

Ecole Polytechnique - Ecole Centrale-Supélec

- CERVEAU ET COGNITION

COGNITION VISUELLE

ET ARCHITECTURES DE CALCUL NEURONAL

Yves Frégnac

Emeritus

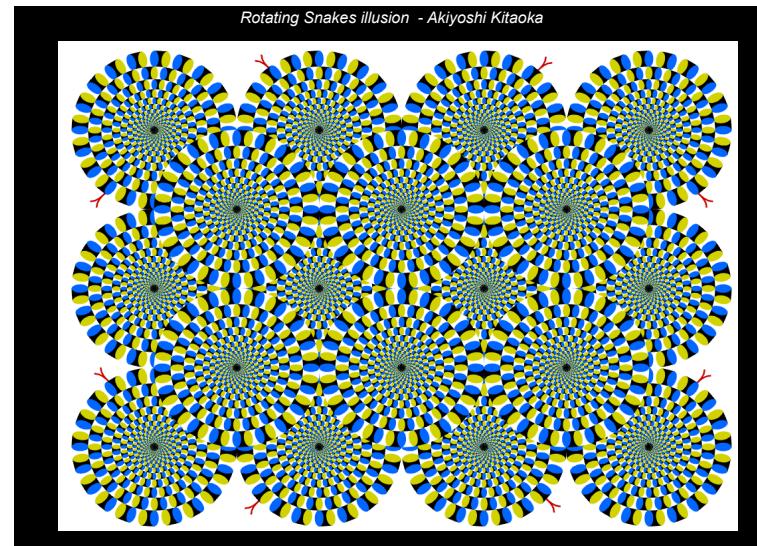
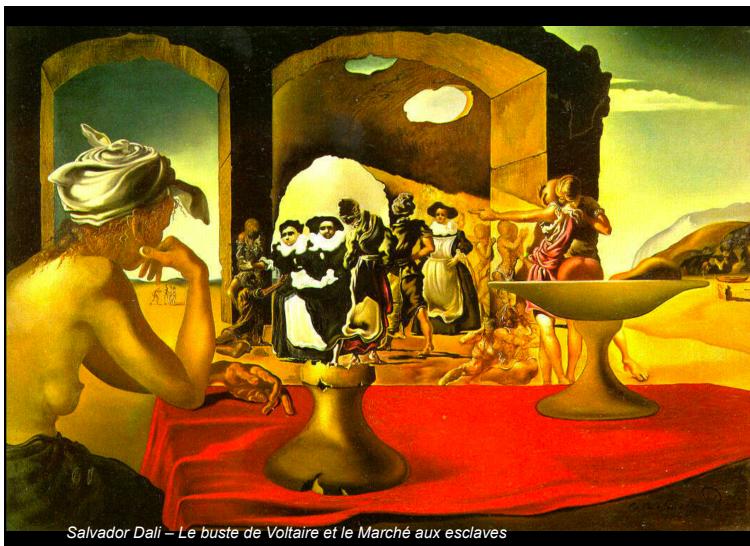
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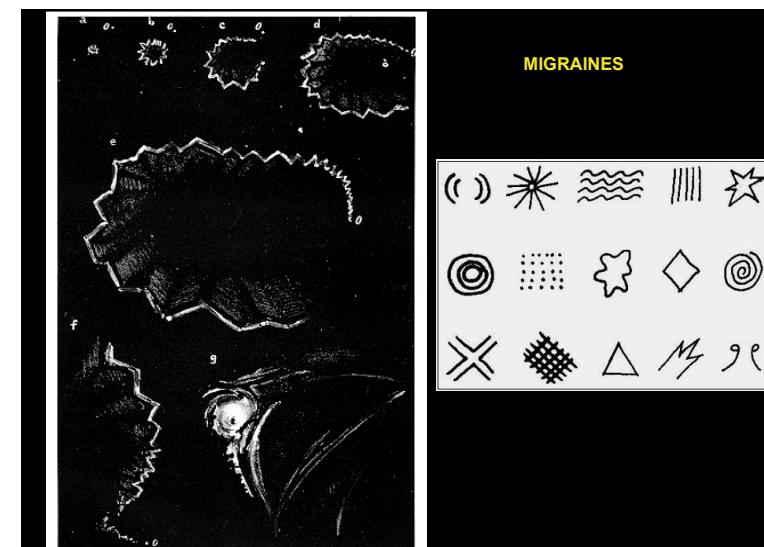
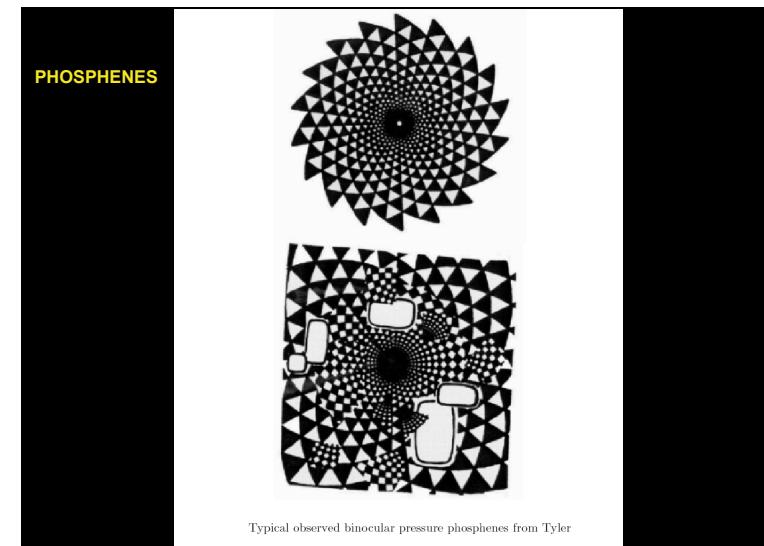
A detailed 3D rendering of a brain slice, likely a coronal section, showing various colored regions and neural structures. The image is filled with intricate purple and black lines representing neural pathways and cell bodies. A prominent yellow-green region is visible in the center-left, possibly representing a specific cognitive module or model. The overall image is a complex, artistic representation of brain architecture and computation.

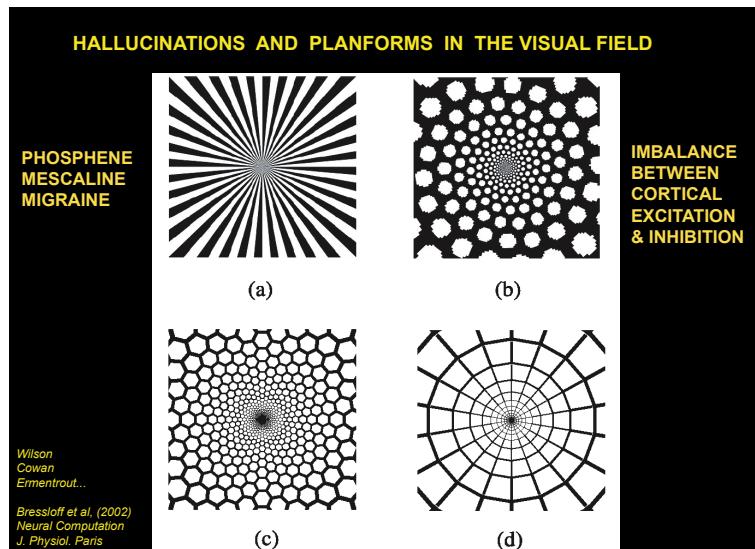
By courtesy of Eb Fetz



Architectures Cognitives Visuelles

- Hallucinations et Vision entoptique
Evidence pour une architecture mésoscopique régulière
- Le Cortex « Cristallin » :
Colonnes (orientation), bandes (ocularité) et hypercolonne
- Le Cortex « Liquide »
Architectures de Lien, Propagation et Théorie de la Gestalt
- Le Cortex « Volatile »
Complexité des états dynamiques, Chaos déterministe et Images naturelles



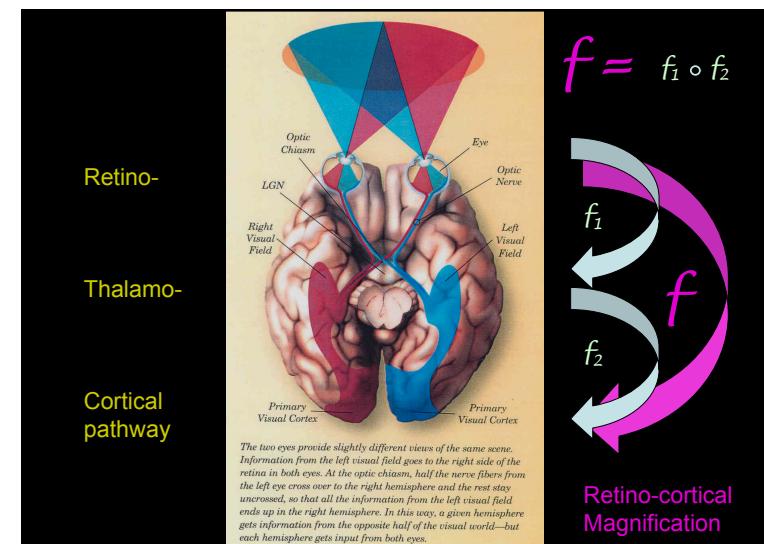
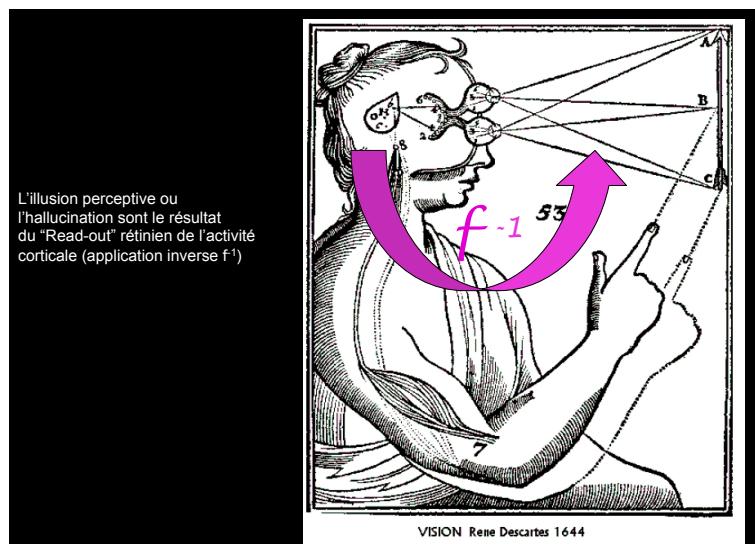


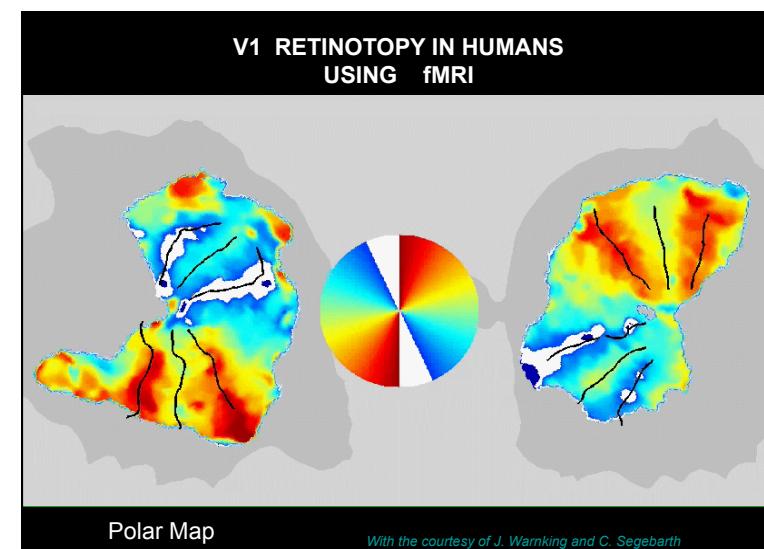
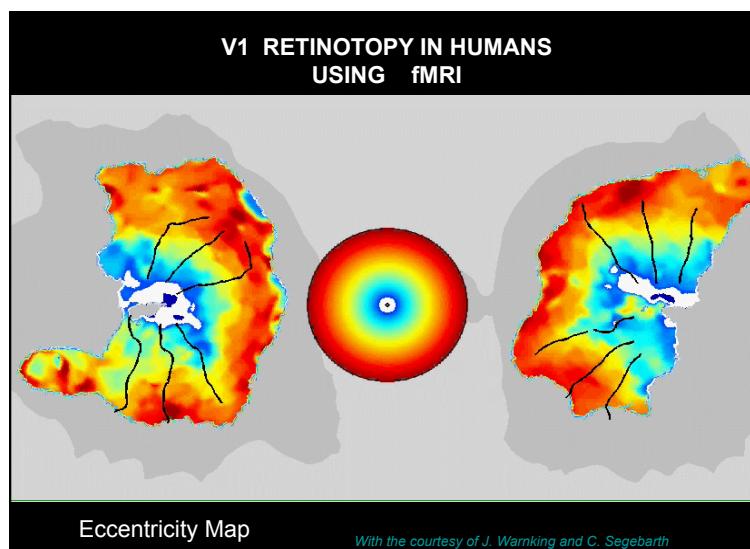
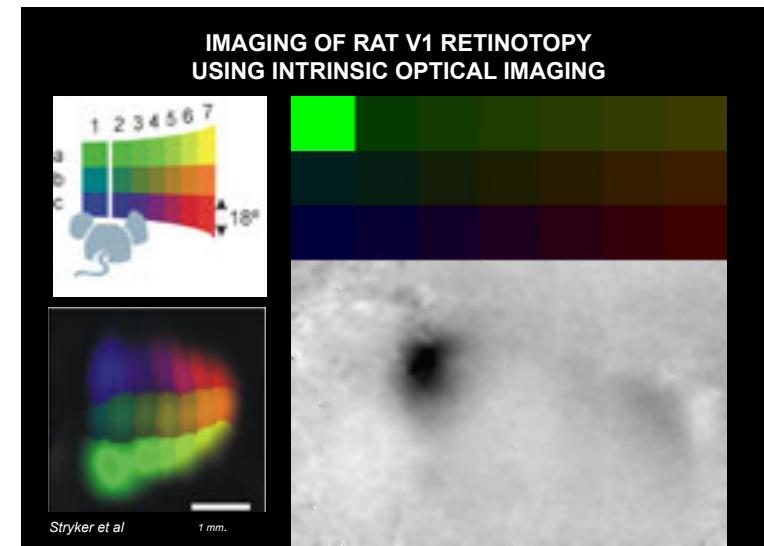
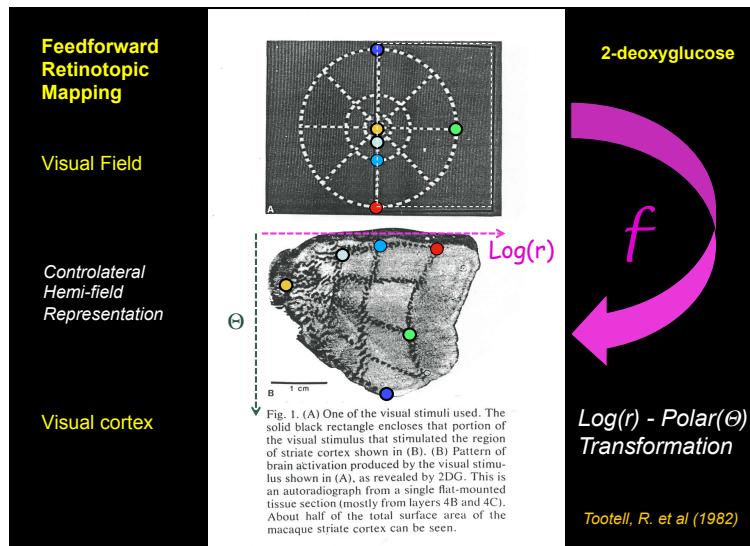
Perceiving the inner architecture of the visual brain

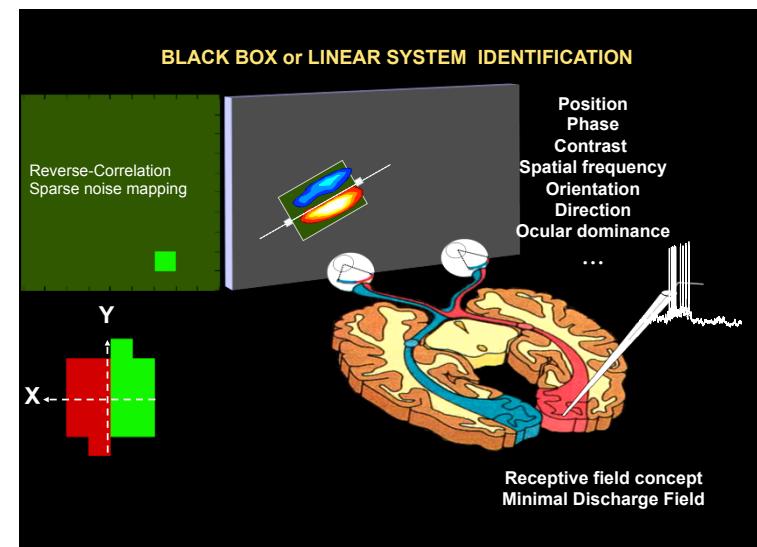
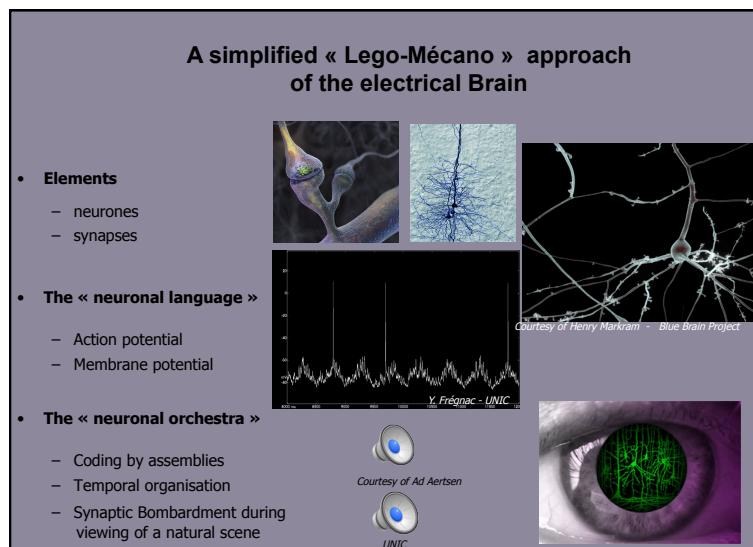
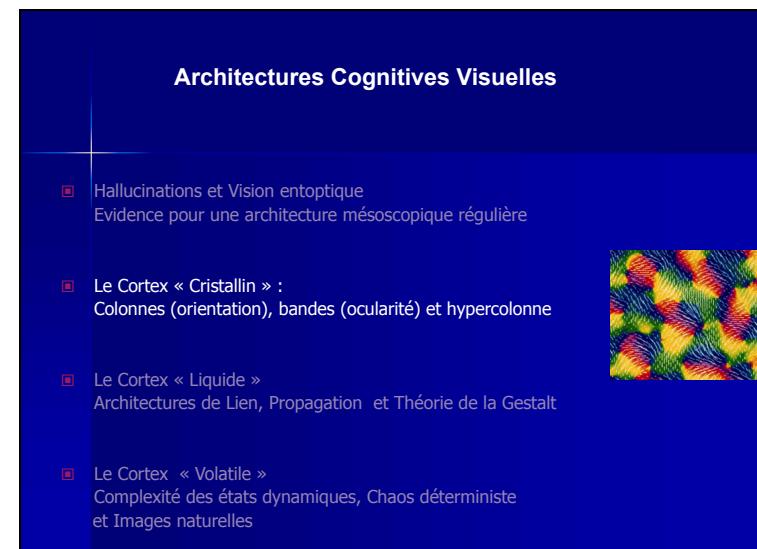
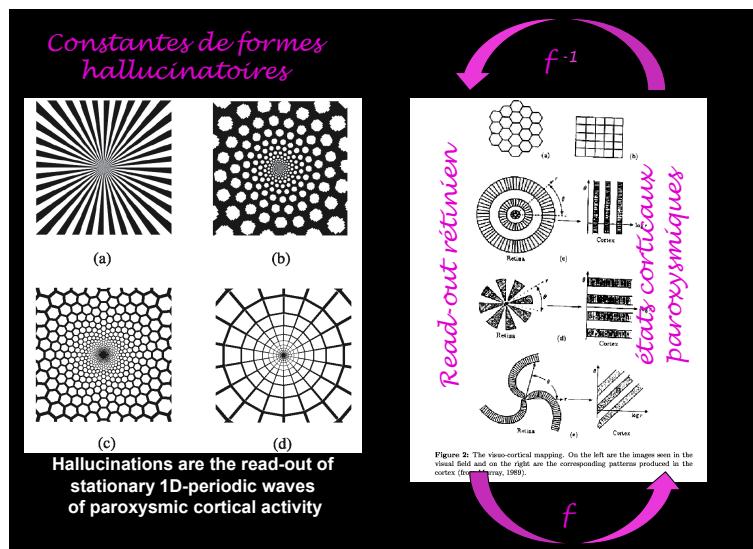
« We wish to stress merely one point, namely, that under diverse conditions » (eye-ball pressure induced phosphenes, drug-induced hallucinations, migraine) « the visual system responds in terms of a limited number of forms constants » (Kluver, 1928)

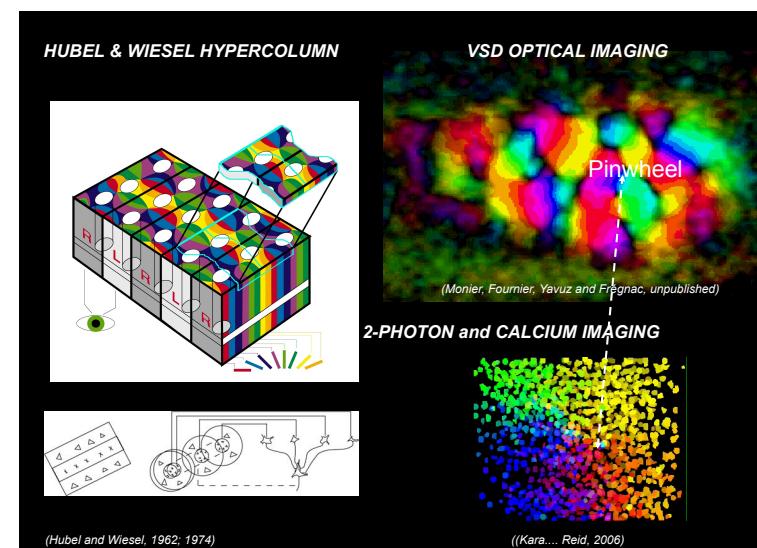
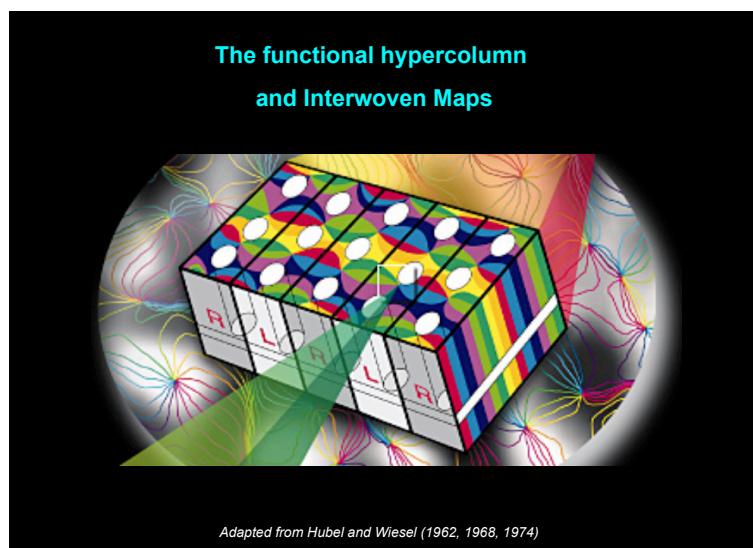
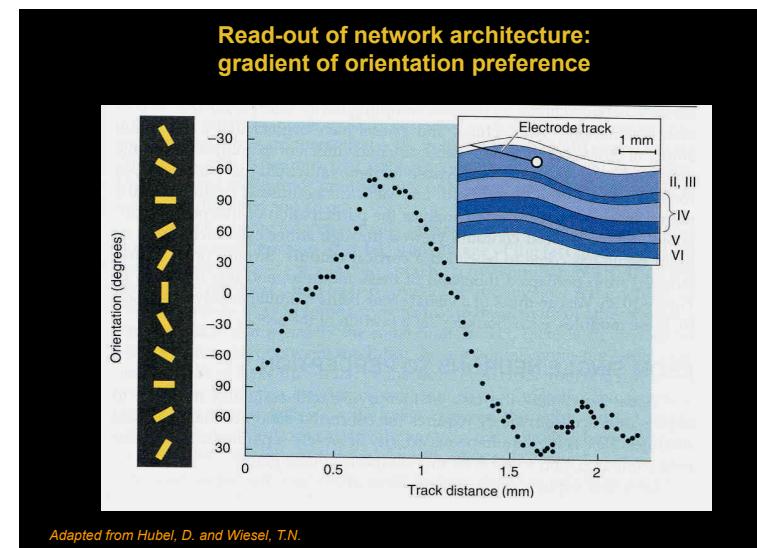
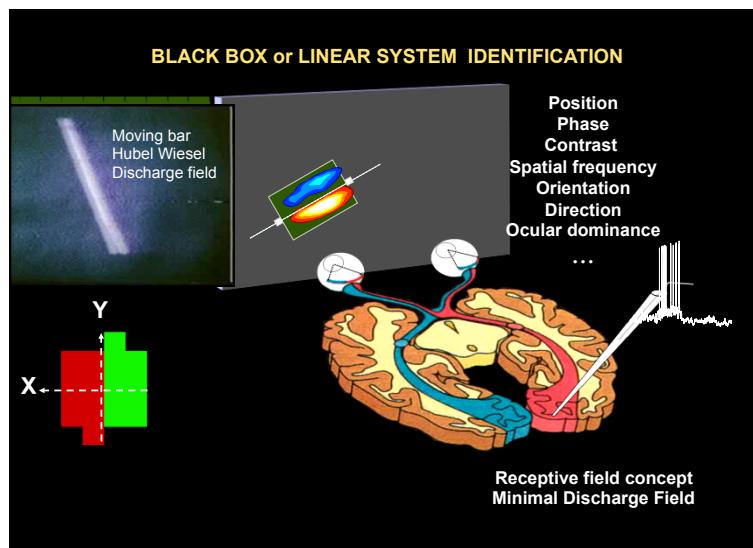
« It remains to compute the actual patterns of V1 activity that develop when the uniform state loses stability. These patterns will be linear combinations of the eigenfunctions described above, which we call planforms » (Bressloff et al. 2002)

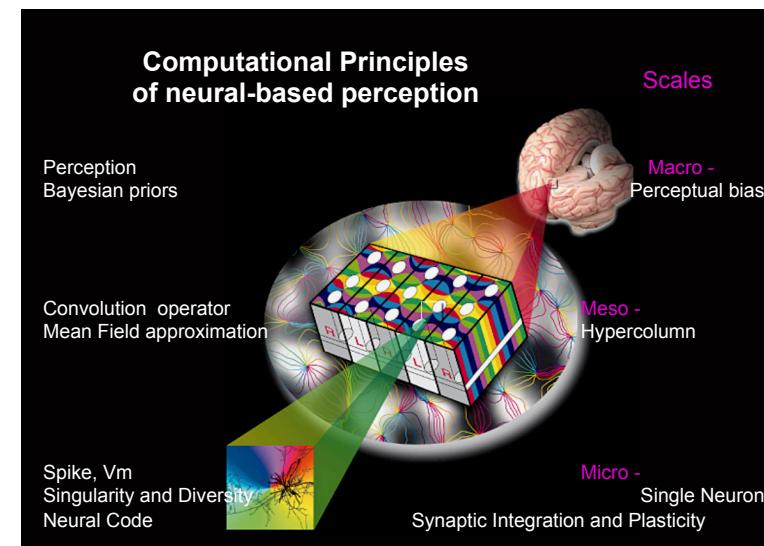
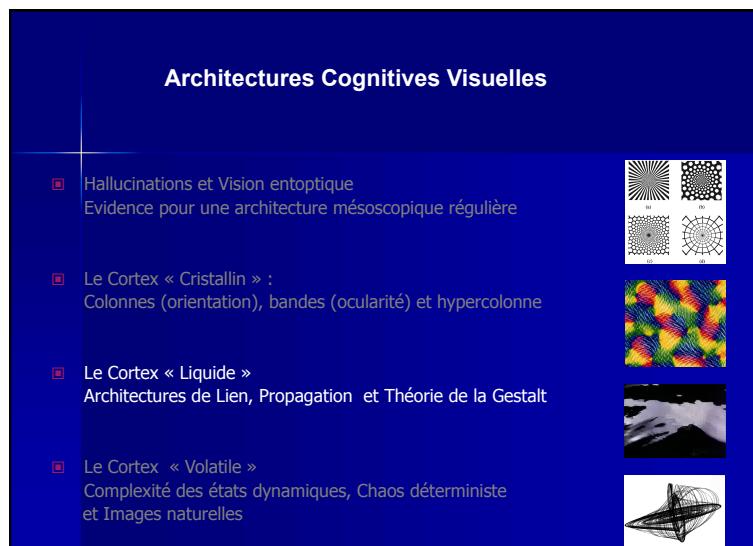
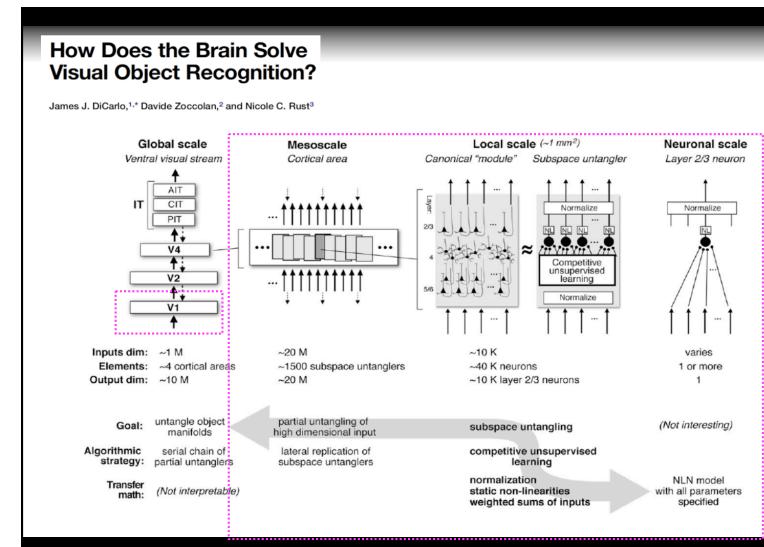
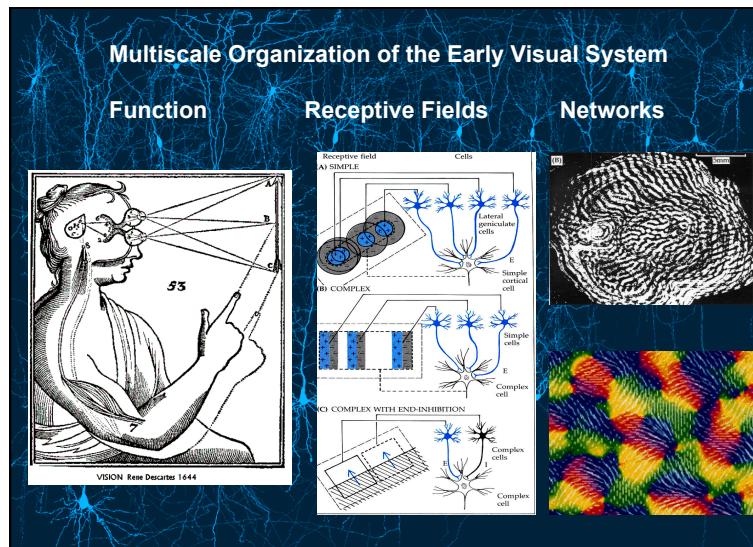
« The characteristics of entoptic vision derive from the structure of the visual system ». These entoptic « geometric patterns must be regarded as indicators of some further selective process in the physiological pathway, a kind of functional Golgi stain by which certain neural activities are elevated into consciousness while the majority of possible discharges remain ignored ». (Teyler, 1978)











Mesoscopic Phenomenological Models Mean Field Theory

- Mesoscopic modelling of VSDI maps**
- Wilson-Cowan equation**
- W : Kernel of lateral connectivity (space x time)**

Neural masses in the column

- Column: small network of neurons
- Neural masses confined to layer and neuron type (homogeneity)
- NM = column n, neuron type

Neural field

- Mesoscopic model of area
- 2D continuum of mesoscopic columns (M columns)
- Columns communicate via horizontal connections through synapses
- Column activity: state vector $V(r, t)$, N components

Neural field equation
Wilson & Cowan 72

$$\dot{V}(r, t) = -DV(r, t) + \int_0^t W(r, r') S(V(r', t)) dr' + I^{ext}(r, t)$$

Dynamics of column r :

$$\begin{bmatrix} V_1(r, t) \\ V_2(r, t) \\ \vdots \\ V_N(r, t) \end{bmatrix}$$

Linear term: synaptic dynamics
Integral term: global contribution from horizontal connections
External input
Output of column r

Nonlinear integro-differential equation

Retrieving multiscale network dynamics from single cell subthreshold activity

CORTICAL SPACE

Optical functional Imaging

+ 2D continuum of mesoscopic columns (M columns)

Simultaneous multiple recordings blind connectivity

Intracellular recording of the synaptic rumour (subthreshold V_m)

Dissection of effective connectivity

INPUT SPACE

Demultiplexing of input signals based on space, time and feature coding

TIME

Complexity in V1 Receptive Fields : Multiple Connectivity Kernels

- The Feedforward Kernel : the Ice-cube model of Hubel and Wiesel**
- The Intracortical Re-entry Kernel : Hidden impact of network recurrency in the synaptic integration field**
- The Lateral kernel : Horizontal and Feedback connectivity and spatio-temporal diffusion**

Psychophysics : The Perceptual Association Field

Pop-out : contour integration

Flanker Facilitation

The local Association Field - Binding rules

Polat and Sagi , Vision Research, 1993

Field, Hayes and Hess, Vision Research, 1993

