On principles of consciousness - A novel hypothesis

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Abstract

Based on studies of activities in the diencephalon, the reticular, hippocampal formation and the workspace of the thalamus, it is important to accentuate the role of the latter as a pacemaker in creating thalamic activity and activation waves. The appearance of waves, synchronous oscillations and rhythmic activities in reticular-thalamic and limbic system lead to the majority of cortical activations. In addition, the role of myelin and myelin proteins in a cognitive model of conscious processes is perceived in a completely different light. Myelin is essential for normal functioning of the nerve fibers and crucial for activities and activations in the central nervous system - CNS. Understanding the thalamic-limbic activity and the thalamic dopaminergic system, the role of myelin and the relatively high content of myelin in the thalamic activation and processing system (in the thalamus, the hippocampus and basal ganglia) as the correlates of consciousness, is certainly a beginning for understanding the principles of consciousness.

Keywords
thalamic activity, limbic system, activation waves, myelin, myelin proteins, dopamine, thalamic dopaminergic system, electomagnetic interference, resonance and dopaminergic damping, action and associative action potentials;

ACTIVATION WAVES AND CYCLES

The exchange of energy states with waves created in the reticular-thalamic activation system – TAS and closed in the thalamic-limbic processing system – TPS (in the nuclei of basal ganglia, limbic system, the thalamus and the hippocampus) unfolds in the activation cycles. Because of constant causality in the wave patterns the retarded time, connected with the changes of energy states in the thalamic-limbic system, is taken into account: the beginning and end of every activation cycle. The epilogue of cortical activations and processing – in the time of the activation cycles – is a multiplication of action potentials into associative action potentials and the appearance of electromagnetic interference. The waves from the thalamic activation system combine with wave patterns mainly from myelin proteins. These are in sheaths or layers on protuberances of neuroglial cells surrounding neurites. Electromagnetic waves from stimulated myelin proteins (MBP) change (after final interference) the wave patterns, parts of wave sequences or fragments in activation wave. The common denominator of all interferences in cortico-cortical loops is the combination of electromagnetic waves with the patterns of activation waves, or rather, the recursive intake of inner experience into action and associative action potentials. Even though in research they are detected and defined as brain waves grouped in frequential ranges from delta (slow) to gamma (fast) waves, the inner experiences (25) and latently experience (from hippocampal formation) are wave patterns (wave sequences) in the wave energy, or rather the multitude of information according to which the motoric, sensory and psychic functions are performed. The formats of strengthenings (or weakenings) in wave patterns with constructive (or destructive) interference can be understood as “disturbances” in synchronous oscillations and rhythmic activities, but these same disturbances are inner and latently experiences or elemental information in the conceptuality of mental experience. Therefore, the very thing that develops in the “theater of consciousness” (3).

Activities in the diencephalon (1, 7) esent the correlates of consciousness. Reticular formations and the thalamic system create continuous rhythmic activities, synchronous oscillations that create the majority of cortical activations (28, 31). Myelination, the encircling of nerve fibers with myelin (myelin sheath, lamellas and fibers), enable cortical activations and transitional membrane potentials. The activities of dopamine DA receptors D2/D3 in the thalamic dopaminergic system (24) contribute to the final reenactment of experiences and sensations in the processing centers of consciousness.
The thalamus, the central structure of the diencephalon, is made of two oval and symmetric structures above the brain stem, between the cerebral cortex and mesencephalon. Thalamic nuclei – approximately 15 dorsal, ventral and reticular nuclei – are functional units or sections with extensive afferent influx of signals from sensory systems, as well as signals and activation patterns from cortical regions.
Stimuli (signals from the sensory system) are directed to cortical regions and entities in interferential currents, combined with activation waves in TAS. During the activation cycle (Figure 1) when the wave patterns are inert, they strengthen (or weaken) interferentially, change and supplement each other with inner experience. The patterns of inner experience in waves represent the multitude of information needed to perform psychic functions in the TPS centers.

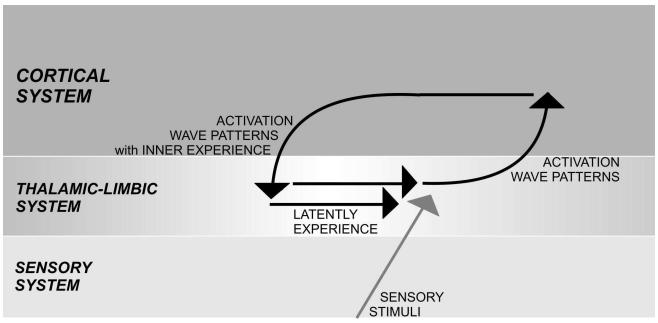

Figure 1 | *Representation of activation cycle.*

After distribution in the TPS centers and the transformation of inner experience and latently experience into mental experience, the remainder of wave again become, partly or

completely, a part or a sequence of the activation waves, the rhythmic activity in a new activation cycle.

ROOTS OF CONSCIOUSNESS

During the process of hominization, the evolutionary stage of Homo sapiens that is, incidentally, still continuing, the level of consciousness has continuously increased, man has cognized and understood easier the world around him, as well as himself and the world within him.
Man's bipedalism is one of the deciding factors contributing to the appearance and consequent development of consciousness. The pivoting point in the evolution of man was the descent of the spine from the occiput into the lower part of the skull (Figure 2). Along with the changes of the skull base and arch (because of increased volume) developed new, the youngest and still developing structures of the cortex in the evolution of the brain: the layers of neocortex.

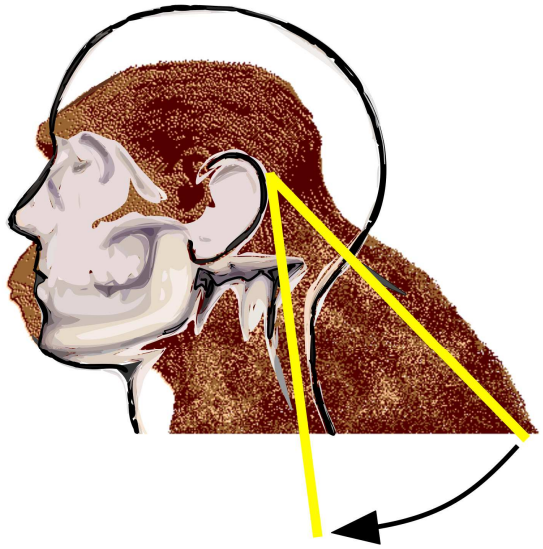

Figure 2 | *Movement of the head's centre of gravity (comparison between Homo erectus and Homo sapiens)*

This was followed by an expected simultaneous and appropriate level of neural pathways and myelination in every one of the six layers of the neocortex. Deformations in the throat and the windpipe enhanced the range of vocal chords and, what is even more important, the capacities for articulation, man got accustomed to breathing through the nose and mouth. Living in communities strengthened the need for man to express himself and communicate. In addition, the diverse nourishment enabled man to live and survive even after numerous cataclysmic events and in conditions of extreme climate changes. This diversity contributed to the intake of nutrients, even those the body does not synthesize (for example essential amino acids), which were primarily supplementary and later necessary.
The assumption is that primal fear as a negative feeling or psychic condition indirectly stimulated the appearance and evolution of higher psychic functions. These functions are in the domain of a group of biogenic neurotransmitters acquired during biosynthesis or decomposition of the "fear hormone":
tyrosine <> dopamine <> norepinephrine <> epinephrine.

FROM "ADEQUATE" TO "PERFECTED"

The structures in the diencephalon (thalamus, hypothalamus, basal ganglia, reticular and hippocampal formation, etc.) are primary and evolutionally the oldest structures of the central nervous system in vertebrates. They regulate and control the basic physiological functions and needs of the organism. The telencephalon constitutes of the cerebral cortex (cortex, neocortex, etc.), developmentally the younger structure exclusively acting as a support to the structures of diencephalon. This support is seen in the supply of the thalamic-limbic system with brain waves, in the cortical activations enriched with inner experience.
It is typical for the architecture of neurons and neuroglial cells in the neocortex to intensify the support of psychic centers from "adequate" to "perfected". Vertical creation of neural pathways between the layers is seen in the degree of signal treatment, or action potentials. Horizontal creation of pathways in one or more layers is seen in the degree of content entirety or complete information in the patterns of activation waves.
The degree of signal treatment in the activation waves and the preservation of the content integrity are critical for cortical activations and processes inside cortical regions.

ERTAS

The concept of the described model in cognitive neuroscience is based on the extended reticular-thalamic activation system or ERTAS (17, 18). This model refers to activities, stimuli and the activation waves (31) with its processing (the multiplication of action potentials into associative action potentials and the interference of electromagnetic waves). In a functional sense, this is an example of stimulative interaction (stimuli from the sensory system), activation waves (rhythmic signals from the thalamic-limbic activation system) and constant sampling (enriching) of waves with wave patterns of inner and latently experience (when appearing as wave interference). Signals from sensory fibers in the thalamus (with the exception of a few olfactory) "change" to the pathways of ERTAS activation waves. Sensory signals and the activation waves form an incessant energy current into the regions of the cerebral cortex. The energy current, processed and enriched with inner experiences in the cortex, ends its path, the path of the activation cycle, in the thalamic-limbic processing system.
This involves transmissions and interactive relationships in several anatomical structures closely related with behavioral and cognitive contents and with consciousness. This global workspace (12) includes not only the thalamus and its nuclei

but also the reticular formations of the brain stem and the mesencephalon (middle brain), basal ganglia, the corpus callosum and the limbic system with the hippocampal formation. It also includes the dispersed projection system with its fibers branched in the cortico-cortical connections in all parts of the cortex. Together, these structures represent the ERTAS processing platform.
ERTAS can also be understood as a global workspace of psychic functions interactively connected (because of inflow and outflow) with a sensory-motor systems and cortical regions. From this point of view, ERTAS has a key role in processes conditioned by consciousness (2).

The majority of activations are provoked by wave patterns (membrane potentials, action potentials) in the TAS activation waves. The flow of energy currents (through cortical loops) into the global workspace of the diencephalon is the beginning of the last phase of every activation cycle.
Basal ganglia, the thalamus and the hippocampus represent the core of the thalamic processing system (TPS), the system of psychic functions, and the modulation of consciousness.
Signals or energy currents from the cortex, received in the TPS and basal ganglia and directed to the thalamus (Figure 3), are subject to glutamatergic (glutamate), GABAergic (gama-aminobutyric acid – GABA) and dopaminergic (dopamine) transmissions.

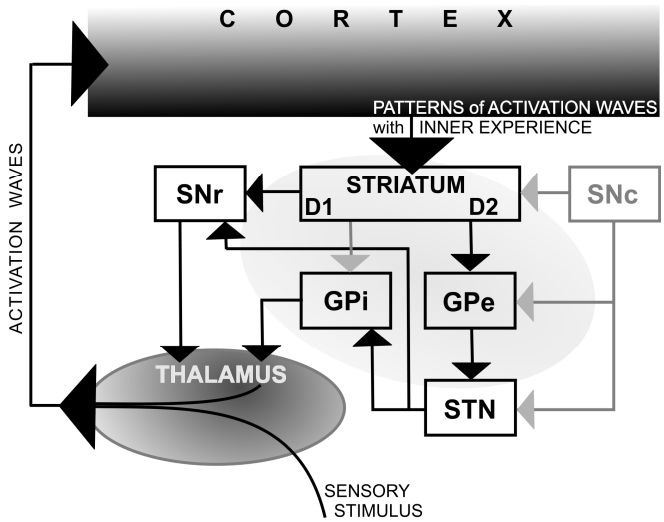

Figure 3 | *Diagram of connections in the thalamic processing system*

The TPS, through the entry nuclei of the striatum, accepts the activation waves with excitatory glutamatergic transmissions, but the thalamus accepts them strictly with GABAergic transmissions. GABAergic and cholinergic transmissions from the striatum and other nuclei of basal ganglia (outgoing nuclei: substantia nigra pars reticulata – SNr and inner globus pallidus – GPi), directed toward the thalamus, are subject to modulation (regulation) with dopamine D1/D2 receptors (4, 6, 26). More research about the distribution of dopamine receptors reveals a relatively high density in the nuclei of the thalamus and their heterogeneous distribution (20, 24). The research was made in vitro with an autoradiographic technique and with positron emission tomography (PET). This kind of density of D2/D3 receptors (mainly in laminas and influx nuclei) means that the majority of target or prominent projections in the thalamus are stimulated and regulated with dopamine.

WAVE PATTERNS FROM MYELIN PROTEINS

The cells of the central nervous systems (CNS) are neurons and specific neuroglia: astrocytes, oligodendrocytes in the CNS and Schwann cells in the peripheral nervous system (PNS). Neuroglia support and supply the neurons, maintain appropriate conditions for the transfer of signals in the synapses, which lies in the purview of astrocytes (32), but they also transfer, process and modulate the activation waves, which is a responsibility of the oligodendrocytes in the CNS or the Schwann cells in the PNS. The main function of oligodendrocytes is to direct the neurites (in the neuron development phase) and isolate electric impulses (action potentials). Oligodendocytes are the key cells in myelination of the CNS (33). Their protuberances make up the myelin sheaths surrounding the neurites or axons (21, 29). The process of surrounding the neurites (myelination) begins in the 15th week of gestation. After birth, as the child learns, recognizes and understands the world around them, the myelination of the brain unfolds. Myelination establishes and strengthens the foundation for inner experience.
Myelin sheaths are mainly made of lipid layers (up to 70-80 %) inside which are layers of myelin proteins (up to 20-30 %) of various structures and stadiums (10, 33). The role of lipids and the behavior of proteins in the myelin are an example of perfection in the functional sense. The necessity of myelin proteins, mainly MBP - myelin basic protein (16) in functional schemes of the CNS is based on their electric and electromagnetic properties. Electromagnetic waves from awakened myelin proteins indentify the inner experience. In the space surrounding myelin proteins – because of the electric charge and the movement of charges (triggered action potentials) – we find electric and magnetic fields.
Lipids in the sheaths ensure the perfect conditions for the protein activity and, furthermore, protect and keep the proteins in their original molecular structures. Lipids do not protect the proteins against wave motion from the environment, but they can prevent these very delicate molecules from changing structurally because of outside influences or contact with surrounding proteins. In the space around myelin proteins – because of electric charges and wave patterns in action potentials – form electric and magnetic fields. External charges (in neurites) combine with the charges of myelin proteins: proteins oscillate and create electromagnetic waves; these waves induce electric current. Stimulated and agitated proteins become the source of electromagnetic waves (Figure 4) with wave lengths

(amplitudes, wave frequencies) that are typical and unambiguous for every one of these molecules.

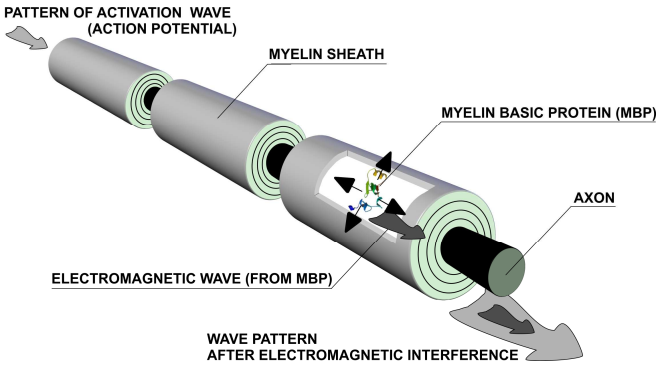

Figure 4 | *An example of electromagnetic interference on a neurite after the activation of a neuron*

Electromagnetic interference (15, 23) is a way of combining the waves from myelin proteins with the activation waves (action potential in wave patterns). Their electric fields combine and unite into a sort of resultative field on the principle of supposition. The end result is a new or changed wave sequence, a pattern in the activation waves. This difference can be identified as a "quantum" of inner or latently experience or as a BIT – a basic unit in the theory of information that is later, in combination with other inner experiences (as a group of bits or bytes), identified in the experience or consciousness. Heisenberg's uncertainty principle in quantum mechanics states that simultaneous determination of a particle's position and momentum with random accuracy is unreliable. Thus, the determination of position and momentum of a "pattern" in inner experience, acquired in wave patterns, is equally unreliable.

ACTION AND ASSOCIATIVE ACTION POTENTIALS

Action potential is a transitional change of an excited cell's membrane potential with characteristic phases of depolarization, opening of Na+ -ionic channels, sustenance of potentials above 0 mV (with Ca_2+ flowing into the cell and K+ flowing out), repolarization and stagnate membrane potential. After the action potential is triggered, begins the absolute, stagnant or relative refractory stasis. Refractory stasis results from the inactivation of Na+ -ionic channels. Stimulants in the activation waves following the triggered action potential cannot trigger a new immediate action potential.

Electric charge of myelin proteins is preserved and transported as an induced electric current in the myelin sheath and along the body of the oligodendrocytes, its cytoskeleton (structures of microtubules and microfilaments), toward other protuberances with myelin sheaths on temporarily inactive neurites (for example on account of refractory time). One oligodendrocyte can have up to 50 myelin sheaths surrounding neurites of several neurons in functionally same or neighboring cortical regions (5, 14). The electric charge is passed along synaptic channels (the space between the myelin sheath and the neurite) directly into a neurite, the body of a neuron, and continues its path along the neurites as associative (doubled) action potential (Figure 5). Nodes of Ranvier, places on a neurite between two neighboring myelin sheaths, assist in the depolarization because of its permeable polarization (the opening of Na+ -channels) and enable the orientation of associative action potentials – from the point of entry on the neurite into the body of a neuron – toward their endings.

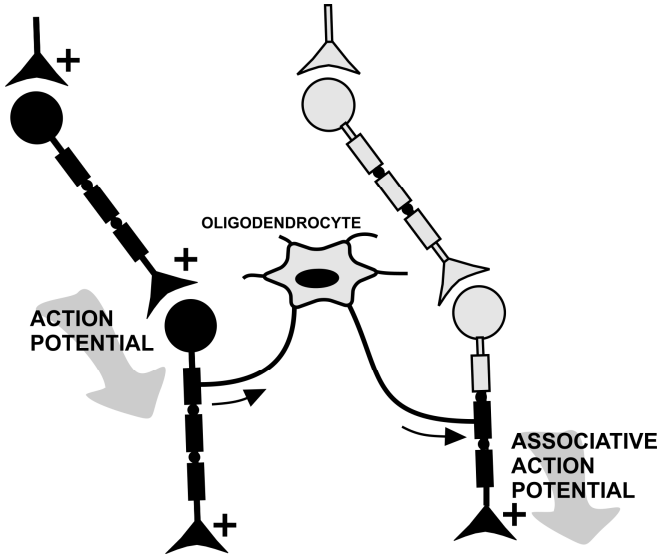

Figure 5 | *Example of action potential multiplication into associative action potential (along the oligodendrocyte).*

Triggering the associative action potential the Na+ and K+ -ionic channels concentrated on nodes of Ranvier create depolarization, a transitional change in membrane potential (13). The permeable polarization in nodes of Ranvier causes the obligatory transfer of associative action potentials along the neurite. Schwann cells on nerve fibers in the PNS have the same function as myelin sheaths and nodes of Ranvier in the CNS. Schwann cells maintain, directly channel (stimulating or impeding) and, in the electromagnetic interference, strengthen signals while they are transmitted.

The horizontal advancement of neural paths in the neocortex ensures the appropriate level of the contextual wholeness and completeness of information in the activation waves. Action potentials are distributed along small or large pyramidal neurons and travel along branched neurites to several targets (an example are centers of intermuscular coordination in the lower layers of neocortex). Doubling or multiplication of action potentials into associative action potentials corresponds to the level of contextual heterogeneity and extensiveness of inner experience in the activation waves. The wave pattern of one action potential is combined, in the activation waves of one or more

activation cycles, with contextually similar or completely different wave patterns of associative action potentials from the same or several different centers or regions of the cortex.

RESONANCE AND DOPAMINERGIC DAMPING

When "psychic" energy as a state in processing centers – the hippocampus and the thalamus nuclei and lamellas – is converted alternatively into chemical and thermal energy, respectively, and back into electric energy, the thalamic sections become a stage for experience, light and sound, smell distinction, feeling of fear and pleasure, dreams, imagination, thought, memories, etc.
Resonance is a systemic occurrence in the brain. It appears with the conversion of signals (after perception) in the sensory system and with the activation of wave patterns in the thalamic-limic activation system. It appears with the release of associative action potentials and electromagnetic interference in cortical regions, with the distribution of wave patterns from the cortex to the nuclei of basal ganglia, and at the conclusion of every activation cycle in the sections of the thalamus and the hippocampus.
Magnetic resonance (MR) imaging or functional magnetic resonance can record the activity in the "focal points" of cortical regions (11), where the processes of signal multiplication, the appearance of associative action potentials and electromagnetic wave interferences take place. Neurotransmitters like dopamine or acetylcholine maintain the circumstances in which the patterns of activation waves are transmitted and transformed. Dopamine is a pronounced stimulant and modulator of resonance and, on account of its metabolism, also its executor in the phase until final damping. Until the phase of final damping the dopamine decomposes (into homovanillic acid) and is secreted from the system. Low concentrations of homovanillic acid in the urine conclusively point to a disorder and a deficiency of dopamine in the CNS.

Resonances of dopaminergic inhibition are accompanied by seeming loss of energy. Alternating conversion of energy, with resonance in its complete or partial inhibition, creates electrical but also chemical and thermal energy. We can deduce that the effect of each of these forms of energy would leave permanent results in the cell infrastructure of the thalamus section or anywhere in the CNS. The strengthened waves (of electric charge and heat) would excessively heat the tissue in the immediate proximity. Dopamine stimulates resonance and can also simply "absorb" the converted thermal energy and keep its levels in the vicinity normal. Each resonance in the sections of the thalamus is enough to create one more inner experience. In the sections of the hippocampus is one latently experience more.
The environment of the dopaminergic system with D2/D3 receptors inhibits the secondary transmitters (19, 22, 30) and stimulates resonance. Dopamine decomposition in the dopaminergic damping regulates the duration of resonance or its decay rate, which the cells endure in an agitated state. This equals the time in the thalamus global workspace, when experiences are recreated through inner experiences.
If the decomposition of dopamine is disturbed, the decay rate or the decay time is extended. The presence of hallucinogenic substances (LSD) and psychostimulants: amphetamines, cocaine (8) hinders or extends the decay time of dopamine. When the decay time is extended, the resonances from cycles following each other are prevented, or are simply mutually negated before the decay time. The consequences of the first occurrence are seen as interruptions in thought connections or as a changing experience of time and space. In the latter occurrence the consequences are seen as disturbances of perception and partial or full disfiguration of objects seen.

PSYCHIC ENERGY IN EQUASIONS

The energy flow of the activation cycle determines the amount of transferred (changed for accepted and/or delivered wave patterns) energy with waves through the workspace of the thalamus and the hippocampus.
The differences in energy levels of the activation cycle are calculated: the starting level in TAS and the end level in TPS. The energy in TAS is the level of activation waves interacting with latently experience from the hippocampus and signals from the sensory system. The energy in TPS is the level with the inflow of wave patterns from cortical regions, caused with outflow of activation patterns from TAS. Along the activations are paths of wave patterns in TPS (through basal ganglia to the thalamus and the hippocampus) which can be excitatory (stimulative) or inhibitive (impeding).
Taking into account the retarded time, the prevalent amount of "psychic" energy (E_P) – which changes into experiences – is actually the difference between the energy levels of every activation cycle in TPS (E_{TPS}) and TAS (E_{TAS}):

$$\Delta E_P = E_{TPS} - E_{TAS}$$

In a state equal to the heaviest quantitative disturbance of consciousness (a state of coma) E_{TPS} would equal E_{TAS} and $E_P = 0$. The sum of energy in TPS is:

$$E_{TPS} = E_{TAS} + E_{SS} + \Sigma E_{ASP} + \Sigma E_{IE} + \Sigma E_{LE}$$

E_{SS} means the energy of signals from the sensory system, ΣE_{ASP} the sum of associative action potential energies, ΣE_{IE} the sum of energies from wave patterns with inner experiences and ΣE_{LE} the sum of energies from wave patterns with latently experience (Figure 6). E_{TAS} is continually changing while accepting E_{SS}, E_{IE} and E_{LE} at the same time E_{ASP} is changing while accepting E_{IE}. The quantity of psychic energy in resonance with full inhibition or in resonance with partial inhibition is:

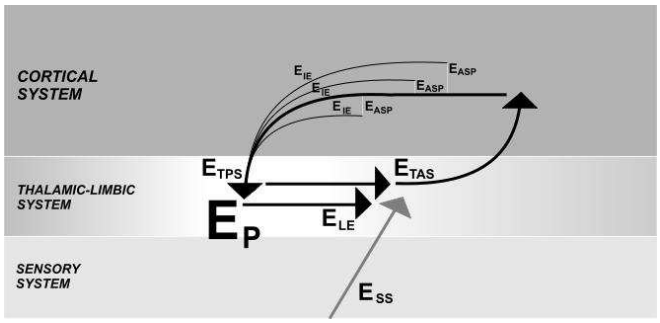

Figure 6 | *Energy levels in the activation cycle.*

The conversion of "psychic" energy or seeming loss of energy transforms the wave patterns of inner and latently experience into mental experience. After resonance a part of the energy of associative action potentials, signals and patterns of activation waves with inner experience and latently experience from the hippocampus is transferred into E_{TAS}, the energy of activation waves of the next activation cycle.

As the inhibition in resonances is usually incomplete (partial), a part of E_{SS} or E_{IE} remains integrated in the wave pattern of the next activation cycle. With this, new associative action potentials and wave patterns with inner experience – in a new cycle – are renewed or gained. These are upgraded experiences or feelings that began in the preceding activation cycle or cycles.

CONCLUSION

Speech and the use of language as a form of verbal communication, expression of thoughts and feelings, etc. are only reflections from a sequence of combinations, whose variables are wave patterns of inner experience. There are an immeasurable number of these variables constantly flowing in cycles through the processing centers of consciousness at any time. The fact is an identical vision of an experience or knowledge can never be recalled from "memory". Every attempt combines a different combination of inner experience variables into mental experience.

To say that consciousness is exclusively human is only marginally correct. The differences between motive quantities of proteins and other particles in TPS, or in the workspace of the thalamus, are reflected in different stasis or levels of consciousness. Among more important factors of these differences are the ability of neural matrixes, the degree of myelination, the quality of transmissions and quantity of neurotransmitters. Experiences gained during cognitive development that man uses every day enable the maintenance and preservation of the level of consciousness. The difference in the energy of an activation cycle between TPS and TAS (with or without E_{SS}) can also be determined in other organisms, especially in higher mammals; however, these differences are proportional with the number of associative action potentials and consequently also wave patterns with inner experience. Usually, those patterns prevail that are predicated with instinctual behavior or are the result of simulations and outside signals. Among those are also "disturbing" patterns from cortical activities that correspond to categories of inner experience. The number of these patterns with inner experience is negligible but not unimportant. The brain of higher mammals enables and ensures the support for different aspects of cognition and behavior, which would not only mean these organisms would be aware of their surroundings but also, under certain conditions, aware of themselves.

I would like to mention one last interesting tidbit connected with the thalamus and the thalamic activation system. Trauma to different anatomic or functional units in the CNS can lead to illnesses with neuropsychic disorders. Any trauma to the thalamus leads to the most advanced disorders of consciousness and coma.

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