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Expected cortical measurements in the context of the Theory of neural Cognition

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Abstract:

The TnC offers a framework related to how the cortex allows cognition to occur. It states many things that could be measured and should be verified:

1. *The cortex is made of a hierarchy of cortical maps (about 600 of them).*
2. *Any map has bi-directional connections (up and down) of about the same importance. Upward connections are more focussed when compared to the backward connections.*
3. *The self-organization of the cortical maps during development (from infancy to adulthood) obeys a strict order: firstly the primary sensory cortex cortical maps, then the secondary cortex cortical maps and finally the associative cortex cortical maps.*
4. *Primary cortex maps are modalities dependent, secondary cortex maps allow the fusion of several modalities and associative cortex maps are modality independent.*
5. *Each map acts as a novelty filter, allowing only new 'information' to pass to the higher levels.*
6. *The number of events required to organize a two thousand macro-columns cortical map is estimated to be around one million.*
7. *Extra-ordinary situations, when processed by an (already) organized cortical map, activate macro-columns at the periphery of the map.*

Others predictions are made referring to the neural causes of mental diseases, but are out of today measurement technology.

Presentation:

The Theory of neural Cognition states that the cortex is a made of hierarchy of cortical maps (fig. 1).

The hierarchy level is given by the number of intermediate maps between the sensory inputs maps (primary cortex) and the given map (fig. 2).

Each map is self-organized through the inputs it receives. The number of events necessary to organize a map is estimated to be 100 times its number of mini-columns A map of 7 cm^2 contains about 1.6 million mini-columns (*i.e.*, a diameter of 70 10^{-6} m per mini-column). Each mini-column is composed of about 100 neurons, which allows for a 'continuous' activity of the mini-column (where the maximum frequency of a neuron is about 10 Hz, with a refractory period of 9 ms). There are as much forward connections (from sensory inputs to higher level of abstraction) as there are backward connections (from higher level of abstraction maps towards primary cortex area). The backward connections are supposed to be less focused than the forward ones (fig. 3).

Forward connections account for the exo-geneous attention, where the backward connections account for the endo-geneous attention. An organized cortical map exhibits only very localized - but strong - activities, compared to diffuse and mild activities (fig. 4).

Pairs of maps act like novelty filters. Only 'unknown' events are passed to the next level of abstraction. Known events are events which have been thoroughly experienced by a given pair of maps. In this context, 'thoroughly' means more than a hundred times. Unknown events refer also to the context in which the event is experienced: any time, there are predictions about what will be the next map activation, if the prediction matches the received inputs, then it is filtered (stopped). If the inputs were not predicted then neural activities keep going and reach the next level. The predictions are made by pre-activation of neighbor mini-columns of the present activity at the highest organized level (*i.e.*, map) (fig. 5).

Backward connections help to spread this pre-activation to the lowest levels, where it helps filtering the events. It is a similar mechanism that achieves endo-geneous attention. The neighborhood property of the cortical map (conservation of the input space topology) edicts that about 80% of the received events will be filtered (and 20% will continue). Therefore, it is possible to predict the relation between the number of organized neurons (*i.e.*, cortical maps) and the number of events experienced by the cortex owner (human and animal). This relation follows an exponential curve with a quick increase at the beginning of the life and an asymptote as soon as the individual starts avoiding risk (i.e., novelty) (fig. 6).

The first maps to organize belong to the primary cortex and imply only one sensory modality per map, then maps belonging to the secondary cortex are organized and involve inputs from at least two primary maps (in case, two different sensory modality: fusion). The last maps to organize belong to the associative cortex and account for abstraction levels 3 to 10 (there seems that there is not enough life-time to organize more than 10 levels of abstraction). The number of levels of abstraction can be deduced from the time required between sensory input and a cortical map activation. Since, there is no difference of neural processing between low and high level maps, this relation is directly proportional (fig. 7).

There is also a direct relation between the number of organized maps and the level of abstraction achieved by the highest map. (fig. 8).

Education being by definition progressive learning of unknown, but more and more complex relations between events. A qualification of the novelty of a given event (for a particular individual) can be estimated by the level of abstraction its neural trace will reach. This relation is direct and straightforward (fig. 9).

The degree of 'emotion' related to an event is directly proportional to the distance between its neural generated activity on the highest map and the center of this map (fig. 10).

All figures are available at:

`http://gsite.univ-provence.fr/gsite/Local/umr_6149/umr/page_perso/Touzet/Publi/Touzet-EWCBR-2011-ppt.pdf`