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Evolution of group consciousness – a cybernetic approach

Basis of an anthropological dating and forecasting technique

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Keywords Language, Psychology, Cybernetics, Systems theory, Ethnography

Abstract *The approach of biocybernetics and non-equilibrium systems dynamics is used to analyse biological, psychological, anthropological and cultural evolution. Using experimental data, positive feedback of biological activation and Prigogine-Einstein fluctuation analysis, the energy dissipation equations for biological and anthropological evolution are developed.*

Introduction

The evolution of Man is a culminating landmark development of the biological evolutionary process, which began with the primordial soup of self-organising and self-replicating biotic polymers, thereby initiating the evolutionary chain:

Protozoa → Invertebrates → Vertebrates → Primates → Hominids → Man,

including Man's civilization, culture and psyche and encompassing his various cognitive states and transformations. Recently non-equilibrium thermodynamics and its related field, self-organisation theory, have been used to explore a theoretical foundation of biological evolution (Zotin, 1990; Brooks and Wiley, 1986) and of anthropological/cognitive evolution (Prigogine, 1976). The basic *modus operandi* is the cybernetic process of self-amplifying deviation or evolutionary positive feedback, which is also found in economic growth and social development (Maruyama, 1963; Dutta Majumder, 1979). Our approach is inspired by the rather less-known investigations of Darwin, who indicated the gradual phylogenetic evolution of emotion, dream and trance in primates and man (Darwin, 1878). To neurologists, psychologists and anthropologists, the biological basis of the evolutionary self-organisation of the brain and cognition, over millions of years, offers a captivating arena. The diverse phenomenology of

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altered states of consciousness and their temporal neurobiological evolution offers a most fascinating pathway to the study of mental processes and the human self. As the pioneer of American psychology James (1958) emphasized:

> ... Our normal waking consciousness ... is but one special type of consciousness, whilst all about it, parted from it by the filmiest of screens, there lie potential forms of consciousness entirely different. We may go through life without suspecting their existence; but apply the requisite stimulus, and at a touch they are all there in all their completeness. No account of the universe in its totality can be final which leaves these other forms of consciousness quite disregarded.

Cybernetics and system theory: a link to theoretical neuropsychology and anthropology

A cybernetic and informational-thermodynamic angle has been used by us (Roy *et al.*, 1992, 1993a, b, 1995) and by Badalamenti and Langs (1992) to probe transformations of cognitive states or their evolution. Onsager (1968) and Prigogine (1977) have pioneered the development of non-equilibrium thermodynamics, so as to elucidate biological processes. A number of contemporary biologists and psychologists have attempted to use this new paradigm to analyze various problems in psychodynamics, cognition, bio-regulation, perception, action and intention (Shaw and Kugler, 1991). The evolution of human brain, cognition and consciousness is the culminating landmark development of the biological evolutionary process. The evolutionary process was actuated by increased supply and feedback of energy (Zotin, 1990), and the disciplines of bioenergetics, thermodynamics and biocybernetics, can furnish a suitable methodology. Phylogenetically speaking, the higher the evolutionary advancement of intelligence, the higher the level of cognition, energy dissipation or entropy production, and more the organism departs from thermodynamic equilibrium or stationary state. This is the well-known concept of "Dissipative Structure", as elucidated by the Brussels school of Glansdorff, Prigogine and Nicolis, whereby energy dissipation, i.e. entropy production, becomes the basic locomotive of evolution and self-organisation through positive feedback (Nicolis and Prigogine, 1977) (see Figure 1 (Schema 1)):

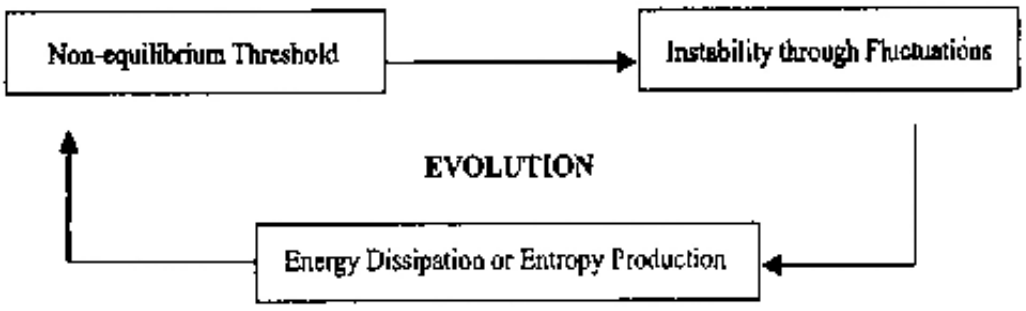

Figure 1. (Schema I): The biocybernetic "dissipative structure" model of evolution, whereby energy dissipation or entropy production is the generator of evolution through positive feedback by means of amplification of fluctuation or deviation from stationary state

It should be noted that, though we use a cybernetic thermodynamic model of evolution with a mathematical foundation, there have been other approaches to the study of anthropological evolution, some of which, even though qualitative, have furnished deep theoretical insights. Examples are Lovejoy's approach to primitive evolution through the concept of primitive energetics, Levi-Bruhl's Law of Participation characterizing primitive mentality, Freud's *magnum opus*, *Totem and Tabu*, exploring the evolution of family, marriage and social relationships, as well as Levi-Strauss's structural anthropology which developed the structural-hermeneutic approach to anthropological evolution through the *modus operandi* of the myths and collective consciousness as the basis of stable social structures (Jung, 1989; Gardner, 1995).

Unification of systems theory and cybernetics

The dissipative structure formalism of biological evolution is a fluctuation-amplifying or deviation-increasing process. This amplification is the "evolutionary feedback" and can be termed autocatalysis: each deviation or fluctuation further increases its own deviation; the dynamics of this type of systems with positive feedback are referred to as Type-II Cybernetics (Maruyama, 1963), in contrast with the earlier types of systems studied, which tend to minimize deviation or fluctuation and operate with negative feedback (Type-I Cybernetics). Type-II systems were emphasized by the Nobel Laureate economists Gunnar Myrdal and Jan Tinbergen, the well-known anthropologist Margaret Mead and complex systems theorist Ilya Prigogine as well as by the cognitive scientists Maturana and Varela (1992) through the concept of "autopoiesis" i.e. self-creation. As the work of Prigogine and Stengers (1986) implies, the fluctuation-amplifying Type-II cybernetic paradigm can clarify the origin of life and biological information.

One of the present authors, Dutta Majumder presented the first Norbert Wiener Award paper on "Cybernetics and General Systems – A Unitary Science" in 1977 (Dutta Majumder, 1979, 1993); it included a panoramic vista of principles of cybernetics and control to various branches of science, a Type-I approach. The current Wiener Award lecture by Prigogine (1999) stresses the importance of fluctuation, instability and bifurcation, a Type-II cybernetic approach. Dutta Majumder's efforts elucidated that Cybernetics and General Systems Theory form a universal theory of action and are applicable to the full range of disciplines in the life-sciences: biology, sociology and psychology. The other author Roy attempted a neurocognitive application of systems theory and thermodynamics for the interdisciplinary program for Rolex Foundation for Scientific Enterprise (Roy, 1977). In this paper we try to develop an evolution equation to characterize human anthropological development and activity over the last 100,000 years and use the equation as a dating equation to predict historical dates from the level of activity. For the sake of comparison we just recapitulate the conventional dating equation in anthropology using radio-carbon.

Radio-carbon dating equation. The dating equation currently used in anthropology is through radioactive carbon $[_6C^{12}]$. Nitrogen $[_7N^{14}]$ in the

atmosphere is the result of cosmic ray reactions. The $_6C^{12}$ is radioactive with decay constant $\lambda = (-)0.00012$ and half life = 5,730 years, the decay yielding again $_7N^{14}$. All organisms take in $_6C^{12}$ and a constant level of this isotope is maintained; at death the $_6C^{12}$ intake ceases, and its proportion decreases at a constant exponential rate (Libby, 1960). From experimental measurement of the $_6C^{12}$ level in ancient human remains it is possible to gauge the age within 5-6 percent error. Letting R denote the fraction of undecayed $_6C^{12}$ nuclei, the dating equation is:

$$R = e^{-0.00012t} \tag{1}$$

This technique is usable up to 70,000 years. We now proceed to develop the anthropological evolution equation separately.

The equation of system evolution: equilibrium→non-equilibrium transformation

We have construed earlier that biological or cognitive evolution is associated with increasing energy dissipation or activation, a transformation from equilibrium or stationary state (with low dissipation or activation) into a non-equilibrium state (with high dissipation or activation). As a system departs from the equilibrium or stationary state and moves into the non-equilibrium state, the thermodynamic fluctuations of the system gradually increases. Recall Einstein's fluctuation formula:

$$p = C\exp(\Delta S/k) \tag{2a}$$

where p is probability density of fluctuation of parameters $U_1, \ldots U_n$ from the equilibrium or stationary values $U^0_1, \ldots U^0_n$; k is a constant and ΔS is entropy change, i.e. $\Delta S = S - S_0$ (Einstein, 1905). Here S_0 is the value of entropy at the stationary state. Note that the Einstein equation is the inversion of the Boltzmann entropy equation

$$S = k \log_e p.$$

An equation analogous to Einstein's is derived independently through Markov analysis (Presnov, 1978) using Medawar's formulation that biological development is stochastic. The Brussels and Calcutta schools of non-linear thermodynamics have extended Einstein's Equation (2a) to the non-equilibrium domain (Glansdorff and Prigogine, 1971; Chakrabörty, 1974). From non-equilibrium dynamic analysis, we know that the energy dissipation or system activation of an entity at non-equilibrium state ψ and at equilibrium or stationary state ψ_S is related as follows (Roy *et al.*, 1993a; Zotin, 1990):

$$\psi = \psi_s(k'/p).(dp/dt) \tag{2b}$$

where $k' = kT/V$. We can consider the energy dissipation per unit volume or per unit weight. Actually we can substitute weight for volume, since the density of the tissue or organism remains more or less constant as time elapses. Thus if we consider energy dissipation per unit volume or weight, $k' = kT$. To develop Equation (2b) further, we need to explore the nature of the function (dp/dt). We give attention here to the "equilibrium or stationary state → non-equilibrium state" transformation, this transformation being associated with increase or amplification of the fluctuations. During fluctuation amplification or increase with time, the probability density "p" should be a function of thermodynamic parameters as well as time. Since, in the fluctuation process, the thermodynamic parameters are themselves dependent on time, the probability density would be dependent only on time. Hence:

$$dp/dt = f(p). \tag{3}$$

where the function f(p) is continuous and differentiable. Applying Taylor's theorem to Equation (3):

$$dp/dt = f(p_s) + [\{f'(p_s)(p - p_s)\}/1!] + \{f''(p_s)(p - p_s)^2\}/2!] + \ldots \tag{4}$$

In the transformation in question, the system gradually departs from the stationary state. From Equation (4), we see that at the stationary state, that is, as $p = p_s$ and $dp/dt = 0$, then $f(p_s)$ is zero. Then, as the system departs from the equilibrium or stationary state, $f(p)$ goes on increasing. Thus the change in the rate of probability density increases as the system transfers away from the stationary state and proceeds to non-equilibrium state; this implies that $[f'(p_s)]$ is positive. Both p and p_s, being probability, are below 1, and since we are only moderately far (and not very far) from stationary state,

$$p \approx p_s, \qquad \text{i.e.} \qquad (p - p_s) << 1.$$

Thus, in the Taylor series, we can neglect higher orders $(p - p_s)^2$ and onwards. So Equation (4) reduces to:

$$dp/dt = f'(p_s)(p - p_s) \tag{5}$$

whence

$$dp/dt = -\alpha(p_s - p) \tag{6}$$

where we denote $\alpha = f'(p_s)$. As $f'(p_s)$ is positive, α is positive. Substituting Equation (6) in Equation (2b), we see that:

$$\psi = \psi_s + g[(p_s/p) - 1] \tag{7}$$

Here we define $g = \alpha kT/V$. However, since we are considering unit amount of the system, $g = \alpha kT$. Integrating Equation (6):

$$p = p_s[1 - D \exp(+\alpha t)] \quad (8)$$

or

$$p_s/p = [1 - D \exp(+\alpha t)] \quad (9)$$

Eliminating p_s/p between Equations (7) and (9), gives:

$$\psi = \psi_s + [\{gD \exp(+\alpha t)\}/[1 - D \exp(+\alpha t)] \quad (10)$$

As the system is not very far from the stationary state, we can take it that $t << 0$ (Figure 2(a)). In that case

$$D \exp(+\alpha t) << 1.$$

Therefore, the denominator in Equation (10) approximates unity, whence Equation (10) becomes:

$$\textit{System Evolution: } \psi = \psi_0[1 + A \exp(+\alpha t)] \quad (11)$$

which is the Evolution Equation for the Equilibrium→Non-equilibrium transformation. Note that A and α are positive numbers and we use "A" for denoting gD/ψ_s and "ψ_0" for ψ_s. Observe that we can also derive Equation (11) in a different way (Roy and Dutta Majumder, 2000a) by using the notion of time reversal, which is based on Onsager's stochastic "detailed balance" concept, namely the time reversal invariance of elementary steps associated with irreversible phenomena (Onsager, 1968; Nicolis and Prigogine, 1977). A schematic graph of Equation (11) is shown in Figure 2(a). Transposing Equation (11):

$$\Delta\psi = A\psi_0 \exp(+\alpha t) \quad (12)$$

where $\Delta\psi = \psi - \psi_0$, i.e. $\Delta\psi$ is the increase of ψ over baseline stationary state value ψ_0. Taking the natural logarithm:

$$\ln[\Delta\psi] = B + \alpha t \quad (13)$$

where $B = \ln(A\psi_0)$. Thus the semilog plot of $\ln[\Delta\psi]$ against time t would yield a straight line (Figure 2(b)) with positive gradient. Note that in the Equations time is measured positively into the future, and negatively into the past (Figure 2(b)). We now proceed to systems analyse the biological, psychological, anthropological and sociological evolution, i.e. the full spectrum of human evolution, in terms of the mathematical description of systems evolution developed above.

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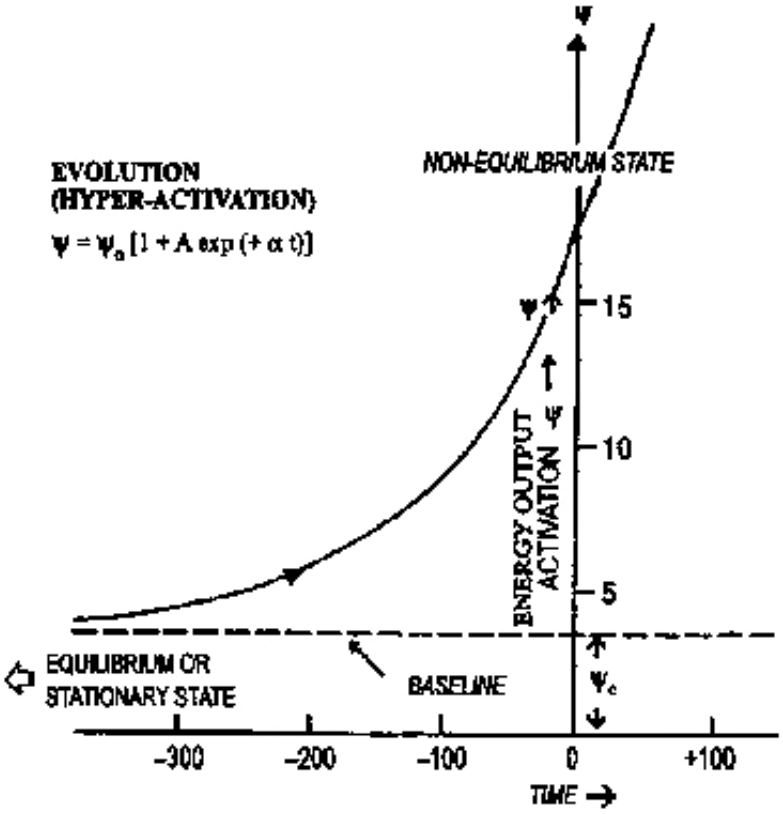
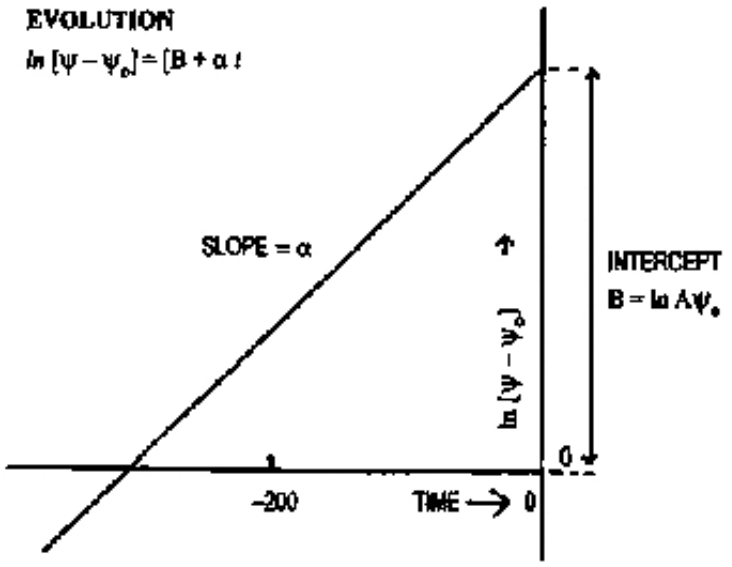


(a) Schematic representation of increasing energy dissipation or system activation during Evolution (eq. [1]), viz. *Stationary-state* → *Non-equilibrium state* Transformation. Arbitrary units in axes used



(b) Lognormal plot of eq. [2], displaying linearity. Collinear points in such semilog plot of energy data underscore the applicability of biocybernetic and thermodynamic model developed here

Figure 2.

Biological evolution of life

Irreversible thermodynamics of open systems and non-linear processes of fluctuation-dissipation have been a basic facet of quantitative and dynamical analysis of evolution. Figure 3(a) displays the "Aromorphosis development", namely the incessant increase of vital activity, as estimated by energy dissipation. i.e. entropy production per unit mass of tissue, as animal evolution occurs across almost a billion years. Note that in Figure 3 time is measured in negative years before the present; this follows the conventional practice: future time is denoted as positive, whereas past time is negative. Figure 3(a) is constructed from experimental or empirical data, namely calorimetric measurements of adult organism, furnishing energy dissipation per gram of the organism's tissue, i.e. ψ-value (Roy and Dutta Majumder, 2000; Lamprecht and Zotin, 1996). This value is plotted against the evolutionary time when the type of animal first appeared on the earth, which is known from radioactive dating of fossils.

For the entry "man with fire", the ψ-value can be gauged from paleo-anthropological studies. Figure 3(b) constructs the semilog plot and shows that the empirical biological evolutionary data obey our theoretically-derived evolution Equation (13), and hence Equation (11). Line of best fit is drawn in Figure 2(b). For calculating $\Delta\psi$, we take ψ_0 to be the ψ value (energy production) of amoeba, 0.098mW (Hemmingsen, 1960). This protozoon is reminiscent of the prototype primary organism which is taken to be the initial stationary state from which animal evolution started about 1,500 million years ago, producing sponge-like organisms about 1,000 million years ago. The terminal entry "intelligent man with fire" indicates the event of invention of fire occurring about 750,000 years ago.

The characteristic equation

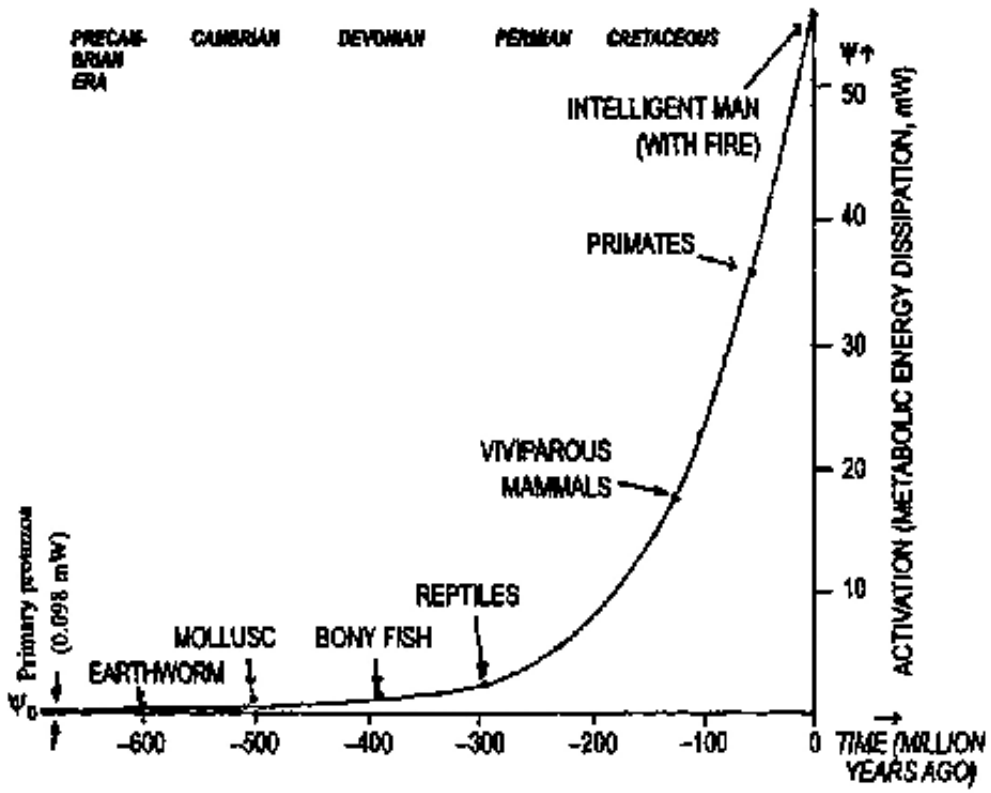
By measuring the slope (α) and the intercept [$B = \ln(A\psi_0)$] from Figure 4(b), we calculate that $\alpha = +0.0087$/million year and $A = 1{,}887$ thus Equation (11) becomes:

$$\textit{Animal evolution:} \qquad \psi = 0.098[1 + 1887 \exp(+0.0087\, t)] \qquad (14)$$

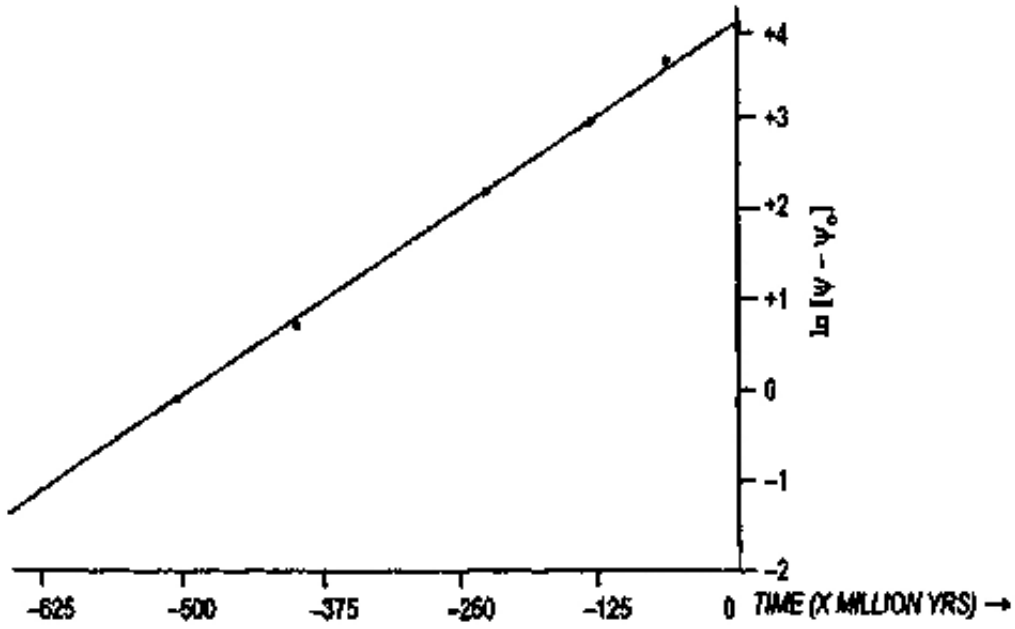
where ψ is energy dissipation index in milliwatts and t is time in (negative) million years before the present time, expressed as say –500 million years.

Biological evolution equation as a dating equation for neuro-cybernetic thermoregulation

During the evolution of vertebrate intelligence and ultimately man, one of the most important biological transformations was the evolution of the biocybernetic property of thermoregulation or control over body temperature and activity. This was one of the most crucial neurocybernetic attainments through the brain's hypothalamus, which controls the body temperature-regulating centre in preoptic-anterior hypothalamic area. We can also use the evolution Equation (14) as a dating equation for determining the time of this biocybernetic evolutionary development from cold-blooded (poikilothermal)



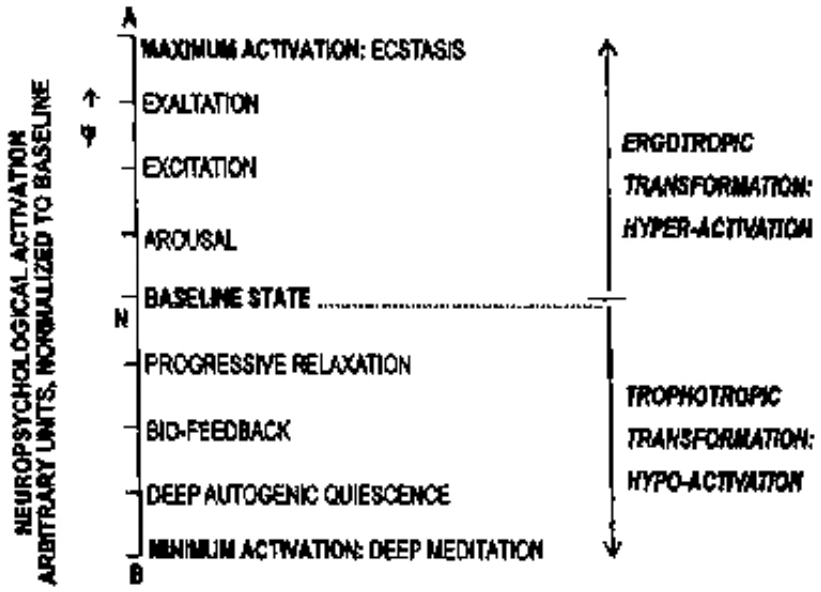
(a) Biological evolution of life culminating in intelligent Man



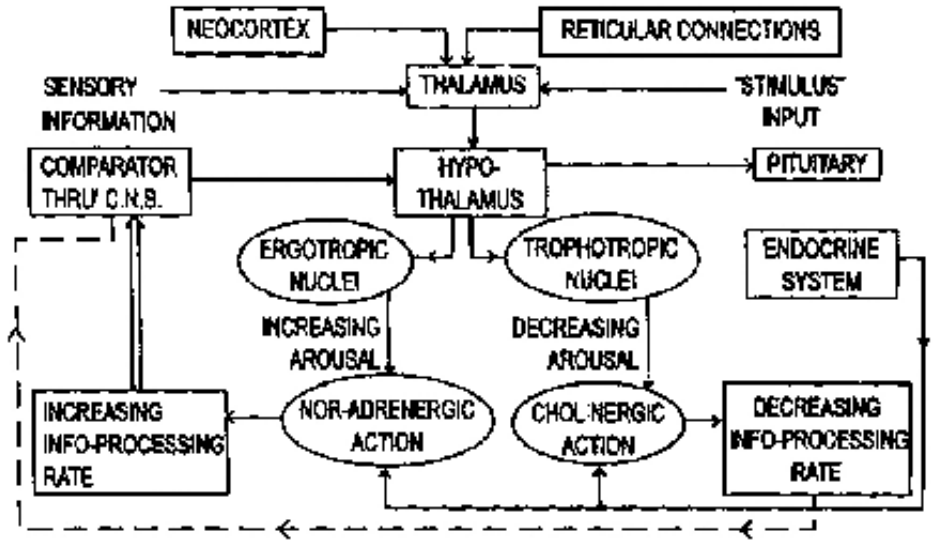
(b) Plotting ln [$\psi - \psi_o$] against time. A straight line of best fit is obtained showing that cybernetic-thermodynamic analysis helps to quantitatively elucidate the biological evolution of the human intellect

Note: Linearity confirms applicability of our model

Figure 3.



(a) Spectrum of States of Consciousness and Neurocognitive Transformations mapped according to activation level, as measured by energy dissipation or information processing intensity



(b) Neurocybernetic model for control of cognitive activation and information processing rate

Figure 4.

animals to warm-blooded (homeothermal) animals. This transition corresponds to the heterothermal stage, the intermediary sequence of vertebrate evolution:

Poikilotherms → Heterotherms → Homeotherms.

Homeotherms are animals, like birds and mammals, having proper biocybernetic thermal homeostasis and constant body temperature, which may vary very slightly (say within 1-2°C of mean) according to seasons or day-night cycle. Poikilotherms are animals, like amphibia and fishes, whose body temperature

varies in direct proportion to the external environment temperature of the seasons or day-night cycle. Heterotherms are those transition creatures in between, whose body temperature shows some partial thermoregulation; the body temperature varies with the environmental temperature, but the temperature variation is damped and smoothed out and is much lower than that of poikilotherms; the heterothermal temperature variation is much lower than direct proportionality. The appearance of initial thermoregulation, namely the evolutionary development of poikilotherms into heterotherms, crossed a critical metabolic energy threshold and heat barrier and was a decisive development which paved the way for the more advanced homeothermal vertebrates (including man), who maintain much higher entropy production rates and evolutionary speed. We empirically know that ψ value of this heat barrier is 5mW (Zotin *et al.*, 1998). So we put $\psi = 5$mW in Equation (11). Solving it, we arrive at:

$$t = (-)\ 301 \text{ million years ago.} \tag{14a}$$

Is there any fossil evidence implying that there originated animals, showing signs of heterothermicity and temperature damping at that distant time of the Carboniferous geological era? Circumstantial paleo-physiological evidence indicates that there were comparatively smaller carnivorous Cellosauric reptiles (80-100kg), about a man's size, which appeared about 290 million years ago (Lamprecht and Zotin, 1996). They had maximum brain development index among reptiles:

Cellosauric reptiles: Brain encephalization coefficient $c_b = 0.126$.

This value remarkably approaches the mean encephalization of today's advanced animals:

Modern Mammals $c_b = 0.127$

which originated about 200 million years after cellosauric reptiles. Hence we may adduce that the fossil existence of cellosauric reptiles corroborates our mathematical prediction of an early origin, 300 million years ago, of the neurocybernetic progression, regarding the intermediate "missing-link" animals bridging the

"cold blooded → warm blooded" transition threshold

of the heat barrier. Indeed the difference between the time predicted by our equation and that of cellosaurian fossils is only 10 million years, i.e.

$$\text{Error} = 4\%.$$

We thus see that our neurocybernetic evolution model furnishes some valuable insights into some contentious issues and that the model can be used as a dating equation with a span of a billion years.

Psychological evolution and psychotaxonomy: cybernetic state representation of consciousness

We now proceed to explore the concept of evolution and transformation of consciousness through increasing activation, positive feedback and amplification of fluctuation apropos the Prigoginian paradigm of Dissipative Structure; which incisively elucidates in the Wiener Lecture (Prigogine, 1999). We contend that one of the most systematic ways to classify the bewildering variety of alternate states of awareness is using the activation level of the particular state, where activation denotes the neuropsychological arousal level (Figure 4(a)). The arousal estimates an important cognitive variable, viz. cognitive information-processing rate (Fischer and Rockey, 1970; Fischer, 1986). Activation is very accurately correlated ($\rho = 0.99$) with the subject's respiratory consumption rate (Duffy, 1972) and respiratory oxygen consumption rate corresponds to entropy production, i.e. energy dissipation (Zotin, 1967). Hence neuropsychological activation is a measure of the subject's entropy production or energy dissipation rate, i.e. cognitive information processing rate. Figure 4(b) shows the neurocybernetic components of our model based on hypothalamic tuning, which regulates activation; we base our formalism on Hess's (1949, 1974) pioneering work on arousal and its hypothalamus-modulated control. As per our formalism, psychological states fall into the following two categories (Figure 4(a)):

(1) *Ergotropic transformation* with activation or cerebral information processing level higher than normal baseline of the waking state. Ergotropic transformation is mediated through the sympathetic autonomic process via noradrenergic chemical neurotransmitter, the coordinating centre being the anterior midbrain. Ergotropism is associated with beta or fast EEG activity (Corby *et al.*, 1978) and can be induced by techniques which increase cortical vigilance or cognitive activity such as actively focused or selective contemplation on a single object of concentration (active "foveal attention"). There is intense mental absorption, called "concentrative contemplation". Other well-known procedures are autogenic arousal discharges, Ishiguro, Krya contemplation and intense concentrative meditation (Roy and Dutta Majumder, 2000a; Ludwig, 1985). Prince (1968) has explored the cybernetic basis of ecstasis trance.

(2) *Trophotropic transformation* with arousal and information processing rate lower than normal baseline level. Trophotropism is reciprocal of ergotropism and is mediated through the parasympathetic autonomic process via acetycholinergic neurohormone, the coordinating centre being the anterior hypothalamus. Trophotropism is associated with alpha or slow EEG activity and with relaxation of fluctuation of skin resistance, i.e. psychogalvanic response (Benson *et al.*, 1974). Trophotropism can be induced by passive "macular" attention with increased quiescence, there is no effort of focusing and the awareness

settles down to an equipoise level without any discursive or purposeful activity; this is the called "mindfulness contemplation" or relaxative meditation (Roy *et al.*, 1993a; Goleman, 1972). Trophotropism is attained through autogenic relaxation, biofeedback, zazen, greecian passive ligatural meditation, hesychasm and cotention. Pegand (1984) has developed a penetrating cybernetic analysis of the trophotropic process.

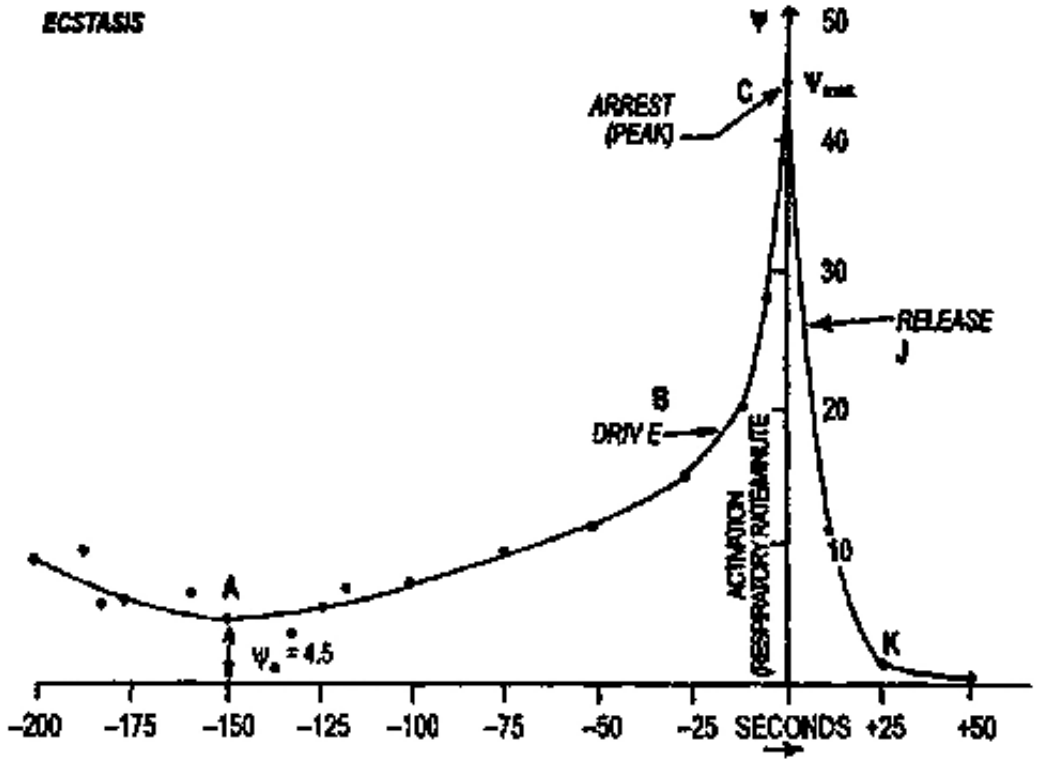
Evolution equation for ecstasis stage of consciousness

The psychodynamic illustration of evolutionary transition of consciousness and of "brain as a dissipative structure" model is evidently the ergotropic transformation engendering increase of activation and information processing rate (Figure 5(a)). We construct Figure 5(a) by utilizing the findings of the Stanford group (Corby *et al.*, 1978). The extreme hyper-activation state is called "ecstasis" in Greek. Activation or energy dissipation is estimated by respiratory oxygen consumption rate, i.e. product of respiratory rate and respiratory amplitude. Since the spirometric respiratory amplitude is nearly constant for the subject being studied (Corby *et al.*, 1978), we can estimate activation here by respiratory rate. In ergotropic transformation the rate of entropy production, cognitive activity, problem solving and intelligence increases; in extreme hyper-activation, there are profound insight, grasp and inspiration along with the Eureka experience (Mandell, 1990).

Ecstasis is experientially felt as surge or rush of arousal, a high release or rapt peak of exaltation; experimentally this has been observed through Positron Emission Tomographic (PET) neuro-imaging or Polycontrast Interphase Photography (Galbraith, 1999). We find that this observation of arousal surge is universal, by whatever technique the peak or ecstasis is induced, e.g. concentrative contemplation (Krishna, 1980), psycho-analeptic drugs (Grof, 1993) or hyper-kinetic trance (Fabing, 1956). In Figure 5(b) we graph the semilog plot and the clearly observed linearity in Figure 5(b) satisfies Equation (13), thus confirming that our non-equilibrium cybernetic analysis applies to evolutionary psychodynamics. By measuring slope and intercept of Figure 9(b), we find that $\alpha = +0.024$ and $A = 5.45$. So Equation (11) becomes

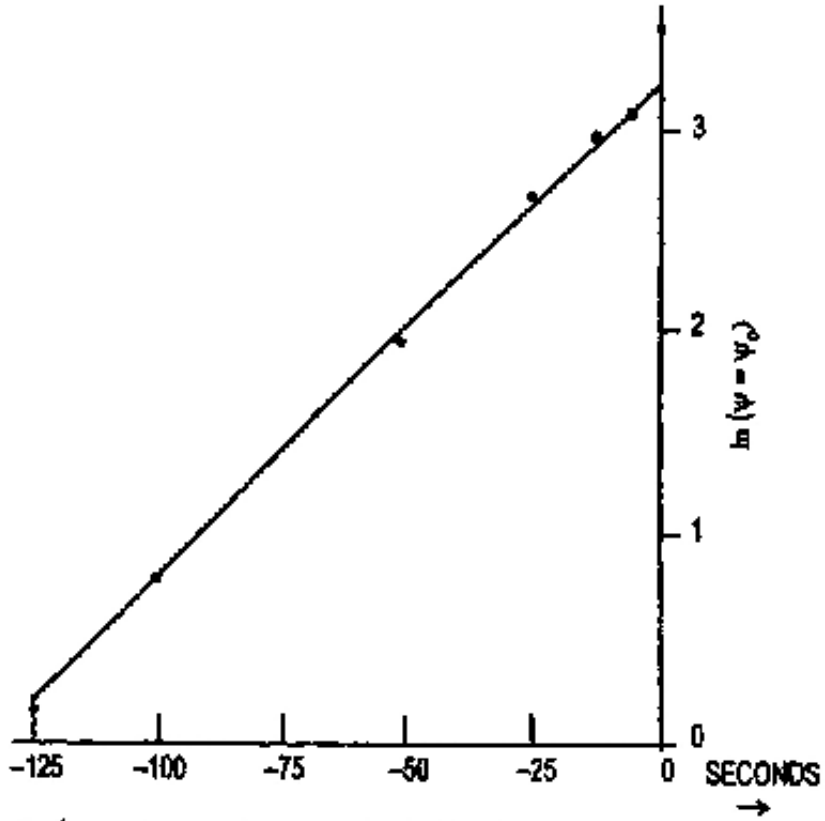
$$\textit{Ecstasis evolution:} \qquad \psi = 4.5[1 + 5.45 \exp(+0.024\ t)] \qquad (14)$$

where ψ is activation in respiratory rate/minute and t is time in (negative) seconds before the peak, expressed as, say, –8 sec. From Equation (14), half life = 29.1 seconds, progression constant = +0.024. From Figure 5(b), we find that $\chi^2 = 0.05$ (statistical chi-test), implying that our system's dynamical model appears to be correct. Note that the parameter ψ_0, A, B and α in Equations (11) and (13) depend on the subject's neurological constitution and autonomic tone, and does vary somewhat from person to person. There may be some who will reach the peak slowly ("stabilizers") and some rapidly ("responders"). From Fischer's (1971, 1986) investigations, we may say that persons, having high scores in introversion and intuition indices of the Myer-Briggs psychometric test, would be "responders", and low scorers "stabilizers". However, all subjects would have



(a) Neurocognitive evolution with increased energy dissipation and activation as ecstasis develops. Vertical axis has been shifted to the right to pass through peak arousal point.

Note: The Drive-Arrest-Release sequence. Experimental data obtained from Corby *et al.* (1978)



(b) Plot of $\ln(\psi - \psi_o)$ against *time*, emphasing the linearity

Figure 5.

an exponential rising curve like Equation (13), though the steepness (α) may differ.

Biocybernetic peak ratio: diatropic coefficient

The ψ_{max}/ψ_o activation ratio in ecstasis (Figure 5(a)) is 44/4.5, i.e. 9.9. This precisely concords with a fundamental biothermodynamic constant, Diapason coefficient D, defined as ratio of maximum metabolism attainable by any organism to that of its basal metabolism. $D = 9.9 \pm 0.3$ (Zotin, 1990). D is an ubiquitous parameter across all vertebrates, from fish, amphibia and reptiles, to birds, mammals and man. Hence we call our ergotropic peak ratio ψ_{max}/ψ_o as *Diatropic coefficient* δ. The concordance between the two coefficients underscores the deep evolutionary biological basis of the ecstasis state of consciousness. Our evolutionary view has been corroborated by animal behaviour studies (Hunt, 1984). The δ's limiting value is a clear manifestation of neuro-cybernetic homeostasis (Figure 4(b)), preventing unlimited excessive hyper-activation and damage to brain. It may be observed that our biocybernetic formalism insightfully analyses the equilibrium $\rightarrow$ non-equilibrium transformation, whether in phylogenic evolution of consciousness across a billion years (Figure 3(a)) or in the development of ecstasic consciousness across minutes (Figure 5(a)). Such ubiquity is an expression of the universality of thermodynamics from neuronal processes to development of life. Nicolis and Prigogine (1977) predicted some evolutionary relationship and mechanism in the development of life through thermodynamic principles. Through the results presented in Figures 4 and 5 we extend their concept to evolution of human psyche and predict the existence of some universal principles similar to that of systems energetics or systems thermodynamics. We know that ψ_0, the basal metabolic rate (BMR) value of physiological baseline man, is 22.5 milliwatts (Lamprecht and Zotin, 1996). So

$$\psi_{max} = 9.9 \times 22.5 = 220 \text{ milliwatts} \qquad (15)$$

Anthropological evolution

Did progressive Darwinian evolution actually reach a final level in the ordinary (normo-activational) psychological state of the intelligent man of 750,000 years ago (Figure 3)? Or conversely, whether further intensification of neurocognitive activation was subsequently possible in extraordinary psychological states later in history? From our analysis of current anthropological, paleopsychological and ethno-pharmacological data, the answer to the latter question appears to be in the affirmative (Roy and Dutta Majumder, 2000b). Actually, Nature found a possibility to increase energy dissipation still further through hyper-arousal ergotropic trance or contemplative rituals and techniques which evolved in man during the ancient prehistoric Eurasian culture in the post-Neolithic age. Thus there was effected the ergotropic transformation of human consciousness long back in pre-history. We now elucidate concrete evidence and non-equilibrial cybernetic analysis.

The anthropological significance of ecstasis and its ergotropic transformation
Ecstasis state and the peak trance phenomenology induced thereby are one of the most significant cognitive states in human sociology, anthropology and prehistory, as shown by vast empirical evidence (Laski, 1972; Krishna, 1980; Gackenbach and Bosveld, 1990; Furst, 1982). Before man learned to cultivate plants for food, he long knew how to care for herbs that provided him with psychotropic extracts for drinking, which could induce exaltation through ergotropic hyper-arousal trance states in him. This evidence comes from numerous caves, such as the Sanidar caves in Mesopotamia, Northern Iraq, which were inhabited by man as long as 50,000 years ago (Hoffman, 1990). Ethno-pharmacological analysis indicates that these plants have molecules which contain the indole ring, which is closely related to nor-adrenalin, the neurotransmitter of ergotropic hyper-activation. Hyper-arousal trance of exaltation was a locomotive of human evolution during the post-Neolithic-Chalcolithic era, through the primary ceremonial clans centered on the activity of organizing ritual ecstasis trances, remnants of which are still found in Central Eurasian tribes and mythologies. This activity spurred the rudiments of agriculture, clan bonding, ritual worship, shamanism and group participation, as shown by a host of anthropological, paleo-sociological and ethno-pharmacological findings across various cultures in Central Europe and Asia. We mention the studies of the paleo-pharmacognosists Le Barre and Wasson and of the Harvard school of Eliade with field observations in Romania, Caucasia and India (Eliade, 1962, 1987; La Barre, 1970, 1985; Wasson, 1958, 1968).

Psi-metry: evolution equation for dating anthropological development
We can suggest a term "psi-metry" [ψ-metry] to imply measurement and application of the ψ-function of entropy production or energy dissipation. The mathematical analysis of psi-metry developed above can be used to illuminate the phenomenology of anthropological evolution and help develop a dating and forecasting equation useful for either dating some historical events or predicting future trends. The non-equilibrium biocybernetic formalism we developed (Roy and Dutta Majumder, 2000a) enables us to quantitatively approach the origin of the primordial Eurasian civilization mentioned earlier, using the concept of psi-metry of neuro-psychological transformations. We desire to know at which date in history did man attain the peak ergotropic state by means of the hyper-activational trance procedure using organised ritualistic practices of ingesting plant extracts. We need to construct the anthropological evolution equation during the recent several hundred thousand years. Note that the energy dissipation ψ is in milliwatts per unit mass (i.e. gram) of the human organism. Hereunder, we will omit saying the "per unit mass" specifically every time; this characteristic will remain implied. To determine the exact form of Equation (11) in the anthropological domain, we need to find the values of A, α and ψ_0, where ψ_0 implies the energy dissipation at the start of psycho-cultural and anthropological evolution, which started with the discovery of fire by

"intelligent man". The value of this energy dissipation on the discovery of fire, which happened 750,000 years ago, is 56.2mW (Lamprecht and Zotin, 1996; Eppler, 1990) and this is our ψ_0 value.

We observe that there are two important biothermodynamic evolutionary advancements in anthropological progression, associated with motive power and energy dissipation for man:

Schema 2: Energy dissipation at reference events of anthropological evolution

(1) *Animal domestication*, which ensured large availability of animal motive energy, the Agro-metal Revolution, enabling cultivation of lands with animal-driven metallic ploughs;

(2) *Industrial revolution*, the initiation of steam engines as a substitute for animal power.

Observe that we should not mix up anthropological evolution with the biological evolution of Figure 4. The time scale of the first process runs into several hundred thousand years, whereas the latter process spans over a thousand million years. The scales of the two processes are enormously different (of the order of 1,000) and hence we can take these two processes as being separate from each other. Nicolis and Prigogine (1977) have shown that processes with far divergent time scales can be treated independently of one another. We still have two unknown parameters A and α. To know these two unknowns, we now require two significant anthropological events, whose energy dissipation levels ψ and time of occurrence t are known circumstantially. From historical and anthropological data, we know the values of energy dissipation and time of occurrence of the steam industrial revolution and the agro-metal animal domestication revolution mentioned earlier (Lamprecht and Zotin, 1996; Eppler, 1990) (see Schema 2 and Figure 6). We take 1990 as our zero point of the time-axis where $t = 0$. Observe that we have used a negative sign to denote time in the past, following our standard convention of using time measured negatively:

(1) *Animal domestication* (our Point M): 6000BC, i.e. $t = -7{,}990$ years ago, where the energy dissipation index $\psi = 135$mW (for a productive individual using animal motive power).

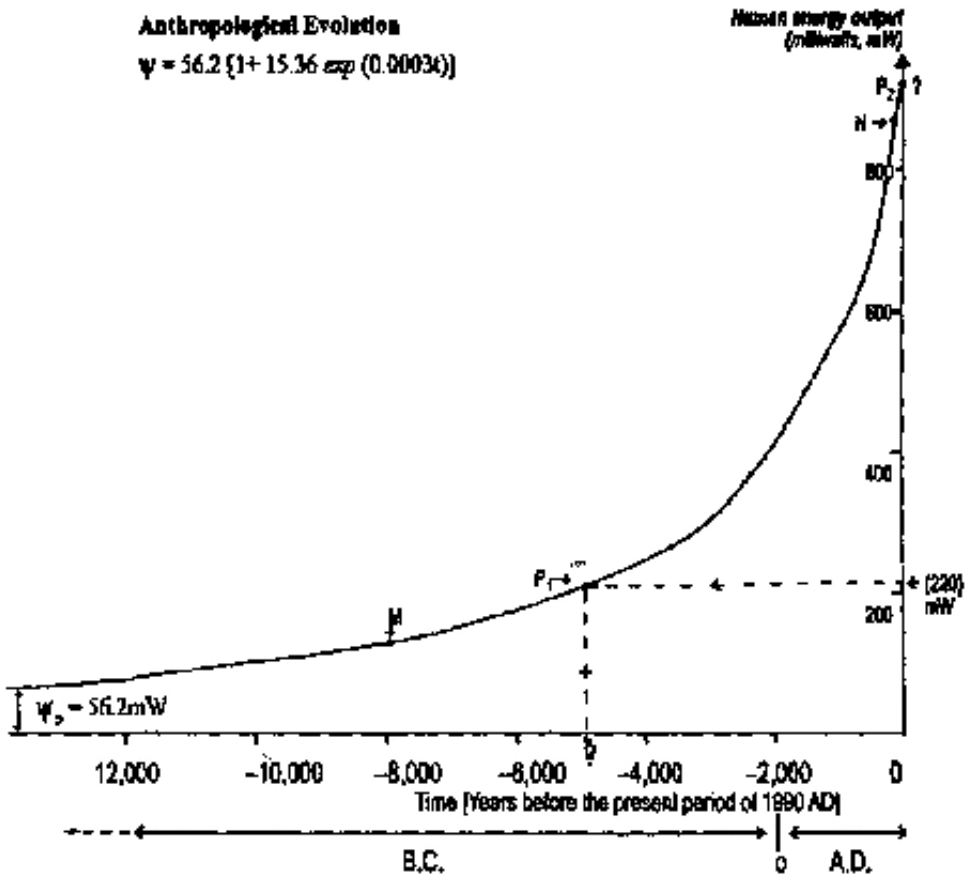
(2) *Industrial revolution* (our Point N): AD1800, i.e. $t = -190$ years ago, where energy dissipation index ψ 866mW (for a productive employed industrial worker).

In Equation (11), we substitute these two sets of values, and ψ_0's value (56.6 milliwatts). Solving for A and α we obtain:

$$A = 15.36 \qquad \alpha = +0.0003.$$

Hence:

Anthropological evolution:
$$\psi = 56.2[1 + 15.36 \exp(+0.0003\, t)] \quad (16)$$



Note: The equation determines historical period of ancient Eurasian trance civilization and also forecasts energy output in contemporary human sociological context

Figure 6.
A dating technique for anthropological evolution

where ψ is energy-dissipation in milliwatts; past time t before 1990 is prefixed by a negative sign, whereas future time after 1990 is prefixed by a positive sign. All time is measured in years. As per convention, the half life T is defined as $\ln 2/\alpha$ and the mean life τ as $T/\ln 2$. Thus we calculate the mean life of anthropological evolution to be 3,332 years. Since energy dissipation or work intensity of the culture is involved, we can call the approach an "ergometric" procedure (Greek: Ergon = work). We now desire to use the anthropological evolution Equation (16) as a dating equation and find the date of occurrence of the peak time of the ecstasis trance culture in the human evolution of group consciousness. We know the ψ value of ecstasis trance as 220 milliwatts (Equation (15)). We put this value in Equation (16), and solving the ergometric equation:

$$t = -5{,}493 \text{ years ago,}$$

i.e.

$$t = 3503\text{BC}. \tag{17}$$

This is the mathematically predicted age of the anthropological trance culture. With 5 percent tolerance the range becomes:

Eurasian Trance Cultural Civilization = 3370BC *to* 3640BC.

1258

Empirical evidence confirming the mathematical model and the Ergometric equation

(1) *Comparative philology and linguistics*

One of the widely known plant extracts used for the organised ecstasis ritual trance was the hops shrub, having indole neurochemical derivatives. Still today, various Indo-European languages use dialectic variations of the same root term *Kan*:

In Polish, the dialectic word is "Konop" (indicating the hops plant, with botanical name *C. ruderalis*);

In Old Russian, the word is "Konoply";

In French, "Chanvre";

In Old Bulgarian, "Konopla";

In Persian – "Kanab";

In Irish – "Canaib";

In Sanskrit – "Cana";

In Lithuanian, the relict and extant language closest to Sanskrit – "Canap".

This etymology shows the great antiquity of the psychotropic extract. The hops plant still grows widely in the central Eurasian region even today. From comparative philology one knows that this root word *Kan* evolved during the early Bronze age; we know from archaeological excavation that the early Bronze age was from 3600-3900BC (Hoffman, 1990).

(2) *Archaeology*

Indeed herbal extract for ritualistic or medicinal purposes was used in ancient Egypt, c. 3500BC. Note the critical excavated ceremonial urn of the Bronze age (c. 3600-3400BC) from Wilmersdorf, Germany, with hops plant (La Barre, 1985).

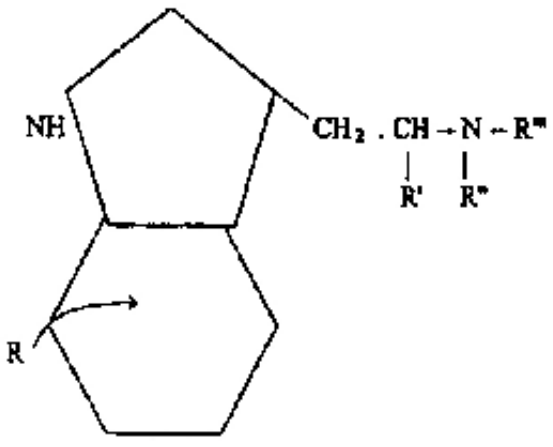
(3) *Ethnology*

It transpires that the pristine form of the hyper-arousal trance culture was based on "soma" herbal psychotropic extract of the central Eurasian/Euralo-indic civilization. This potion was extracted from the botanical mycotic species *Anamita muscaria,* which grows widely in Central Eurasia, whence the Indo-Europeans originated. Ever since the extinct proto-Sanskrit and proto-Eurasian languages of the Caucasian-Vedic-Aryan era were discovered by modern Western linguists, one knows that this state of ecstasis was ritually induced by the primeval practice of trance induced by ingestion of the well-known potion

"soma" in the ancient culture. This practice has been found to be the basis of the whole metaphenomenology of the above Eurasian civilization from the Atlantic to the Pacific (La Barre, 1985; Wasson, 1968; Furst, 1982). A similar conclusion comes from the elaborate studies of the French philologist Renou, the German indologist Max Muller and the Irish comparative language scholar O'Flaherty. It is now known that the effective molecular constituent of extract "soma" are alkaloids Muscimol and Ibotenol, based structurally on the tryptamine nucleus, which is psycho-pharmacologically allied to the indole molecule, and is related to the basic molecules which mediate the hyperarousal transformation via the brain's hypothalamus, namely noradrenalin/serotonin neurotransmitters (Figure 7 (Schema 3) and Figure 8 (schema 4)).

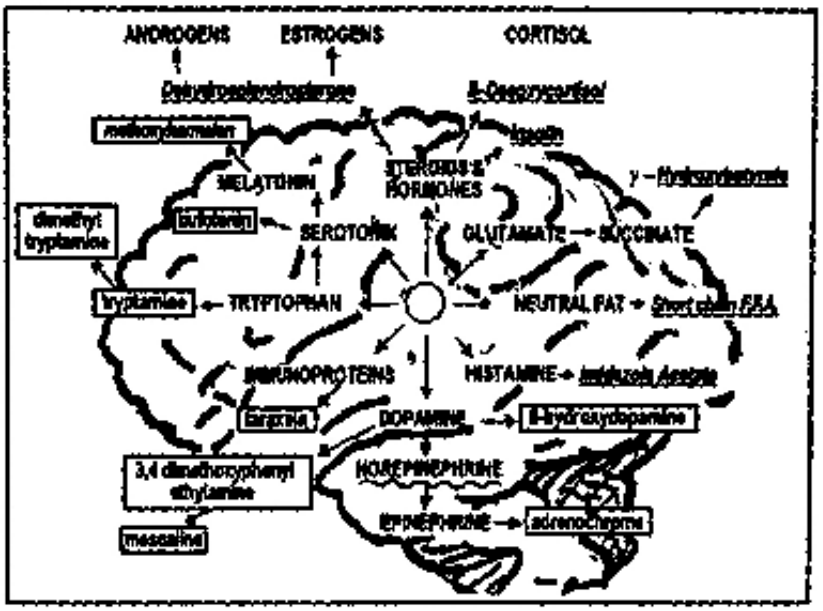
Let us paraphrase La Barre (1985):

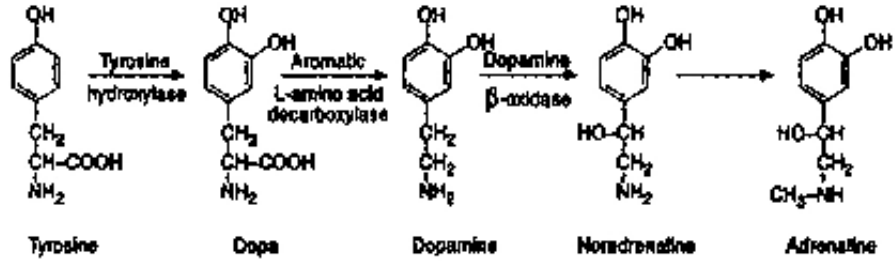
> ... All religions begin in the hyper-arousal vision through trance of an individual, who is accounted "charismatic" to the degree that his message coincides with the unconscious wishes of his clientele ... The long mysterious drink, called "soma" and "ambrosia" in the Rig Veda and Greek cultures respectively, was without question the major religious psychotropic hyper-arousal extract of ancient Eurasia. The extract exerted an incalculable influence on various later religions, including Hellenistic Orphism and Eucharist sacramental drink that shaped Christianity. In their oral form, the earliest Vedic hymns date from about 1800BC; but once the Aryans entered India around 1500BC, the identity of the plant, which does not grow South of the Himalayas, was lost and never rediscovered in Hinduism, despite much discussion in the endless priestly commentaries. In the Rig Veda only priests drank ritually prepared soma, which was supposed to confer religious powers ... much as in the Greek legends of "ambrosia" (probably pan-Indo-European mead, traces of whose use reach even as far as back as Mesolithic wall engravings).
>
> Since the discovery of the extinct Eurasian mother languages Sanskrit and Uralic by eighteenth century Europeans, soma has been the apparently insoluble riddle lying at the heart of Eurasiatic-Vedic studies. The Rig Veda religion is dramatically manifested in the ecstasis hymns to soma, all Aryan-Indic practices of mysticism were merely attempts to replace the missions granted by the lost soma. And mysticism is indubitably the core and foundation of the ancient Caucasian-Indian religion. Soma, a suspected plant psychotropic hyper-arousal drug, is thus at the root of visionary Indian Vedantism and European Mysticism. In 1968, armed with only the prehistoric etymology of the word "soma" and the Rig Veda ecstasis hymns to proceed on, R.G. Wasson solved the riddle, through a meticulous intercontinental anthropological



Note: The molecular groups R, R', R'' and R''' vary in different ergotropic extracts

Figure 7. (Schema 3). Tryptamine-based molecular moiety as the basic structure of ergotropic neurochemicals or plant extracts





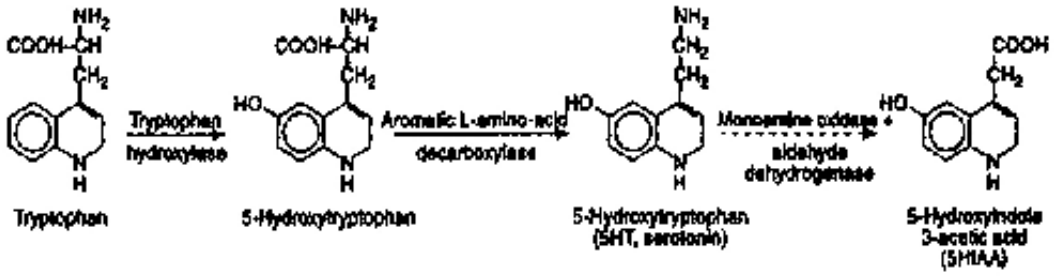


Figure 8.
(Schema 4).
The human brain and its neuromodulator chemicals and pathways which produce ergotropic hyper-activational response with increased energy dissipation and entropy

survey and analysis of primitive races and practices across Eurasia. He displayed overwhelming evidence that illuminates much of ancient Eurasiatic religion and civilization, in one of the most admirable triumphs of modern scholarship in ethnology and pharmacognosy, showing that soma/ambrosia was the potion made from the botanic species *A. muscaria* (Wasson, 1958) ... The whole thrust of ancient Caucasian-Eurasian religion and culture construes to be the specialized goal of obtaining hyper-arousal trance and visions, through drinking such psychotropic extracts. Behind all the later religious traditions, both Indic and European, looms the very old Eurasiatic soma-ambrosia of antiquity.

Hellenic and Indic evidence

The term "soma" is linguistically cognate and similar to the well reported extract "ambrosia" of Greek or "amrita" of Sanskrit, or "haoma" of the Caspian region, as studied by anthropologists. Indeed the Mediterranean culture referred to the use of ambrosia to produce hyper-arousal before warfare or athletics. Hence the

ecstasis practice should at least date from the time when the undivided Indo-Europeans were living together as a single stock in Central Eurasia of the Caspian region. Contemporary genetic and ethnological findings indicate that Indo-Europeans broke up and dispersed from Central Eurasia during the Chalcolithic era (Mazumder, 1950), so as to spread from India and Iran to Ireland and Iceland. Historical findings put the range of the Chalcolithic era from 3800-3500BC (Hoffman, 1990). Thus we see that the date 3600BC (5,590 years before the present) is the one date which is common to the three empirical findings (1)-(3) above. This value falls well within the range of the Eurasian trance culture we mathematically deduced earlier. Comparing the definitive value of 5,590 years (say 5,600 years) with the mathematically produced time 5,493 years (say 5,500 years) of Equation (17), the difference is only 100 years, i.e.

$$\text{Error} = 2\%.$$

Hence we propose that the date of the definitive peak of the Eurasian civilization can be taken as 5,500-5,600 years ago, that is 3500-3600BC approximately. A notable manifestation of the commonality in the origin of this trance culture is that the ritual pantheon of ancient Greek and of Indo-Iranian people is equivalent. For instance, the primordial indo-european "diw" ritual transformed into the rituals associated with the "deus" sanctum in Greece and the "dwija" sanctum in Aryo-Indics. "Diw" means "the illuminating experience", an obvious reference to the synaesthetic cross-modal visual sensation observed in ecstasis trance peak. The neurocybernetic and information processing foundation of such cross-modality in ecstasis has been developed by us elsewhere (Roy and Dutta Majumder, 2000b).

Peak date: It may be mentioned that the date given above is the date of the proper development of the herbal extract-based trance culture. There may have been sporadic evidence of usage of psychotropic plants earlier, but we are concerned with the date when the trance culture reached proper development, as in the ambrosia-soma civilization in Greek and Aryan people. Note that this condition of proper development of anthropological event is intrinsic to derivation of our equation. For example, we date the steam industrial age to reach proper development at AD1800, only when the efficient steam engine of James Watt became readily available. We do not consider earlier sporadic uses of steam power like Newcomen's engine of the 1720s or Heron's steam jet device of ancient Macedonia.

Forecasting technique: psi-metry in sociological development

Could we use Equation (16) which describes human progress, for forecasting? What would happen if we put time $t = 0$, which implies the contemporary time, namely 1990, as per our convention for the equation. In that case we arrive at:

$$\psi = 921 \text{ milliwatts}$$

Hence the energy dissipation or ψ value of the average working productive individual of the world should be 921 milliwatts. Note that, as mentioned in the

first portion of this chapter, this value is actually energy dissipation in milliwatts per gram. We should observe that the term "working" individual specifies that we are considering the population segment which is working or productive and actively contributes to the economy. This segment is the working age group of the adult sector, i.e. 18 to 60 years of age, excluding retired older people above 60 years or children up to 17 years. Note that this is the same connotation of the basic value of energy dissipation of the Industrial Revolution (866 milliwatts) which we use to construct our Equation (Equation (16)). The latter basic value is actually that of the industrial productive worker at the steam age of AD1800, this value is not the value of non-productive individuals as retired old people or children of that time. To check the correctness of the predicted value of Equation (18), we need to compare it with the empirical value of the global per capita energy dissipation obtained from economic data. We now proceed to find out the latter value. From demographic data this adult segment G (18-60 years of age) can be calculated for the whole world population (Hoffman, 1990):

$$G = 52.5\%.$$

We should also subtract the unemployed people who do not contribute to productivity. This percentage is 6 percent of the *total* population. Hence the unemployed percentage U of the *adult* population is: U = 6 percent of 52 percent = 3.1 percent. Therefore the employed productive segment E is:

$$E = 52.5\%\text{-}3.1\% = 49.4\%.$$

From empirical economic data, it is known that the energy dissipation index for the world, inclusive of its whole population, is 448 milliwatts per head in 1990 (Eppler, 1990; Lamprecht and Zotin, 1996). Actually the latter authors give the 1993 value (495 milliwatts) and inform that the annual value of increase is about 2.5 percent, from which we compute the 1990 value to be 448 milliwatts. The value is world average; there may be nations with higher or lower values. However, we are here concerned with the overall global value. Hence, we calculate the energy dissipation index for average productive individual of the world in 1990:

$$\psi = 458 \text{ milliwatts}/49.4\% = 927 \text{ milliwatts}.$$

Observe the close correspondence between this value and the theoretically predicted value of 921mW (Equation (18)). Difference is only 6mW. Hence

$$\text{Error} = 0.6\%.$$

We thus note that the anthropological equation is fairly accurate, and can be used for estimating past dates as well as for energy dissipation level in the future, the errors being only 2.5 percent and 0.6 percent respectively, in our illustration. However, some correctional factors may need to be incorporated if the equation is used for future forecasting. Since this anthropological equation is for mankind as a whole, it describes global individual energy dissipation by

the productive individual. There may be different nations and different geographical regions within a single nation, which may depart from the Equation (e.g. cities *vis-à-vis* rurality). The equation may be useful to global planners, ecologists and futurologists, and its parameters are:

Half life = 2,310 years, exponential constant = +0.0003 per year,
relaxation time = 2,580 years, mean life = 3,330 years.

Comparing ergometric dating with radiometric dating

Let us compare the ergometric dating Equation (Equation (16)) with the radiometric dating Equation (Equation (1)). The latter's half life is 5,730 years. Since the half-life of our ergometric dating equation for anthropology is numerically less at 2,310 years, there is much more change in the graph within the last 10,000 years; hence it appears to be mathematically more sensitive for use within the last 10,000 years, i.e. from the Neolithic age onwards. One should discern that the ergometric equation is a rising growth equation with $\alpha = +0.0003$, while the radiometric equation is a falling decay equation with $\alpha = -0.00012$. However, in contrast with the ergometric equation, the radiometric equation cannot be used for forecasting or futurology.

Historical and cultural evolution

The time horizon for anthropological evolution above, encompassing almost a million years, is too vast for historians who deal with time horizons of the order of 1,000 years. Can a similar non-equilibrium transformation be found in the cultural realm as man progressed along historical time, say during the last millennium? Of particular interest to us here is whether we could discern anything comparable with the change of ψ or its components ψ_1 or ψ_2 function as time alters. Actually ψ consists of two components: ψ' and ψ'', the intrinsic and extrinsic activation respectively:

$$\ldots \psi = \psi' + \psi'' \tag{19}$$

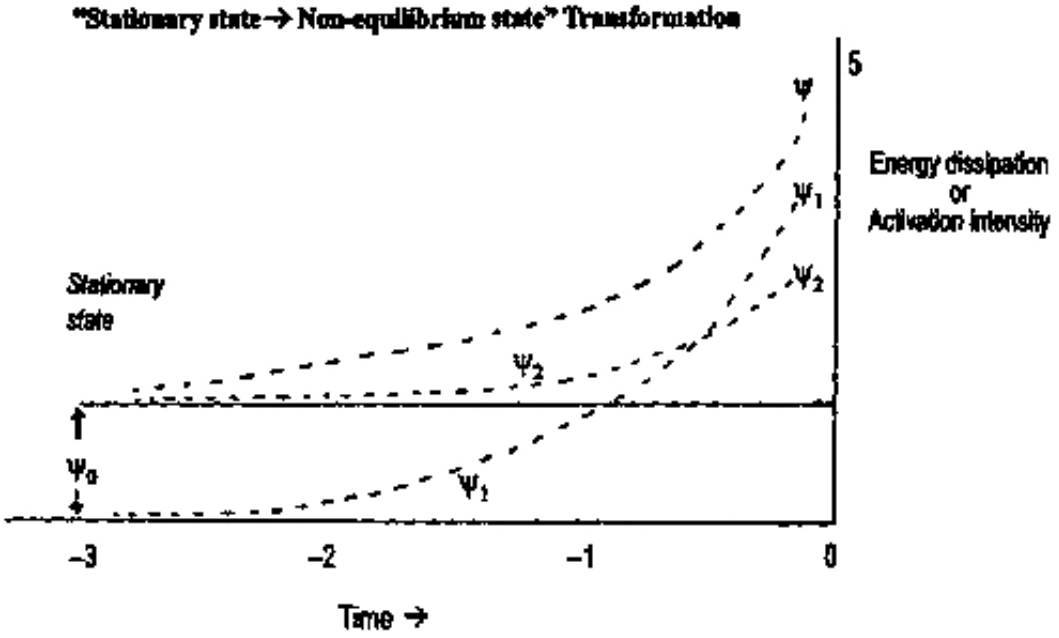
We can obtain the pattern of equations of the components by supplemental calculation like that we followed in deriving Equation (11) and using boundary conditions (Roy *et al.*, 1993b; Roy and Dutta Majumder, 2000b):

$$\psi' = 1/[1 + e^{-\beta t}]. \tag{20}$$

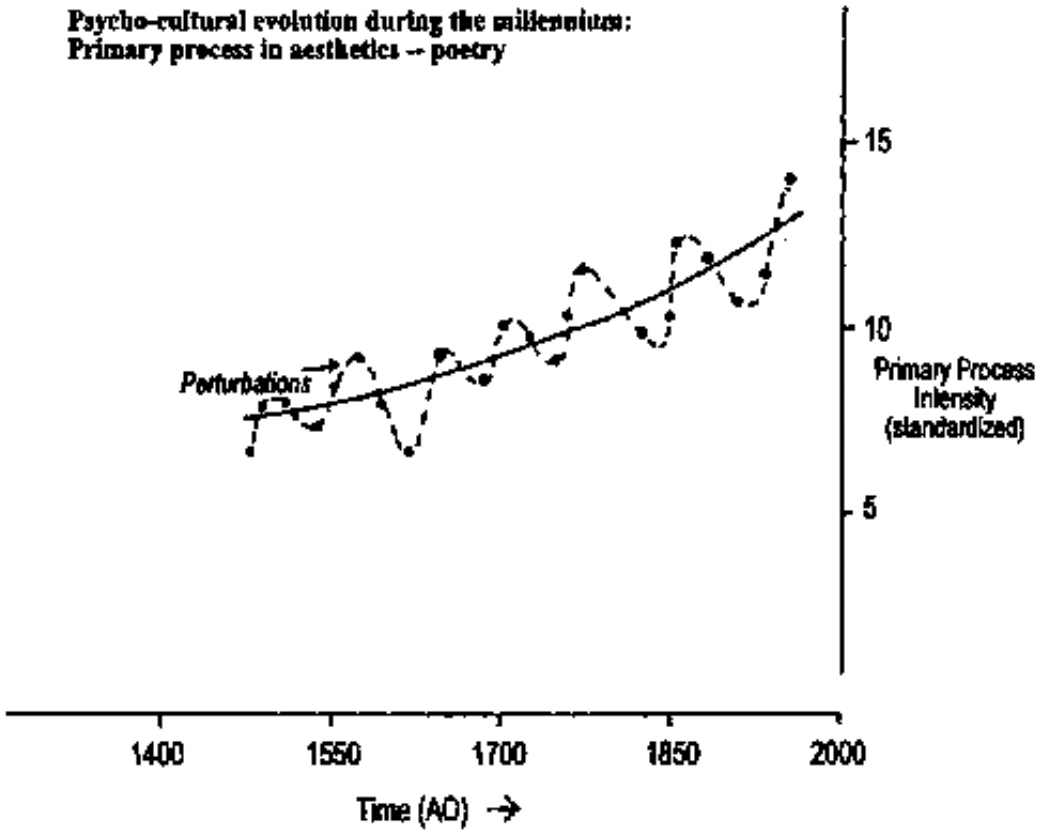
and

$$\psi'' = \psi_0[1 + e^{+\beta t}]. \tag{21}$$

In Figure 9(a), we draw the pattern of the time evolution of ψ' and ψ'' from Equations (20) and (21); the ψ curve is obtained by adding ψ' and ψ'' as per



(a) The two components, ψ_1 and ψ_2 functions, during the "Stationary state → Non-equilibrium state" transformation (Schematic figure; arbitrary units in axes used)



(b) Increase of primary process intensity (ψ_2 function) in poetry across the millennium. The perturbative line denotes the actual values due to stylistic oscillations (see text). The solid line is the basic trend, whose close correspondence with the ψ_2 curve may be noted

Figure 9.

Equation (19); both the components go on monotonically increasing and intersect each other. From various experimental investigations (Lapkin, 1983; Zotin, 1990; Lurie and Wagensburg, 1979), we infer that $\psi''$and ψ' correlate respectively with the two basic modes of functioning of the organism, namely equilibrium and non-equilibrium modes:

(1) ψ' *function* correlates with the non-equilibrium situation and process of differentiation in organisms.

(2) ψ'' *function* correlates with equilibrium or stationary situation and condition of non-differentiation.

From empirical findings (Sperry, 1981; Darwin, 1878; Bogen, 1990), we can likewise infer the two basic cognitive modes:

(1) *Non-equilibrium or propositional and differentiating mode*, which is concrete, hierarchically-evolved and ... organized cognitive activity (secondary process thinking); it is the analytic and objective mode of thought.

(2) *Equilibrium or appositional and de-differentiating mode*, which is symbolic or imaginal-type, ... hierarchically-earlier cognitive activity (primary process thinking); it is the intuitive and subjective mode

Hence ψ' and ψ'' function would respectively correlate with secondary and primary process thinking. With historical evolution the intensity of both processes would increase, as shown in Figure 9(a). We now explore this in millennial history.

Evolutionary aesthetics: lexical statistics

We present Figure 9(b) to show that empirical observations follow our model. In the psychocultural realm, the primary process and secondary process intensities may be gauged by textual and linguistic analysis of the aesthetic composition, especially poetry, made during the successive generations as time progresses. We have used the records and data of Martindale and co-workers at the University of Maine (Martindale, 1984) to construct our graph. In their records, primary process index is scaled so that mean is zero. In our graph we have re-scaled the primary process index so that the mean is 10. This is just a matter of convenience to give greater clarity to the primary process axis. Nevertheless, the shape of the graph and its temporal increase remain invariant. Using a kind of linguistic content analysis using SEMIS and LEXSTAT (lexical statistics) computer programs, those experimenters have developed an elaborate investigation to explore the alteration in the intensity of de-differentiated primary process activity, in aesthetic poetic narratives across the past millennium. Thereby we can arrive at the primary process and secondary process content expressed as a percentage of total words. The Maine group also finds that secondary process mode also increases with time; this corresponds to the progression of the ψ curve in our mathematical model (Figure 9(a)).

Evolution in poetry: ψ'' activation function

Actually poetry is a constituent of aesthetics, and it is in poetry where one can most accurately gauge the mental state of the culture which created it: music and art are ambiguous, as they are more of an emblem and more difficult to understand in detail than poetry which is plain verbal. Figure 9(b) shows the change in primary process intensity (i.e. our ψ'' function) in poetry, as there is a hyper-activational transformation, from the hypo-aroused tranquil state of 1490 to an invigorated hyper-aroused state of 1950. Representative samples of poetry across every literary generation of 20 years during this span were analysed statistically as mentioned. Note that the curve in Figure 9(b) corresponds closely to the mathematically-predicted curve of ψ'' in Figure 9(a). Observe that there are small undulations in the curve of Figure 9(b); this is actually due to the stylistic variation: primary process declines during temporal periods of initiation of any new style and rises once the style is established. Apropos Berlyne (1988), we may construe that perturbations are actuated by periodic stylistic changes. Indeed the objectively-measured arousal potential of literary productions appears to be the catalyst of aesthetic development associated with increased cognitive activation or entropy production. Actually our non-equilibrium cybernetic model can furnish quantitative analysis and insight into the evolutionary process, intrinsic to the aesthetic progression of the human psyche.

Evolution of language

The first experimental evolutionary theory was investigated and published by the Calcutta school of Eurasian language studies, namely from the researches of Sir William Jones and coworkers of the Calcutta centre of The Royal Asiatic Society in the 1770-1790s. Surprisingly, these investigators observed evolutionary operations in the development of language, 70 years before Darwin formulated the model of evolutionary operations in biology. Indeed we can develop a development equation for language. Modern comparative linguistic studies indicate that the rate of evolutionary change of different languages is about the same; two languages have approximately 85 percent of their features in common after 1,000 years of separation (Jones *et al.*, 1992). That is, as one language originates from another, 100 percent commonality between the two languages at the start reduces to 85 percent commonality after 1,000 years. This is a decay equation whose general form is $N = N_0\, e^{-\alpha' t}$, where N_0 and N are the commonalities in percentage at the start and at any later time t. Evidently at the start, we see that $N_0 = 100$ percent, whereas, when $t = 1{,}000$ years, $N = 85$ percent. Substituting these values in the decay equation, we solve and obtain $\alpha' = 0.00016$. Hence the equation expression linking N and t is $N = 100\, e^{-0.00016t}$. The percentage of new words Y in the language is [100–N]. Thus we arrive at the development equation for language:

$$\textit{Language development:} \qquad Y = 100 - (100\, e^{-0.00016t}).$$

Here Y is the percentage of newer words which separates two languages which earlier had a common origin, and the elapsing time t is in years. From the value of α' we calculate the mean life of the language development process to be 6,250 years. Compare this with the mean life of the anthropological development process of 3,330 years deduced earlier. We clearly see that the former is roughly the double of the latter. Actually doubling the latter gives 6,660 years, which differs from 6,250 years by only about 400 years, i.e. only 6 percent. This margin is acceptable because in decay equations used for dating (e.g. radioactive dating), 5-6 percent is the acceptable margin of error, as mentioned earlier. Thus it appears that language progression is the subharmonic of anthropological evolution, the two processes being quantitatively linked, and both processes may be the manifestation of a common deeper dynamic system. Such a dynamic system could be the primate evolutionary process, especially because the rudiments of sign language and intelligence are present in primate evolution. Indeed there can be a mathematical basis of this linkage between anthropological and linguistic development through the concept of Stochastic Resonance, a non-linear dynamical property of complex systems, whereby a biological or evolutionary process can generate, or be linked with, a harmonic of another process (Bulsara and Gammaitoni, 1996). We have elsewhere developed the application of stochastic resonance and its harmonic implications in the evolution of human intelligence and cognitive activity in a biothermodynamic context (Roy and Dutta Majumder, 2000a). To sum up, we can discern that language is thus an "Evolutionary Clock" spanning tens of thousands of years, and can be used to date past cultures and their narratives by comparing language divergence.

Concluding remarks

Utilizing the approach of non-equilibrium cybernetics which encompasses the Prigogine-Einstein fluctuation formalism and the related self-organization and evolutionary paradigm, our analysis endeavours to offer a neurocybernetic basis of primitive trance, ritual and origin of theopraxis and religion. This mathematical approach furnishes a systems dynamical model of biological and human evolution in general, and anthropological and cognitive evolution in particular. This ancient progression was engendered by the increase of activation and entropy production in the prehistoric Eurasian race when they practiced the ecstasic trance, a central feature of post-Neolithic Caucasian civilization, which developed into the ritual of ingesting the psychotropic herbal extract "ambrosia" in Greek-Mediterranean culture and "soma" in Aryan-Indic culture. The extracts contain the neuromodulators ibutenol and muscimol, containing the phenylethylamine or 4-aminotetraline structure, and is related psychopharmacologically to nor-adrenalin, the neurotransmitter which mediates psychophysiological hyper-activation, energy dissipation and entropy production. Indeed the biocybernetic analysis developed determines the peak of the ambrosia-soma culture to be at 3600BC and integrates into a single equation the major events of human evolution:

Fire → Ritual clan-bonding → Agriculture → Industrialization → Contemporary information age

The equation is constructed using energy dissipation index values at the invention of fire, of agriculture realized by animal power, and of industrial revolution. The model also quantitatively illuminates the two other events: Ritual clan-bonding enabled by ecstasis trance, and the postmodern age of electronics and information. The equation can also be used as a novel dating equation in contrast with the conventional radio-carbon dating equation of anthropology. Furthermore, we develop an equation for evolution of life for the last billion years, starting from unicellular organism to intelligent man. This equation helps to date a critical biocybernetic advancement in the organism, viz. thermo-regulation of warm blooded animals, which occurred through the intermediate stage of heterothermal control about 300,000,000 years ago. Fossil evidence of cellosaur reptiles corroborates the correctness of the equation. Non-equilibrial cybernetic analysis also clarifies the historical cultural evolution during the last millennium through intrinsic activation function in arts and aesthetics. We also mathematically analyze and deduce the equation of the process of language evolution and explore how it could be linked to the process of anthropological evolution through the well-known process of stochastic resonance observed in complex systems dynamics.

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