The Imperfect Recognition
- Chaotic and Recurrent Mechanisms in High Level Vision

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Introduction: Experimental Findings

Based on experiments with visual evoked responses, I showed in a previous paper that the cognitive activity of the brain can be objectively evidenced as distinct from perception by means of the *variability pattern* (VP) of a group of evoked responses (ER): in normal subjects the evoked potentials present in the first 300-500 ms after visual stimulation a characteristic dispersion, a *variability pattern* reflecting a chaotic activity. VP is related to the stimulation event and not to some random background activity of the brain. In patients with major cognitive impairments the VP is absent: *No cognition --> No variability pattern.* Two of my conclusions were (a) that VP reflects the *cognition* function as distinct from the phenomenal perception in the visual process and (b) that the neuronal cognitive activity has a *chaotic* component, responsible for the VP.

Interaction of Perception vs. Expectancy

In the present paper I propose a model of the recognition process, explaining among others *why* the above-mentioned neuronal activity would be chaotic and *how* the neuronal populations involved in "high-level vision" (i.e. at the transition from perception to cognition) would interact in order to perform the process of recognition.

The recognition includes a comparison between the attributes of an object or visual scene *perceived* at present and the attributes of that or another object or of a cluster of objects *memorized* in the past. (For both categories, "object" means here "neuronal counterpart of an object".) If sufficient attributes *A1,A2,A3....* (colors, contours, size, position relative to the horizon etc.) are coincident, the recognition is sucessful and the presently seen object is identified, recognized. If not, confusions, omissions, optical illusions may appear.

An indispensable concept related to recognition is the *expectancy*: a present object is not compared with all of the unnumerable memorized objects, but with a subset related subjectively to the present circumstances of the perception: if we are looking at a text, we expect to recognize letters and digits; if we are looking along a road we expect to recognize cars, and so on.

The recognition is represented here as a chained activation of the neuronal populations, driven recurrently by the exogenous *perception* of visual attributes and the endogenous *expectancy*. The chaotic component of the visual responses can be sufficiently explained by a variable, unpredictable sequence of attribute processing.

Besides experimental data, the model is based on the following ideas supported by current litterature:

Different neuronal populations activated in the process are working in parallel, but *asynchronously*; there is no pacemaker to synchronize them.

- Recognition is not an instantaneous, sudden event, (in spite of the subjective impression), but a process with a 300-500 ms duration.
- Although the sensory information arrives from retina in a continuous flow, the recognition is not a continuous process, but repeats itself *cyclically*, with the above-mentioned period.

The Mono- and Multi-Attribute Recognition

The model includes:

- a *mono-attribute recognition loop* of neuronal populations driven by (a) the perception of the attribute and (b) the memory-based *expectancy*, and interacting via excitatory and inhibitory synaptic signals ;
- a short-lived (300-500ms) recurrent chain of mono-attribute modules which performs the *multi-attribute recognition* ;
- a *chaotic* module selector which determines for each recognition instance the order in which the mono-attribute modules will be chained.

In the mono-attribute loop, the perception signal is *excitatory* (in terms of synaptic action), while the expectancy signal is *inhibitory*. The diagram and equations of their interaction represent a special case of feedback loop and explain the recognition of a specific attribute, as well as the effects of surprise, habituation and learning.

The multi-attribute recurrent process includes the chaining of a few mono-attribute loops and represents the build-up of a normal recognition process. Illusions and pathological cases (hallucinations, forms of agnosias) might correspond to the severance of the synaptic connections or to the selective deficiency of inhibitory or excitatory neurotransmitters.