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# Constructivist Aspects of a Mathematical Model of Consciousness

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# CONSTRUCTIVIST ASPECTS OF
# A MATHEMATICAL MODEL OF CONSCIOUSNESS

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My professional background is applied mathematics. For many years, I have been engaged in applying mathematical statistics and experimental design (also a branch of mathematics) to various problems of science and technology. In the past 10-15 years, I changed the direction of my activities and started to apply mathematics, especially its probabilistic aspects, to problems of a philosophical status. My goal was to construct a probabilistic model of language (Nalimov, 1979, 1981) and then consciousness as a whole (Drogalina, 1990; Nalimov, 1982, 1989).

As far as I can understand, applied mathematicians had little interest in the opposition, formalism-intuitionism, since this subject was assumed to interest mathematicians concerned with the foundations of mathematics rather than those engaged in its applications. Philosophical aspects of intuitionism, predominantly developed by Brouwer (1975), generally remained unnoticed.

Recently, especially after the fairly significant paper by J. Wheeler (1988) was published, interest towards the problem of intuitionism will probably increase by those who use mathematics to solve nonmathematical problems. This happened to me. Having read the above paper by Wheeler, I noticed that my approach to constructing a model of language and consciousness is constructivist. Later, I understood, as well, that the position of Brouwer, one of the founders of intuitionism, was close to mine. However, all this requires detailed analysis–to which this report is devoted.

I. The Idea of Constructivism in a Probabilistic Model of Consciousness

Exposing our ideas, we naturally make use of Aristotelian logic. But, to my mind, formal logic is but an instrument of communication between people. The process of thinking (acquiring new meanings) is intuitive. Initial premises are spontaneously generated on the semantic continuum. Then they are reduced to semantic discretes and are revealed through logically formulated texts. Despite its external logic, the text is perceived by us as a process of experience. Each of us can understand the same text differently, and probably, not the way it was conceived. That is what I want to record by my model of consciousness.

I am aware of the possibility that the process of thinking can be expressed by other languages as well–in the languages of music, dance, etc.–but I am not going to treat this subject here.

This is my initial position: meanings are primordially given in their potential, unmanifested form. That is Platonism. But should Platonism be interpreted as "naive realism" (which is common in constructivists' statements (Panov, 1984)? Humans do not read meanings mechanically, but creatively unpack the continuum of meanings, resorting to nonformal probabilistic, i.e., purely numerical logic (remember Platonic adherence to numbers). Note also that our physical world is also determined by a set of initially given fundamental numerical constants: but notice how varied are the landscapes of the Earth. Another example is color perception. We are initially given the faculty to perceive a short segment of the electromagnetic wave scale. But how great and multiform is the set of color images we have, especially that of an artist.

Constructing a model of consciousness, I resort to a semantic continuum, i.e., space without vacant positions. The hypothetical semantic continuum acquires, by nature, actual states when we (active observers) set a system of preferences on it, making use of a probabilistic measure (probability density). [This is how quantification takes place: creation of a text (one of all possible texts since the probabilistic measure can be given in different ways).] We can draw an analogy here with quantum-mechanical concepts: the observer does not perceive in the microworld the particle actualized in space/time; it becomes tangible only after the reduction of the wave package. We are able to say, following Wheeler (1988), that in the world we observe there is no continuum, only discretes. A continuum is our idea which permits us to construct the world in a comprehensive way.

Our model contains axioms but they are not used to prove any theorems. Axioms per se form a model of consciousness. According to the methodology of constructivism we do not preliminarily proclaim our adherence to probabilistic logic: it emerges directly from the model constructed. Rejection of the law of the excluded middle (one of Brouwer's principal ideas) is not postulated beforehand: it follows naturally from the Bayesian version of logic formed within our model.

We do not formulate any "laws of consciousness," assuming that the order in the system investigated is formed by the probabilistic nature of deep thinking based on the regulating role of meanings in the functioning of consciousness.[1]

We do not make any attempt to prove the correctness of the model: it has the status of a metaphor. We believe it should be proposed for consideration because we feel it looks elegant enough and has great explanatory power.

II. The Initial Premises of the Model

1. Assume that the entire evolving world that we perceive may be regarded as a set of texts. When we deal with the biosphere, then individuals, species, and other constituents represent texts. When we deal with the social environment, we call all texts significant manifestations of human consciousness directed at communicating with others, and even with oneself. Human Ego is also regarded as a specific living text capable of independently changing (reinterpreting) itself.

2. Texts are characterized by discrete (semiotic) and continual (semantic) constituents, the latter not directly observable.

3. Semantics are determined by the probabilistically given structure of meanings. Meanings are what turn a symbolic system into a text.

4. All potential meanings of the world are initially correlated with the linear continuum of Cantor, the numerical axis $\mu$ on which all real numbers are located in the order of their increasing values. Otherwise, the meanings of the world are compressed the way numbers are compressed on the real axis.

5. Compressed meanings represent the unpacked (unmanifested) World: the semantic vacuum.

6. Unpacking (emergence of texts) is realized through probabilistic weighting of the axis $\mu$: different measures are ascribed to its different intervals. The metric of the scale $\mu$ is assumed to be initially given and remains unaltered.

7. Correspondingly, the semantics of each concrete text is given by the distribution function (probability density) $p(\mu)$. In the general case it is possible to speak of texts determined by the probability distribution function set on a multidimensional space. Meanings in the text are always

given selectively. We are not to know everything. Recall the proverb: to know everything is to know nothing. The function $p(\mu)$ turns out to be the window through which we can examine the semantic world.


III. Logic

The model we constructed made us develop a corresponding probabilistic logic looking somewhat uncommon.

Assume that any change in the text, its evolution is linked with a spontaneous emergence in a situation y of the filter $p(y/\mu)$ that interacts multiplicatively with the initial function $p(\mu)$. The interaction is given by the well-known formula by Bayes:

$$p(\mu/y) = kp(\mu)\,p(y/\mu)$$

where the distribution function $p(\mu/y)$ determines the semantics of a new text emerging after the evolutionary impetus y; k is a normalizing constant. In our case the Bayesian formula acts as a syllogism: from the two premises $p(\mu)$ and $p(y/\mu)$ necessarily follows a text with new semantics $p(\mu/y)$. In Bayesian syllogism, in contrast to the categorical syllogism by Aristotle, both the premises and the corollary are not atomic but probabilistically fuzzy, and at least the second premise is of a conditional (conditioned by the situation y) character, not a categorical one.

The essential features of Bayesian logic are: (1) the semantic system is acknowledged to be open: it is open to the spontaneous emergence of filters; (2) the transpersonal nature of consciousness is recognized: spontaneity of emergence of filters is related to existence of transpersonal cosmic consciousness (see Figure 1, Map of Consciousness); (3) Bayesian syllogism is applied to fuzzy meanings on the continuum: thus it excludes the emergence of atomic, point-like meanings; (4) logical operations have a numerical nature: the right-hand part of the Bayesian formula contains a multiplication sign which is revealed numerically; (5) the possibility of a strong disjunction is excluded; the language proves to be free from the law of the excluded middle; it is therefore free from the rigid distinction between truth and falsity.

It follows from the above that deep (prelogical) thinking is mythological by nature.

Note once more the closeness of our approach to the philosophical tradition of Brouwer, who emphasized the insolvency of formal logic based on the law of the excluded middle. We do not postulate the rejection of the law of the excluded middle; it follows directly from the model constructed. Thus, we continue to develop Brouwer's ideas.


IV. Map of Consciousness

In our system of concepts, the nature of consciousness is of a multilevel structure. Figure 1 presents a map of consciousness. The upper level is that of logical (Aristotelian) thinking that has an explanatory function in the process of communication. The second level is a domain of prelogical thinking. Here initial premises are elaborated that are later (on the upper level) comprehended by Aristotelian logic. This is the level of creative activity. Our task is to reveal probabilistic, or to be more accurate, Bayesian logic, active on this second level. The second level is supported by cellars of consciousness where we come across archetypes and contemplative images. The entire system is based on the bodily level where neuropeptides are active. Thus, we believe that not only the brain but the body itself is part of consciousness. The map shows that consciousness is an open system: it is open to the transpersonal level, the cosmic consciousness (or noosphere, otherwise gnostic pleroma)

supported by the protective layer of the collective unconscious where, in terms of Jung, archetypes act as keys. It is on this cosmic level that the spontaneous generation of creative impulses occurs.

V. Explanatory Power of the Model[2]

The probabilistic model allows us to see the world of semantic phenomena at a new angle.

1. *Model of everyday language.* Why do we understand one another speaking a language whose words are polymorphous? How do Russians manage to guess which meaning of the English word "set" is used in a phrase, if it is explained by 1,817 Russian words in the two-volume English-Russian dictionary? The answer to such questions was our book (Nalimov, 1979, 1981). It has been shown there that understanding is provided by the emergence of the filter $p(y/\mu)$ narrowing down the meaning of the world in a situation given by the surrounding context y. Hence, our faculty to understand, strictly speaking, senseless sentences. Once, on the door of the Translator's Department, I read the following note: "Due to the absence of translators the minimal term of translations will be 7-10 days." Here the context of the word "absence" makes us choose the filter that allows us to understand the problem is not the absence of translators, but their insufficient number. Bayesian logic allows us also to understand the process of the expansion of meaning by forming two-word terms. In front of our eyes, the term artificial intelligence was coined which for some time was perceived by many as semantically contradictory because it united two principally opposed elements. Within our system of concepts, the meaning of this term should be regarded as given by a two-dimensional distribution function $z = p(\mu_1, \mu_2)$ revealing a correlation between two probabilistically arranged structures. In our recent works we introduced the term Bayesian syllogism that links what has remained unlinked before. It is noteworthy that to elucidate the meaning of a word in ancient India, it was ascribed a long chain of synonyms.

2. *Understanding texts.* Understanding texts, as well as words in the text, is always a creative process. Any text should be brought closer to humankind, otherwise it will be rejected or can even cause aggressiveness. Bringing texts closer to oneself is always achieved by generating corresponding filters. Understanding is always re-understanding of what has been understood, or unpacked before on the semantic continuum. Understanding is not only an epistemological process, but also an ontological one: the newly acquired meanings form new conditions for existence. Recall the history of Europe: For twenty centuries, endless reinterpretations of the original Christian text continued on. New movements, new churches, new sects kept emerging; religious wars broke out. In old Russia, there was even a sect of skoptsi (castrates): its emergence can be related to a formation of a needle-shaped filter-like $\delta$-function. And Marxism, with its tendency towards the extreme forms of social orderliness–isn't it also just another reinterpretation of the same ancient text?

3. *Creativity* is unpacking what has yet remained concealed on the semantic continuum by a small probabilistic weight. New meanings acquire a great probabilistic measure; old ones fade away. New meanings are always a forestalling, a challenge, often a revolt.[3] They comprise a spontaneous insight and are therefore incomprehensible for the outward observer. Recall how non-Euclidean geometries emerged: Why did Euclides himself, being a great geometrician, fail to see that his structures were not valid for the sphere? Why does it take almost two thousand years for the fifth postulate to lose its unconditional significance? Why was Gauss not brave enough to publish his results, and why did Lobachevsky's paper remain so long without a response? Recall the famous French mathematician, Galois, who was killed in a duel at the age of twenty. On the eve of the duel he was looking through his manuscript rejected by the Academy of Sciences and wrote a letter to a friend where he gave a brief exposition of his ideas. He was not understood at that time because he answered a question that had not yet been asked. Only later were mathematicians ready to perceive the obvious significance of what had already been revealed to them. Indeed, though we speak of mathematics, the story looks completely mythological.

4. *Logic of the illogical.* Some of our concepts are perceived more easily when formulated in the language of probabilistic logic. Here are a few examples. (1) *Free will.* It was Hegel who paid attention to the fact that the idea of freedom is subjected to the "greatest distortions" to a greater degree than any other idea. Indeed, Western thinking, following the path of dichotomy, always and in vain, tried to separate free conduct proper from determined conduct. Bayesian syllogism allows the freely generated filter $p(y/\mu)$ to interact with the determined component $p(\mu)$ produced by the entire cultural past, upbringing, etc. Thus, in any new situation, y, the predetermined (fate) component, is multiplicatively mixed with free will, the spontaneous element.[4] (2) *Nirvana.* This is the most difficult Oriental concept for us to grasp. An urge towards nirvana is an urge towards smoothing down karma-given selectivity in the system of value concepts. Nirvana is achieved when $p(\mu)$ is degenerated into an untruncated (tending towards infinity) rectangular distribution. Due to the normalizing condition, the segment cut off on the ordinate by the straight line setting this distribution will tend toward zero. Strictly speaking, the notion of the function $p(\mu)$ loses sense, and generation of any filter $p(y/\mu)$ also becomes senseless. Individuality is annihilated; it turns into everything–or into nothing. Meanings disappear, having lost the selective evaluation. The semantic continuum returns to its initial, unpacked state. Thus the possibility opens up to transcendence, the exit into depersonalized cosmic consciousness void of earthly meanings. This is the world of nonexisting Existence. (3) *Paradoxical nature of freedom.* For a person in the state of absolute freedom (i.e., freedom from all attachments) the concept of freedom loses sense. What is the use of ascertaining whether the free choice of the filter $p(y/\mu)$ if $p(\mu)$ degenerates into a uniform distribution with the ordinate tending to zero? (4) *Three modes of time: Past, Present, and Future.* Well-known are the words by Heidegger about the impossibility to divide time into three modes. For him, the Past is not something which is no more, it is always within the Present, and determines both the Present and the Future. The mode of the Future is "forestalling"; it is concentration on the Future which gives to "here-being" the authenticity of existence. These ideas of Heidegger are easily interpreted in the probabilistic language. Assume $p(\mu)$ to be value orientation produced by the Past; $p(y/\mu)$, the question addressed from the Future into the Past and related to the problem y emerging in the Present; $p(\mu/y)$, the answer revealing the new value orientation. Free will makes selection in the future that exists only as unrealized potentiality. The Future acquires the possibility to affect the Present by changing the Past dominating it. We can speak of the present-moment existence of the Past and the Future, since in our model the Past is converted by the Future in the Present.

5. *On the possibility of existence of essentially different cultures.* Imagine that in the semantically satiated space, local geometrical waves are formed mixing the points of the space. Here is a visual, though approximate, image of how it will look: cut a sheet of paper with the function $p(\mu)$ plotted on it into stripes parallel to the abscissa, mix them up and glue them together in this random order. After this manipulation, now of a topological character, the curve $p(\mu)$ will be essentially nonsmooth. And if we happen to meet a Person whose consciousness will be that unsmooth, we will in all probability assume he or she to be mentally ill, though may be a carrier of an essentially different culture who got into our culture by chance. It is possible to assume the existence of other Universes not only in the physical world (when nondimensional fundamental constants change their numerical values), but also in the semantic world (when meanings are rearranged on the numerical axis).

6. *Anomalies in the perception of texts.* Not all primordially given meanings are equally open to everybody. When a child is born, his or her consciousness must be characterized by the nearly rectangular distribution function $p_0(\mu)$. It lacks selectivity as yet, but the child is prepared for its formation, perceiving the coming filters $p(y/\mu)$. However, anomalies may occur. The initial rectangular function $p_0(\mu)$ may contain "black holes" (segments whose ordinates equal zero). This is how oligophrenic children appear who are unable to perceive our culture. Among our colleagues, there are also people who are completely incapable in their outlook to go beyond the limits of positivism (or primitive materialism), and socially they cannot imagine a free world not wrapped in totalitarianism. Something of the sort occurs in color perception of the physical world: color-blind people are unable

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to distinguish all the different colors on the electromagnetic scale alotted to us. At the same time, none of us can go beyond our limits of the scale, although other species, for example, bees, can.

VI. Semantic Nature of Personality

It seems relevant to examine here four structural constituents of personality.

1. *Human Ego*. When we meet a person and through talking and interaction get to know him or her, we form a mental image which is primarily determined by the system of meanings the person professes. Then we are ready to identify his or her Ego with the text set by the probability density $p(\mu)$. This function may be many-apexed, needle-shaped, fuzzy, or sharply asymmetric, depending on the individual's psychic peculiarities. Ego is not a stable state but a process, because the system of semantic (value) concepts changes continuously, especially in crucial situations; if Ego is regarded as a text, this text will be very special, live, and capable of incessant reinterpretation of itself. Here we come close to Buddhist views of the illusory nature of personality.

2. *Metaego*. Metaego is a faculty of generating filters which restructure our system of value preferences and which is not directly grasped by us. This seems to be the most powerful characteristic of personality: a person remains oneself, i.e., preserves the faculty of generating nontrivial filters, especially in crucial situations. It should be emphasized that personality is revealed in tragic situations, provoking the emergence of nontrivial filters. Here our ideas are in resonance with the trend in Western European thinking known as French personalism.[5] It contains the concept of "integral heroism," and the tragic is regarded as primordial ultimate reality, unyielding to rational cognition and expanding the boundaries of personality. What reveals personality is tragic personal experience, not the logic of school education.

3. *Multidimensionality of personality*. Peering into ourselves, we see that each of us represents at least a two-dimensional personality–otherwise the incessant inner dialog with ourselves would have been impossible. The ego of a two-dimensional personality is given by the probability density $p(\mu_1, \mu_2)$.

Personality proves to be composed of a twin couple $\mu_1$ and $\mu_2$ linked by the correlation coefficient $\rho\{\mu_1, \mu_2\}$. When a new parameter enters the model, the unpacking of the semantic continuum becomes more sophisticated: the weights are no longer attached to the segments of the semantic axis but to the segments of the plane given by the axes $\mu_1$ and $\mu_2$. With the increase of the personality dimensions, the sophistication of unpacking grows. We start to peer into the semantic world through a number of interconnected windows, and each of them reveals its own text. Through those texts we see the semantic world and ourselves in it. Multipersonality is now broadly discussed in American psychiatry (Beahrs, 1982) and proves to be related both to pathology (splitting of a personality, when the correlation coefficient is close to zero), and creativity; from the social point of view, harmonious multipersonality is the overcoming of alienation and aggressiveness. One of the most vivid examples of a multidimensional personality was Dostoyevsky: his characters are utterly different and, at the same time, the author is also seen through them.

4. *Hyperpersonality*. What we mean here is the concept of a personality as a multidimensional semantic structure personified in different bodies–consider, for example, hypnosis, transference in psychoanalysis, emergence of the collective consciousness in the agitated crowd, collective ecstasy in religious mysteries, or even a state of amorousness and special sexual practices leading to a merging of personalities as in Tantrism.

VII. Biological Evolutionism as a Creative Process

This subject is beyond the framework of the present paper but is examined in detail in a previous book (Nalimov, 1985). We shall confine ourselves to a few brief remarks. Remaining within the position of hermeneutic philosophy, we can regard the biological world as a set of texts constructed on the initially given morphogenetic continuum. Individuals will be elementary texts; their correlated population will represent a species. Using this language, it proved possible to describe biological evolutionism the way we had described evolutionism of texts generated by our consciousness. We feel the attempt itself to construct a model of global evolutionism invariant towards peculiarities of concrete processes to be very noteworthy.

VIII. Matter vs. Meanings

This problem was posed as early as in ancient Egypt in the famous *Book of the Dead* (Papyrus Ani) written in the middle of the second millenium B.C. Since then, not much progress has been achieved in the solution of this fundamental problem. Serious efforts of neurophysiologists have not been a success either: so far they have not managed to formulate any concepts about how to bridge the gap between physical and semantic manifestations of the Universum. Nor have physicists, using quantum-mechanical descriptions of consciousness, done this convicingly enough.

Jahn and Dunne (1988), though, showed quite obviously that the notion of the wave function of consciousness may be interpreted in the description of the process of obtaining and using environmental information or introducing it into the environment while interacting with technical devices. Undoubtedly of interest is also the program of "holomovement" developed by the English physicist, David Bohm (1987). However, its initial premises are not completely clear either. The vague point everywhere is the problem of how, what we call meanings, are generated to structure our intellectual and spiritual life.

We feel that the bridge between matter and meaning may be constructed by the geometrization of our conception of the Universum. We know that field concepts play a central role in contemporary physics. Now there is hope that in the near future a unified field theory will be created combining the four fundamental physical interactions. We introduced a field concept of the nature of consciousness, having given a mathematical interpretation to a basic premise in Plato's philosophy. Hence the hope of constructing a super-unified field theory embracing both physical and semantic reality. The degree of geometrization of our views on consciousness can be deepened if we pass from probabilistic (Bayesian) logic to metrical logic, having rejected a somewhat artificial limitation on the constancy of metric (predicate of spatial length) of the semantically satiated space. In this case, we shall resort to gauge transformations broadly used in contemporary physics, assuming that the change of the text, its evolution, occurs at the expense of local deformation of the scale in the proximity of the points of semantic space. The text is now regarded as an excited (i.e., of different scales) state of the semantically satiated space. The text becomes a semantic exciton. We need not be troubled about translating from one language into another since different languages have the right to exist only when the translation from one into another becomes a nontrivial problem.

IX. Conclusion

From what has been said, it follows that our model proved to be constructed from the point of view of constructivism. It was not conceived this way. It happened by itself.

The model we propose satisfies the requirements set by Brouwer to be intuitively clear. The clarity is achieved by the geometrization of the concept of meaning, which had been prohibited by Descartes

(mind is not extensive), and the prohibition still holds today. The geometrization of consciousness brings description of the semantic world close to that of the physical world. That opens the way to constructing a *super-unified* field theory explaining both worlds. It is essential to note here that any serious model of Reality can be constructed under the condition of something fundamental being given. In physics (and consequently in cosmology) fundamental constants are given. This is followed by questions without answers: How did the constants emerge? Where are they localized? How long will they exist? Are other sets of constants possible? Constants are given by numbers, the nature of which is *semantic* rather than physical. Numerical constants seem to be built into the physical world (Nalimov, 1993). And, indeed, if this is so, we can say that the physical world is guided (arranged) by a semantical one. And this manifests presencing of consciousness in the Universe. However, science disables such a viewpoint of Reality.

Now let's resort to human consciousness. To grasp the nature of consciousness it is necessary to accept the existence of elementary (primordial) meanings which are somehow arranged (as, for example in my model, on the linear continuum of Cantor). Again unbearable questions are brought about here: Who creates primordial meanings? Where are they localized? How long will they exist? Is another arrangement of elementary meanings possible? From the mechanistic point of view, it is easier to give up everything that is obscure. But then, any appealing model is beyond construction.

Elementary meanings are not generated by brain cells. The brain is capable of operating on meanings, but cannot create them out of nothing. The proposed approach is somehow close to the conception by Kant, which deals with a priori forms of space and time perception which allow the ubiquity of mathematical constructions.

So, it is possible to state (utter) that the lack of an appealing model of consciousness is due to the deficiency in courage to accept nontrivial (even "absurd") initial premises. This is also true with respect to the brilliant books by the mathematician (and physicist) R. Penrose (1989; 1994).

All the above naturally refers to biological evolutionism if we treat biological individuals as manifestations of biological texts, while species are multivariate formations of closed texts (as discussed with reference to Nalimov, 1985).

It takes courage to break through scientific orthodoxy.

## NOTES

1. Here again we come very close to Wheeler's (1983) ideas. He speaks about "law without law" and raises the problem of the possible role of meaning in the coming third era of physics. He says: "Is the regulating principle behind the structure of physics the demand for meaning? Should we be asking, 'What makes meaning?' Do we have to invade the world of philosophy to make headway with that problem?" (p. 404).

2. The contents of this section have been presented earlier (Drogalina, 1990; Nalimov, 1989).

3. This was examined in our book earlier (Nalimov, 1989).

4. It follows from the above that the concept of freedom has more clarity on the internal levels of consciousness than on the level of Aristotelian thinking. This was directly supported by our meditation experiments (Nalimov, 1982).

5. Its basic premises were formulated by Emmanuel Mounier before World War II.

6. Previously, this book was not allowed to be published in Russia. It has only recently been published there: Nalimov, V. V. & Drogalina, Zh. A. (1995). *Real'nost' Nereal'nogo* [Reality of the unreal: Probabilistic model of the unconscious]. Moscow: Mir Idei.

7. This is my cardinal book which I failed to get published abroad as I was informed "it goes beyond the accepted scientific paradigm," and I was supplied with a "proper" book as an example to follow. The tutorial publishing house was a famous one, yet too much within conventional limits.

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# FIGURE 1

## Map of Consciousness

5. Meta-level (Cosmic consciousness)

o o o o o o o o o
o o o o o o o o o
o o o o o o o o o o

6. Cellars of cosmic consciousness
(The collective unconscious)

1. Level of thinking
(Aristotelian Logic)

2. Level of pre-thinking
(Bayesian logic)

3. Cellars of consciousness
(Contemplation of images)

o o o o
o o o o o
o o o o

4. Bodily facet supporting
consciousness