

Body internal communication channels

(v.1.6.)

Abstract

This paper¹ describes certain (sometimes hypothetical) aspects of body internal communication including quantum and neural channels. Quantum channels are viewed as focused on mental (cognitive & psychological) activities that run in quantum space in many brain regions. Neural channels deal with neurophysiologic signals passing thru neural networks "wired" with synapses. Potentiality of quantum activity is tremendous because important role of microtubules in such processes as cell motility, mitosis and intracellular transport. A body communication run simultaneously over neural and quantum networks that differ physically but functionally are complementary to each other. The question of cooperation of these two types of network needs further research using quantum sensitive medical devices. It is not clear how that interaction is realized - do the both networks act in hybrid mode within one common strongly integrated area or are synchronized at the final output of communication event.

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 philosophy 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.

We should mention here also the neurobiological and quantum model of W.Freeman, in which self-organizing pathways are accompanied by quantum transitions in controlling intentionality in brain [28,29].

Another essential contribution to this subject is Penrose–Hameroff quantum model of consciousness (called Orchestrated Objective Reduction - Orch OR) that recognizes gravitational collapse of the wave function as an occasion of awareness. [23] Penrose & Hameroff claimed 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. “[17].

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.

¹ This paper is closely related to the paper „Brain to Machine-Computer-Mind Interfaces (Reflective remarks)”
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It is already known that quantum space strongly interfere with neural space because determines the shapes and properties of molecules like neurotransmitters and proteins, and these molecules affect how the brain works.

1. Notation

Notation used below is based on OSL language².

<i>NQS - neural & quantum space</i>	
<i>channels</i> { Σ neural-network-layer [Ξ - neurotransmitter flow, Φ quantum flow], ENS :Enteric nervous system, BL :body-language, ..}	
body-language (facial-expressions,body-posture,gestures,touch, eye-movement,..)	
Σ - neural networks, Q – quantum networks, Ξ layer	
Σ (Ξ (I,M,O) <! I,M,O -input,middle,out>	
Q[\approx <object>(ω_1 , ω_2)]	
BCC	<!Body Communication Channels>
Nervous system	$\Sigma/Q?$ (CNS,ENS,PNS)
CNS	<!Central Nervous System>
ANS	<!Autonomous Nervous System>
ENS	<!Enteric nervous system>
PNS	<!Peripheral Nervous System>
\approx	<!quantum space>
ω	<! quantum entanglement>
$\omega_{(?)}$	<!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>
$:$ $::$	<!equivalent > <!belongs to>
$/$ $\&$	<!or > <!and>
$,\dots$ $,\dots$	<!more , much more >
UUUU.xxxx	<!xxxx belongs to UUUU>
<i>Topology:</i>	
\bullet	<!located in>
$\gg\ll$	<!outside>
{.[(..).].}	<!nested list of items>
\mathbb{Y}	<! output>
<i>Attributes:</i>	
	optional
\pm	replaceable
\perp	blocked
	isolated
?	questionable
#	<!number of>

2. Communication

“Engines” of human communication are related (or rooted) to consciousness, subconsciousness and ad hoc somatic response actions³, all anchored in central, enteric and peripheral nervous systems.

communication-engines[consciousness(mind,..),subconsciousness(instinct,intuition,..),
cosmic-consciousness(astral-body)⁴]
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. 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 in *SDMLB* (State Dependent Memory Learning Behavior) 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 (neurons⁵ or fields⁶) 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:

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

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

5 MUA and SU signal aquisition

6 LFP signal aquisition

[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 only “object” capable to drive thru that dispersed “territory” is the mind.
 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(EntericNS,sympatheticNS, parasympatheticNS)

parasympatheticNS(ventral vagal system<!social engagement>,dorsal vagal system/dorsal motor nucleus,..)

ANS(vagus(heart-rate rythm,“face-heart connection”, "fight or flight" behaviors,..))

ENS(neurons(sensory,motor,inter)..,)

PNS(ventral-horn neurons,dorsal-root ganglion neurons,..)

}.

Relation between central, autonomous (vagus plays main role⁷) and peripheral systems is bidirectional and includes probably quantum as well as standard neuron actions.

CNS <=>(≈,Σ) PNS

ANS(vagus)<=>PNS

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.

Brain

A brain is the most important, interesting and mystic organ of human-being. Resarchers 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]

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,

⁷ Polyvagal theory (1994 S.Porges) appreciates the role of the vagus nerve in emotion regulation, social connection and fear response,

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(mithochondria,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,»mirror⁸)}}

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),

communication-layer(single,multichannel)

neurotransmitter[#60(acetylcholine,glutamate,y-aminobutyric-acid,glycine,oxytocin,
vasopressin,endorphins,serotonin,dopamine,..)]

BN- biological-network specification:

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

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

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 \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 \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,..),..]

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prefrontal-dorsolateral-cortex \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 specification

BNN{(corpus-callosum,visual,memory,basic-functions,retina,language,social,..)⁹

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

Σ motor/muscles¹⁰ {primary-motor-cortex[tract(dorsolateral:pyramidal,ventromedial)] \Rightarrow spinal-cord, }.

Σ spatial-attention(posterior parietal cortex,frontal eye fields)¹¹

Σ face-recognition(middle-cortex, temporal,temporopolar cortex)

Σ self(posterior-cingulate-cortex,medial-prefrontal-cortex,inferior-posterior-lobe)¹²

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

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 seems to be 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,

9 some of widely known brain neural networks.

10 [14]

11 [15]

12 [16]

feature-extraction(AR,ARR, neuron-firing-rate,potential-amplitude,...),
classification,..),output(classifier label¹³,..)]
<!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 method¹⁴(CAR, PCA,ICACSP,surface-Laplacian,bipolar reference)],
<!for spatially distributed signals>,
statistical(PCA<!Principal Component Analysis>,ICA<!Independent Component Analysis> ,..)]

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,..]
psychologicalView¹⁵[love,hate,satisfaction,frustration,agression,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,..),
neurological(autism-spectrum,tumor,migraine,multiplesclerosis,epilepsy,stroke,..))

totalEngine =>/ → ontologicalView

totalEngine(brainStructure,brainContents)
ontologicalView(brainId,brainAging(neurons(#dead,#born¹⁶,#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,..]

13 represents the identification of brain pattern

14 [2]

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

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

Concluding remarks

Body internal communication channels are based mainly on peptides and nervous system, including neural and quantum activities, that are main flows of central body operating system. Each 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 consciousness, subconsciousness and mind.

A great attention in communication channels area has been paid to neural networks, but more to discover is in quantum communication. An investigation of neural networks is necessary to fully understand the brain behaviour. This task may be helped by mapping some supposedly separated brain neural networks into artificial ones that could be done successfully, while "screening" the whole brain (or dispersed area like limbic system) to the assembly of interconnected artificial networks is a very complex task due to complexity and embedded plasticity of brain when passing many changes of wiring (a synaptic coupling) between neurons in response to inputs and new experience. Examples of interdependent neural networks are networks of spoken language and motor control.

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 (neurons¹⁷ or fields¹⁸) 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 biomolecules¹⁹). 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".

17 MUA and SU signal aquisition

18 LFP signal aquisition

19 enzymes, proteins

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