A Toy Model of Consciousness and the Connectome, First Approximation, Second Part

Ability Potential of A Neural Network As A Prognostic Connective Indicator

Stan Bumble, Ph. D.

Abstract: The paper vixra:1305.0128 is continued to consider a toy model of a triangular lattice as a neural network. The Ability Potential of this network to reach levels of consciousness is defined and produced for different levels of connectedness and interaction energy of the "neurons". This approach is used to approximate and anticipate some of the results that may occur in the much more complex human connectome project.

The previous paper attempted to make use of a lattice application of statistical mechanics to represent a neural network. In that work an application of order-disorder theory was applied to physical adsorption. There a gas was adsorbed onto an adsorbent consisting of a triangular lattice of sites. The pressure of the gas versus the fraction of sites occupied was plotted for various values of the connection of the sites and the interaction energy between each pair of sites that were occupied and connected. This model was adopted to show consciousness versus site occupancy, connectedness and energy of interaction. The present paper changes the term used for consciousness to Ability Potential or A.P. The ability Potential is construed in the adsorption model to indicate 1-P/Po or A.P.. This Ability may in the present case indicate the potential to form a memory, to actuate a sensory sensation, to do a calculation, and to calculate or perform any act generally associated with a neural network.

It is to be emphasized here that the model and results that will be obtained from this toy model are approximate. The reasons for pursuing this work is that the actual work that is proceeding in the U.S. and Europe on the connectome project as described in the literature is a very difficult and long project. The work here is just to predict and summarize some of the final results that will be found and to help that eventual process along the way.

Statistical mechanics has in the past proved very adept in tackling other very difficult projects and has used some helpful scientific aids, such as the ergodic theorem, that states that if you follow an individual model over an infinite amount of time, it will go through all the states that are seen in an infinite population at an instant in time.

In the former vixra paper we derived a table of values of Z, C, and A.P. that are the coordination number, value of the energy of interaction between two adjacent occupied sites and the Ability Potential derived from figures plotted there. This is slightly expanded and given belowas Table I.

Table I

Z	C	P/Po
4	2.1	0.42
6	1.75	0.55
8	1.58	0.64
12	1.35	0.71
4	1.3	0.73
20	1.2	0.78
30	1.13	0.8
50	1.08	0.83

Plots from these numbers are shown below.

Table I and and the plots below are only given for critical values for Z, C and P/Po. This occurs when the values of P/Po remain constant over extended values for Θ (value for the fraction of the sites that are occupied). We now change the title for P/Po to A. P. for Ability Potential and conceive of the sites to be occupied for active neurons instead of particles of gas. Consciousness is then the realization of the Ability Potential to be constant and extended but can be at different levels when criticality is reached. The consciousness exists when the Ability Potential is global to the extent that it acts over a large part of the Ability Potential reservoir that is considered. This is encountered when occupancy of active neurons is spread over a large part of the brain. However, the strength of this consciousness can vary.

The model used here is approximate because it is only for the bond as the basic figure. Better approximations can be used if we consider larger basic figures, such as the triangle, the rhombus and the hexagon, etc. These basic figures may be considered and can lead to more comprehensive results. They have all been used in approximations for the application that are possible in this model and the results become more accurate as the basic figures becomes more complex as proven by experimental physics in other studies with this model. However, the mathematics becomes more complicated as well.

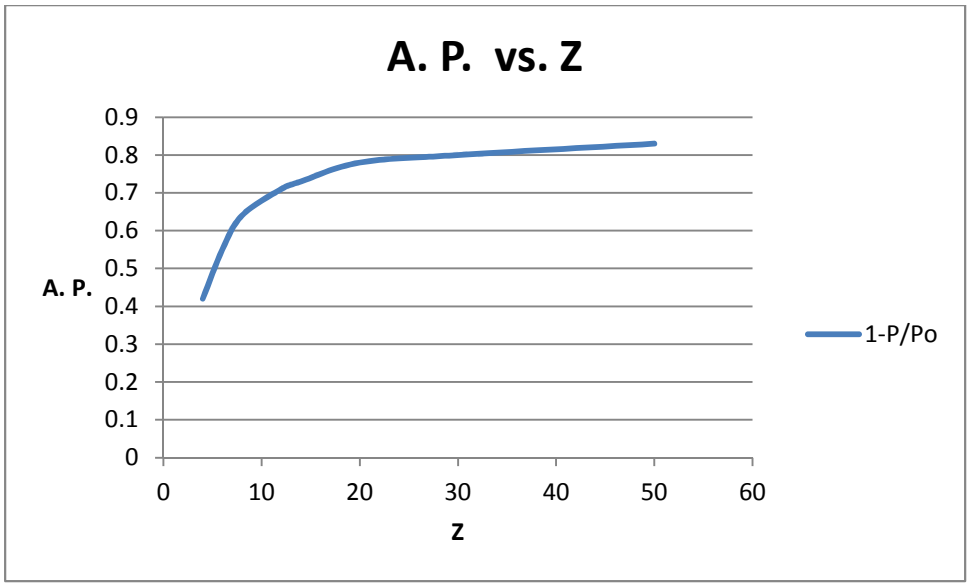

Figure 1

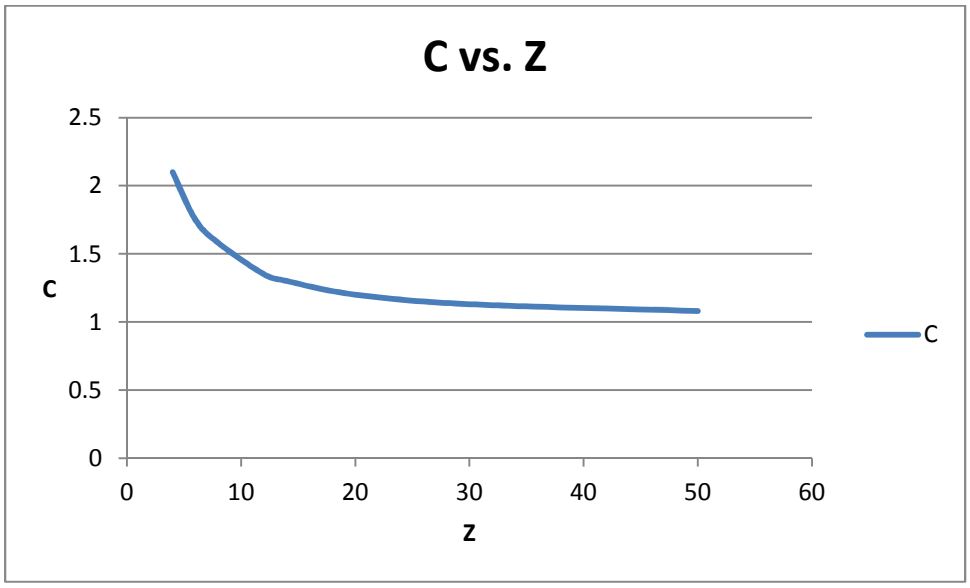

Figure 2

Figure 1 shows that as the coordination number increases so does the Ability Potential. Figure 2 shows that as the coordination grows the interaction energy decreases.

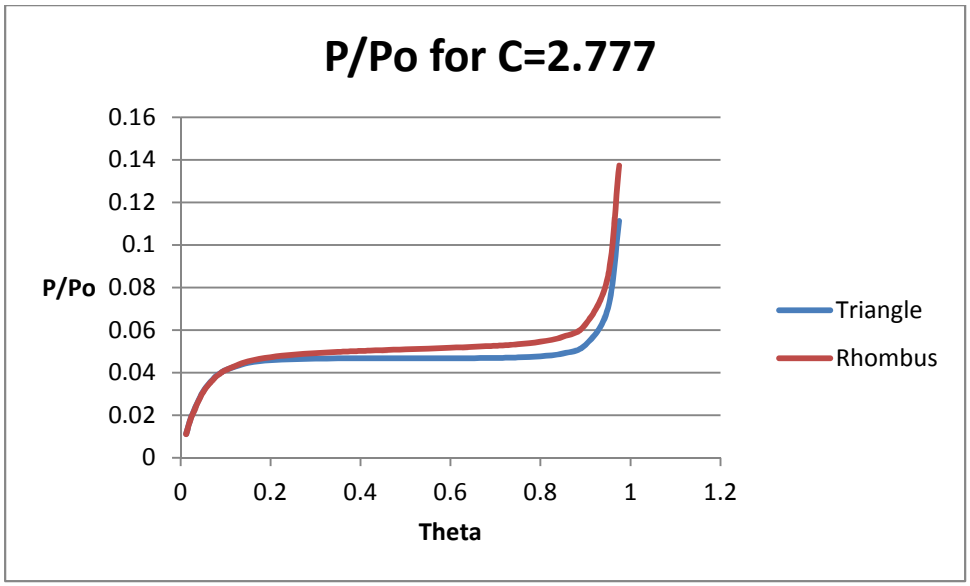

Figure 3

Figure 3 shows P/Po plots for the triangle and rhombus as basic figures when Z is equal to 6 and C = 2.78. Here the triangle, as basic figure, is at its critical value and the rhombus figure is close to its critical value. In fact the rhombus has a critical value of 3.0 which is also the value found for the triangular lattice. P/Po shown as the ordinate can be converted to it's A. P. form and the graph will then be appropriate in that application.

Notice that the A. P. value is actually 0.95 by the format given at the beginning of this paper. We consider this critical region of the A. P. to be consistent with a consciousness which occurs when the A. P. value has a global spread (constant value over a wide range of Θ). Now all the values given in the table above were found in critical regions for the bond. We can have critical values for any basic figure that is consistent with the integer Z that represents the coordination number or the number of connections to any point in the lattice. Although Z is an integer the parameters C, and A. P. can be non-integers. We are left with three variables, Z, C, and A. P., to locate our critical regions. Let us call this a "codon" to characterize our critical areas of consciousness. By a codon, I am thinking of a codon that is used in molecular biology to indicate an amino acid that is used to help form proteins, essential molecules in life processes. Here, however, the codon is a set of three numbers, not letters of the alphabet, and is employed to indicate a particular level of consciousness.

A. P. will increase as attention and repetition is increased. Engaging cognitive resources will also raise A. P. These factors all raise C. This is reflected in increased synaptic efficiency. Memory cell assembly can be aided by more complex basic figures. Global interaction helps to raise the consciousness level. Distraction can lower the A. P. These effects can be temporary and metastable. Reweighting, reconnection, rewiring and regeneration (reference 7) will all affect C and hence Ability Potential. Sequential connections are important in genomics but have no effect in this model. Both secretion of neurotransmitters or electrical transmission increase the value of C and Z. The looping of neural pathways from the thalamus to the upper layer of the cortex and

back again as depicted in reference 7, cannot be applied with this model. Other network theory items could be applied such as “six Degrees of Separation” or neural network partitioning into clusters for better control. In a recent issue of Nature magazine (July 8, 2013) there are several articles that treat neural networks. However these networks are in simpler organisms (the mouse, the fly and C. elegans) than that of human beings. The treatment of the connectome of human beings will be much more ambitious.

Methods: The Quasi Chemical Method

This method can be used to derive the equation for P/Po shown in references 1 and 2.

Postulate 1. Whenever there is a “reaction” such that the number of occupied sites in the “reactants” equals the total number of occupied sites in the “products,” the change in energy of the isothermal process can be accounted for in terms of the energies associated with the formation or destruction of the requisite bonds.

Postulate 2. Whenever there is a “reaction” such that the total number of occupied sites contained in the “reactants” does not equal the total number of occupied sites in the “products” and the total number of bonds in the “products” equals the total number of bonds in the “reactants,” then the energy exchange for the isothermal process is ϵ-$\mu^{(g)}$ for each occupied site that is “created,” and $\mu^{(g)}$-ϵ for each unoccupied site that is “created” in addition to a suitable constant.

In the above μ is the chemical potential and ϵ is the energy of adsorption.

Direct Products and Group Theory

We have o (p_o^a) to represent the unoccupied point and ● (p_1^a) to represent the occupied site in the point basic figure (a). We also have ○-○ (p_o^b) to represent the unoccupied bond and ○-● and ●-○ (p_1^b) to represent the bond occupied by one particle and ●-● (p_2^b) to represent a fully occupied bond basic figure (b).

When an unoccupied basic figure is occupied by one more particle we indicate this by the symbol m. We use the equation below to indicate m_{is} when a basic figure i becomes the basic figure s, that is when a particle is added

$$m_{is} = (x)^{(g-h)}(x')^h(y)^r(z)^t$$

In the above the variables x, x', y and z can be identified by the algebra in the reference (which will be sent to the reader upon request). In the above equation x indicates one particular position in the basic figure, x' indicates another position in the basic figure, y and z represents two different bond interaction energies in the basic figure.

We then have

○ - > ● = a_1

○-○ - > ○-● or ●-○ = b_1

○-●- > ●-● = b_2

And using the equation for m_{is} above and the equations:

$b_1 = Ka_1$

$b_2 = (Ka_1)^2$

and since

$$\Theta = (p_1^b + p_2^b)/(p_o^b + 2\,p_1^b + p_2^b) = (b_1+b_2)/(1+b_1+b_2) = (Ka_1)[1 + Ka_1C]/(1+Ka_1+(Ka_1)^2C)$$

The equation above can be rewritten as

$$CK^2 a_1 + K(1-a_1) - 1 = 0$$

Solving for K, we have

$$K = (\beta - 1 + 2\Theta)/2\Theta C$$

Where

$$\beta = [1+4C\Theta(1-\Theta)(C-1)]^{1/2},$$

$$K = (P/Po/a_1)^{(1/Z)},$$

Thus

$$P/Po = (\Theta/(1-\Theta))(\beta-1+2\Theta)/2C\Theta)^Z$$

And this was the equation that was used for the first paper in the first approximation[1].

Conclusions: The coordination of the simulated neurons is again accentuated in this toy model of a neural network. The interaction energy is also found to influence and produce various levels of consciousness in this network. Various items from the recent literature can be understood more clearly with some of the results from this model.

Bibliography

1. S. Bumble and J. M. Honig, J. Chem. Phys., 33, 324, 1960

2. Stan Bumble, Vixra: 1303.0046, Astrophysics, Dark Energy: Order-Disorder in the Cosmos

3. Ryoichi Kikuchi, A Theory of Cooperative Phenomena, Physical Review, 81, 988, 1951

4. H. Hijmans and J. M. deBoer, Physica, Vol. 221,465, 499, 1955

5. Stan Bumble, Vixra: 1305.0128, A Toy Model of Consciousness and connectomes, First Approximation

6. Seung, S., Connectome, Houghton Mifflin Harcourt, Boston, 2012

7. Churchland, P. S., Touching A Nerve, Norton & Co., 2007