. Whenever a connection is inhibited or not activated, the information $I_{jk}^{i\alpha}$, corresponding to the probability of activation of the neuron O_k^i by the neuron O_j^i through the neurotransmitter $\nu_{i\alpha}$, is null and the constraint $(a_j^{i\alpha})$ is relaxed.

From the optimization point of view, C_i decreases when the maximum bearable cognitive complexities $b^{i\alpha}$'s [of unused pure strategies] increase, what means, while the minimum meaningful amounts of information $a^{i\alpha}$'s are kept constant (C_i can get under U_i), that improving consciousness may be reached by bringing the Unconscious to the Conscious or, what is relatively the same, that the consciousness reaches deep unconscious events or mental patterns. In other terms, unused pure strategies matter extremely in the process of determining the level of consciousness especially when the corresponding complexities are very high: the sensitivity and, to a large extent the sensibility, rely on those high complexity strategies which are kept unused. As suggested previously those strategies are based on cycles or loops of neurons, a part of which is shared with other strategies. A work or an analysis is thus a way to use strategies of moderate cognitive complexities which share common sets of neurons with other [high complexity and consciously unused] strategies, when it is possible to put to light unconscious mental processes ($C_i < U_i$) and eventually the successful consciousness consists of the relatively high complexity strategies which are used while C_i increases and exceeds U_i. The use of "peripheral" moderate cognitive complexity strategies is a means of desensitization or of building a fine solution to a problem whereas an efficient decision may be made using relatively high complexity strategies.

In the same way, the minimum meaningful information values can vary and although they are economically limited by the maximum bearable cognitive complexities, the cases where they exceed these limits must be considered. These cases would lead to a systematic situation in which the Unconscious overwhelms the Conscious without enabling any understanding from the subject, relatively to the strategies corresponding to those "overflows". Such "blindness" associated with strategies is generally judged as malfunctions or [mental] diseases for two main reasons: the subject presents deficiencies that disable him or her according to the common sense of autonomy and his or her value as an economic agent is denied, at the time of his living, by the community or the society in which he or she lives.

In both situations, the optimization research and the overflow, characterized by $C_i < U_i$, involve difficulties to use some [high complexity] strategies or sets of neurons: temporarily when these strategies can be approached through the training of other ones using the same sets of neurons until the high cognitive complexity pure strategy can be used; or permanently as long as no solution or learning can enhance the cognitive capacity put to the test or "simplify" the level of the minimum meaningful information through the use of "peripheral" strategies.

Physical interpretation of the Brain Matrix

It seems appropriate to draw a parallel between the principles of quantum mechanics and those which underlie the brain functioning according to this article. Whether it is to describe a harmonic oscillator or the electronic structure of an atom, the mathematical formalisms initially presented orbits – associated with angular frequencies – or near orbits in a phase space – that can be compared with neural loops – and were next rapidly structured by a Hamiltonian and wave functions.

The wave function, which characterizes the probability of being measured according to the need of observables or quantum operators, is the basic principle of considering any physical object as a wave – at least of probability – while at the time of the measurement of some of its properties, the object falls into the category of material particle or of any other observable piece of matter.

This controversial concept of the collapse of the wave function ψ also applies to the Brain Matrix B_i which is a set of probabilities of neural activations and the expansion of which can be compared with the one of ψ in a Hilbert space. This collapse is the cornerstone of the wave-corpuscle duality of any physical object. For a neural network its application relies on the use of a "selected" set of neural loops associated with given neurotransmitters, this set, at a given time, forming probably a part of consciousness, the permanent "measurement" of an environment by a given mind interacting with it. So the collapse of the Brain Matrix consists in the transition from a set of seemingly random probabilities to a deterministic set of neural loops which gives rise to reality in a mind; whereas the collapse of the wave function (DeWitt 1970) is the mechanism whereby the probability wave "gives rise" to a measurement of the physical reality.

The selection of pure strategies as being consciously used can be compared with the identification of the subspace corresponding to one given eigenvalue of an operator, this eigenvalue being the result of the measurement of the observable – the operator applied to the wave function – with a probability computed according to quantum rules (Basdevant 2009) synthesized in the figure 5.

It is important to notice that consciousness is associated with a probability lower than one whereas a quantum observation is supposed to be associated with a maximum probability.

However, there are still fields of physics where the theory of the perfect measurement is not observed and the parallel between the model of consciousness – developed in this article – and quantum physics, should be valid for a long [measurable] time.

$$\psi \leftrightarrow B_i$$

$$|\psi\rangle = \sum_\alpha C_\alpha |\phi_\alpha\rangle \leftrightarrow B_i = \sum_\alpha C_{i\alpha}\pi_{i\alpha}$$

Operator $\hat{O}$,
Eigenvalue $a_\alpha / \hat{O}|\phi_\alpha\rangle = a_\alpha |\phi_\alpha\rangle$

$$C_i = \frac{\sum_\alpha C_{i\alpha} b^{i\alpha}}{\sum_\alpha b^{i\alpha}}$$

For every $\beta / a_\beta = a_\alpha$

$$P(a_\alpha) = \sum_\beta |\langle\phi_\beta|\hat{O}|\psi\rangle|^2 = \sum_\beta |C_\beta|^2$$

(Probability for the eigenvalue to be measured)

$$C_{i\alpha} \geq C_i \Rightarrow \alpha \in A$$

(The set of β's is equivalent to A)

Result of measure $= a_\alpha$

$$\sum_\beta |C_\beta|^2 = 1$$

For used strategies (consciousness):

$$\sum_{\alpha \in A} C_{i\alpha} = 1 - \sum_{\alpha \notin A} C_{i\alpha}$$

Figure 5. Quantum analogy of the Brain Matrix

Higher scale Brain Matrix principle

As it has been introduced, the Brain Matrix B_i characterizes the neural network N_i and it seems appropriate to consider this structure at a higher scale, the one of a community of individual thinkers, each of whom embodies one (i) of the n networks of neurons. As a consequence of this statement a meta-Brain Matrix can be written:

$$M = \sum_{i=1}^{n} \Gamma_i B_i, \quad \sum_{i=1}^{n} \Gamma_i = 1, \Gamma_i \geq 0 \qquad (0.15)$$

It is assumed that $N_i = N$ for all i. This assumption based on an egalitarian view enables to tackle philosophical concepts associated with relational aspects inside a community.

This higher scale Brain Matrix M is also doubly stochastic and this expansion can be compared to the one of each of the individual Brain Matrices. Beyond the facts that B_i's are not necessarily permutation matrices and that two different neural networks belong to two different bodies whereas the initial expansion into permutation matrices characterizes a sole network, the main difference is that the relations between two neural networks are physically different from the connections between neurons and from the entanglements of neural loops activated through different neurotransmitters. Nevertheless those relations exist and put into correspondence the networks by basic psychological rules which induce neural activities of higher societal meaning.

The decomposition in permutation matrices

At that scale, as a bistochastic matrix, M has also an expansion in permutation matrices and thereby its use can be analyzed according to the first Freudian topics while considering the thresholds U and C. It justifies the notions of collective unconscious, common beliefs and culture and to a certain extent it gives also a historical sight of action as being the consciousness of past events but missing the investment needed for predictability based on the study of the interactions between individuals or agents. So such a Freudian expansion, which is not unique, must be considered a posteriori as a possible truth and cannot exclude alternative interpretations that could better correspond to the reality of M as the convex combination of the B_i's.

A particular case of expansion of M in permutation matrices is the following:

$$M = \sum_i \left[\Gamma_i \sum_\alpha C_{i\alpha} \pi_{i\alpha} \right] \qquad (0.16)$$

And the thresholds can be defined as:

$$C = \frac{\sum_i \sum_\alpha b^{i\alpha} \Gamma_i C_{i\alpha}}{\sum_i \sum_\alpha b^{i\alpha}}; \quad U = \frac{\sum_i \sum_\alpha a^{i\alpha} \Gamma_i C_{i\alpha}}{\sum_i \sum_\alpha a^{i\alpha}} \qquad (0.17)$$

It is then possible to build M^C as being the extension of M and to reproduce strictly the analysis of B_i^C in adding that sensitivity and sensibility have here to be considered at a political level in the event of the need for coordinating all the agents and for managing the complexity of such a task. This management relies largely on surveys, statistics and "big data" analyses and requires strategies, at least one (Chauvet 2013) in order to create or enter a market place. That is thus not being naïve to think that those strategies of higher level can be the same as [and representative of] those of elementary agents and this is why a policy is all the more efficient that it is based on the beliefs of the agents that are to be managed.

The global scale of organizations

At this new global scale, the communication channels with an environment or between individuals are various and use all the senses: hearing, sight, touch, smell and taste. Thereby, the activation of all or parts of the sets of neurons of a body by another one, through those channels, can be considered in a continuum of neural networks with mechanical, electromagnetic or generally physical and chemical interfaces. The complexity of human thinking appears then as the structuring of internal loops of neurons in order to cope with various aspects of surroundings and to build a consistent interpretation for making the right decisions.

In that context, Γ_i is the magnitude of use of the communication capacities of the agent i. It is then possible to define:

$$\gamma = \frac{\sum_{i=1}^{n} a^i \Gamma_i}{\sum_{i=1}^{n} a^i}; \quad \Gamma = \frac{\sum_{i=1}^{n} b^i \Gamma_i}{\sum_{i=1}^{n} b^i} \qquad (0.18)$$

The reasoning of the paragraph on “the exact model of the brain and complexity solving” can also be reproduced and adapted to the thresholds γ and Γ but the stakes are no longer restricted to the individual and a kind of competition within organizations must be taken into account. As Francis Bacon said (1597), maybe after other powerful thinkers, knowledge is power, what could mean that knowing more than peers about a subject is the opportunity to impose the deeply structured knowledge as a political asset for establishing one’s authority or influence on a society and such an establishment constitutes the mainstream of the dominant way of thinking, another means of generating a common belief or to a large extent a shared consciousness. But there is a great risk that this sharing leads to authoritarianism, or less severely to paternalism, imposing some reasoning or other thoughts that could turn into relative prejudices when empowerment gives to individuals the freedom of choosing their own truth.

The three-tier model of the first Freudian topics has for equivalence, in the context of governance, the triptych of ethical power $\Gamma < \Gamma_i$, uncertainty $\gamma < \Gamma_i < \Gamma$ and risk $\Gamma_i < \gamma$.

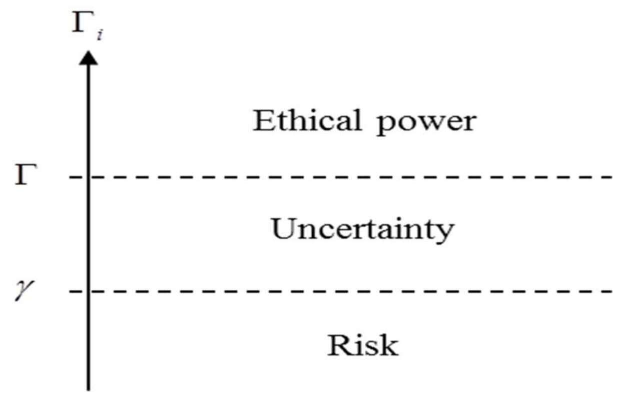

Figure 6. Scale of knowledge mastery

From the optimization point of view, Γ decreases when the maximum bearable knowledge densities b^i’s [of highly risky mixed strategies] increase what means, while the minimum significant densities of knowledge a^i’s are kept constant, that improving power may be reached by bringing the Risk awareness to the Ethical power or, what is relatively the same, that this power is directly facing up to risky situations, to dangers or to conflicts. In other terms, purely risky mixed strategies matter extremely in the process of determining the level of right decision making especially when the corresponding knowledge densities are very high: the effectiveness and, to a large extent the efficiency of an organization, rely on those high densities of knowledge strategies which are supposed not to be used on an ethical plan. As suggested previously those strategies may be kept in the collective unconscious, known as risky ($\Gamma < \gamma$), until they create historical events. They may be good or bad according to the values of a society. They are sometimes by-products of the public power and other policies and the corresponding events are the victory of a part of the society and the defeat of another part. The historical meaning of those events eventually comes up when the high risk strategies, incarnate by men or women, reach an ethical level of interpretation while Γ increases and exceeds γ.

In the same way, the minimum significant densities of knowledge values can vary and although they are economically limited by the maximum bearable knowledge densities, the cases where they exceed these limits must be considered. These cases would lead to a systematic situation in which the Risk [or danger] overwhelms the Ethical power without enabling any historical stability, relatively to the strategies

eISSN 1303-5150

corresponding to those "overflows". Such instability associated with strategies is generally considered as chaos from an ethical point of view for two main reasons: the society or organization presents ethical deficiencies or inconsistencies that disable it according to the common sense of democratic law and security and its values [on a free market] cannot be recognized by other organizations or societies.

In both situations, the optimization research and the overflow, characterized by $\Gamma < \gamma$, involve difficulties to use some [high bearable knowledge densities] strategies or agents: temporarily when these strategies can be approached through the democratic proceedings until a political decision can be made; or permanently as long as no solution or political stability can enhance the historical meaning which is given over to high risk behaviors of agents.

The optimization of information transport at the global scale

This optimization is obtained when B_i's are permutation matrices. This is the case when the entropies H_i's are at their minimum but this condition is only sufficient for G - corresponding to M - to be minimum. The necessary condition implies: to get back to the conscious-preconscious-unconscious model involving individual optimization of information transport when the expansion of M uses those of B_i's; or to oblige individuals to adopt the closed simple mind model (Chauvet 2016) with information density or cognitive constraints imposed by external standards instead of personal biological needs.

If the closed simple mind model is actually in force on the same pace for everybody, all the B_i's can be permutation matrices at the same time but the communication magnitudes Γ_i's may not be tuned for M to be a doubly stochastic matrix and the conditions to get an efficient functioning $(G = H = 0)$ at the global scale may not be realized: the rows and the columns of M are not filled with only ones or zeros. In other terms authoritarianism and an unsuitable communication lead to ineffectiveness or inefficiencies. Furthermore if the pace in force is too slow it might lead to individual mental disabilities (Chauvet 2016).

Conclusion

The doubly stochastic model of neural networks enables to integrate the description of the functioning of such networks as for the role of neurotransmitters. Actually the decomposition of bistochastic matrices representing the activation graph of neurons allows for distinguishing loops of nervous cells – or near loops – activated by the different kinds of neurotransmitters in action in the neural networks. This decomposition in permutation matrices can be considered, in an analogy with the quantum wave function, as a collapse leading to "measurable" behaviors. In order to characterize these macroscopic behaviors within the brain functioning, principles of optimization applied to the information transport in the neural networks give rise to a three-tier model of consciousness which reexamines the concepts of preconscious and unconscious of the first Freudian topics. The conclusion of this new examination is that consciousness is highly relativistic and can draw in the deepest resources of the mental apparatus according to the situation. But this conclusion is only possible because of the setting of a neural network into a temporal viewpoint of an implicit functional evolution.

So an outlet of the theory presented in this article could be other pieces of research at the interface between the quantum brain – of functional mind states – and the time-dependent relativistic description of the corresponding neural network evolution. Such a research could be computerized but being so, would also be constrained by temporary technologies and would lose the genuine reflection of a real brain.

The more artificial concepts of the higher scale developments present a rough theoretical extension based on uniformity of individual neural networks. It is ethically sensible and enables to understand a tiny part of political sciences from the viewpoint of physics. Ethics and policies could then be studied, but certainly not managed, through models inspired by the brain matrices.

This article is a step towards the brain "chaotic" behavior mastery and proposes an original set of mathematical tools within the framework of neural networks computational attempts to find an actual and long-lasting consciousness of all what consciousness involves beyond any speculative insight.

eISSN 1303-5150 www.neuroquantology.com

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