Poster ID 128

Physical measurement of brain perception abilities. Foundations of a working methodology for the design of "intelligent" beings

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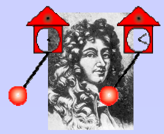
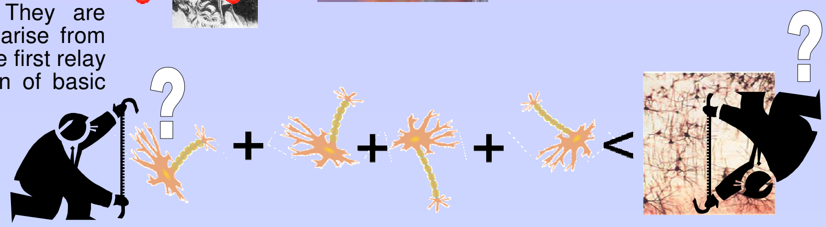
1. Rationale:

- Important attributes like consciousness, satisfaction or comfort are severely ill-defined.
- Mental phenomena (Thinking, Consciousness, Creativity in music or art, Personal judgments, Moral) can't be measured at the scales of cell-organization-to-tissues or tissue-organization-to-organs
- They are not the output of some individual biological sensor nor simple combinations of different types of sensors. They are emergent properties of the brain. Emergent properties arise from dynamic interactions between neurons, probably since the first relay stations of the sensory pathways where the recognition of basic physical properties of the incoming stimuli takes place.

Coordinated clapping in a theater after performance



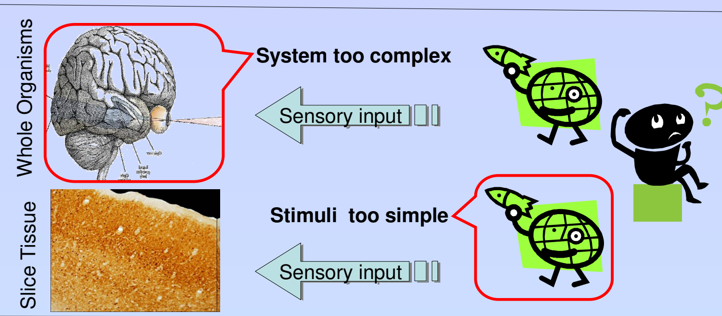
Emergent properties in Complex Systems: A complex system is a system composed of interconnected parts that as a whole exhibit one or more properties not obvious from the properties of the individual parts."



2. Goal:

Bridge the methodological gap posed by the difficulty in physically measuring mental phenomena to determine the level and organizational complexity required to artificially implement "intelligence"

Methodological gap: In whole organisms we observe mental activities. But as complex phenomena arise from an extremely complex neural structure with complex interactions, we don't have powerful enough tools to grasp them, i.e., to break down the minimal necessary components. In simple systems i.e. tissue slices or limited brain regions, no mental functions can be observed even if they potentially exist because no such function can be stimulated by the simple experimental inputs used and only signal transduction through the tissue is observed.



3. Rationale of the Approach:

- Rather than breaking neural tissue, synthesize it to design an experimental "brain" with gradually increasing (and controlled) levels of structural and functional complexity
- Measure/Define intelligent behavior in tasks that arise from environmental actions (nontrivial electrical stimuli) that are fully controlled and have a degree of complexity equivalent to that of the designed neural tissue.
- A qualitative jump in the response of our brain at a certain level of complexity will indicate emergence of a new property.

4. Expected Impact: If we succeed in synthesizing gradually more and more complex neural tissues then:

- We could explore what degree of complexity in the tissue structure (number of neurons, density and topology of the neuronal connections or even the synaptic communication between structurally different neural tissues) is needed to make emerge real properties like perception or intelligent behavior (Definition of Neural Substrates of Perception)
- We could relate the processes of perception to specific structures/functions of the neural tissue and
- We could measure perception using physical variables either at neuron or at network level in terms of connectivity, number of nodes, electric activity, Ca++ fluxes, metabolism,. etc.

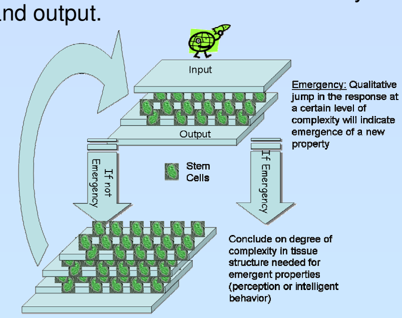
5. Methodology: Definition of physical substrates of perceptual processes and quantification and measure of perception by direct measurement of physical quantities using three-dimensional neural networks generated "in vitro" from embryonic stem cells.

6. Status of the work

- we have defined the requirements of the system
- we are working in the design of the whole application and
- **we are looking for the best partner for "in vitro" 3D neural tissue building.**

5.1- System Design: Design of an in vitro three-dimensional neuronal network with real neurons generated from embryonic stem cells seeded in porous biomaterial supports that are placed in perfusion bioreactor systems for long term viability. Design and development of two opposite surfaces in contact with microarray electrodes to be used as input and output.

5.2.- System Training: Train the neuronal network during development with neurotrophins so that specific spatiotemporal electrical signals in the input are memorized and later recalled.



5.3- Input Complexity: Upgrade of the complexity of the spatio-temporal input signals and evaluate the capacity of the system to respond specifically after the training.

5.4- Multiple Memories: Evaluate the ability of the system to store in memory two or more signals taught sequentially. Determination of memories interference, and memories intentionality and relation between these in terms of input signal correlations).

5.5- System Analysis: Biochemical examination of the expression of proteins participating in memory. Electrophysiological examination of the formation of activated neurons pathways during training. Analysis of spatial distribution of synaptic connections during the stage of training. Analysis of the characteristics of the output signals.

5.6- Design Criteria for Perception: Correlation of system analysis with system performance for the evaluation of the relative importance of the design parameters to the system performance.

5.7- Definition of Neural Substrates of Perception: Determination of the degree of complexity in tissue structure needed to make emerge real properties like perception. Determination of the relations between perception processes and specific structures/functions of the neural tissue. Measurement of perception using physical measurable variables either at neuron or at network level.