

Body internal communication channels

(v.2.1)

Abstract

This paper describes basic aspects of body internal communication including neural and quantum channels. Quantum channels are viewed here as focused on mental (cognitive & psychological) activities that run in many brain regions using microtubules lying along axons. Neural channels deal with neurophysiologic signals passing thru neural networks "wired" with synapses. Potentiality of quantum activity is tremendous because important role of microtubules channel in such processes as cell motility, mitosis, intracellular and intercellular transport. A body communication run simultaneously over neural, quantum and biochemical spaces in endocrine system. They differ physically but functionally are complementary to each other. The question of cooperation needs a further research.

Keywords

brain2mind interface, brain interface, nervous system, neural networks, quantum space, entanglement, body communication channels, biological network, neural network, quantum network, microtubules, enteric nervous system

Inspirations from the past

Roots of quantum philosophy¹ could be find in the ancient world ("Soul of the World" Plato) and more recently in Carl Gustav Jung's theory of "collective unconscious".

Quantum field theory as the basis for an explanation of consciousness was applied in the 1960s by theoretical physicist Hiroomi Umezawa and results of it was called later QBD (Quantum Brain Dynamics).

Research [29] stated, that quantum mechanical phenomena such as quantum entanglement and superposition, may play an important role in brain's functions.

Self-organizing pathways in the neurobiological and quantum model of W.Freeman are accompanied by quantum transitions in controlling intentionality in brain [28,29].

The essential contribution to this subject is Penrose–Hameroff [23] quantum model of consciousness (called Orchestrated Objective Reduction - Orch OR) that recognizes gravitational collapse of the wave function as an occasion of awareness. Penrose & Hameroff claimed [17] that the consciousness should obey the rules of quantum mechanics: „our brains are composed of cells called neurons, and their combined activity is believed to generate consciousness. Each neuron contains microtubules, which transport substances to different parts of the cell. Microtubules are structured in a fractal pattern which would enable quantum processes to occur. This, they argue, could explain the mysterious complexity of human consciousness.“.

The Relational Block World (RBW) model of Stuckey [12,33] defines fundamental 'consciousness symmetries' as relational with quantum nonlocality feature. A nonlocality is a specific feature that cannot be associated with neural networks although the topology of them is changeable but would be known at a given moment (embedded plasticity when many changes of synaptic wiring between neurons are made in response to inputs and new experience).

Medical engineering seems to be the way to overcome a weakness of philosophical metapsychology in order to prove dualistic (spiritual and physical) nature of human. A good scientific environment for quantum research might be holistic approach embracing neuro-processes (neuroscience), somatic-processes, consciousness & subconsciousness. Such trend is visible in a phenomenology. [26].

The roadmap of research should probably include BQI (Brain Quantum Interface) equipped with high sensors medical devices capable to register quantum waves and microtubules streams. It is already known that quantum space strongly interferes with neural space because determines the shapes and properties of molecules like neurotransmitters and proteins, and these molecules affect how the brain works.

¹ without direct reference to quantum mechanics of course

It could be suggested that the both spaces are at least partially integrated because microtubules are located also along axons.

1. Notation

Notation used in this paper is based on OSL language².

<i>NQS - neural & quantum space</i>	
<i>channels</i> {: Σ <i>neural-network-layer</i> [Ξ - neurotransmitter flow, Φ quantum flow], ENS : <i>Enteric nervous system</i> , BL : <i>body-language</i> , ..}	
body-language (facial-expressions,body-posture,gestures,touch, eye-movement,..)	
Σ - neural networks, Q – quantum networks, Ξ layer	
Q[\approx <object>(ω_1 , ω_2)]	
BCC	<!Body Communication Channels>
Σ &Q?(CNS,ENS,PNS)	Nervous system
CNS	<!Central Nervous System>
ANS	<!Autonomous Nervous System>
ENS	<!Enteric nervous system>
PNS	<!Peripheral Nervous System>
\approx	<!quantum space>
ω	<! quantum entanglement>
$\omega_{(i ?)}$	<!partial entanglement>
$\omega_{(?!?)}$	<!total entanglement>
<i>Relations</i>	
\Rightarrow	<! mapping or multitracks>
\leftrightarrow	<!bidirectional passive unary relation 1:1>
\rightarrow	<!forward unary passive relation - no change of state>
\Leftrightarrow	<!complex or many to many active relations>
\Leftarrow, \Rightarrow	<! backward, forward active relations>
$\vdash, \ddot{\vdash}$	<!equivalent > <!belongs to>
/ &	<!or > <!and>
,... ,...	<!more , much more >
UUUU.xxxx	<!xxxx belongs to UUUU>
<i>Topology:</i>	
●	<!located in>
»«	<!outside>
{.[.(..).].}	<!nested list of items>
¥	<! output>
<i>Attributes:</i>	
	optional
±	replaceable
⊥	blocked
	isolated
?	questionable
#	<!number of>

2. Communication

Communication is the fundamental feature of human-being and includes variety of means: neural networks, peptides & quantum microtubules flow and maybe more... Electrochemical signals flow through neural networks has usually complex mapping and functionality³. A good example of the scale of communication is the largest transmitting cable (corpus-callosum) made of some hundred million⁴ axons, that links the two hemispheres.

A human being as a biological system is self-contained and equipped with advanced cognitive and physiological capabilities. It operates on-line (in real time) and is aimed to maintain stability (homeostasis) against the changes issued by the flow of matter and energy coming from internal and external environment. This stability works thru body sensors and internal body communication channels.

Sensors are widespread throughout the body including exteroceptors (contacting with the outside), interoceptors (detecting information from internal organs and processes) and proprioceptors (detecting sense of position and load). Receptors are the sensing elements that communicate a signal from the ligand to the cell to elicit a specific physiological response. A ligand is a molecule (*neurotransmitter, opioid peptide, hormone, etc*) that can bind to the receptor and produce a specific response.

```
{body-sensors[sight(eyes),sounds(ears),smell(nose),taste(tonque),pressure,itch,
  temperature(thermoceptor),magnetoreceptor,time-receptor,
  mechanoreceptor(body-position(muscle_sensors),muscle-tension(muscle_sensors),
    touch(skin),body-awareness(proprioception))
  <!mechanoreceptors respond to physical changes including touch,pressure,vibration,stretch>,
  balance(innerear),blood-acidity,pain(nociceptors),
  blood-hormones&drugs(chemoreceptors),],
  brain-sensors[neurotransmitter,neuropeptide,quantum-sensors,..]}
```

Perceptual system builds information from relations between sensory signals and actions, forming a structured (circular, dynamic) internal model in the brain. (Brette R.[39])

State and behaviour (feels,reactions) of human-being mostly depend on built-in DNA and ontogenetic experience saved as links in neural networks. According to E.R.Kandel [37] such gene products as mRNA molecules and proteins are delivered to the specific synapses whose activation triggered the gene expression.

“Engines” of human communication are related (or rooted) to consciousness, subconsciousness and ad hoc somatic response actions⁵, all anchored in central, enteric and peripheral nervous systems.

```
communication-engines[consciousness(mind,..),subconsciousness(instinct,intuition,..),
  cosmic-consciousness(astral-body)6]
communication-signal-type[(magnetic,electro-magnetic,electrical,chemical,enzymes,proteins,
  fluid/blood-flow,quantum-particle)
  messenger-molecule (transmitter,hormon,immunotransmitter, growth-factor,..)
  transmitter[peptide(neuropeptide#100),neurotransmitter(#60)]
```

Peptides play also important communication role as hormones and a type of neurotransmitters. Peptide signals play a vital role in cell-to-cell communication associated with such behaviours as maternal behaviour and pair bonding, heart rate regulation, food intake and growth, gut & muscles modulation and many others. Hormones facilitate communication between various parts of the body—including tissues, muscles, nerve cells, and organs. Neurotransmitters are signaling molecules that transmit messages specifically from nerve cells to their targets, including other nerve cells, muscle cells, or glands.

3 Important function of controlling many organs is performed by peptide and quantum networks.

4 200-250 million nerve fibers (axonal projections)

5 In this paper we dont touch body defensive actions in case of inflammation, injury etc.

6 Hypotetical assumption - *Might be the case of entanglement* -inspired by Hugh Everett concept of „Many-Worlds”[18]..

Neuropeptides are chemical messengers made up of small chains of amino acids that are synthesized and released by neurons of the central and peripheral nervous system. Compared to brain neurotransmitter in micromolar size neuropeptide nanomolar signaling is more sensitive. Peptide cell-to-cell communication is triggered by depolarization of the cell and then peptides are released thru dense core vesicles. Neurotransmitter also needs action potential and its job is to carry signals from one neuron to the another nerve cell (modulatory neurotransmitters can send messages to many neurons at the same time), a muscle cell or a gland.

Quantum processes in a human-being body are the part of biological computation capable to process many different types of “data” (analog with different substances) dispersed over the body and noisy [27]. A crucial role in this variety play information transducers encoded in the limbic-hypothalamic system. They transform information from one form into another one, particularly encode the phenomenological experience of “mind” and emotions into the hormonal “messenger molecules” of the endocrine system. This limbic-hypothalamic system filter coordinates all the major channels of mind-body regulation via the autonomic, endocrine, immune, and neuropeptide systems. Messenger molecules (neurotransmitters, hormones, immunotransmitters, etc.) flowing through these channels are the structural informational mediators of mind-body communication and transformation [36]

According to resonance theory of consciousness it acts using a specific mechanism of electrical synchrony and shared resonance of gamma, beta and theta waves that leads *micro-conscious* entities to combine into *macro-conscious* entities and allows different parts of the brain to achieve a phase transition in the speed and bandwidth of information flows between the constituent parts\ [34]. It is similar to neural network technology of “all or nothing way” principle when connections are made by activation of neural circuits (neurons⁷ or fields⁸) having required action potential.

The quantum school explains consciousness by applying quantum theories and explains that consciousness has a quantum origin, is non local and creates our perceived reality from vibrating entities that can have multiple versions based on the observer's perception.[22]
A_consciousness is a very complex function acting by several cognitive information flows: associative, reflexive, perceptual, emotional, verbal, analytic. It constructs complex changeable networks. Subconsciousness and cosmic-consciousness could base (*hypothetically*) on quantum mechanisms of superposition and entanglement.

Body internal communication is ruled in such way that the “army” is dispersed but “commanders” have been precisely located. Each part of the body has its own ‘control center’ [21] that is responsible for its functions:

[movements(motor-cortex),voluntary-movement(frontal-lobe),
involuntary-function(brainstem),pain&sensations(sensory-cortex),
judgment&foresight&sbmell(frontal-lobe),
language-comprehension(parietal-lobe),speech(Wernicke’s-area,Broca’s-area),
hearing&intellectual&emotional-functions(temporal-lobe),
visual-functions(occipital-lobe(primary-visual-area))
swallowing&breathing&heartbeat&wakefulness-center(brainstem)]

The “objects” capable to drive thru that dispersed “territory” are the mind and consciousness.
mind[wisdom(thinking,reasoning,learning,recognizing,communication),knowledge,...]

3. Nervous system

{[nervous-system(CNS,PNS,ANS)
CNS(brain,spinal-column)
<!spinal-column/cord carries signals between the brain and the rest of the body>
ANS(ENS:EntericNS,SNS:sympatheticNS,PNS:parasympatheticNS)
ANS(vagus(heart-rate rythm,“face-heart connection”, "fight or flight" behaviors,...))

7 MUA and SU signal aquisition

8 LFP signal aquisition

ENS-neurons(sensory,motor,inter)
PNS(ventral vagal system,dorsal vagal system/dorsal motor nucleus,..)
PNS-neurons(ventral-horn neurons,dorsal-root ganglion neurons,..) }

Relation between central, autonomous (vagus plays main role⁹) and peripheral systems is bidirectional.

CNS \Leftrightarrow (\approx , Σ) PNS

ANS(vagus) \Leftrightarrow PNS

The motor vagus nerve constitutes the main peripheral neural structure of PNS twchich consists of fibers that innervate smooth muscle cells of internal organs, vessels and exocrine cells in the lung, the heart, the gastrointestinal tract, the pancreas, the liver and more.. Vagus transmits parasympathetic signals to and from the heart, lungs, and digestive tract. PNS consists of nerves coming from CNS (brain & spinal cord) to body parts. ENS is capable of operating via the vagus independently of the brain and spinal cord. It controls the motor functions of the system and secretion of gastrointestinal enzymes.

ENS is the area of communication between the brain and the gut via both the neuronal communication and hormone release. Sensory cells in the gut influence hunger and satiety. [38]

Body internal processes, including communication, are the part of behaviour processes.

{behaviour processes[thinking,emotions,info-retrieval,memorizing,intuition,communication,..]
emotion(love,hate,satisfaction,frustration,agression,enjoyment,anger,fear,regression, inferiority,..)}
communication[(internal,external(individual,social))]

The base for communication are bio-physiological systems. For example the endocrine system releases hormones that travel via the bloodstream to different organs to regulate metabolism, growth, mood, and other key aspects of mental and physical health.

body-internal-communication

{ communication-space[waving-space(quantum-space,..),wiring(neural-networks,..)
physiological-channel(peptide-flow,..),genetic-channel(genes-network)]
signaling_molecule[#60-100(acetylcholine,glutamate,y-aminobutyric-acid,glycine,oxytocin,endorphins,
adrenaline,cortisol,dopamine,estrogen,gherin,growth-hormone,insulin,melatonin,
ytocin,progesterone, testosterone,vasopressin,serotonin,..)]
signal[electrical,magnetic,electromagnetic(photon,..),chemical,natural,..]
mode[network-layer(single,multi),signal-stream(single,multi),neuro-thread(single,multi)]
<!The neuron's cells are arrayed in layers. The topmost layer provides feedback from other cortical regions,
the lower two layers (filled with pyramidal cells) handles the long-distance communication> }

According to Rossi E.L.[40] the mind is closely connected to genes and according their rules sends neural-messages from the limbic-hypothalamic system to endocrine system to take such actions as metabolism, growth, activity-level, sexuality, immune-response .

mind-genes connection[neurohormonal-messenger-molecules \Rightarrow steroids-hormons \Rightarrow genes expression]

Brain

A brain is the most important, interesting and mystic organ of human-being. Researchers have been trying to explore this "territory" by means of brain-machine/computer-interfaces (BCI) and by an investigation of biological neural networks using artificial mathematical models.

A BCI is currently defined as "a system that measures central nervous system (CNS) activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output "[3]. This is an independent of peripheral nerves and muscles output pathways channel for controlling a device through neural signals to perform dedicated tasks. [14]

BCI can be defined, in short, as a neural control interface (NCI) based on medical devices.

brain[forebrain,midbrain,hindbrain]

forebrain[thalamus,hypothalamus],basal-ganglia(caudate-nucleus,putamen,globus-pallidum),
cerebral-cortex]

9 Polyvagal theory (1994 S.Porges) appreciates the role of the vagus nerve in emotion regulation, social connection and fear response,

midbrain[tectum,colliculus(superior,inferior),tegmentum,substantia-nigra]
hindbrain(brainstem:reptilian-brain,cerebellum,medulla,pons)
brain-area[cortical-region,subcortical-region,nucleus(clump/layer)]
subcortical-region[thalamus,globus-patlidus,putamen,substantia-nigra,corpus-striatum,..]
cerebral-cortex:neocortex[lobe(frontal,parietal,occipital,temporal)]
cortical-region[primary-visual,entorhinal,inferior-temporal,orbitofrontal,
lateral-prefrontal,inferior-parietal,..]
functional-cortex-area(visual,sensory,tactile,auditory, ..)
somatosensory-system[subsystem1(touch,pressure,pain,tickle,itch,vibration,temperature,
proprioception,kinesithesis),subsystem2(sight,hearing,taste,smell)]
multifunctional-cortex-area
[limbic-system(amygdala,hippocampus,hypothalamus,septum,cingulate-gyrus)]
A limbic system is involved in the regulation of emotion, but affective processes spread out also on ventromedial regions in the prefrontal cortex.

neuron {[soma-nucleous(mitochondria,membrane,cytoplasm,vesicle,perycarion),
myelin-sheath,schwann-cell,axon,dendrite],
#active-synapse(connections),synapse(excitatory,inhibitory)
<!synapse is a place where signals are modified by weights>,
activity-level(input,trigger,conduction,fire-output) <!actual function of neuron>
<!receives many signals, outputs signal to one or many neurons>,
input(electrosignal,chemical-pharmacological,natural-signal(light,sound,pressure,..)]
form(multipolar,bipolar,unipolar),creation-type(primary,new-born,»mirror¹⁰)}}

brain-basic-function[sensory(vision,hearing,smell,touch,...),
motor(eye-movement,voluntary-movement, ..)]

brain-mental-function{
mental-basic-function(association,speech,emotion,language-comprehension,coordination,...),
mental-complex-function[consciousness(self,..),cognitive-activity,wisdom,intuition,.].
cognitive-activity(attention-coordinating,decision-making,movement-selection)
mental-hidden-function(intuition,premonition,..)}

mapping[engine \Rightarrow view, view \Rightarrow engine]
view{natural[electrophysiological,biochemical,psychophysical,..]
conceptual(semantic,psychological,mathematical,ontological,..)]
engine[thinking,emotions,info-retrieval,memorizing,communication,...]
communication[comm-layer[stream[message(carrier,protocol,pattern),signal]]]
signal(electrical,magnetic,electromagnetic(photon,..),chemical,natural),

BN- biological-network specification:

type(neural,,biochemical,species-interactions,species-interactions,..)
biochemical(metabolic(quantum(intercellular,..),protein,gene,..),
species-interactions(food-web(preypredator)),host-parasite networks),
space(intracell,intercell,regional,multiregional,dispersed,...)
regulatory-biomolecules(enzymes,proteins,...)..
micro-part[neuron,synapse,receptor,unpaired-electron,neurotransmitter,gliacell,
photon,microtubule-associated-protein,..]
quantum-stream[cellular-microtubules(photons,unpaired-electrons,...)
quantum-actions{[cell-actions(motility,mitosis,transport(intracellular,intercellular,..)],
[molecules-action(shapes&properties of neurotransmitters&proteins)]}}

Microtubules are quantum channels being in dynamic turnover state, subject to treadmilling and dynamic instability.

10 "copy" from outside (during communication with another person)

4. Mind

A mind is closely related to consciousness. This relation is of tricky type: "mind is part of consciousness but consciousness transcends mind" [11]. Another view may see the consciousness as the "self" or visible (readable) part of the mind.

Locations of emotions and a mind are spread over the brain. A limbic system ring-like placements concern several areas in the cerebrum (cingulate gyrus, orbito-frontal cortex, parahippocampus) as well as a number of sub-cerebral structures such as portions of the thalamus & hypothalamus, the nucleus accumbens (in the basal ganglia), the septal nuclei and the amygdala.[5]

A remembering has also extensive environment. The hippocampus receives input from virtually all cortical areas including the hypothalamus, amygdala and ventral medial prefrontal cortex.

Mind capabilities are clearly expressed by such personal features as:

- wisdom: right assessment, choice of solution,
- ability: tough minded/open minded, creative, fast/slow, tolerates disorder/perfectionistic, grounded/abstracted, improving own learning, problem solving, IQ,
- assertiveness, creativeness, independence, stability, leadership.....

brain \Rightarrow **mind-functions** *<!brain to mind mapping>*

somatosensory-cortex,..) \Leftrightarrow [process sensory information(smell,taste,sight,sound)]
hippocampus¶hippocampal \Leftrightarrow [memories(form,organize,consolidate,retrieve)]
hypothalamus \Leftrightarrow [emotions(hunger,thirst,chills,pleasure,pain,..)]
<!hypothalamus is a connector between the endocrine and nervous systems>
prefrontal-dorsolateral cortex,corpus-callosum,orbitofrontal \Leftrightarrow consciousness
corpus-callosum \Leftrightarrow unity of consciousness
orbitofrontal-cortex & limbic system \Leftrightarrow "self"-identity
limbic system \Leftrightarrow emotions

mind-functions \Rightarrow **brain** *<!reverse mapping>*

process sensory information(smell,taste,sight,sound) \Leftrightarrow lobes of the cerebral cortex
memories(form,organize,consolidate, retrieve) \Leftrightarrow hippocampus¶hippocampal
endocrine&nervous systems connection \Leftrightarrow hypothalamus
consciousness \Leftrightarrow [prefrontal dorsolateral cortex,
corpus callosum(unity of consciousness),orbitofrontal("self" identity)]

Brain neural networks definition

Σ globalNS(CNS,PNS,AMS(ENS)) *<!global network system>*.

BNN{(corpus-callosum,visual,memory,basic-functions,retina,language,social,..)¹¹

[nerve-tracts(commisural•corpus-callosum,association•hemisphere),
projection(cortex \Leftrightarrow subcortical structures)]

Σ/Q corpus callosum[Ξ/\approx left cerebral hemisphere \Leftrightarrow Ξ/\approx right cerebral hemisphere}
<!essential for integration of cognitive and emotional functioning>

Σ visual[Ξ retina(Ξ photoreceptors, Ξ interneurons, Ξ ganglion-cells)
 \Rightarrow Ξ thalamus(messages) \Rightarrow Ξ visual area •occipital lobe]

<! puts together the color, motion, orientation, depth information to "see" the image>

Σ memory(Ξ hippocampus \Leftrightarrow Ξ parahippocampal)

Σ basic-functions(Ξ medulla \Leftrightarrow Ξ spinal-cord) *<!swallowing,heart rate,breathing>*

Σ social(Ξ medial-prefrontal-cortex \Leftrightarrow Ξ posterior-superior-emporal sulcus)

Σ language {left-hemisphere[lobe(temporal,occipital,parietal) \approx convergence(auditory,visual,sensory)]

\yenarrowright (Ξ wernicke's-area,broke's-area,..) [right-hemisphere \approx feature-of-speech(emotional,prosodic)]}

Σ motor/muscles¹²{primary-motor-cortex[tract(dorsolateral:pyramidal,ventromedial)] \Rightarrow spinal-cord, }.

11 some of widely known brain neural networks.

12 [14]

Σspatial-attention(posterior parietal cortex,frontal eye fields)¹³
 Σface-recognition(middle-cortex, temporal,temporopolar cortex)
 Σself(posterior-cingulate-cortex,medial-prefrontal-cortex,inferior-posterior-lobe)¹⁴
 Σconsciousness(?posterior-cortex/?prefrontal-cortex/?thalamic-reticular-network)

Brain interface

We suggest to distinguish two kinds of neural interface: very known BCI (interfacing to devices) and BM_dI (interfacing to mind). The first deals with physiologic signals and the second one with mental and psychological phenomena. BCI could help in diagnose and treatment of many impairments using effector devices (computers, game, wheelchair, speech-synthesizer, assistive-appliance, neural prosthetics,..). BM_dI is in predefinition state yet, but would play the important role in treatment of mental disabilities. These two interfaces are complementary and show two sides of the same thing.

BCI <1Brain Computer Interface>

category[(unary,multi/hybrid),(med-standard-device,biologically-interfaced-device(PSbased,..))]
hybrid(multi-brain,multi-device(multi-sensory-stimuli,multi-modal-signals),...)
action-type(active,reactive,passive,..) *standards*[IEEE(...),ISO(....),..]

bci-operating-schema[*SourceObject*,*stream*(*message*), /*amplifier*,*transducer*,*control-interface*,
user-device-dedicated-applications,*ReceivingObject*(*action*,*reaction*),*summary-report*]

SourceObject{[unary(*personId*)/multi(*groupId*)]*cortical-region*[*layer*]/
cytoarchitectural-map(#52-electrode-placement-code),*signal-capture-device*}
transducer[(*signal-acquisition*,*preprocessing*(*artifact-noise-removal*,*filtering*,
feature-extraction(AR,ARR, *neuron-firing-rate*,*potential-amplitude*,...),
classification,...),*output*(*classifier label*¹⁵,..)]
 <!noise-sources(*neural*,*non-neural*(*eye-movement*,*muscular-movement*,*electric-line*)>
 <! due to the eye blink movement, a spike is formed in the signals>
control-interface(*encoding*(*logical_symbols LS*=>*semantic_symbols SS*),*feedback*)
filtering[of(*amplitude*,*latencies*,*frequency*(*theta*,*beta*,*alpha1*,*alpha2*,*gamma*),*uncorrelated signals*..),
method(*band-pass*,*recurrent-quantum-neural-network*,*statistical*,*Fourier-Transforms*,..),
*spatial filtering method*¹⁶(CAR, PCA, ICACSP, *surface-Laplacian*,*bipolar reference*)],
 <!for spatially distributed signals>,
statistical(PCA<!Principal Component Analysis>,ICA<!Independent Component Analysis> ..)]
classification[*training of classifier*(EM,..),(*clustering*(*class*,*multiclass*,*nonclassified*)),
method(*regression*,*derivative-approximation*,*Bayesian*,*Fisher*,*loss-function*,*LDA*,*SVM*,*HMM*,
neural-network(*semipartial-recurrent*,*convolutional*),(DT(*ZeroR*,*1R*,*divide&conquer*,),
k-NN,*NB*,*RBF*,*SVM*,*LogReg*,*Ada-Boost*,*Bagging*,*Stacking*,*RF*,*Boosting*)¹⁷..)],
ReceivingObject[*effector-device* /& *computer*,*human-object*(*feedback2*(*brain*,*limb*,...))]
action[*stimulation*(*muscles*&*nerves*), *mental-typewriter*,*cursor-move*,*speller*,*game*,*painting*,.
device-commands(*neuroprostheses*(*artificial limbs*),*wheelchair-control*),...]
stream{(*signal-source*,*signal-capture-device*)<=> *receiver/device*},
 [message(*signal*(*impulse*)),*flow-type*]
stream-parameters[*standard*(*type*,*id*, *encryptionCode*,*securityCode*,*timeStamp*)
 extended(*timeInterval*,*duration*,*populationShape*,*dynamics*,
dispersion,*measureUnit*,*accuracy*,*disturbance*)],
stream-trigger/actuator(*event/erp*,*time*,*demand*,)... }
 <!stream is one/multi-channel collection of messages directed to one receiving device>

13 [15]

14 [16]

15 represents the identification of brain pattern

16 [2]

17 [19]

<!message is one-channel sequence of signals issued at a given time >
message[cp,data]<!cp:comm:communication protocol>
comm-protocol(tcp/ip,udp,i2c,spi,can,hart,ethernet,wifi,rf,bluetooth,nfc,satellite,6lowpan,
mqtt,zigbee,coap,z-wave,uart,modbus,device-embedded,BCI-p,HL-7...)
session[session-mgr,..](run1(stream1),run2(stream2),...)
operating-mode(training,testing,working,...)
standard-device-function(recording,diagnosis,monitoring,treatment,alleviation-assistance, .).
device-category(signal-aquisition,effector,...)
signal-aquisition(EEG,MEG,PET,fMRI,DTI,NIRS,EOG,EMG,sEMG,ECG,EcoG,SPECT,TMS,...)
signal-type[(magnetic,electro-magnetic,electrical,chemical,enzymes,proteins,fluid/blood-flow),
electrical(SCP,P300,N2pc,N400,SSVEP,SSEP,SMR,c-VEP,...)
potential(ERP(P300,P100,P50,..),SCP,TTD),EEG(SSVEP,SCP,..)]
medDevice-feature{[signal-aquisition-method,communication(embedded,external),
software(embedded,external)] [triggered-by(event,time,demand, ...),
link-mode(<=>,<= , => , ← , →)]}
signal-aquisition-method[sensor(electrode/optrode(type)¹⁸,CT(X-ray),MRI(magnetic-resonans),
NIRS(resonance of oxygenated&deoxygenated haemoglobin)-used in cortical tissue,
fMRI(mri+blood-flow,oxygen level) used to measure neural activity throughout the brain,
DTI(mri+water molecules),EEG(electrical waves)...),
placement(cortical-region/point-of-contact/placement-code/..)
[invasive(greymatter)/semi-invasive(above-cortex,beneath-duramater)/non-invasive(skull),
invasive(inside-of-skull,intracortical),semi-invasive(EECoG,..),
noninvasive(EEG,MEG,PET,fMRI,NIR,..)]
medDevice-category[stationary,mobile(bluetooth,wifi,internet),stand-alone(touch,cable)],
medDevice[signal-aquisition,assistive-device(muscle-detection (eye-movement-EOG,
facial-muscle-EMG,..),neuro-headset,neuroprostheses(robotic-limbs,..),
orthosis(hand-grasp¹⁹,cursor-control²⁰ . .).)]
mobile-medDevice[smartphone,wearables(smartwatch,smartband,headset,...)],
medComputer(classic-comp,bio-comp,quantum-comp,bio-hybrid-comp,...)
effects(direct-effects,side-effects..),contraindications,precautions,patient-state(before,after)],
risk-of-use(risk-classes),conformity(ethical-directives,standards,technical-requirements),
directives-standards(ISO(14971,13485),IEC62366,Regulation2017/745,HF/UE,..)
embedded-software(pacemaker,noise-artifact-removal,frequency-filtering, ...),
noise-artifacts(movement-related,eye-blinking,teeth-grinding,the heart-related,...) ,
[for each mode(training(user.neural-network,classifier),testing,working)
operating-protocol(initialization/activation,parameters-setup(for feature extraction,
signal-translation,classification,..),error-recognition,output-distribution]

mapping(<engine => view> /& <view → engine>)

engine[thinking,emotions,info-retrieval,memorizing,intuition(trust,love,hate),
communication,total-brain,.....]
view{natural[electrophysiological,biochemical,psychophysical,medical,..]
conceptual(semantic,psychological,mathematical,ontological,..)}

emotionEngine => psychologicalView

emotionEngine[frontalLob,hypothalamus,limbic-system,..]
psychologicalView²¹[love,hate,satisfaction,frustration,aggression,enjoyment,anger,
fear of insupport,regression,inferiority,persecution]

totalEngine => medView <!total engine refers to the whole brain>

totalEngine(brainArea/neural network-area,disease-brain-pattern)
medView(disease(neurodegenerative,neurological,..),injury,
neurodegenerative(dementia/alzheimers,parkinsons,huntingtons,..),

18 optrodes -sensors built using liquid crystal and integrated optics technologies

19 in a tetraplegic patient

20 P300s are turned into mouse pointer motion

21 psychological view seems to be located at least partially in quantum space.

neurological(autism-spectrum,tumor,migraine,multiplesclerosis,epilepsy,stroke,..)

totalEngine =>/ → ontologicalView

totalEngine(brainStructure,brainContents)
ontologicalView(brainId,brainAging(neurons(#dead,#born²²,#total)),diseasesHistory,
brainVolume-dynamics(curve,...),brainUsage)

totalEngine =>/ → energeticView

totalEngine(brainStructure,brainContents)
energeticView(brainId,power-consumption vs aging,power-supply-disturbances)

totalEngine => mindView <!total Engine refers to the whole brain>

totalEngine(neural networks,mind-pattern)
mindView[(active/passive),(medical,logical,semantic,psychological,mathematical,ontological)]
mindEngine[thinking,emotions,info-retrieval,memorizing,intuition(trust,love,hate),
communication,..]

Concluding remarks

Body internal communication channels are based mainly on peptides channels and pathways of nervous system, including neural and quantum activities. Each communicating part of the body has its own 'control center' responsible for its functions (e.g. movements, judgement, emotions, hearing, seeing, breathing...). Majority of them are under control of such qualia as consciousness, subconsciousness and mind. Activities rely on the assembly of interconnected networks and embedded plasticity of brain working when many changes of wiring in synaptic coupling occur to get new experience.

A great attention in communication channels area has been paid to neural networks, but more to discover is in the quantum communication. An investigation of neural networks helps to understand the brain functionality and behaviour but there is need of wider approach. Good question is how deeply wave quantum processes interact with classic physiological channels (neural, peptide,..). All biological processes are quantum molecular in nature and quantum "space" could be considered as the real lowest level of execution of "everything".

A complexity of brain networks is very high (almost hundred billions of neurons & trillions of connections) and activity of them is classified as a biological computation. Connections are made by activation of neural circuits (neurons²³ or fields²⁴) having required action potential (or nothing way) and triggered by many events (emotion, motor imagery signals, narrative speech, stress, psychotherapy, medications internally acting mostly thru biomolecules²⁵). A response from the target cell is such as the generation of an action potential, the contraction of a muscle, the stimulation of enzyme activity and chemical, electrical and blood flow changes. Neurons are able to fire either in a burst (after a period of hyper-polarization) or a tonic manner. Active neuron is alive neuron - making connection or being connected is for the neuron a question "to be or not to be".

22 "there is evidence suggesting that neurogenesis of nerve cells takes place in the dental gyrus of the hippocampus in adults" [38]

23 MUA and SU signal aquisition

24 LFP signal aquisition

25 enzymes, proteins

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