

Talk 4:

Joining the Dots: The Ladder of Cognition

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"In biology, it is easy to get interesting answers to questions one didn't ask."

- Ueli Schibler in Cell 169, 1167, 2017

Abstract

Biology is rooted in the operation of consciousness. 'Life' cannot manifest and life-operations cannot be sustained for long without consciousness, which works as an active participating ground with its own specific operations within the systems. Processes of 'life' within the systems are run by 'self', which represents consciousness customized as the CEO for the systems. Information flow in the signal networking is executed through informational bio-molecules of cell and is regulated by different logic modules handled by operations of mind, self and life within the systems. Logic modules are overarched by operation of consciousness. This paper brings out the hierarchically nested labyrinthine structure of the cognitive organ, individual operations of the constituent members of the cognitive organ, and the dynamics in the ladder of cognition. The implications of this cognitive ladder in behavioral neuroscience, cell biology and systems science have been highlighted and its far-reaching influence on research in artificial intelligence, synthetic biology and psychosomatic medicine has been mentioned.

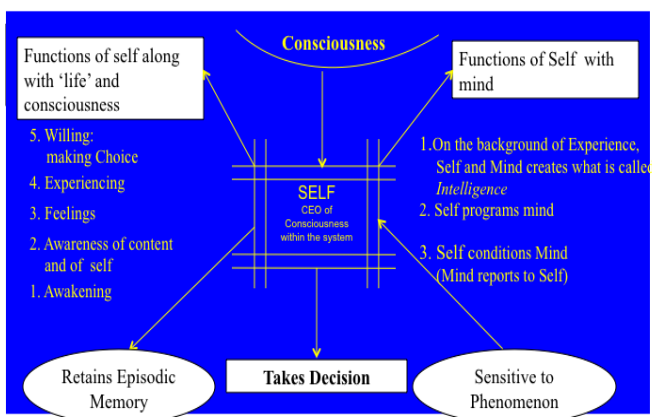
Introduction

Cognition is a universal phenomenon exhibited by all living systems. Cognitive apparatus (cognitive organ), cognitive processes and the objects and products of cognition are important issues in cognitive science. In spite of several experimental works in neuroscience and psychology, and considerable deliberation on philosophy of cognition, the theoretical framework overarching above three issues within the mould of science of informatics is conspicuous by its absence. The objective of this paper is to develop this theoretical framework, which could be applied universally in neuroscience, cell biology, psychology, sociology and evolution.

Consciousness is directly involved in three functions of the organism; cognition, emotion/feelings and volition/will. At the centre of all three functions, there is 'self'. It is the 'self' of the systems, which cognizes, and remains at the center of cognitive organ, cognitive processes in choosing the object of cognition, formatting information into knowledge, experiencing and executing the decision. Therefore, at the outset, we would offer a brief account of this self. This would be followed by description of the cognitive organ. The ladder of cognition with the 'dots'/ milestones and the operations would be dealt next. Finally, we would see their application in behavioral neuroscience, cell biology and systems science.

A brief account of Self in the Science of Consciousness

Self is that which evokes the sense of 'I', 'Me' and 'Mine' for the system. It is self, which feels and expresses emotion through available machinery of the systems. Self wills and opts for volition for the systems on behalf of consciousness. Self is at the centre of cognitive ladder in general, and cognitive apparatus of the systems in particular. This is because self is consciousness's executive representative within the system, Chief Executive Officer (CEO) appointed by consciousness to look after all activities of the systems and to lead the systems to its natural evolutionary goal.



Like consciousness, mind and life, self is also not observable, measurable, reducible. Like them, self is nonlocal and is difficult to localize in time and space. However, self's operations are understandable. Some operations are joint venture of self, life and consciousness. Others are of self and mind. Decision-making process involves all ingredients of the psyche. However, self executes the decision. Self retains the episodic memory. Self is sensitive to phenomenon. Fig.1 outlines functions of the self within the system.

Scientists have recognized this operation of self first in nature within the self-organizing systems. The operation of self has achieved preeminence with appearance of life-operations and mind

operations within the systems. The effort to localize operation of self in various states of brain through MRI recording has not yielded desirable result. Shifting position of self has been recorded with shifting brain states. Since the brain is a far complex system of hundred billion neurons and

nearly two hundred to thousand billion glial cells, it is easier to concentrate on cellular self than on neuro-context self of the brain. Every individual cell of our body, including neuron and glia, has an uncanny sense of self (Mukhopadhyay, 2015). Our immune system works on the basis of division of self and non-self. At the preliminary molecular level, the membrane potential determined by ion-pumps brings the identity of ionic self of a cell. Derangement of ion pumps leads to misrepresentation or even no-representation of self at cellular level. Failure of proton pump leads to unmanageable intracellular edema, which when affects the vital organ like brain the subject deteriorates towards death. Also, MHC-I molecule expressed on the cell membrane works as biochemical representative of self within the cell. The distinction between self and non-self in cell biology is largely based on this molecule.

The Cognitive Organ

What is systems psyche in the context of systems science is the cognitive organ in the context of organic description of the systems. The constituents of this cognitive organ are consciousness, self, life, mind and information. The psyche, therefore, is not monolithic. It is made of five so-called 'puzzle' pieces. It is information, which connects mind in the cognitive apparatus with the physical world of energy, matter space and time. Every constituent of the psyche has its own specific operations and also has joint operation as well with other members of the psyche.

Consciousness: The Ground, Participating Ground and the Background:

Consciousness is the ground without any background. It is not a silent inert inactive ground. It is a supportive and participating ground. Self, life-processes and mind work autonomously under the umbrella of a ground unconditional consciousness. Consciousness offers autonomy to other players of the cognitive organ, which have achieved the desirable degree of perfection for the systems, and lets them free to operate. Consciousness intervenes only when there is conflict of autonomy, failure of any operation or their connectivity, or there is an effort to change or break the integration or the symmetry of the systems or there is an imperative of new creation, worldview formation or, in impetus of redefining or renewing system's consciousness. All these stimuli are responded by consciousness on a threshold for intervention. Functions of consciousness as the core constituent of cognitive organ are shown in the box below.

Functions of Consciousness
I. Maintains its own absolute independence Like a spider it weaves the net but itself is outside the snare of the net.
II. Brings coherence and orders in the systems by <i>A. Passively supporting</i> Autonomous operations of 'self', 'life' and mind, which have achieved the reasonable degree of perfection as desired and decided by the systems. <i>B. Actively participating with 'self' and 'life'</i> , in Awakening, Awareness, Feelings, Experience, Choice and Decision-making
III. Intervention: Consciousness intervenes at the time of <ol style="list-style-type: none">1. Conflict of autonomy2. Failure of any autonomous operations or their connectivity3. Challenge to system's integrity or symmetry4. Taking decision in sync with the world, declaring the Worldview5. Redefining and renewing system's consciousness6. Necessity for a new creation When consciousness intervenes, it takes all constituents of the cognitive organ of the systems psyche in confidence

Mind:

Mind is different from consciousness. It is through mind consciousness, self and life communicate with the physical world. Twenty one differences between mind and consciousness have been tabulated in one of my earlier papers (Mukhopadhyay, 2013). Mind's direct connection with consciousness is responsible for mind's fecundity. Bereft of consciousness, mind is sterile. Mind's infidelity originates from its direct connection with matter. Mind's strength comes from its connection with 'life'. Mind is responsible for the transit of signal to information and vice versa. Mind processes information as programmed by self. Mind retains semantic memory. In specific situation, mind can act as internal sense organ when it has direct access to nonlocal information.

Life:

Three unique features identify life-operations. The cardinal sign of life is homeostasis:certainty-uncertainty homeostasis, symmetry-asymmetry homeostasis and visible energy-dark energy homeostasis. Uncertainty is managed through access to new information, followed by application of inferential logic. Symmetry homeostasis is characteristic of only life. Life-form is unique in the sense that it can manage dark energy released in any

operation and transform this dark energy into visible energy. It can also do the reverse. These functions could be observed in any systems, which is not alive. At present, there is no evidence for this statement but many phenomena like spontaneity, uncoupled action and negentropy as observed in the live system could be accounted by this assumption.

In my earlier paper on emergence of patterns in the complexity (Mukhopadhyay, 2016) and on systems psyche (Mukhopadhyay, 2016), I have described the life-self hierarchical and functional mosaic. Self-organization and life-organization, although differ, work together like yang and yin, as shown in Fig. 2. They maintain a tangled hierarchy.

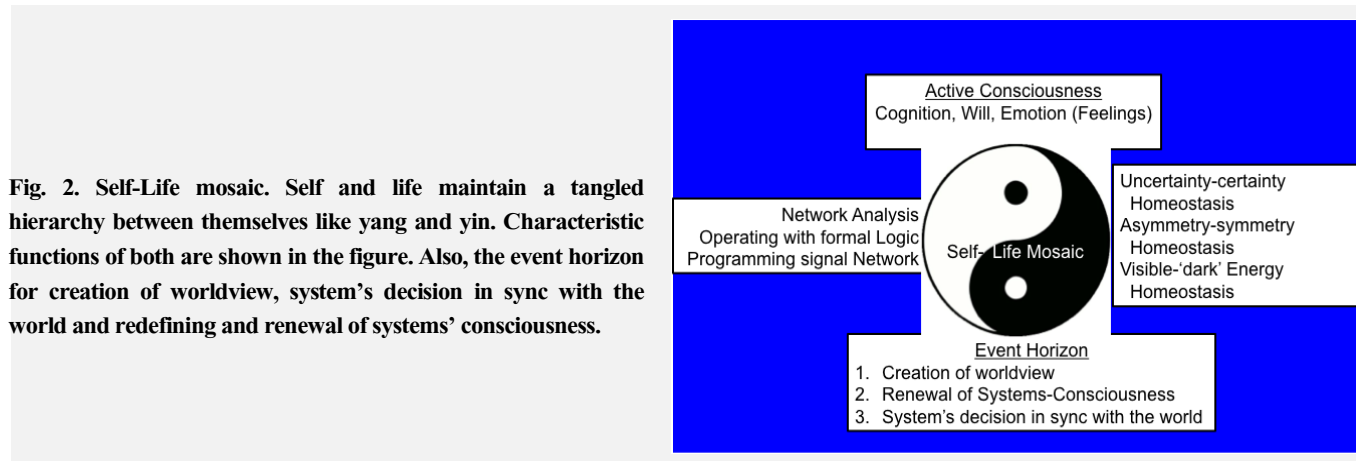


Fig. 2. Self-Life mosaic. Self and life maintain a tangled hierarchy between themselves like yang and yin. Characteristic functions of both are shown in the figure. Also, the event horizon for creation of worldview, system's decision in sync with the world and redefining and renewal of systems' consciousness.

Self:

Self's operations, as shown in fig. 2, are involved in (i) programming the signal network (ii) network analysis and (iii) application of formal logic.

Information:

Information connects the players of local science (space time, energy, matter) with the players of nonlocal science (consciousness, life, self, mind). Information works with other players of non-local domain through mind. Signal is space-time construct of information at the local level.

Event Horizon:

The event horizon is where self-organized critical instability, life organized critical instability and intervention threshold of consciousness meet. The observable events are (i) creation of worldview (ii) renewal of systems consciousness and (iii) system's decision in sync with the world.

'Dots' on the cognitive line

Cognition is a function of a conscious system. As mentioned, cognitive apparatus consists of consciousness, self, life, mind and information, which are also the ingredients of the systems psyche.

Our question is what do we cognize as a system? Is it a signal or information? Is it knowledge or experience? Or, we intuitively work with the wisdom in sync with the world? Is the system's cognition only signal-based? Or, is it information-based, knowledge-based, experience-based or wisdom-based? Or, the dots transit from one into other to reach its logical end?

If we state that signal, information, knowledge, experience and wisdom are the successive dots in the cascade build up during the process of cognition, then to connect these dots with specific operation is a hard task indeed. In this section we will describe these 'dots', spread over the line of cognition.

Signal: Signal is in the physical plane localizable in space and time. It is usually represented by energy within a specified space per unit of time. In mathematical language, it is expressed by frequency. Signal can be encoded, recoded and decoded within the physical system. However, the code cannot be cracked by any physical system. Also, signal has no intention or context of its own.

Information: The meaning extracted from signal makes information. This is obtained by cracking of the code of the signal. The process transits from the local to the intangible nonlocal state. Being nonlocal, information is multileveled. In full form, Information has a measurable folium at the physical level, content folium, which works at the mental level and the intent folium working with the CEO of the system, the self. Connectivity with the self brings intentionality within information, and connectivity with mind generates the context of information.

Knowledge: Knowledge is that information which can be used without any further deliberation on it. Knowledge may be constructed from one single, or multiple interrelated information, and formatted by 'self' to achieve a specific architecture. Knowledge is also in the abstract intangible nonlocal plane, which is related to the systems. Architecture of knowledge is characterized by its specific invariant symmetry. Knowledge can act as a sensor for related information.

Experience: When the specific invariant symmetry of knowledge, single or multiple, survives the challenges of symmetry breaking processes in life, transition of knowledge into experience begins. Following an experience, inside is out and the outside is in. Experience within is the reality outside, and while the invariance of symmetry remains.

What do we experience? We do not experience information or knowledge. In the computer language, the sensation we all feel is 'ambiguous'. Perception in the same language is 'probabilistic' although informative. Sensation and perception are, however, not experience. Concept formation is development of symmetry in the architecture of knowledge. Experience is deeper and broader than this and is dependent on operation of 'life'. What do we experience then? We experience the *design* in the invariance of symmetry in the architecture of knowledge arranged in layers as the manifolds. Experience accumulates over time, as layers, on several domains of knowledge. As knowledge has sensor property, so the experience has sensing property. Experience senses knowledge. Experience is, however, systems-bound, confined within the systems with limited theory value.

Wisdom: In the transition of experience to wisdom what the systems gain is dynamicity and this is achieved with active participation of consciousness. When the experience of the system gets synchronized with the world it does not remain confined to one system. It concurs with the decision of a large number of systems and thus it becomes then a worldview, commonly known as wisdom. Unlike all other previous 'dots'/milestones, the wisdom is intrinsically dynamic and has the ability to govern the systems. On every occasion it acts, it redefines the systems. However, unlike all other dots, wisdom always remains a dot, a point in space or a moment in time!

The above is a bottom-up description of the processes of the dots. Top down, from wisdom is created new design for experience. Supportive knowledge architecture is built up from the conceived design. Necessary information in the knowledge architecture interacts with mind to create appropriate signal, observable and measurable in the physical plane.

Alternative nomenclature for the dots

Signal, information, knowledge, experience and wisdom are the terms taken from linguistics. The terms could be reframed scientifically.

Using the term 'Information':

Signal can be said as space-time construct of information. Information is generally what we mean by Shannonian information. Knowledge could be called Gödelian information, information in the context of the whole and for the whole. Experience is related to information manifold. The pearl of wisdom might be called crystal information.

Using the term 'Knowledge':

Signals, like data, could be considered as factual knowledge. Information itself could be described as informative knowledge. Knowledge is what we get in the textbook as formative knowledge. Experience in this sense is transformative knowledge, while the wisdom may be called knowledge sublime.

Connecting the Dots

Operations and the Operators

Once the dots have been identified, the next step is to join the dots. I have proposed four specific operations in between five milestones, which together form the cognitive ladder. All four operations are in the abstract plane and not in the observable reducible physical plane. Transition of signal to information is carried out by Operation I, information to knowledge by Operation II, knowledge to experience by Operation III and experience to wisdom by Operation IV (Fig.3). The detail of individual operation is available in my recent publication (Mukhopadhyay, 2017).

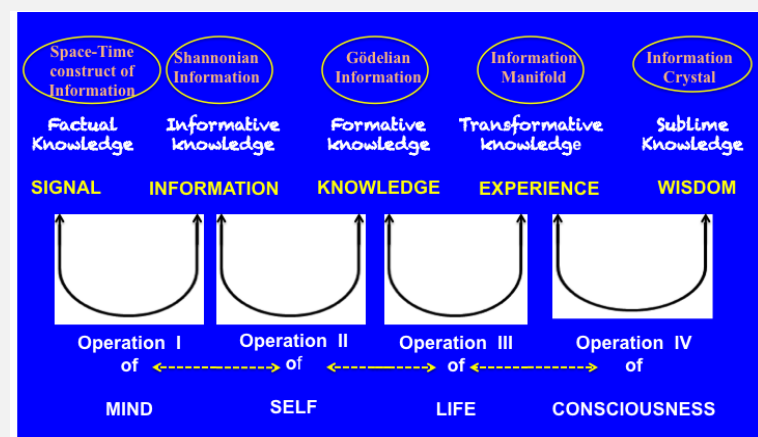


Fig. 3. The cascade of four specific operations. The operations are involved in the transit of signal (factual knowledge, space time construct of information) to wisdom (sublime knowledge, information crystal) and vice versa.

All operations, as shown in Fig.3, are bidirectional, might be specifically gated. As signal could lead to wisdom bottom-up along the ladder, following the ladder from top down the wisdom of multiple systems, which is in sync with the world, may come out as a signal in the sensory physical domain within a live system.

Operations are indeed processes. The question is, whether there is any operator for each of these specific operations?

We do not have any equipment, machine or physical device, which can crack signal code and extract meaning out of it except probably human mind or mind-like structure and processes in nature! For the transit of signal into information, the required operation probably has been so far labeled by humanity as mind operation in consensus and is being used in linguistics. Transition of information to knowledge requires a second operation, which is possible only in the systems, which has been autonomously run by self. To put the information in the context of the whole is possible only by this operation of self, which cares for the whole. Next, knowledge cannot transit to experience in an inanimate system. It requires operation of life. Only a living system can have experience accumulated over time stored in form of episodic memory. In contrast, semantic memory is stored inside mind. Sublimation of experience into wisdom is possible only within a conscious system. Involvement of consciousness makes the static experience of the system dynamic and helps to mature it in sync with the world. At the center of this cognitive ladder situated is self.

Therefore, it is clear now that the operations are carried out within the systems psyche and the operators are nothing but the constituent elements of the psyche, none of which are observable, measurable or reducible, although their effect are observable and measurable as different signals of different strength in the physical plane.

While the operators themselves are nonlocal, there is hierarchical location of their operations within the systems psyche. Mind reports to self for its operation. Self and life independently report to consciousness. All self, life and mind have direct access to consciousness. However, none of consciousness, self and life has direct access to physical plane. Each of them connects with the signals in the physical plane through the final common pathway of mind. That makes mind so important within the psyche. It is mind, which conceives information, delivers 'form' (as signal) and energy (? dark energy). 'Form' is construction of space and time. In this sense, information could be said as father, mind as mother while space, time and energy (? dark energy) are their three children (Mukhopadhyay, 2008). Dark energy homeostasis is a function of life.

Consciousness is not complex but the pathway from the signal to consciousness is complex. There are several factors, which make this cognitive organ and the processes therein, complex hierarchical and labyrinthine. On the skeleton of a tentative pyramidal hierarchy, there is a cascade of reporting system for mind, life and self as described above. There are non-hierarchical interactions between the operators as well. The operations are selectively bidirectional and might be with gating. Besides, there is lateral entry to this ladder. For example, mind in specific situation can have direct access to information. Self remains ever sensitive to phenomenal inputs. Life is seen to sense directly the symmetry alteration. Consciousness, in this context senses attitude and gets perturbed by the attitude of non-submission (? disobedience) and manipulation. Also, the currencies at different depths of nature intercept this cognitive ladder at several points.

Non-hierarchical interaction between the operators could result in complex outcomes. For example, interaction between mind and self with the background memory and experience leads to emergence of intelligence. The interaction between specific information with mind and life leads to emergence of emotional response. Because of presence of information, emotion is intentional while the feelings, handled by self, has no intention. Besides, there are completely new outcomes within the systems when self, life and consciousness act together with emergence of awakening, awareness, experience choice and decision as shown in Fig. 4 (Mukhopadhyay, 2017).

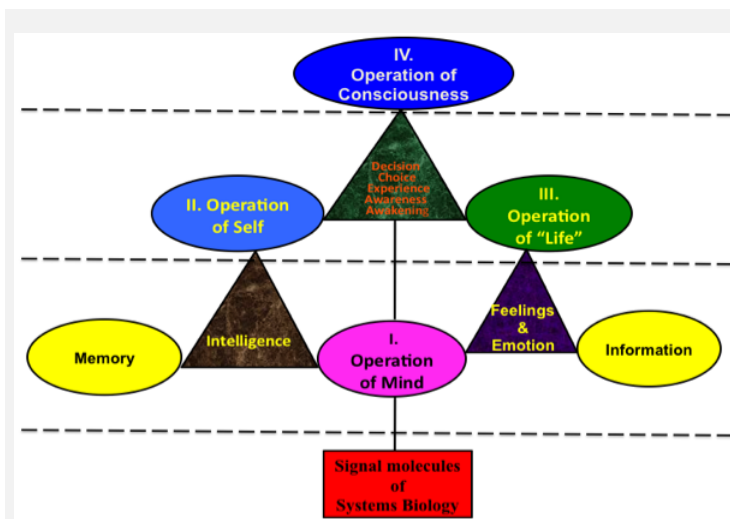


Fig. 4. Cognitive Labyrinth. Operation I (of mind) is immediately next to physical nest of molecular signal networks. In the same sub-physical nest, information, memory, intelligence and emotion work, where information is connected (not shown in the figure) with back-up memory. Operation II (of self) and III (of life) are in deeper sub-physical nest. Consciousness operates (operation IV) from the deepest nest. Only operation I (of mind) has connection with physical nest. Operation II, III and IV connect with physical nest through operation I which remains the final common pathway to the physical nest. Mind, Self and Life all have direct hotline connection with consciousness. Information, bottom-up, has no direct access to operation IV. Connections of information to operation I, II (not seen in the figure) and III are direct. Operation IV accesses information through operation II, III and I.

Non-hierarchical interaction between the operations generates new additional outcomes. Operation III and I, along with information, generate emotion. Operation II and I, along with memory, generate intelligence. Awakening, awareness, experience, choice and decision are outcomes of joint operation II, III and IV.

Consciousness, self, life, mind and even information are non-local. However, as said, within a conscious system their operation could be tentatively localized. Consciousness at the top and the mind at the bottom of the psyche, have hotline connection. Mind is trans-physical. It works across the border of physical nature and the operational currencies are information and signal. Operational site for self and life are sub-physical, sandwiched between operation of mind at the surface, and operation of consciousness at the deeper plane. Operation of consciousness is non-physical in the sense that it is beyond and far deeper than our concept of non-locality. Having defined the dynamic continuum of the cognitive ladder, it would be easier to investigate the steps from the signal to the will and from the will to signal, and from the neural firing to conscious behavior and from volition to its execution through neural signal network.

Brain and Conscious Behavior

Automated or reflex behavior, however complex it might be (e.g., pupillary reflex), does not need any active role of consciousness in their operation. Such reflexes have been offered autonomy in the organization since they have achieved a desirable degree of perfection for the systems. At present, although, we are limited to input-output behavioral analysis on the basis of mono-level neural networking, the link between the brain and conscious behavior is complex, not confined to one flat plane or level. Conscious experience is the result of multi-leveled and hierarchically stratified operations. Following the ladder of cognition as stated above, a multilevel dynamics is proposed to exist between sensory inputs and behavioral outputs that are conscious (Fig. 5). From the neural network to neural dynamics, which involve astrocytes and deeper multi-leveled connectivity, the operation transits to fields of architectural symmetry for developing an invariance. This is followed by emergence of the design in this invariant architectural symmetry in this dynamics on an abstract plane, which is however supported physically by neural manifolds. This all happens with the active support of consciousness. Finally, consciousness actively intervenes with its ‘will’ for the volition of the conscious behavior.

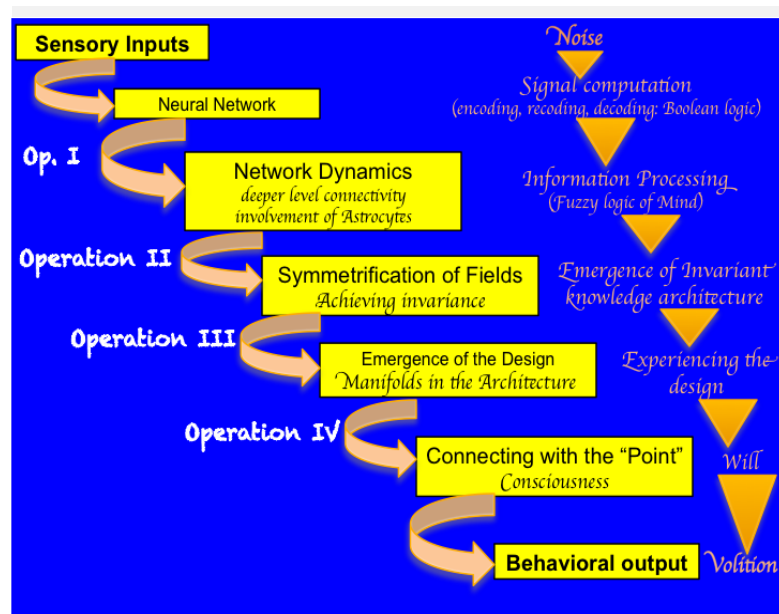


Fig. 5. The layers between the brain and conscious behavior and the processes between sensory inputs and behavioral outputs correspond to the ladder of cognition. The cascade begins with the signal and layers up to neural code, to information on-board, symmetry concord, neural manifold mode. Finally, consciousness’s accord leads to behavioral output.

In several of my earlier papers it had been said that when information geometry concurs with the geometry of neural manifold, there is generation of experience. In the light of this ladder of cognition, let us analyze the statement. Neural code (signal) is to be on board to behave as information. Concurrence is of several possible symmetries for developing a concord. Neural manifold has been described as “Neural Modes” (Gallego et al 2017). Therefore, it can be said that neural code (signal) on (Operation I) board develops (Operation II) concord with (Operation III) neural mode (manifold) to generate experience (Fig. 6). This surely offers the theoretical framework as required for organizing the experimental data (e.g., Pillai and Jirsa (2017), accumulated on this issue. It is worth noting that upto the level of generation of experience, consciousness actively supports all three operations. From signal to experience is thus a bottom up development with tacit active support from the top of a live conscious system. Almost effortless coupling of several natural oscillators within the brain come forward in architecturization of knowledge and emergence of a design in the neural manifolds. However, volition (behavior) requires a profound top-down activity where consciousness has to intervene for the accord; consciousness has to ‘will’ for the volition for expression of behavior to change the *rhythm of the brain and spinal cord* as a whole. This operation IV is under total command of conscious self as CEO of unconditional consciousness. Even when neural manifolds have already been ready with polite submission for transmission of the ‘will’ of consciousness, the execution depends on consciousness’s ultimate wish to act in appropriateness of time to induce dynamicity into this experience. Through this operation local and nonlocal get unified. Through every conscious behavioral expression, the brain redefines its behavioral dynamics.

Cerebrospinal Fluid and Consciousness

Recently there is growing interest for establishing the relation between consciousness and cerebrospinal fluid (CSF). CSF is known traditionally to serve as lymphatic of the brain. However, what is missed in this idea is water in CSF. Interfacial water-lattice connects cellular information-manifold

with extracellular information-manifold. Water lattice manipulates information geometry and informational-manifold. The flow of CSF and its drainage is influenced by respiration. “ Inspiration is the driving force for CSF flow in humans (Dreha-Kulaczewski et al, 2015). Therefore, different varieties of breathing exercises (*pranayam*) help in cleansing the brain in term of traditional idea by encouraging CSF flow and drainage. Change of interfacial water lattice is also to be considered in this context.

At the deep contemplative phase of *samadhi*, respiration becomes still (*Kumbhak*) and the fine layer of CSF over the cortical brain becomes actively still. Water-lattice in this thin layer of CSF becomes conducive to achieve synchronization of consciousness inside and outside the brain. Following several such practices, *sahasrar* chakra might get open.

Dilate the Point of Death. The Hard Problem gets decimated

It is often said that the hard problem of consciousness cannot be solved till death. However if we follow the ladder of cognition and dilate the moment of death objectively, the hard problem is nearly decimated.

Functions of consciousness could be easily understood from behavior of unconscious patients. There is no volition (will), no feelings (emotion) and no cognition in unconscious patients. Cognition, emotion/feelings and volition are three textbook functions of consciousness.

When consciousness is 'out' of the loop in the systems brain, autonomous mind keeps on working as long as, biochemically, Ca^{++} ion channels are functional. The patient does not soil the bed. The patient retains his mind and sphincter control. Ca^{++} wave spread over astrocytic population of the brain keeps mind active within the brain. Information processing goes on. Whenever there is no 'thinking' or no mind function, no information, but only signal processing, astrocytes are not needed at all as in peripheral ganglion, and even in complicated papillary reflex pathway.

Mind is sterile without consciousness. Therefore, if consciousness is not regained, mind cannot continue its autonomous activity for long. Mind operation eventually ceases and there is no control of sphincters. The patient soils the bed.

When both consciousness and mind are out of loop from systems brain, the self in the brain continues its work with the support of proton pump within the cells. Autonomous function of self, bereft of consciousness and mind can continue as long as supporting Na^+/K^+ pump continues.

With the failure of 'self' functioning within the systems brain, the patient develops endothelial leakage resulting in oedema, not manageable by diuretics, steroids or mannitol. Intracellular oedema of astrocytes and neuron makes 'life' impossible to continue its work within the brain. 'Life' eventually has to leave the systems body (Mukhopadhyay, 2015, 2016).

Cellular and Molecular Cognition

Could this ladder of cognition, as stated above, be of any help in systemization of signaling circuits in the complex biological systems of a cell? Bacteria are small but not stupid (Shapiro, 2007). Like us connected through facebook, the bacteria have phagebook for social networking (Hynes and Moineau, 2017). Even the phages are seen to make group decision (Davidson, 2017). Definitely, this ladder of cognition has been building up a theory for cellular cognition and leading to new taxonomy for cells and molecules within the cells. The emergence of specific pattern of operations with identifiable characteristics like that of mind, self and life are important for this new taxonomy.

New taxonomy for Cells:

Behavior of cell depends on its cognitive status. Cells could be classified according to their position in this cognitive ladder. The cognition by a neuron and by a RBC, a platelet or a neutrophil is different. There are cells, which work on mostly signal. Their behavior is signal-based. Red cells and platelets of blood belong to this category. Ganglion cell of peripheral nervous system is also signal-based. Metabolic cells of liver, adipose tissue, endocrine or exocrine glands are 'informed' cells. Metabolomics is run by bio-informatics. Antigen recognizing cells, monocyte, histiocyte, tissue macrophages and, mirror neurons of cerebral cortex exhibit knowledge-based behavior. Memory lymphocytes, natural killer cell, regulator of pacemaker neurons are experienced cell. T-regulatory cell of immune system has regulatory power, which comes from wisdom. It seems that the wisest cell of the body would be the ovum, which handles millions of spermatozoa but allows penetration of only a few and eventually get fertilized by the best one. This taxonomy could be extended to classify cells all over the body. Even the population of neurons from peripheral ganglia to population of neurons of cerebral cortex could be classified on this basis (Mukhopadhyay, 2017).

New Taxonomy for Proteins

Any cognitive activity requires substance support from within the live-system. Cellular cognition is supported by their specific proteomics. Majority of the signal proteins are polypeptides. Folded proteins (as seen within cell membrane) are receptor proteins,

which according to the ladder are ‘informed’ proteins. We are to find out how this secondary structure of protein has something to do with their information-carrying capacity. Tertiary structured proteins are ‘knowledgeable’ proteins as we see in enzymes, and the proteins which act as biosensor. The protein of inflammasome such as NLRP3 acts as sensor for pyroptotic and necroptotic pores (Braz and Dixit, 2016). NLRP6 is a multifaceted innate immune sensor (Levy et al 2017). Caspase 11 enzyme works as a sensor for cytoplasmic LPS (Shi et al 2014). As there are infinite variety of knowledge and experience, so there are similar number of symmetry and super-symmetry in protein structure within a cell. Quaternary-structured proteins are ‘experienced’ protein. For example, hemoglobin, which carries oxygen to cells all over body and by experience, it modulates its structural dynamics as and when it is necessary. Another example of quaternary-structured experienced protein is perforin found in T-killer cell or natural killer cells, which are experienced phagocytes. Experience offers proteins censoring property. Small HSPs (heat shock proteins) have multimeric crystal structure (Kim et al 1998), which with other heat shock proteins censors misfolded proteins. The enzymes involved in DNA repair mechanism are the trinity of ATM, ATR and DNA-PK (Blackford and Jackson, 2017) are also highly experienced proteins, all having quaternary structures. What controls those DNA-repairing proteins? The wise protein in this context is spherical protein of histone. The ‘wisdom proteins’ are usually found to be spherical. The sphere is a design where reflection symmetry, axial symmetry, and rotational symmetry are absolute invariant. Sphere occupies minimum space for the given volume of contents. Inside-out and outside-in phenomenon is possible by eversion of sphere. Sphere can be reduced to a point and a point can be enlarged to sphere. That is probably the reason why the histone in the nuclear chromatin is spherical in shape. Histone is outside the DNA-mRNA-Protein-DNA circularity. Recent research in cell biology suggests that the driver of DNA is in nuclear chromatin (Baumann, 2015, Therizols et al, 2014). Epigenetic mechanisms are wiser than genetic mechanism in nature! I leave this section asking a question for synthetic biology, Is it possible to develop such spherical proteins in vitro?

Such Ladder is everywhere in Science

The ladder of cognition thus described is not only confined to linguistic, human behavior or the cellular system. Because cognition forms the very basis of all disciplines of science, such ladder is identifiable in several other spheres of science. There is similar ladder of sensation perception, concept formation, hypothesis generation, theory development, paradigm emergence and worldview formation. In the science of logic, the ladder begins with the Boolean logic (of signal), and steps up to fuzzy logic (of information in mind), formal logic (during knowledge formation by self), inferential logic (in experience generation by life) and hermeneutics (of conscious systems), which includes non-verbal communication as well. Even in mathematics, we see a similar ladder of arithmetic (and algebra), geometry, symmetry, super-symmetry and the ultimate point of origin. Similar hierarchy is observed in the ladder of organized systems. There are signal-organized systems, information-organized systems, knowledge-organized systems, experience-organized systems and consciousness-organized systems. Computation includes encoding (identified pattern), recoding (dynamic transformation of one pattern to another pattern) and decoding (presentation of pattern) of signal. There follows the ladder then; from computation of signal to mentation (cracking the code by mind), to formatting in the context of the whole (self), to homeostasis of the systems with inside-outside synchronization (life) and development of connection with the world (consciousness). In hierarchy of nature’s currency too, parallel ladder exists; kinetic energy at the physical plane, potential energy (e.g., quantum potential, scalar potential) in intangible information plane, fields (e.g., quantum fields, scalar fields) studded with knowledge, manifolds stacked with experience, and finally at the deepest recess we find the originator medium, the ground. David Bohm’s quantum potential, Ma and Wang’s scalar potential (Ma and Wang, 2012) in the astrophysical realm are warehouse of information.

These ladders are not independent or exactly parallel to each other. All of the ladders are dynamic and intertwined with each other with several interacting points. These intertwined ladders in different domains of science could be of great help in developing a unified systems science.

Concluding Remarks and Perspectives

“Electrical and biological circuits are not directly parallel”. Therefore, we are to go beyond physical circuitry (Andrianantoandro, 2017). We are to find the layers in between. Traveling with such intention, this paper has laid down the roadmap beyond this circuitry and has offered the outlines of bioinformatics from the point of physical signal to subjective experience and universal wisdom. This is a journey from the obvious to the apparently impenetrable. Fulfilling its objective stated at the beginning, the paper offers a theoretical framework overarching cognitive apparatus, operations involved in the cognitive process and the object and products in the cognitive environment.

Information is a very important constituent of psyche. On the other hand, even for a physicist, the whole universe seems full of information! However, that is twenty first century’s dictation of science. Information is measurable. Anything that is measurable is *maya* (etymological root of *maya* is in measurement). Therefore, we are to look forward to the *source* of information. In nineteenth century, when the seer Sri Ramakrishna consciously touched Narendranath, who became known to the world as Swami Vivekananda, Narendra did not observe information every where! He saw ‘life’ everywhere. Everything, he felt, is full of ‘life’!

The source of information is 'life'. That is twenty second century's science. Life can't exist without consciousness. This consciousness has specific operations. That is twenty third century's science. We are working for three centuries ahead.

For the scientists working on consciousness, consciousness could be investigated as an operation, which is necessary and sufficient for transition of signal to information, information to knowledge, knowledge to experience and experience to wisdom, also the vice versa. Consciousness could also be identified as the operation, which takes care of operations of self, life and mind for total quality management of information within the system with minimum turn-around-time.

The narrative unfurls a spiritual dimension. For many of scientists engaged in consciousness study, unconditional consciousness is the God in science. We all living systems are conditional consciousness for a specific situation, and in fact we are extension of this One unconditional consciousness. That is why, the science for consciousness unfurls gradually through evolution and transformation of the scientists engaged in it. Obedience of conditional consciousness to absolute unconditional consciousness is essential for personal evolution and transformation of the scientist.

The narrative of the paper is multidisciplinary. The paper is potentially loaded with promises for future in cell biology, synthetic biology, bioinformatics, brain-behavior dynamics, psychology, psychiatry, artificial intelligence and bio-robotics. There emerges the broad outline of unified systems science. In the science of healing implications are in psychosomatic medicine, mind-body medicine, personalized medicine, life-style medicine or even complementary and alternative medicine.

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