Theory of neuronal Cognition and Consciousness

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Abstract

Formalized in 2010, the Theory of neuronal Cognition (TnC) and Consciousness departs from all existing materialist theories of mind by claiming that our brain does not process information, but only represents information. The logical implication is that we are only a crystallization of our interactions with the environment. Since « extraordinary claims require extraordinary proofs », the goal of my tutorial is to provide researchers at all levels with the neuronal blueprints of a (large) number of cognitive functions and concepts. After the description of the cortex as a hierarchy of self-organizing associative memories, I will show how the synergy between sensory and sensory-motor maps generates behaviors. I will then offer explanations about intelligence (a side effect of the observer knowledge), consciousness (an automatic verbalization), endogenous and exogenous attentions, episodic and semantic memories, motivation or joy (a side effect of associative memories functioning). TnC also offers tentative explanations about a few brain diseases (schizophrenia, depression, Alzheimer's disease, autism) and answers to long-lasting questions such as why we must sleep, how hypnosis works, what is the placebo effect, and how unsupervised systems achieve homeostasis. However the biggest TnC result relates to the fact that the absence of free-will is a sure guaranty that we must promote altruism to increase our personal happiness.

I. **Neurobiological facts**: The cortex

II. **Modelisation**: Behaviors

III. **Cognition explained**: Intelligence, Consciousness, Endogenous and exogenous attentions, Episodic and semantic memories, Motivation or joy

IV. **Mental diseases**: Schizophrenia, Depression, Alzheimer's disease, Autism

V. **Modified states of consciousness**: Sleep, Hypnosis, Placebo effect, Homeostasis

VI. Absence of free-will, altruism and personal happiness

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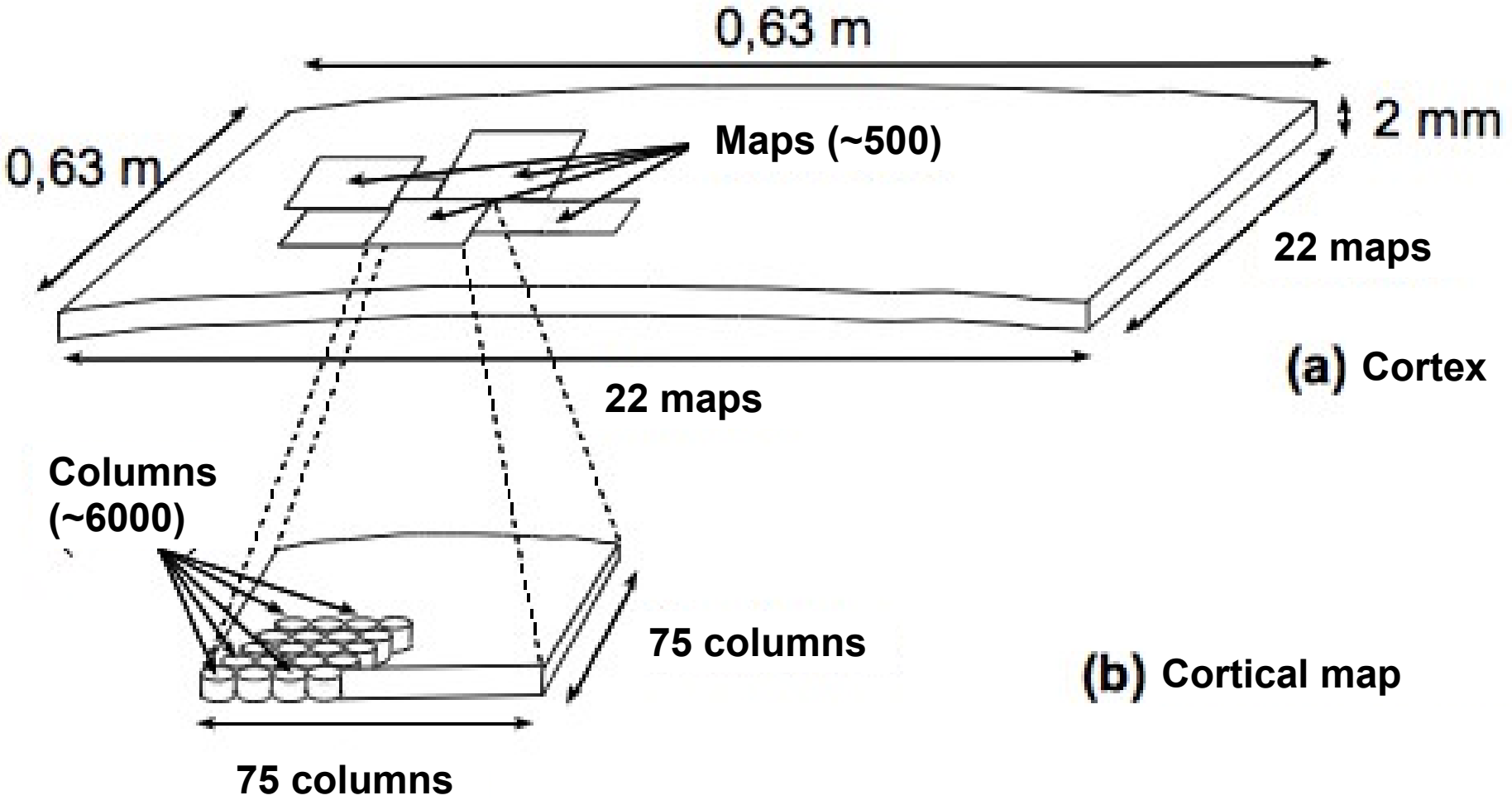
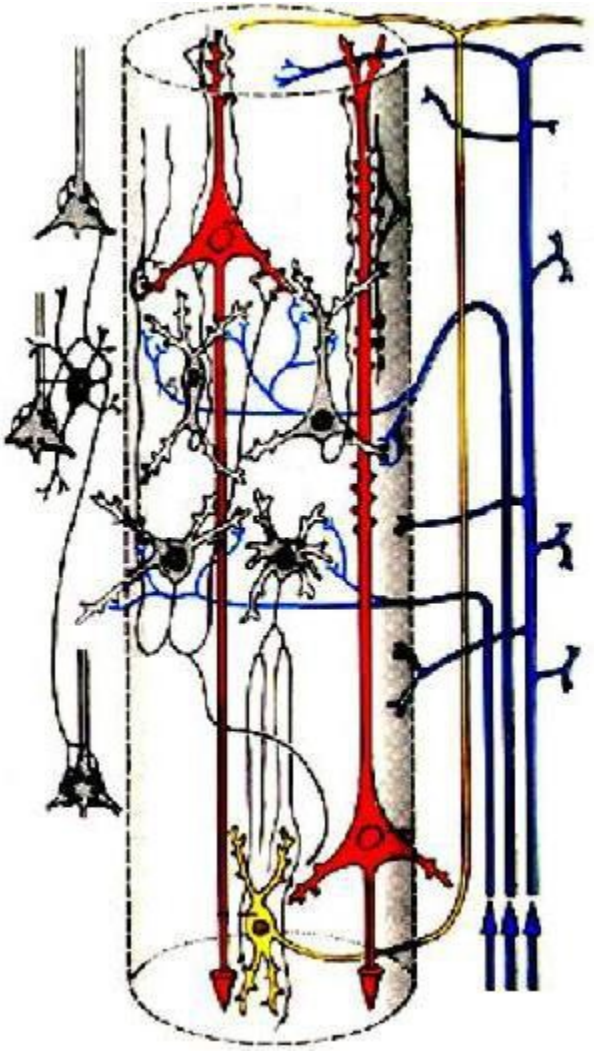
1. Cortex anatomy, cortical column



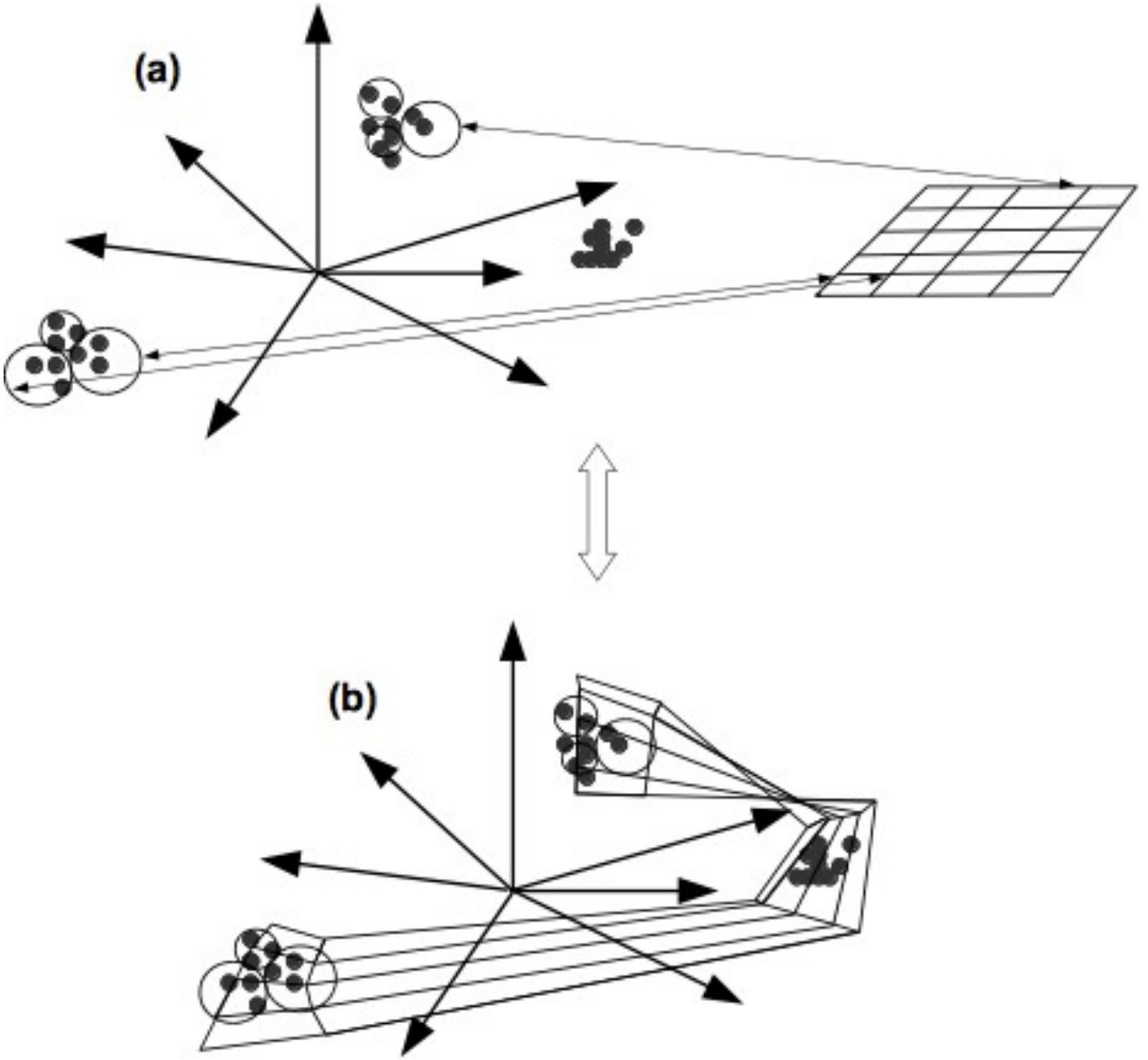
D. Hubel, *Eye, Brain, and Vision*, Freeman, May 1995. ISBN 978-0-7167-6009-2.
http://hubel.med.harvard.edu/book/ch5.pdf

2. Cortical column *vs* neuron

- Transmission of information (depolarisation) is very fast because the neuron « at rest » is already working (-60 mV).
- The cortical column activity does not exhibit the limitations of single neurons: activation can be sustained for very long periods (sec.) instead of been transient and subject to fatigue.

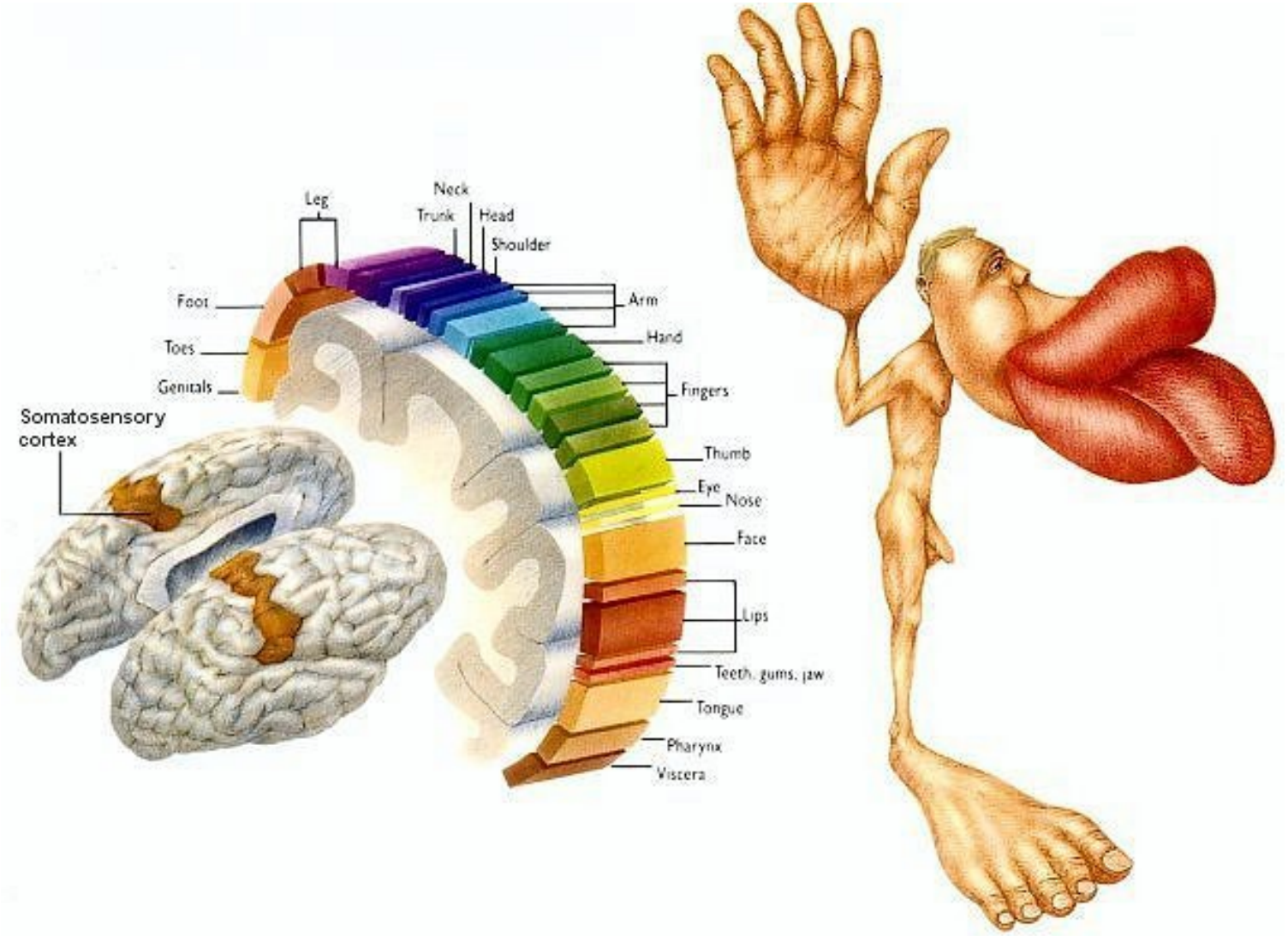


3. Self-organizing maps



Teuvo Kohonen, *Self-Organizing Maps, Springer Series in Information Sciences, Vol. 30*, 2001. Third Ed., 501 pages. ISBN 3-540-67921-9, ISSN 0720-678X

4. Homonculus



W. Penfield, T. Rasmussen, *The cerebral cortex of man*, Macmillan, 1950.

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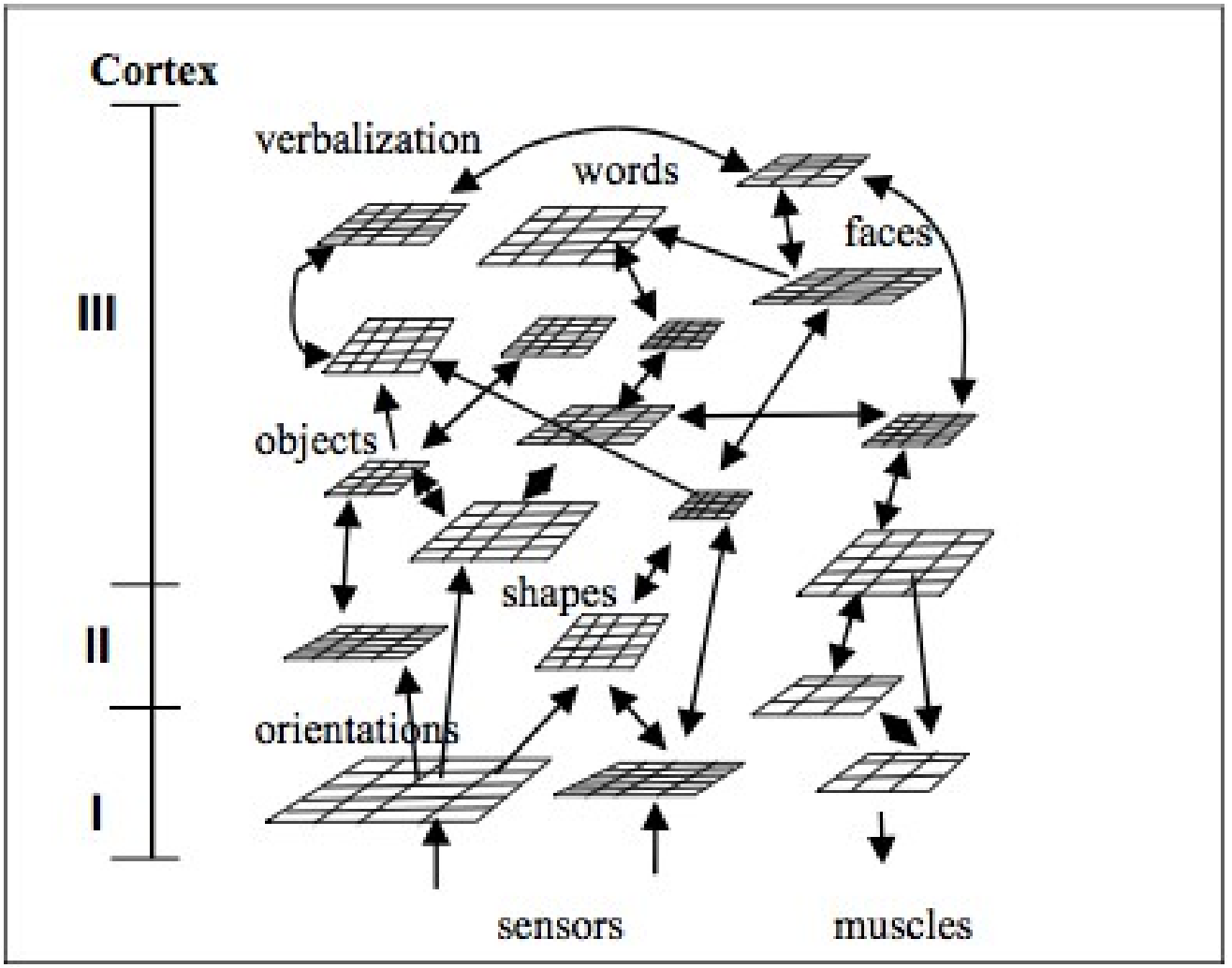
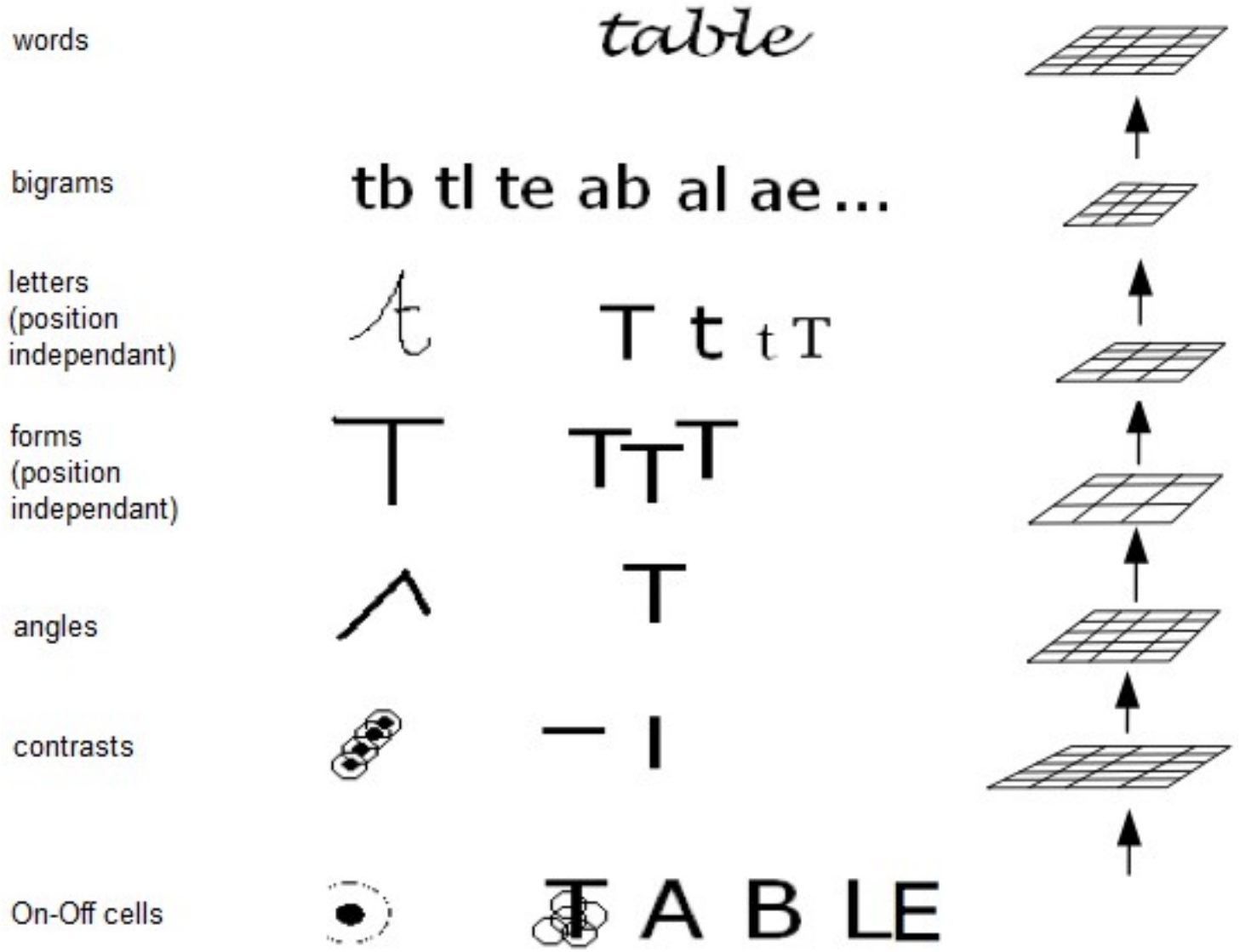
5. Hierarchy of SOM



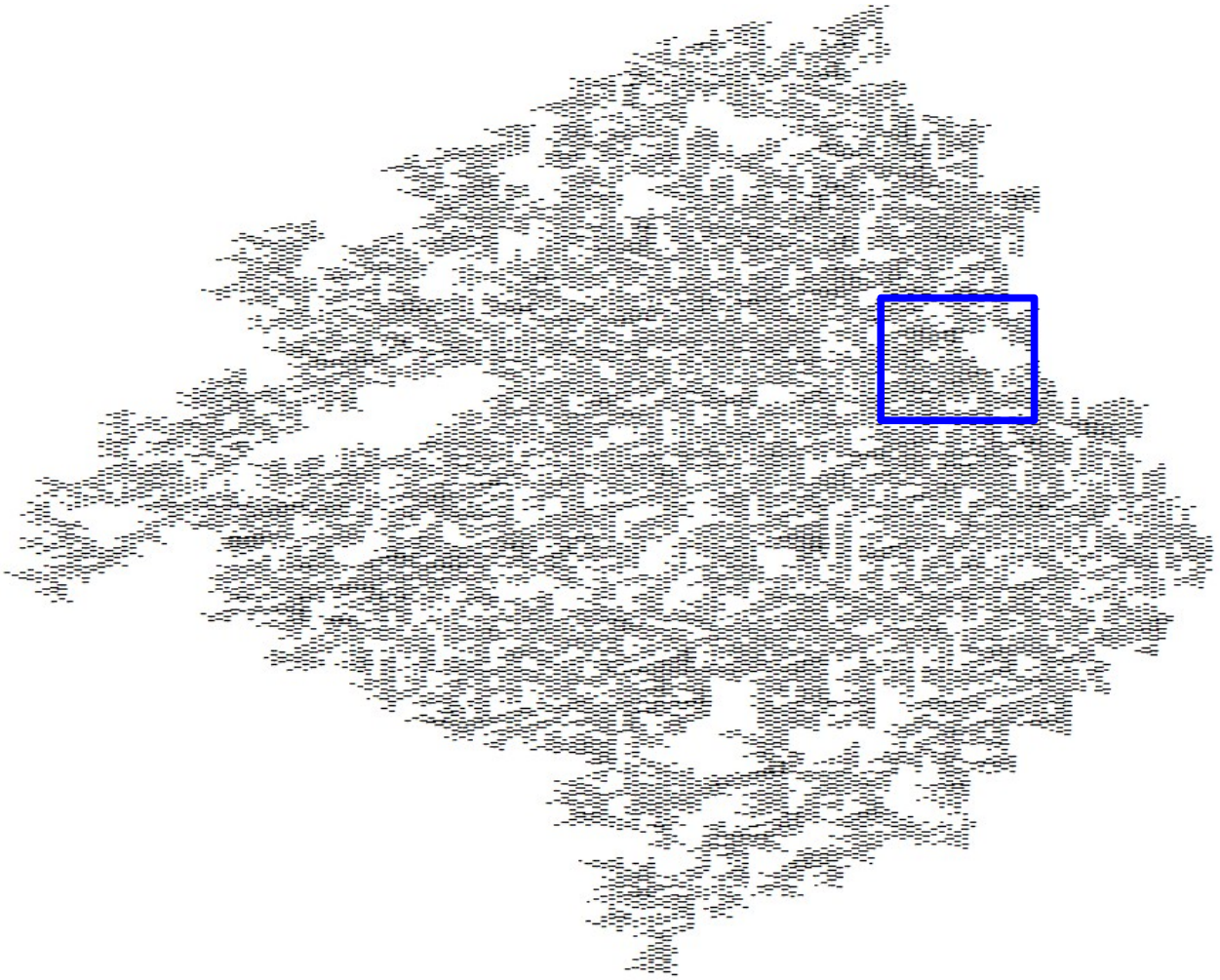
M. Silver and S. Kastner (2009) – Topographic maps in human frontal and parietal cortex, *Trends in Cognitive Sciences*, Vol. 13, No. 11, 488-495.

6. Reading



Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: a proposal. *Trends Cogn Sci*, 9(7), 335-341.

6.1 Orthographic word form map



C. Touzet, A Biologically Plausible SOM Representation of the Orthographic Form of 50,000 French Words, *WSOM 2014* (10th Workshop on Self-Organizing Maps), July 2014, Mittweida, G.

6.2 Orthographic word form map

7. Hebb learning rule

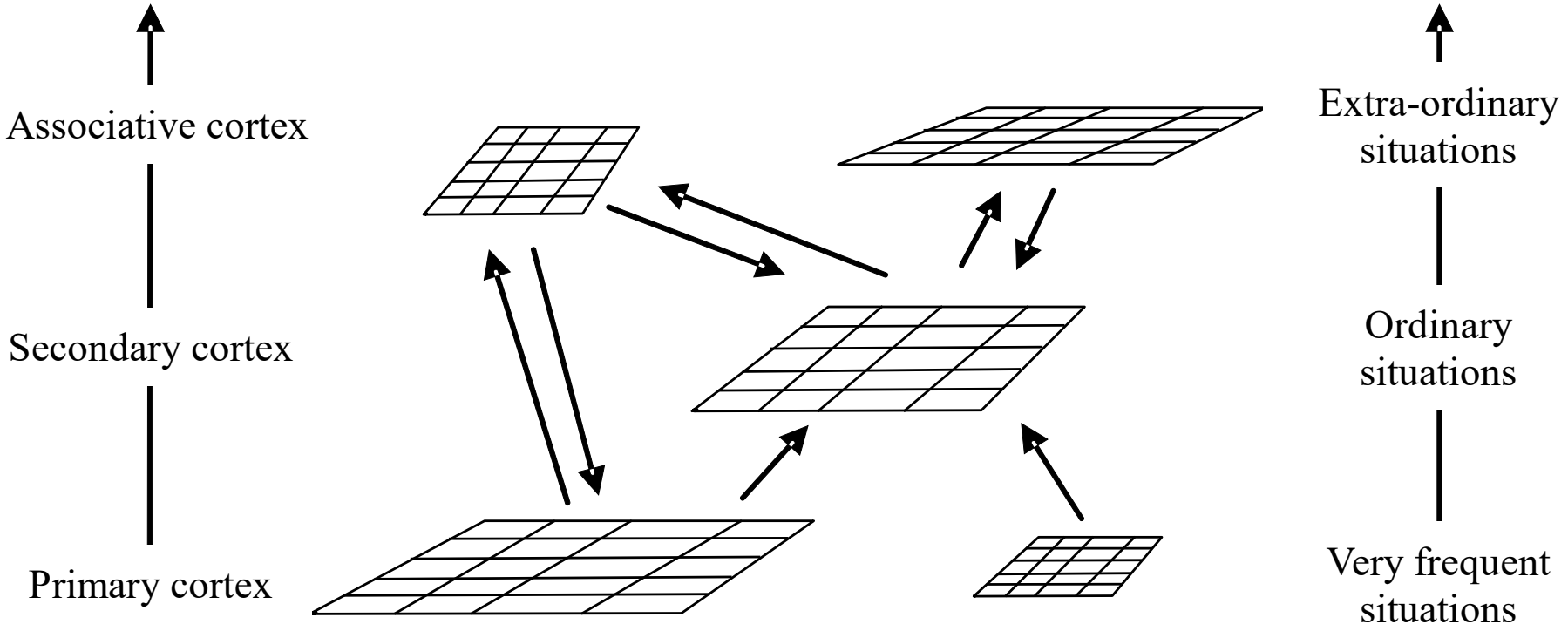
"Let us assume that the persistence or repetition of a reverberatory activity (or "trace") tends to induce lasting cellular changes that add to its stability.… When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased."

- And vice versa...
- A or B alone ?
- Inhibitory neurons ?

- Only known learning rule
- Pure local learning

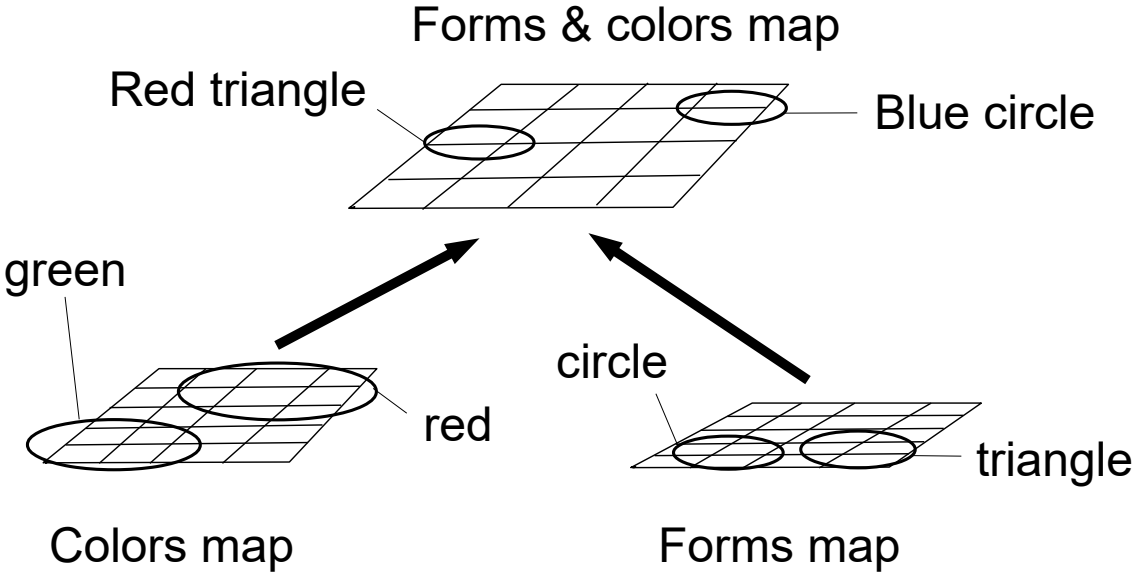
Donald Hebb, *The Organization of Behavior : A Neuropsychological Theory,* Wiley, 1949.

8. SOM as a regularity detector



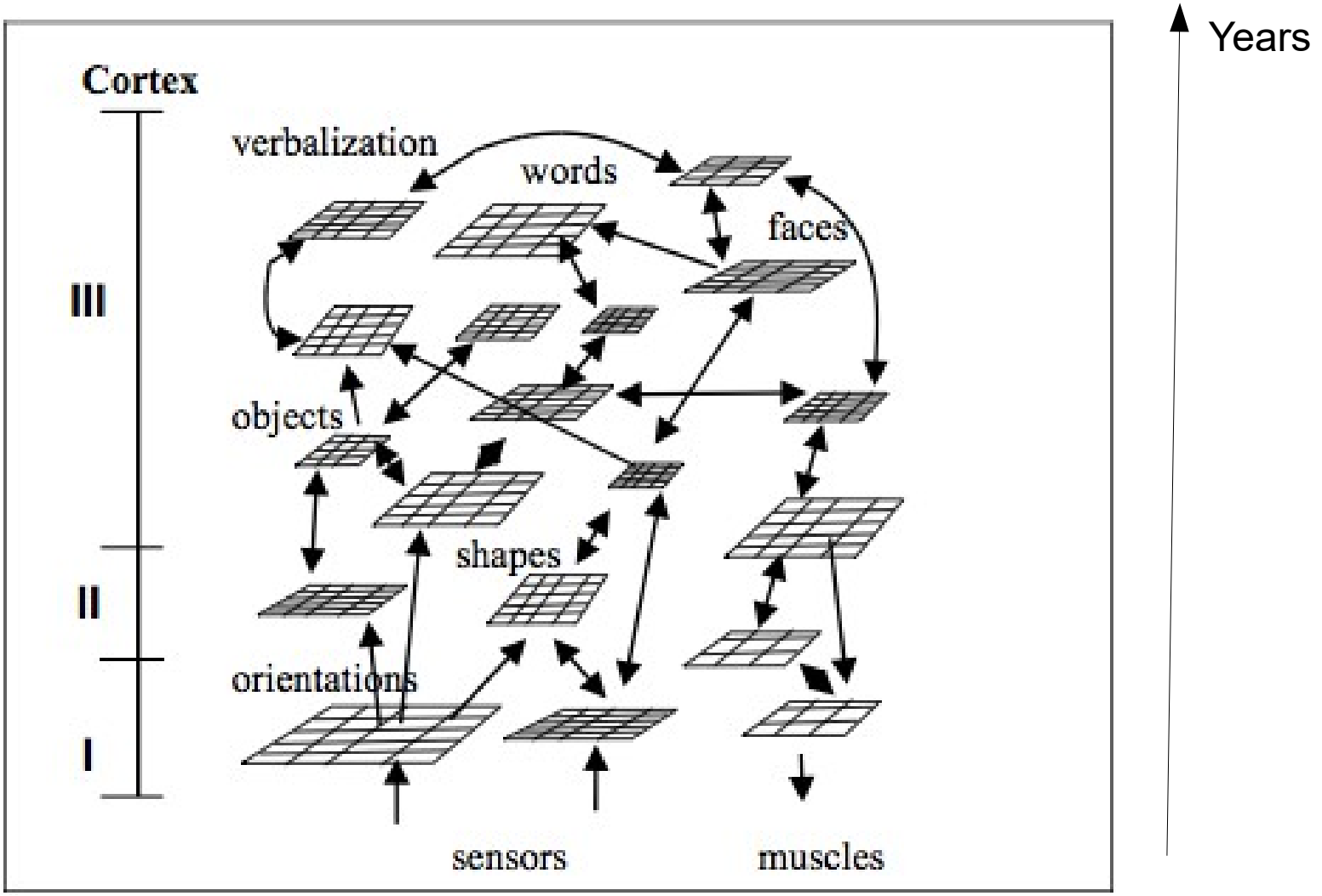
l	1	2	3	4	10	12
%	100	20	4	0.8	$5\ 10^{-5}$	$4\ 10^{-7}$

9. Education, training



- The illusion of semantics

10. Acquisition of language



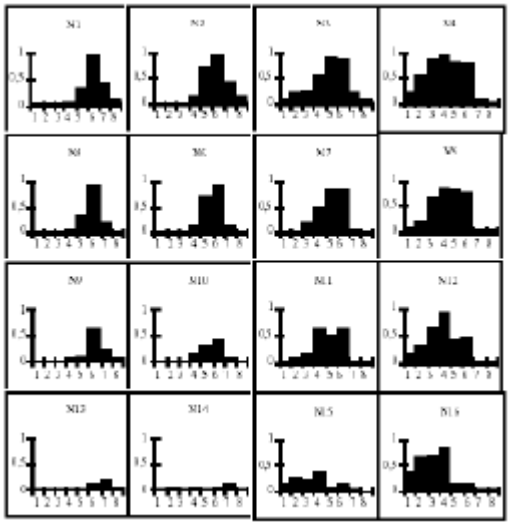
- Feral childs, critical periodsof development

11. Mobile robot sampling the environment

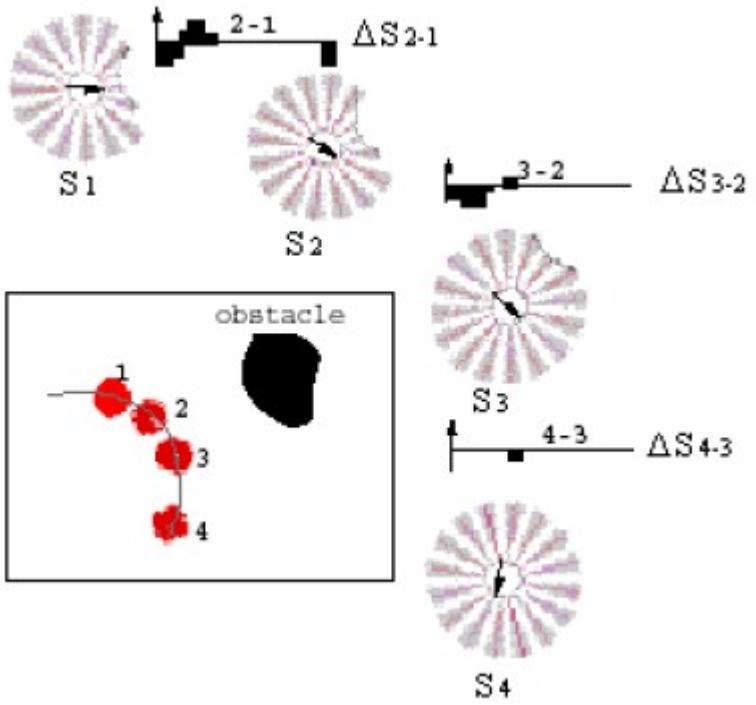
Khepera (8 IR)

Nomad (16 sonar)

12. Sensory and sensory-motor maps



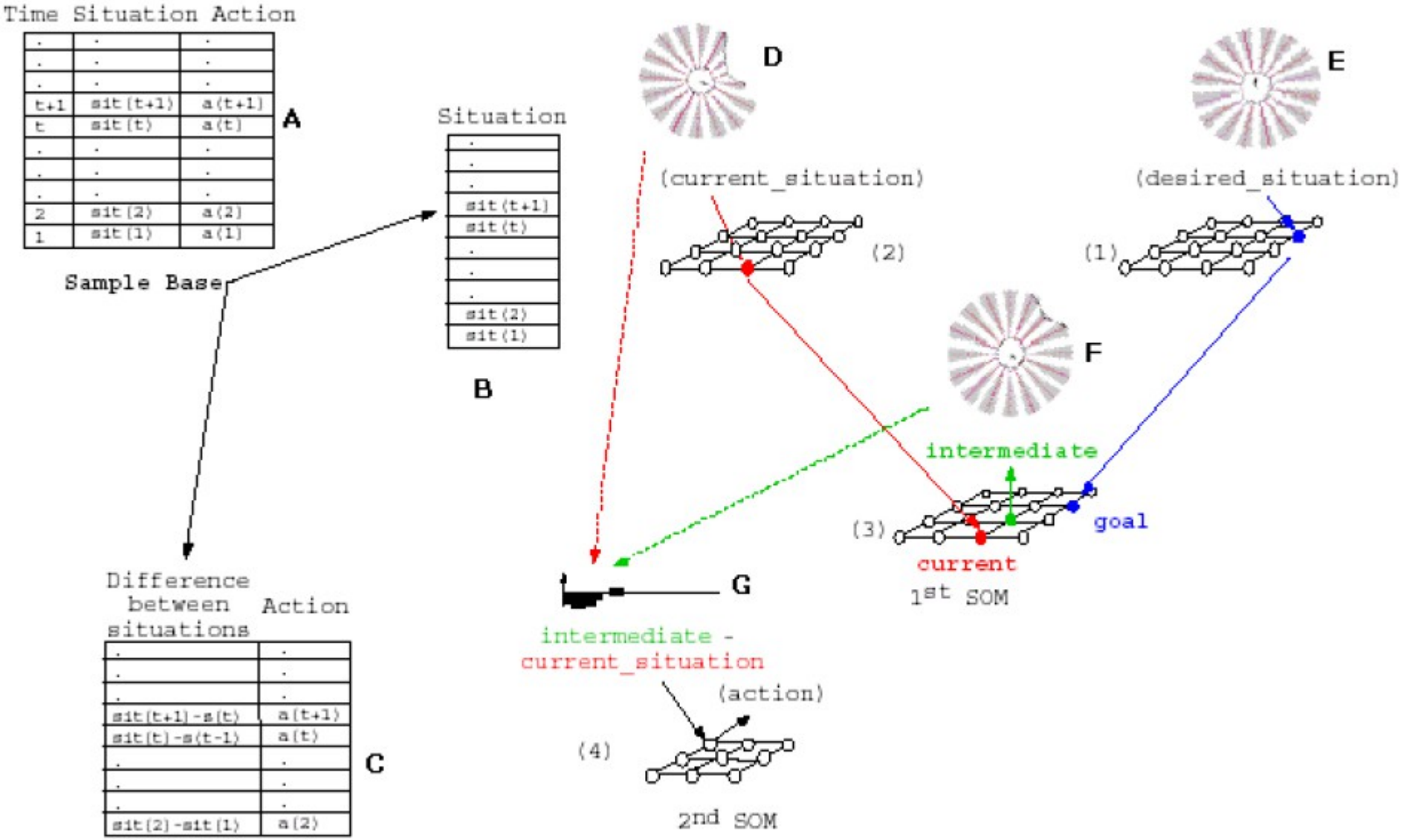
100 learning iterations
(16 neurons SOM)



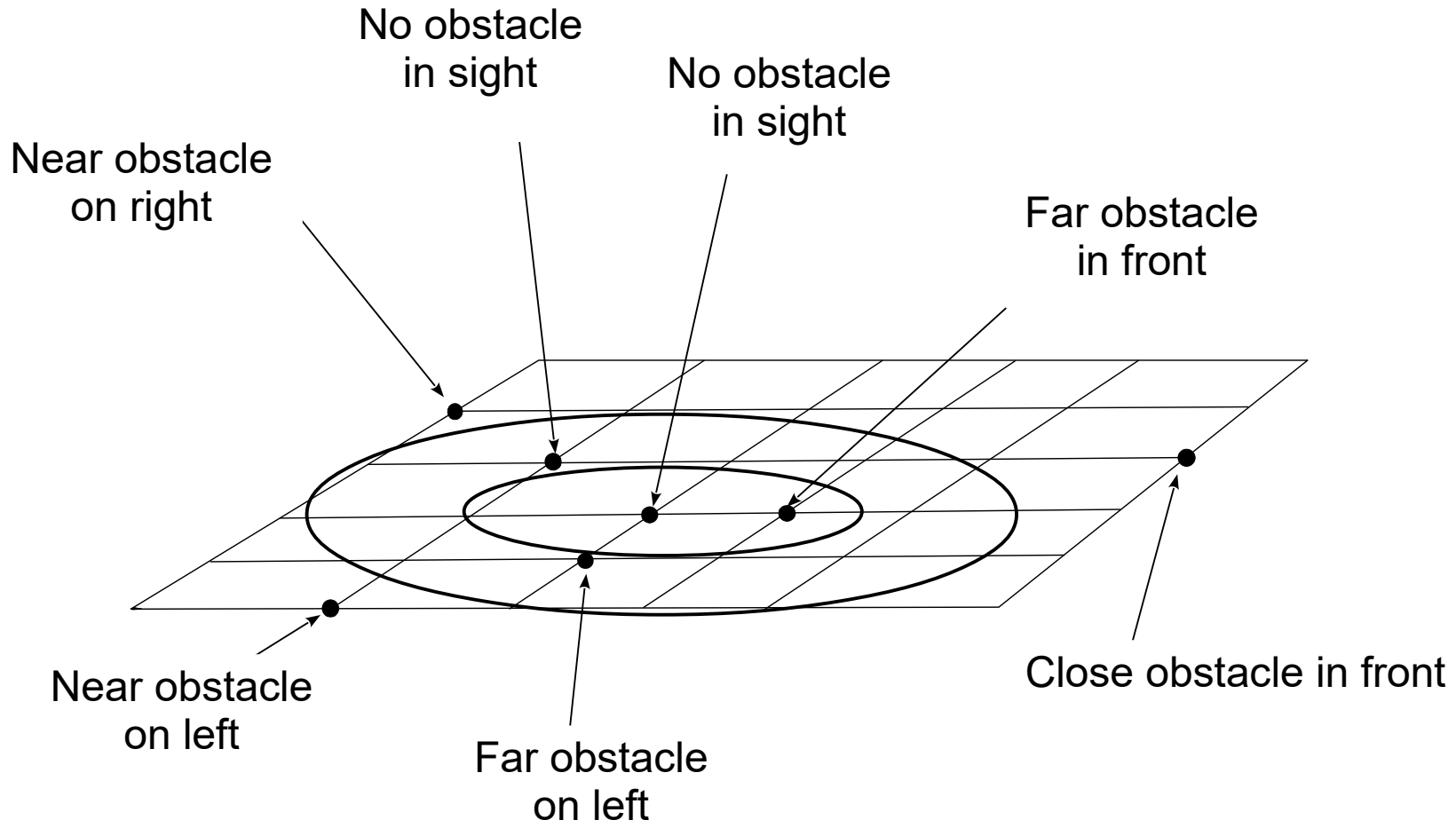
Variations of situations

C. Touzet, "Modeling and Simulation of Elementary Robot Behaviors using Associative Memories", *International Journal of Advanced Robotic Systems*, Vol 3 n° 2, June 2006.

13. Synthesizing a sequence of actions respectively to a goal

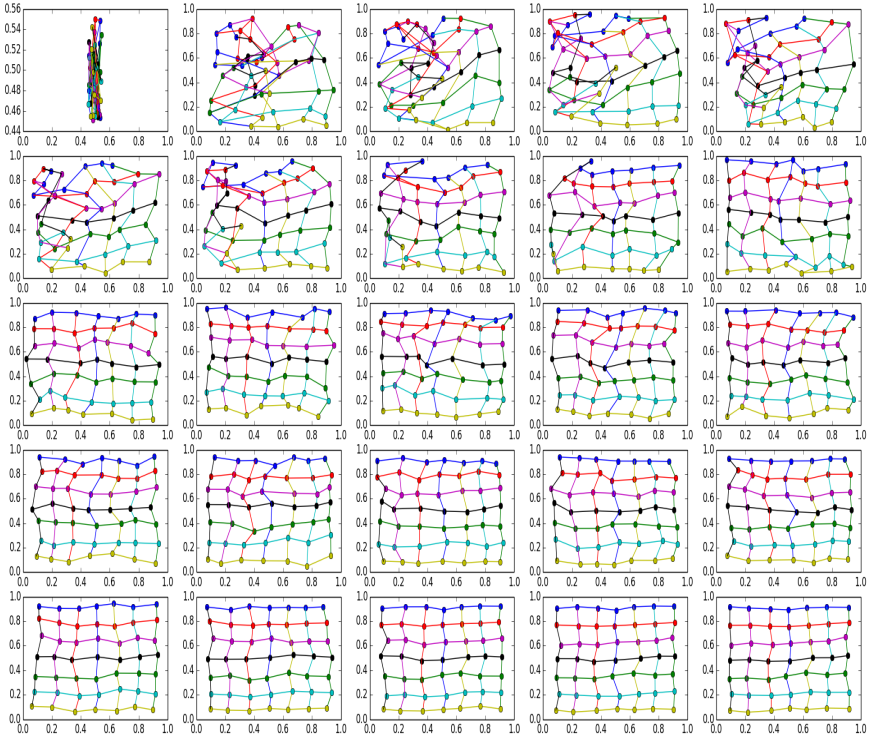


14. Immediate synthesis of multiple behaviors



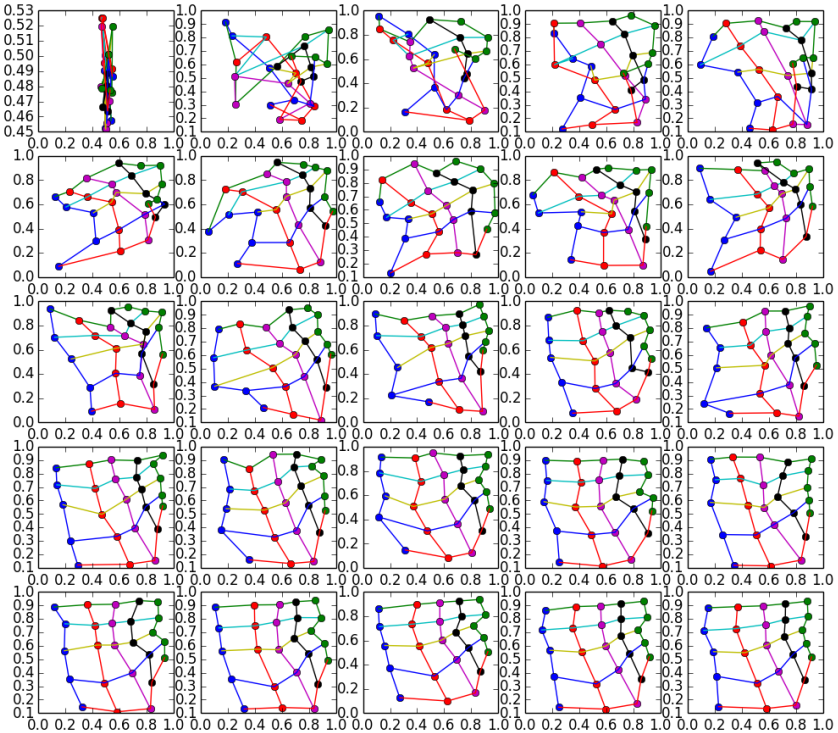
- Hunting, avoiding, following, ...

15. Improving by doing

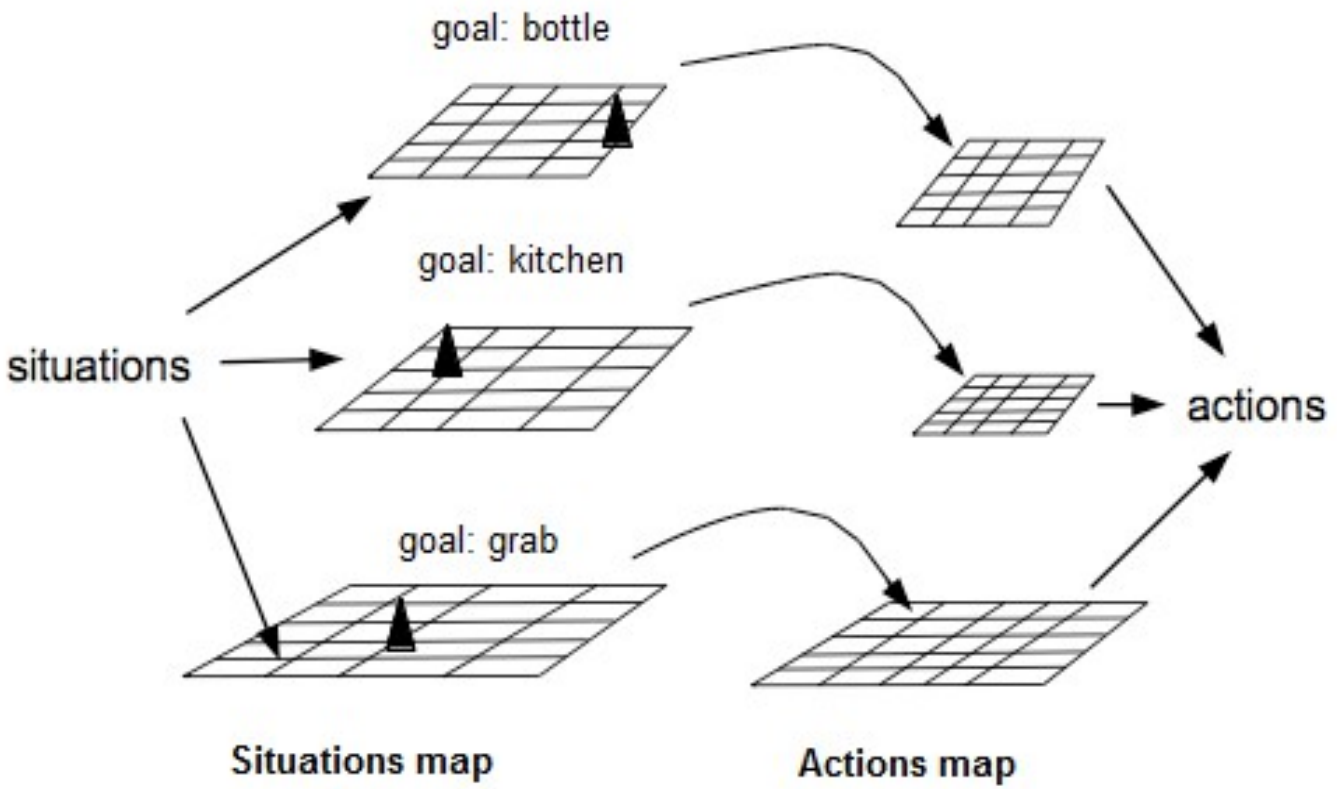


Uniform distribution

Non uniform distribution

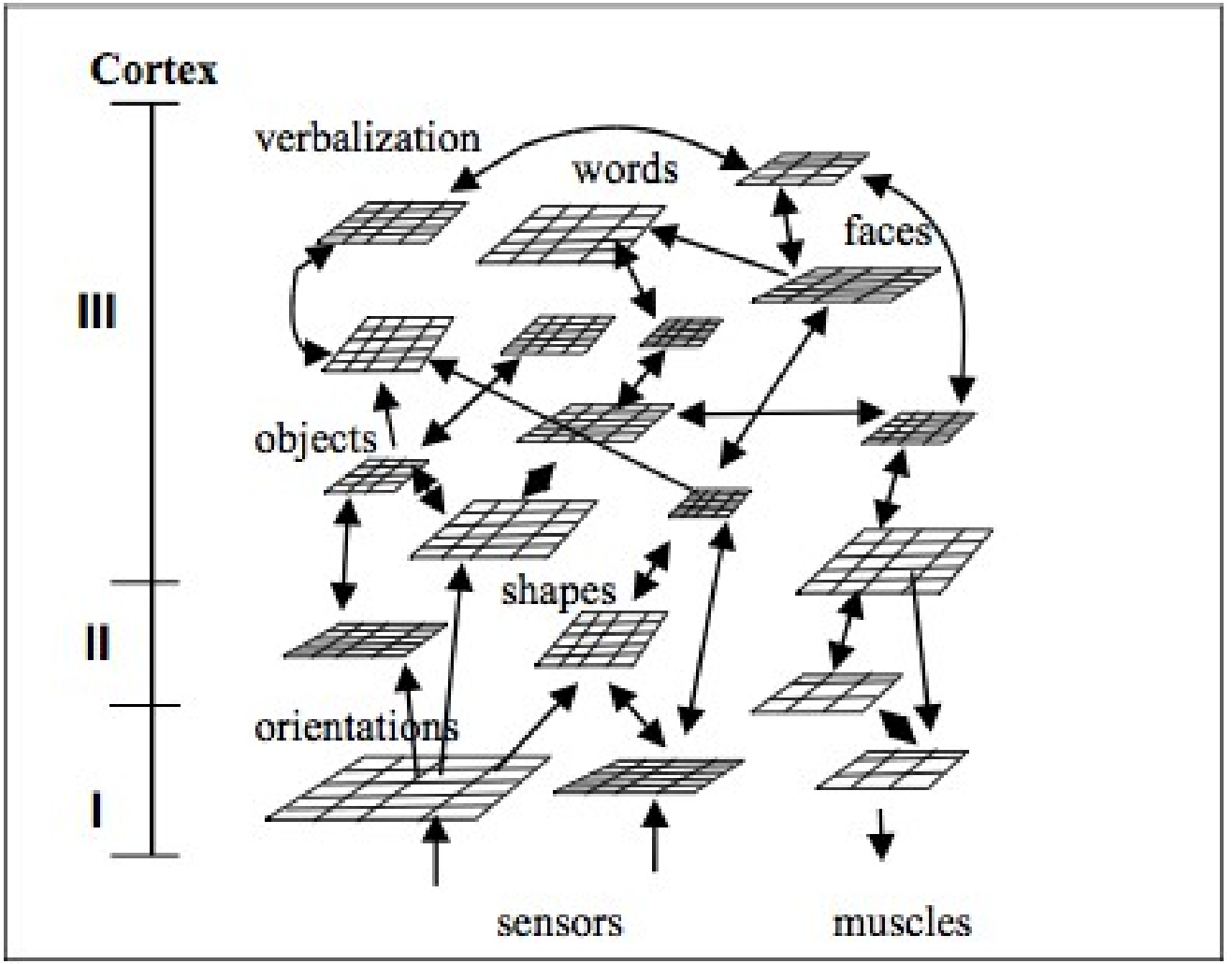


16. Complex behaviors



Gallistel C (1993) *The Organization of Learning,* MIT Press.

17. Cognitive behaviors (planning, reasoning, speaking, etc.)



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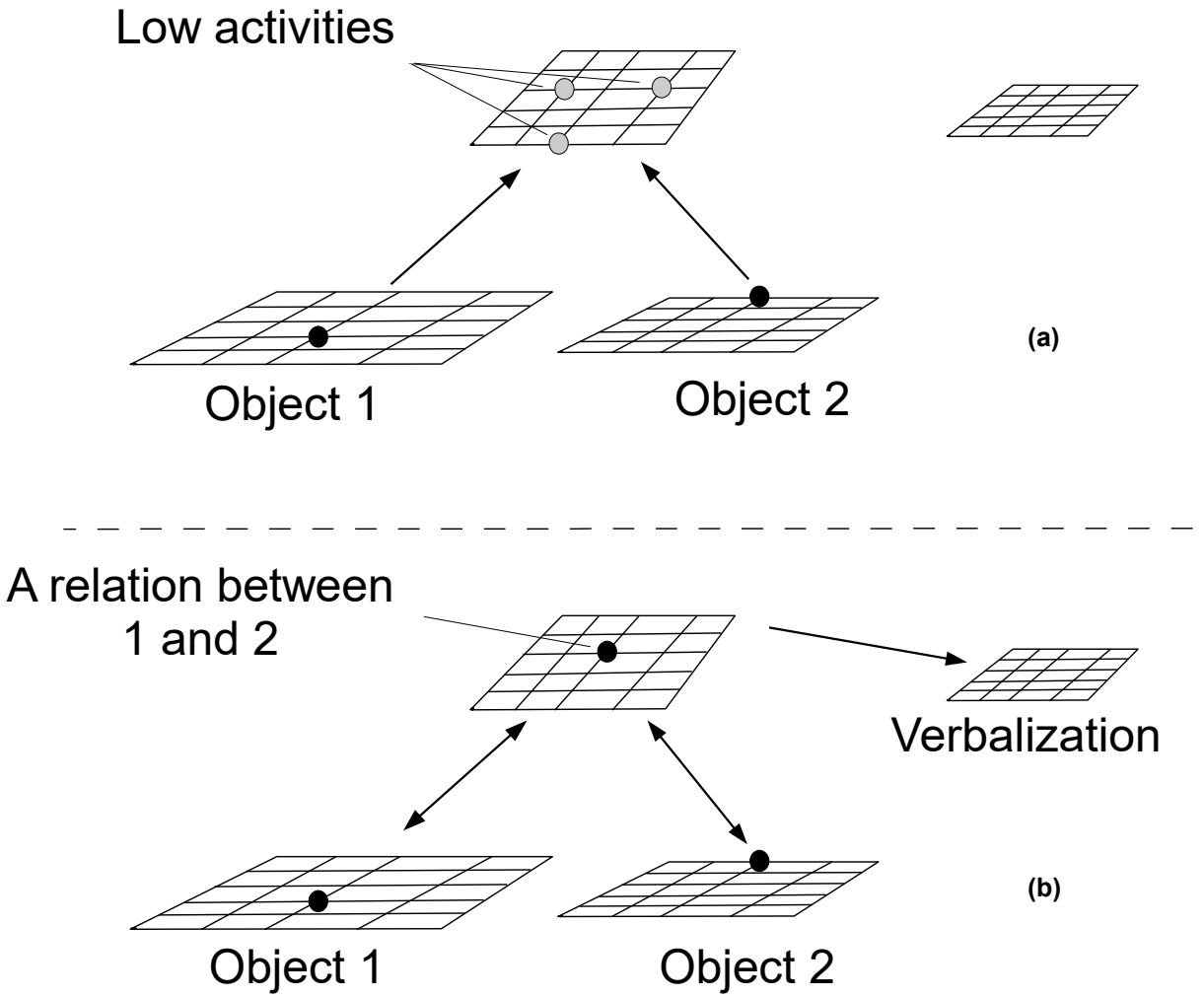
18. The relativity of intelligence

Something is (or isn't) « intelligent » depending on the knowledge of the observer.

19. A matching of two (until yet unrelated) objects

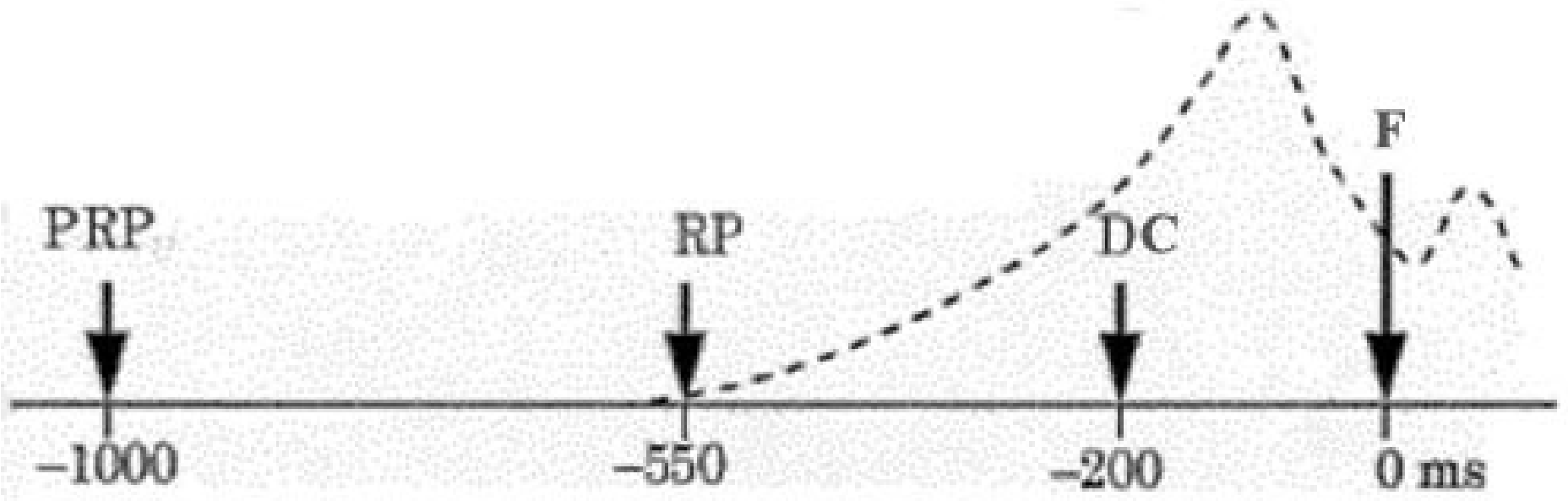


20. I.Q.

Since intelligence is relative, scales such as the IQ do not test or measure « intelligence » but knowledge. Have you already be in such situation (or a similar one) ?

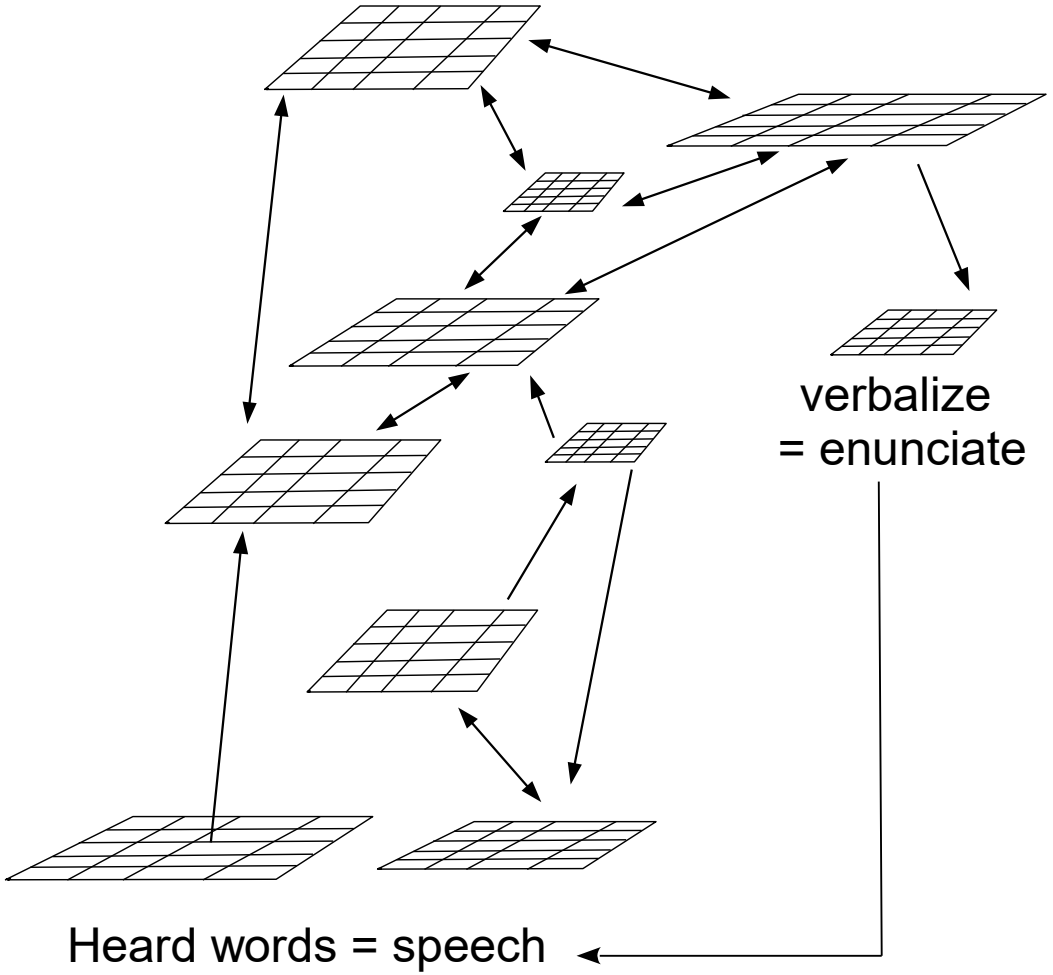
Comparing the IQ scores of young and senior people is meaningless.

21. Libet's experiment (action before automatic verbalization)



Libet, Benjamin (1985). "Unconscious Cerebral Initiative and the Role of Conscious Will in Voluntary Action". *The Behavioral and Brain Sciences* 8: 529–566.

22. Language learning (supervised)



- Baby-sitting

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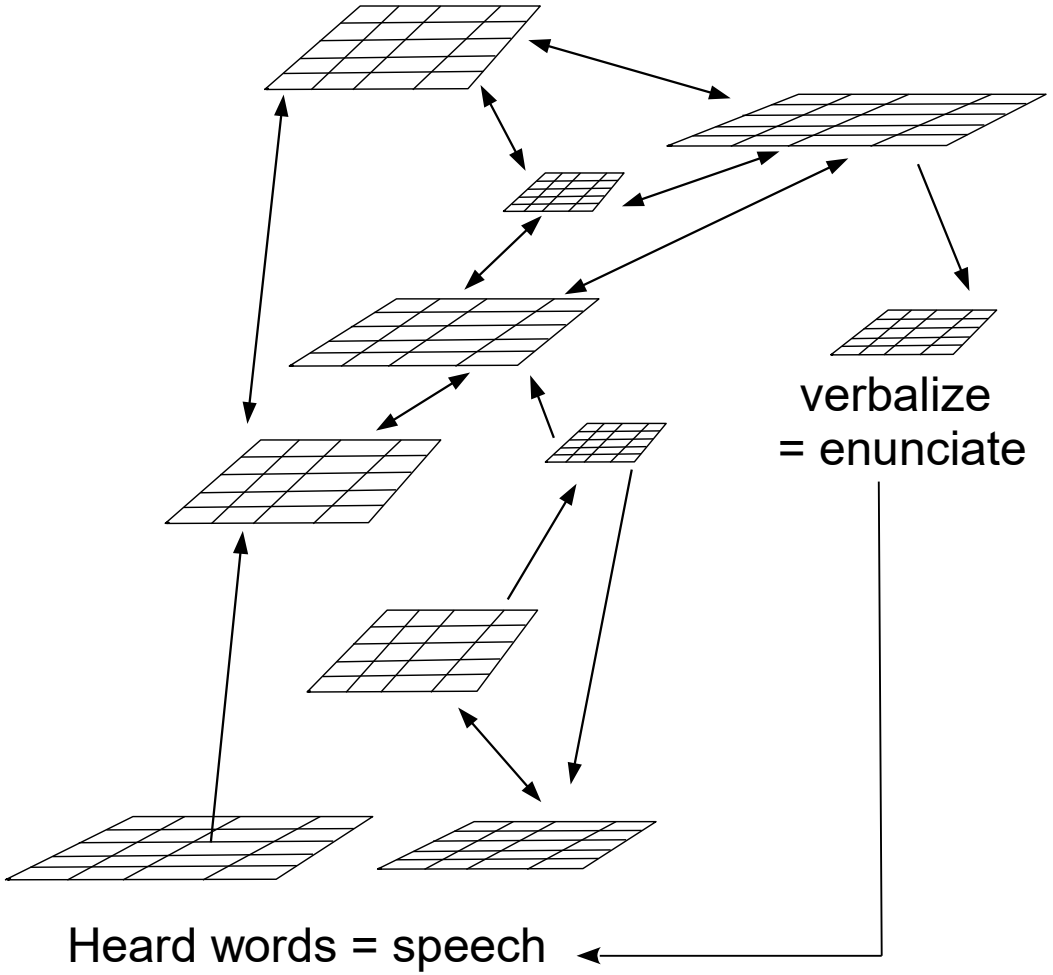


- Baby-sitting

23. Consciousness: automatic verbalisation

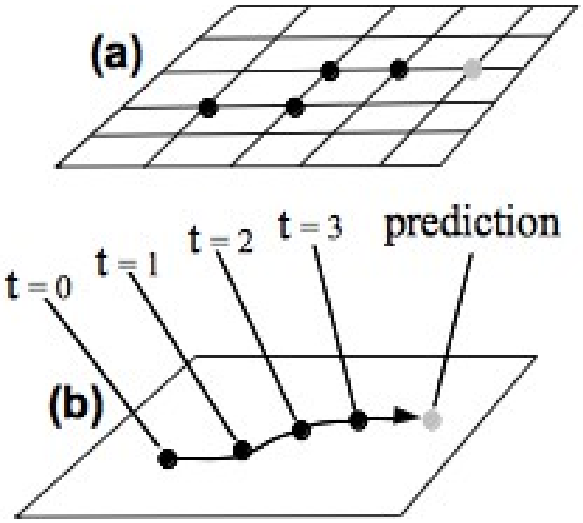
- internal voice
- speech

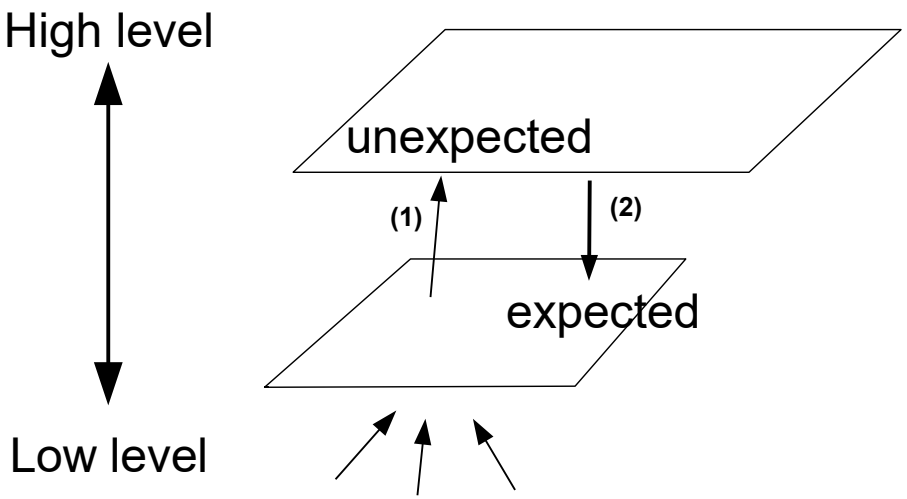
Eliminative materialism

24. Exogenous attention - bottom-up

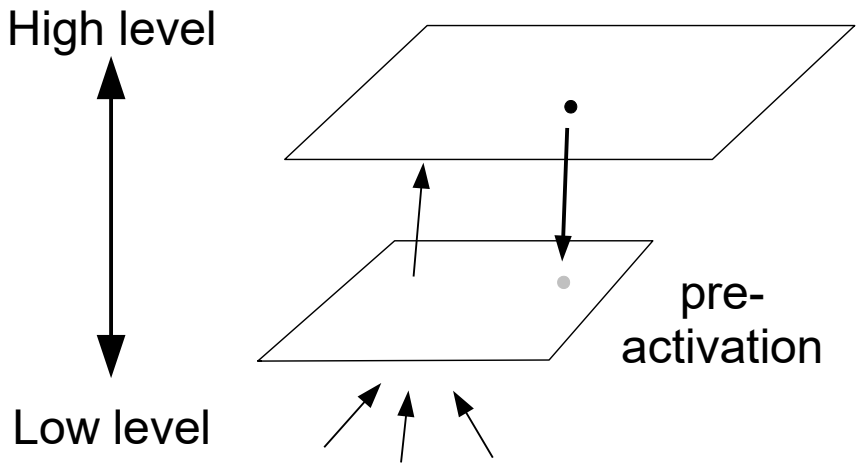
« Selecting one aspect of the environment while ignoring other things »

- Prediction
- A-causal backward connections – loops (novelty filter)



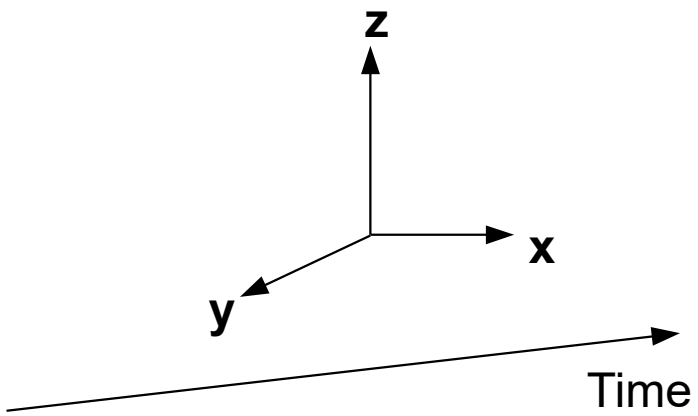


25. Endogenous attention - top-down



26. Episodic memories

- time and space coordinates



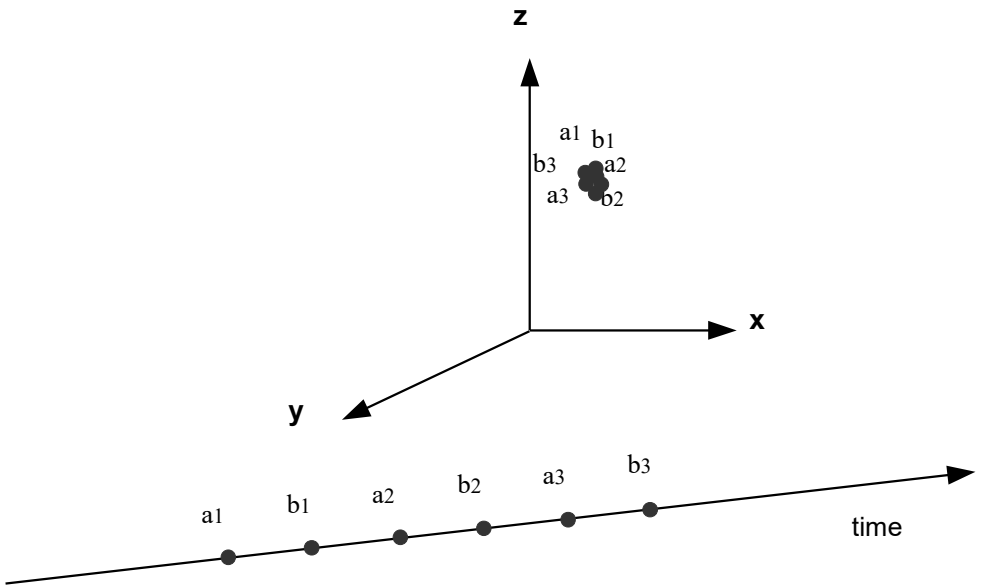
Charles R. Gallistel, *The Organization of Learning, MIT Press, 1993.*

27. Semantic memories

- Episodic memories without time and space coordinates

28. Ratio time *vs* space and gender behaviors

- Space coordinates : male?
- Time coordinates : female?



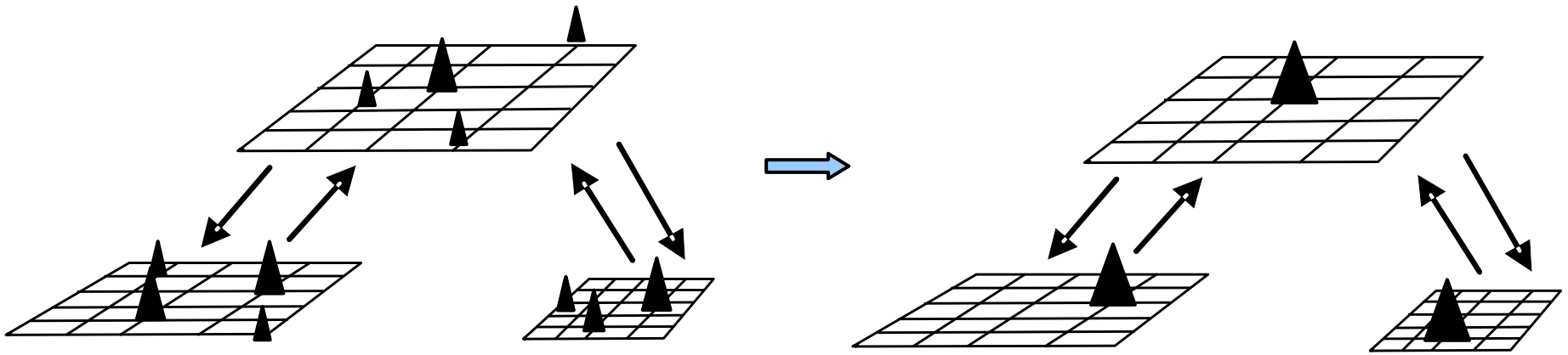
29. Motivation or joy - Definition

A behaviour without an explicit (enough) goal

Touzet C (2011) « The Illusion of Joy » In : J. Schmidhuber, K.R. Thórisson, and M. Looks (Eds.) *Artificial General Intelligence 2011*, Springer LNAI 6830, pp. 357-362.

30. Lower activity states of neural activities

- The smallest common activation pattern between multiple memorized events is an attractor state.



(a) (b)

31. Difficult to predict

- Clue: it is the smallest common coding

- Observation: It is « hard » coded (it does exist).

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32. Schizophrenia - epidemiology

- In France, 1% of the population (600 000), but 5% with Sz troubles
- 60% under poverty threshold, and homeless
- Schizophrenics make 70% of the homeless people!

33. Sz - symptoms

Episodes of psychosis that would last several weeks, separated by longer periods (several months) of recovery.

- Cognitive impairments (memory and attention) and personality disorders.

- « Negative » symptoms such as "Flat affect" (a person's face does not move or he or she talks in a dull or monotonous voice), Lack of pleasure in everyday life, lack of ability to begin and sustain planned activities, peaking little, even when forced to interact.

or

- « Positive » symptoms such as hallucinations and delusions, disorganized thinking, movement disorders.

34. Sz - hypothesis

A too small radius of inhibition around the cortical columns may result in a larger number of situation-goals, leading to antagonist goals (*i.e.*, incompatible goals) → personality disorders

Multiple goals induce:

- higher level of global activations (hallucinations),
- difficulty to recognize the experienced situations,
- neuronal stress (depression after several months).

CBT: Reorganisation of goal maps (error free, supervised)

35. Sz - others facts

- Neuroleptics,
- Canabis,
- Age dependent
- Cognitive impairments
- Hallucination
- Delirium
- Ratio M/F
- Ethnical origins

36. Depression - epidemiology

Comorbitity with Sz, #1 mental disease (17% in the USA, 3% in Japan)

- Reactive depression
- Chronic depression

37. How stress induces depression

Stress frees hormones (glucocorticoids) that allow to:

- increase our strength, our neural processing speed and memorization,
- reduce what else is not necessary such as digestion, immune system, growing, reproduction.

Glucocorticoids increase the sugar consumption at the cellular level, but ...

Robert M. Sapolsky. *Stress, the Aging Brain, and the Mechanisms of Neuron Death.* 429 pp. MIT Press, 1992.

38. How our life is stressful

After too much time (10 y.?) at the same place (job), the only events that come to our attention are the unexpected ones (problems).

Depending of our attitude toward the job, we may experience more and more stress (despite no change in the job conditions). Stress may invade our life.

39. Alzheimer's disease - epidemiology

10 to 20 years of evolution before diagnosis

Post-mortem analysis: neuronal loss (50-70%) and senile (amyloid) plaques.

Risk:

- 60-year-old: 1 out of 10
- 70-year-old: 1 out of 6
- 80-year-old: 1 out of 3

40. AD - symptoms

- Episodic memory is the first alteration (autobiographic)
- Early memories are less affected

41. AD and stress

Stress, as seen with « depression » is a neuron killer.

42. AD - the cetogen diet

Yoshihiro Kashiwaya *et al*., A ketone ester diet exhibits anxiolytic and cognition-sparing properties, and lessens amyloid and tau pathologies in a mouse model of Alzheimer's disease, *Neurobiology of Aging* (2012) 1-10

Mary T. Newport, *Alzheimer's Disease: What If There Was a Cure?* Basic Health Pubns; 2 edition – April 15, 2013.

43. Autism - epidemiology

- Between 2002 and 2006: + 57 %
- In 2006, one 8-year-old child out of 100 is autistic (USA).
- 4% of the babies born in 2010 will become autistic.
- If nothing changes, 10 % ren born in 2018 will become autistic!

Autism diagnosis is based on behavior (not cause or mechanism with typical symptoms) such as impairments in social interaction, impairments in communication, and restricted interests and repetitive behavior.

44. Autism - the critical period hypothesis

Hypothesis: « an alteration of the expression and/or timing of critical period circuit refinement in primary sensory brain areas may significantly contribute to autistic phenotype »[1].

Too slow or too fast maturation of maps implicated in faces recognition[2], etc.

[1]LeBlanc J, Fagiolini M (2011) Autism: A “Critical Period” Disorder? *Neural Plasticity*, Vol. 2011, Article ID 921680, 17 pages

[2]Vlamings PH, Jonkman LM, van Daalen E, van der Gaag RJ, Kemner C (2010) Basic abnormalities in visual processing affect face processing at an early age in autism spectrum disorder. *Biol Psychiatry*. 68(12):1107-13.

45. Examples of critical periods

Visual privation during early development: monocular or complete blindness (cat, primates, human)

46. New results in resetting critical period

Kuhlman SJ, Olivas ND, Tring E, Ikrar T, Xu X, Trachtenberg JT (2013) A disinhibitory microcircuit initiates critical-period plasticity in the visual cortex. *Nature*. 501(7468):543-6.

- Earthing
- Montagnier antibiotics

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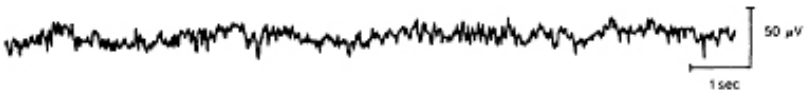
47. The ubiquity of sleep

Even when flying !

One hemisphere at a time!

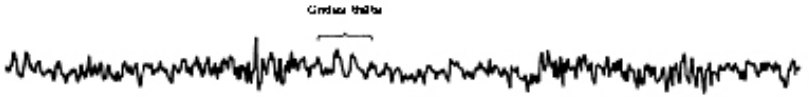
48. The neurophysiology of sleep

Éveil – basse tension – aléatoire, rapide



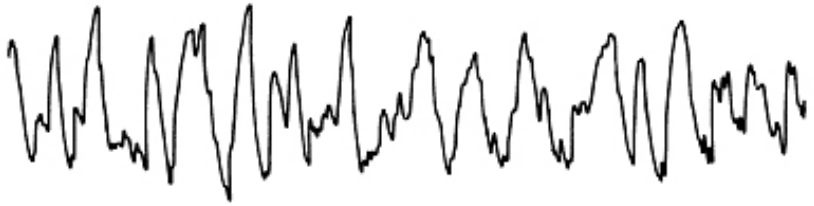
Somnolence – 8 à 12 cps – ondes alpha

Stade 1 – 3 à 7 cps – ondes thêta



Stade 2 – 12 à 14 cps – fuseaux de sommeil et complexes K

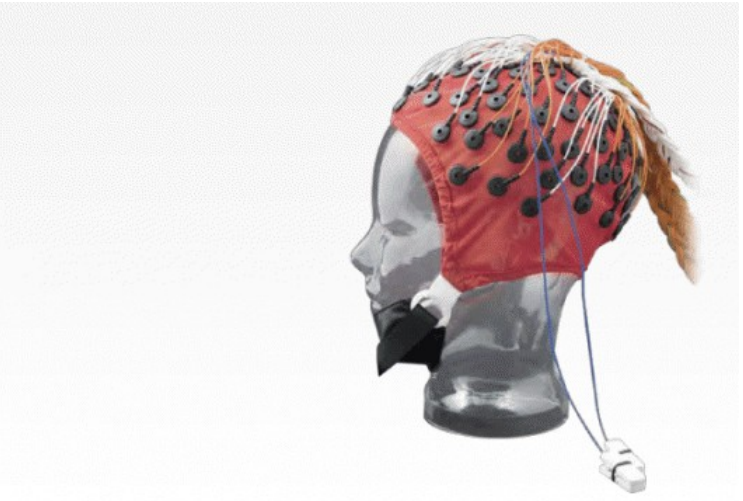
Sommeil delta (lent) – ½ à 2 cps – ondes delta > 75 µV



Sommeil paradoxal – basse tension – aléatoire, rapide, avec ondes en dents de scie

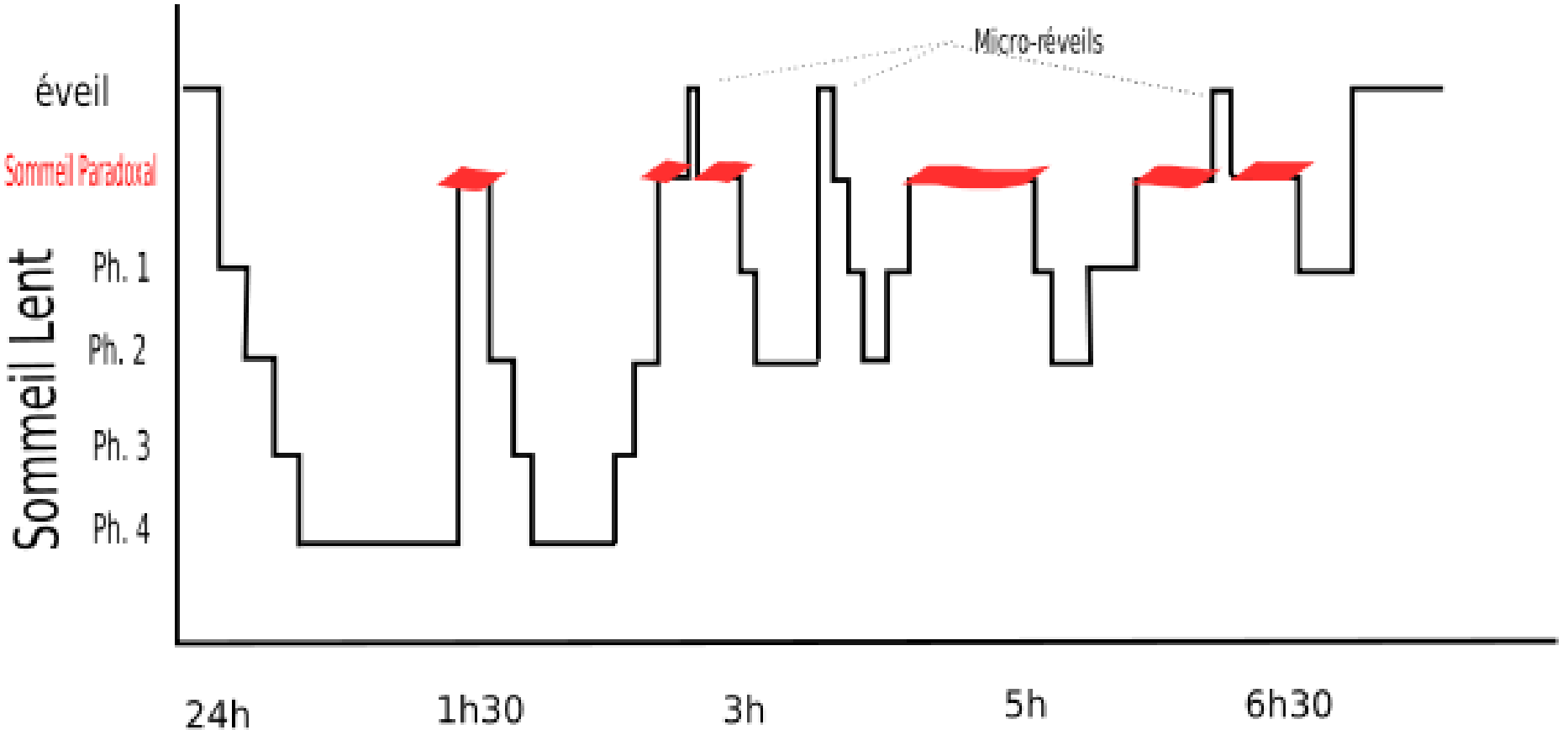
Source : Peter Hauri, *Current Concepts, The Sleep Disorders*, Upjohn, Kalamazoo, Michigan, 1982, p. 7.

EEG



48-1. REM *vs.* non REM sleep

Hypnogram



49. Hebb training of the inhibitory synapses

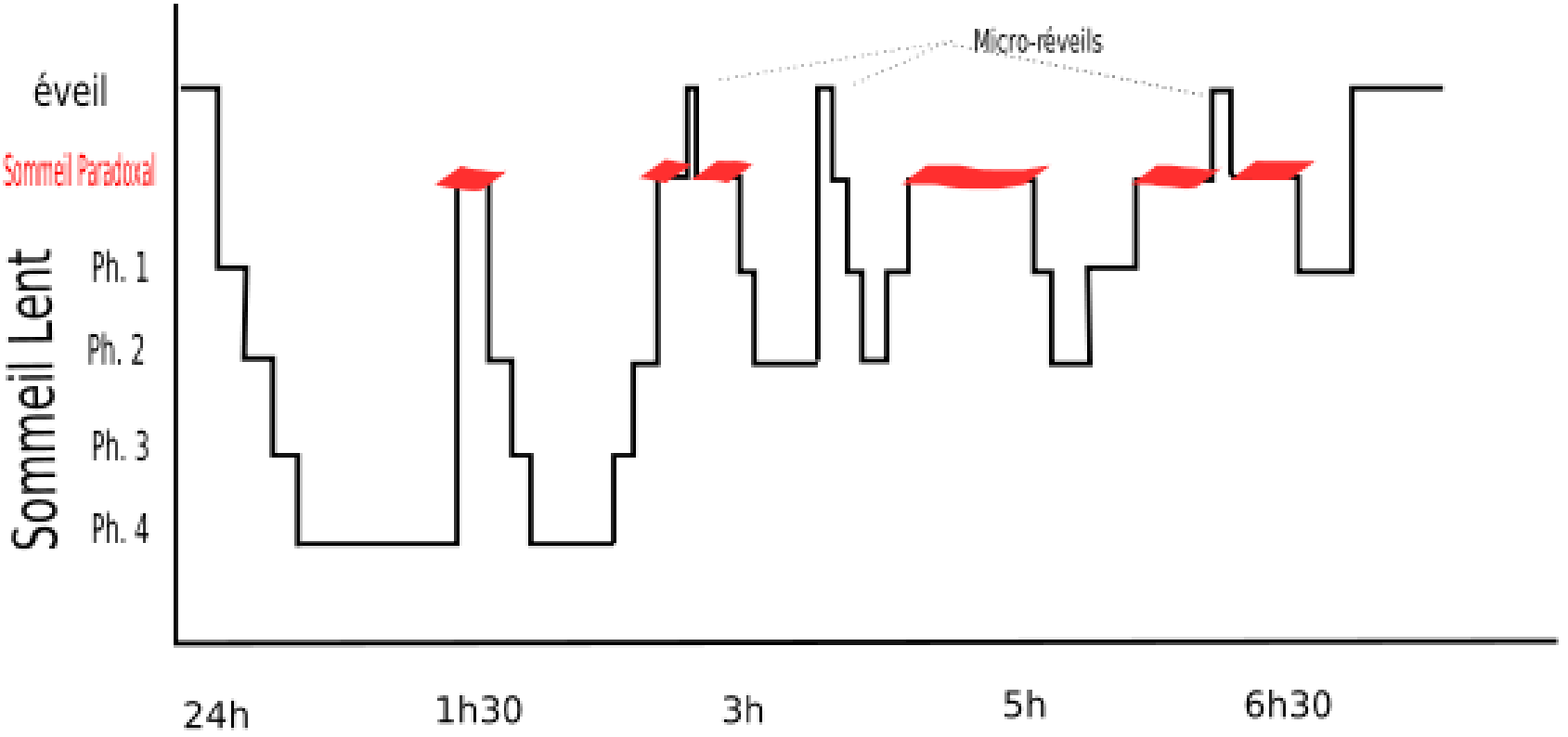
Efficient inhibitory synapses forbid (*de facto*) the activation of the target neuron, it follows that efficient inhibitory synapses decrease their efficiency over time.

Since the plasticity of the inhibitory synapse is demonstrated, then a mechanism must exist that impedes, or restores the efficiency of such synapses.

Through the Hebb's law, such restoration of efficiency is possible if both neurons (neuron A, and neuron B – target of the inhibitory synapse) are firing together. This is exactly what happens during the slow-wave sleep (NREM).

Kullmann DM, Moreau AW, Bakiri Y, Nicholson E (2012) Plasticity of inhibition. *Neuron* 75(6):951-62.

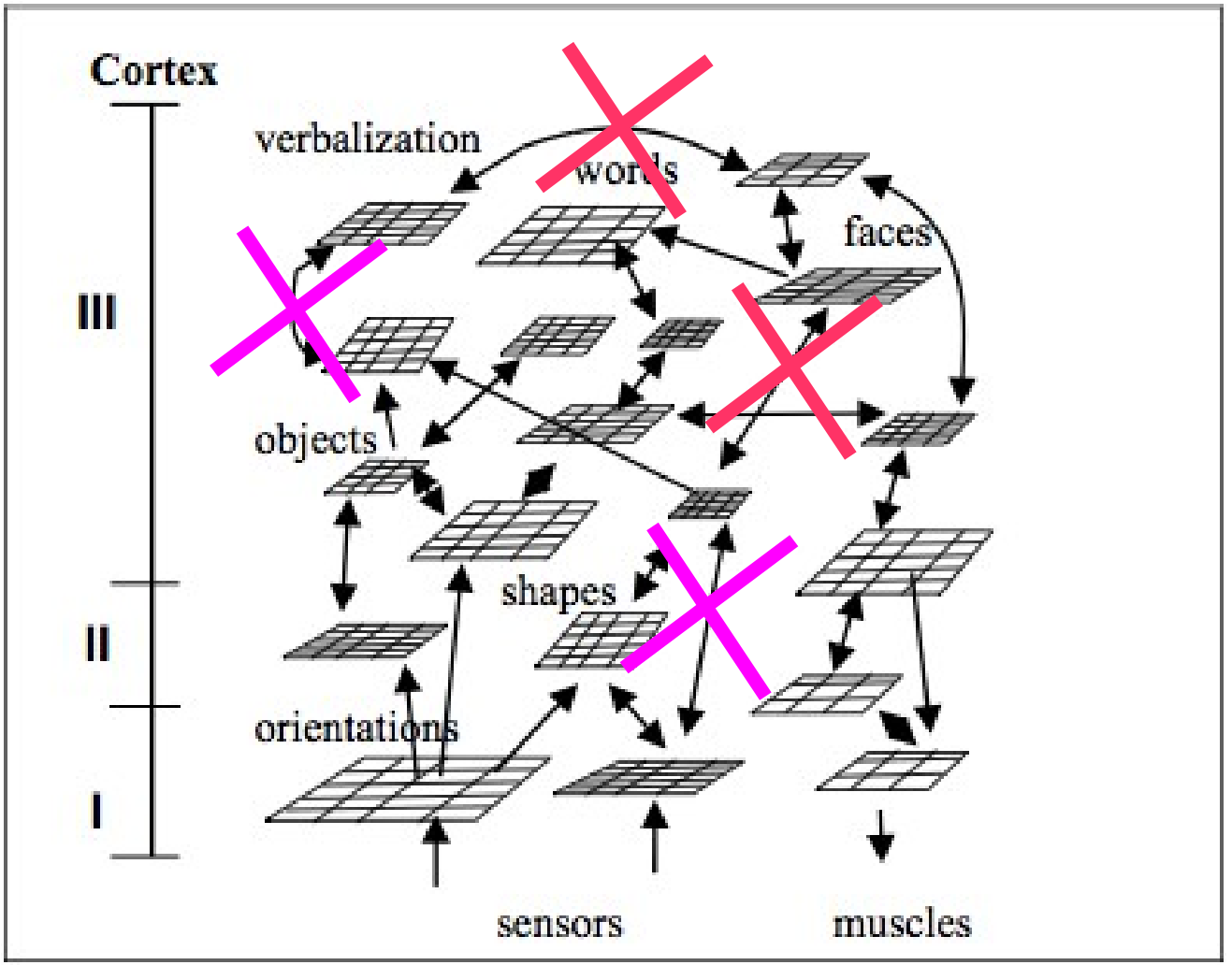
50. Why we must sleep



Cognitive performances fall during the day...

51. Why hypnosis is look upon with anxiety

52. What hypnosis says about brain-mind organization



53. How to induce the hypnosis transe

- Suggestion (ideomotor effect)
- Confusion induction
- « pattern » interruption

54. Why “against” placebo is mainstream research

L'effet placebo est une amélioration de l'état de santé du sujet sans cause objective.

L'effet placebo les gêne beaucoup car la pharmacologie s'est bâtie sur le postulat que le médicament agit sur la pathologie, et que la pathologie existe indépendamment de l'individu.

What is health ? What is a placebo ?

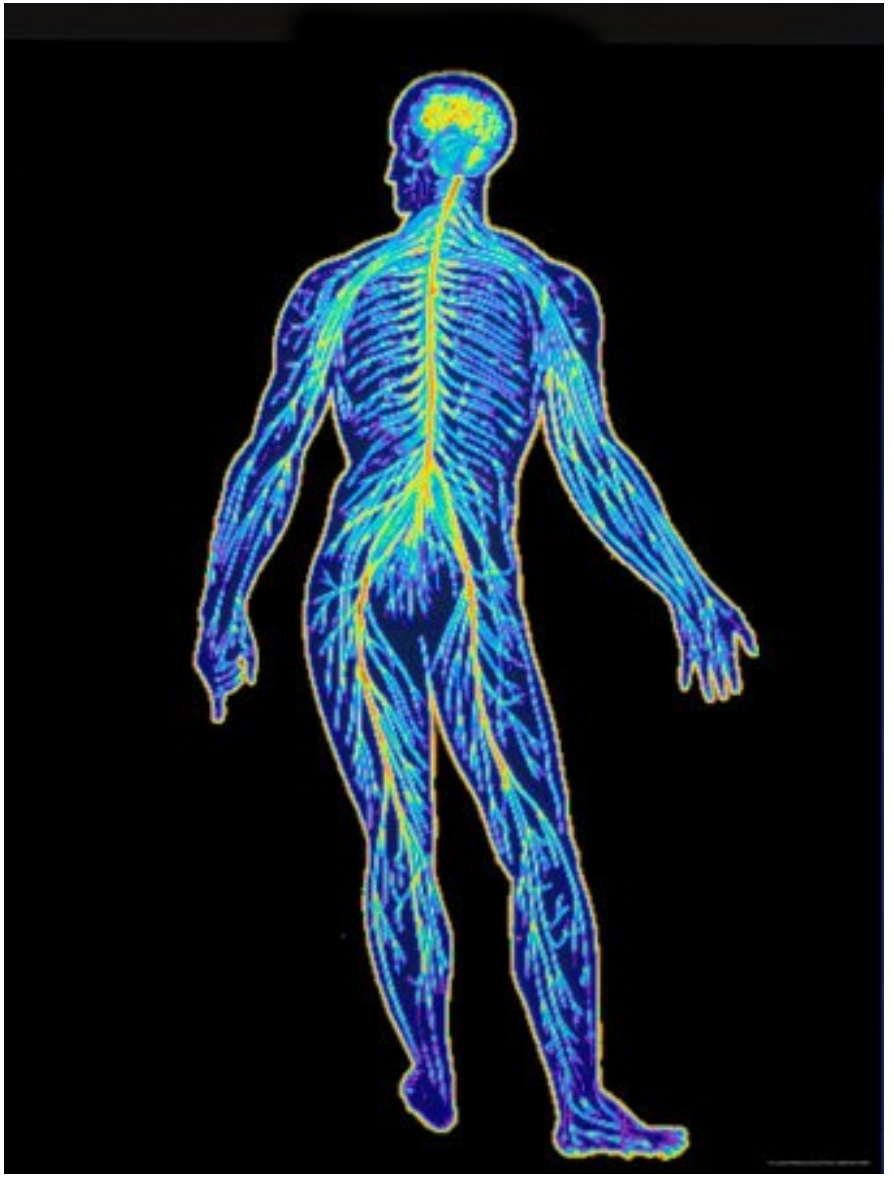
55. Grounding ideas into neurons

De l'ubiquité du réseau nerveux dans le corps,

système sanguin,

système immunitaire,

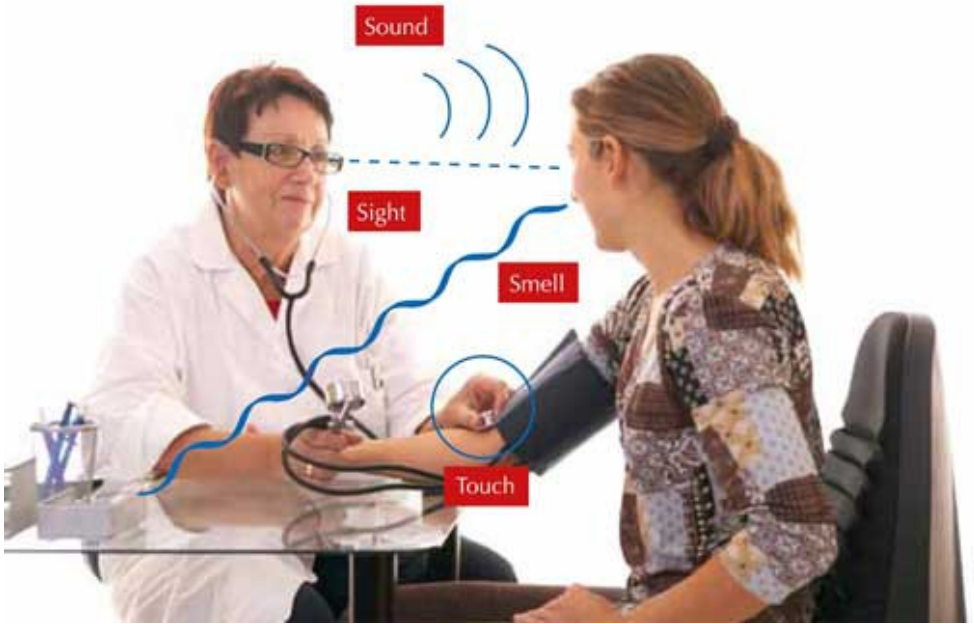
Boucles de régulation



56. Placebo variables

- Selon les individus (son vécu, mais pas sa personnalité).
- Les effets dépendent de la taille, de la couleur, du nombre de pillules, du prix.

Les effets dépendent du pays, du contexte, de la publicité, de la date de commercialisation, des conseils associés lors de la délivrance.



57. New definition, new pharmacology

Connexions neuronales multi-niveaux et loi de Hebb

58. Homeostasis

Stay erect
Blood pressure
Etc.

Regulation around value without supervision (chronic diseases).

59. Hebb+

The equilibrium is defined by the fact that the frequency of changes is particularly low. The last “action” of the neurons will be well recorded, and therefore will be easily replayed next time the situation is similar. This learning – by only allowing complete synaptic modification for the associations that are not immediately followed by other actions – favors the emergence of equilibriums. Applied to biology, these equilibriums may be referred to as “homeostasis”.

60. Supervised learning

Palimpsest learning explains how well-timed additional information (supervision) help organize the various cortical maps.

I. **Neurobiological facts**: The cortex

II. **Modelisation**: Behaviors

III. **Cognition explained**: Intelligence, Consciousness, Endogenous and exogenous attentions, Episodic and semantic memories, Motivation or joy

IV. **Mental diseases**: Schizophrenia, Depression, Alzheimer's disease, Autism

V. **Modified states of consciousness**: Sleep, Hypnosis, Placebo effect, Homeostasis

VI. Absence of free-will, altruism and personal happiness

61. Tentatives to save belief in free-will

Conclusion : no need for free-will to explain cognition and consciousness

A hierarchy of SOMs representing the world events is able to behave in a human cognitive manner...

Templeton foundation

Altruism challenged by belief in free-will...

Roy F. Baumeister, E.J. Masicampo and C. Nathan DeWall, Helpfulness Prosocial Benefits of Feeling Free: Disbelief in Free Will Increases Aggression and Reduces, *Pers Soc Psychol Bull* 2009; 35; 260

62. Why altruism is a sure way to personnal happiness

No free-will → predict the result of events

Good actions induces better mood

Better mood induces more good actions

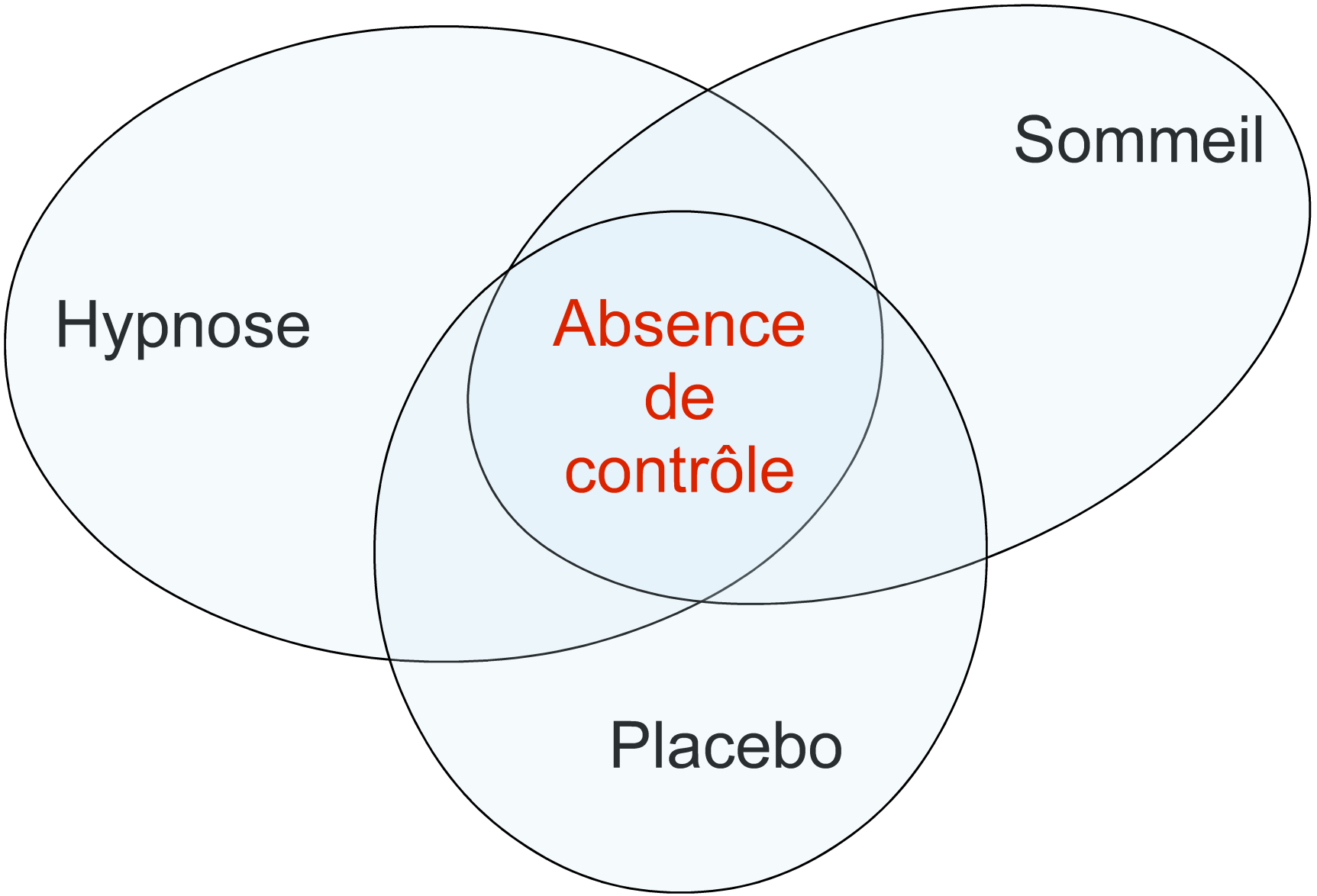
No free-will : no loss of investment

I will received the fruit of my investment.

63. References

- C. Touzet, "The Theory of neural Cognition applied to Robotics", *International Journal of Advanced Robotic Systems*, 2014, to appear.
- C. Touzet, *Hypnose, sommeil, placebo ? Les réponses de la Théorie neuronale de la Cognition - Tome 2*, 166 pages, éd. la Machotte, 2014.
- C. Touzet, *Conscience, intelligence, libre-arbitre ? Les réponses de la Théorie neuronale de la Cognition - Tome 1*, 156 pages, éd. la Machotte, 2010.

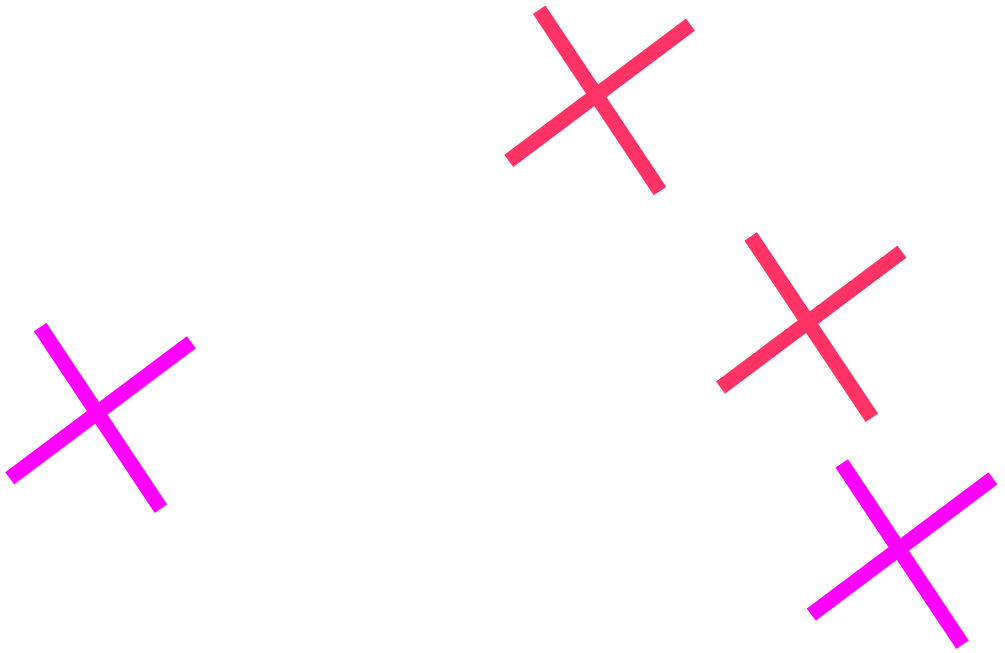
Pourquoi êtes-vous venus ?



L'hypnose médicale

Jean-Martin Charcot, 1882 (Salpêtrière)

L'hypnose : supprimer le contrôle de cohérence de l'activation inter-cartes

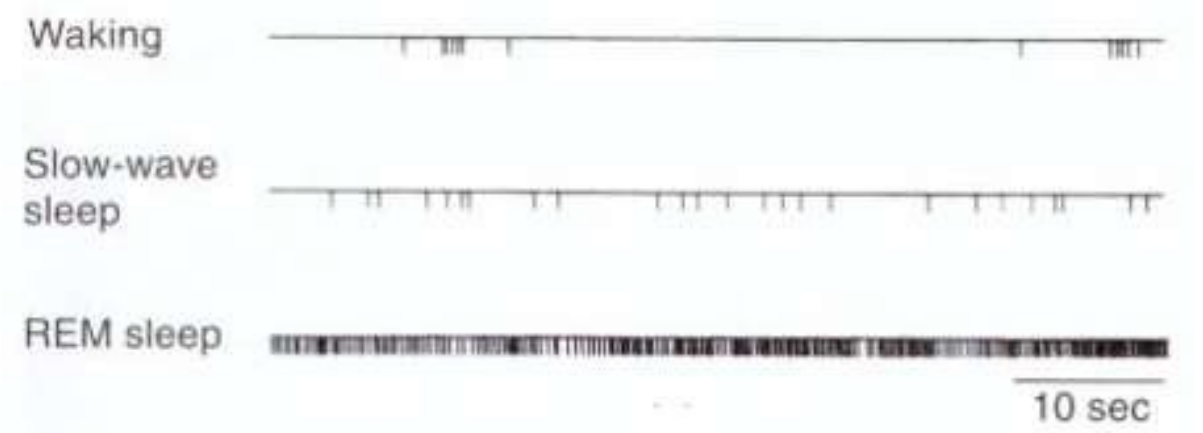


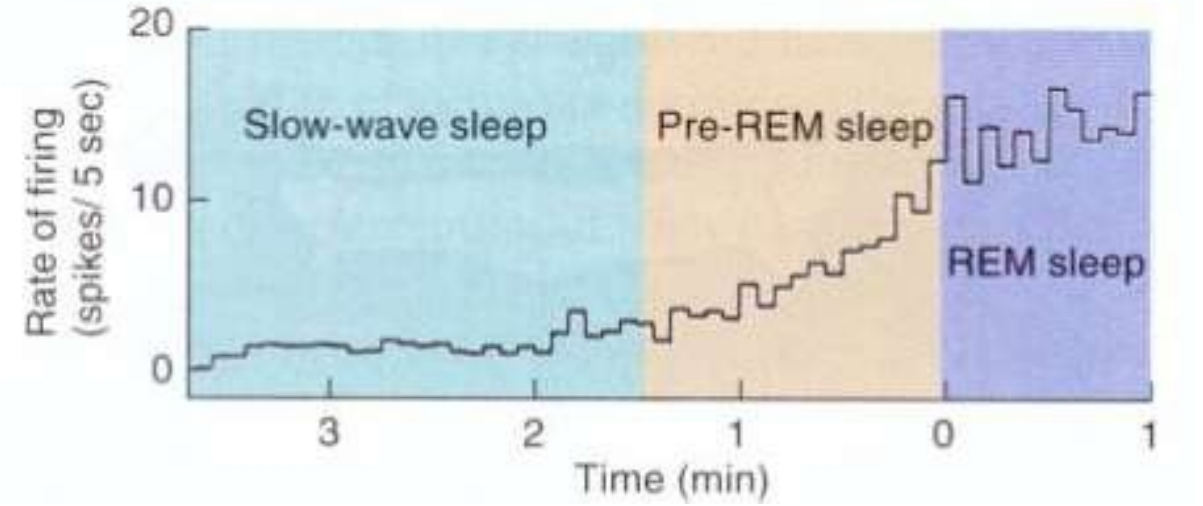
Ce qu'il faut retenir

- C'est la cohérence de l'activation de l'ensemble des cartes corticales qui permet un « contrôle » de la réalité.

- Les suggestions post-hypnotiques sont efficaces car mises en place dans un état d'activation minimale des cartes (que la voix du thérapeute).

Les ondes cérébrales



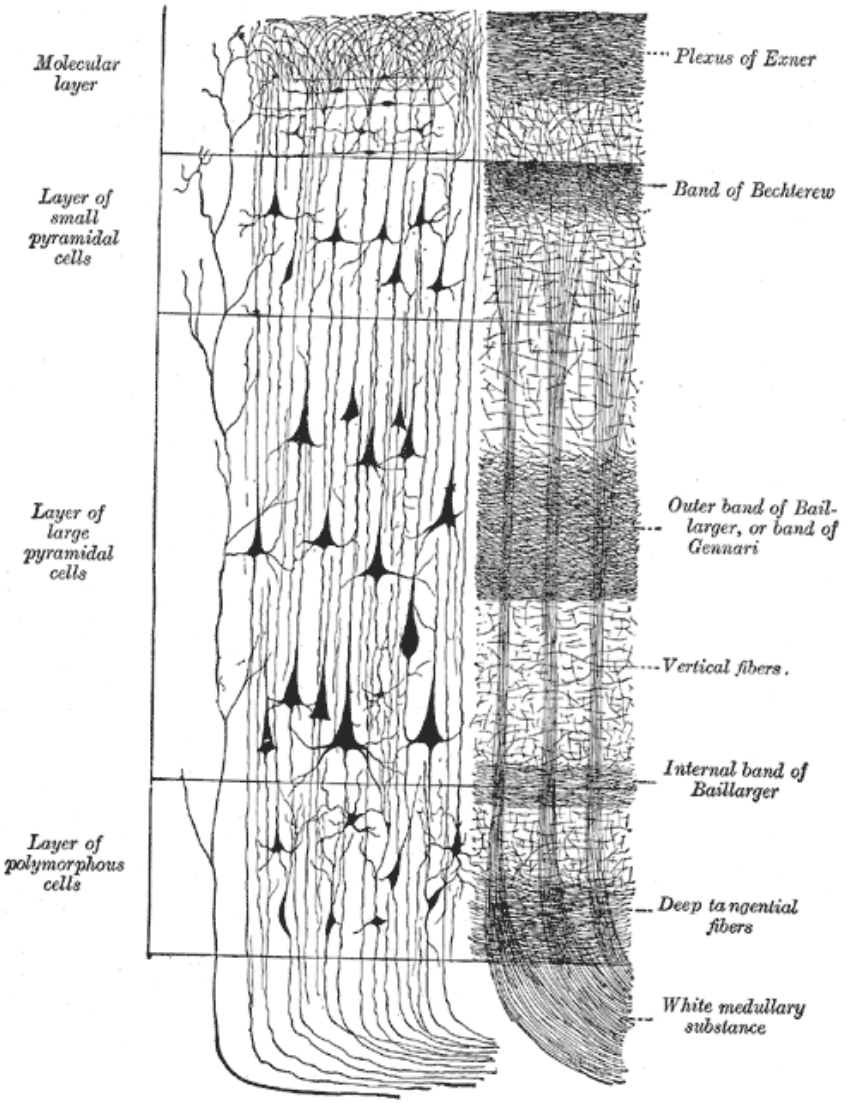


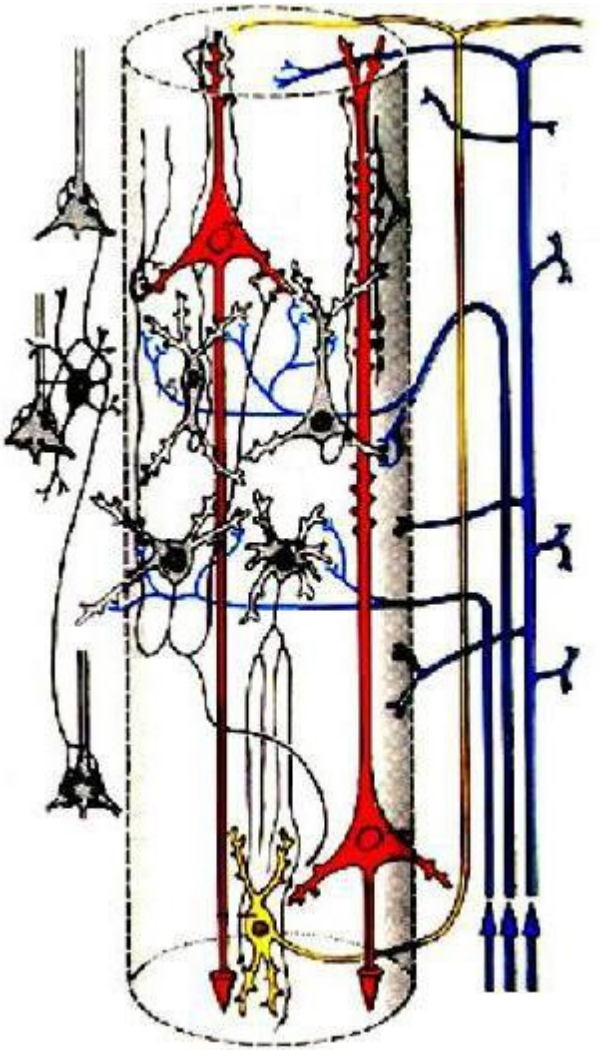
Localisées

Distribuées

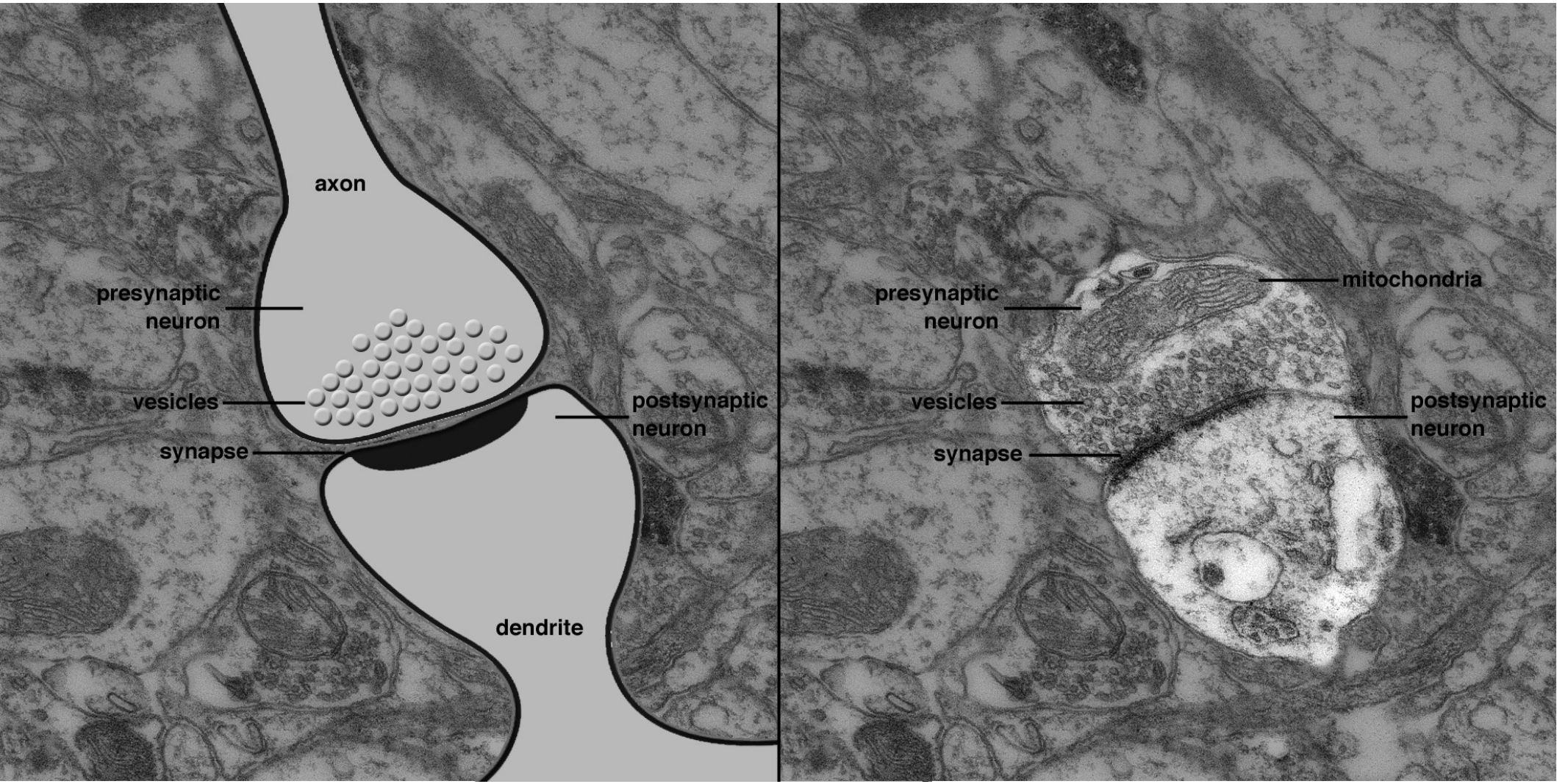
x 20

Les colonnes corticales

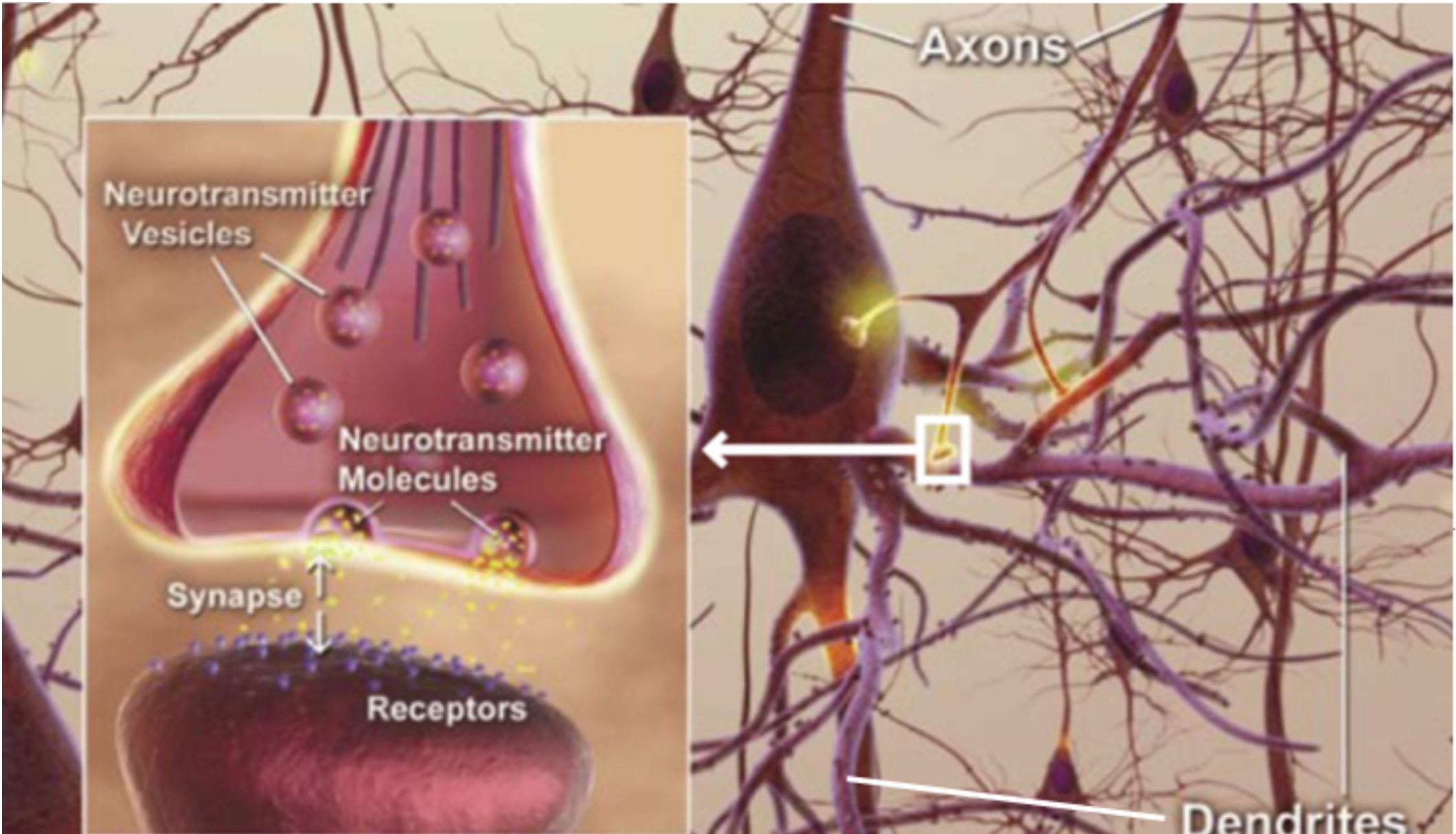




Modification des connexions



Loi de Hebb (1942)



Ce qu'il faut retenir :

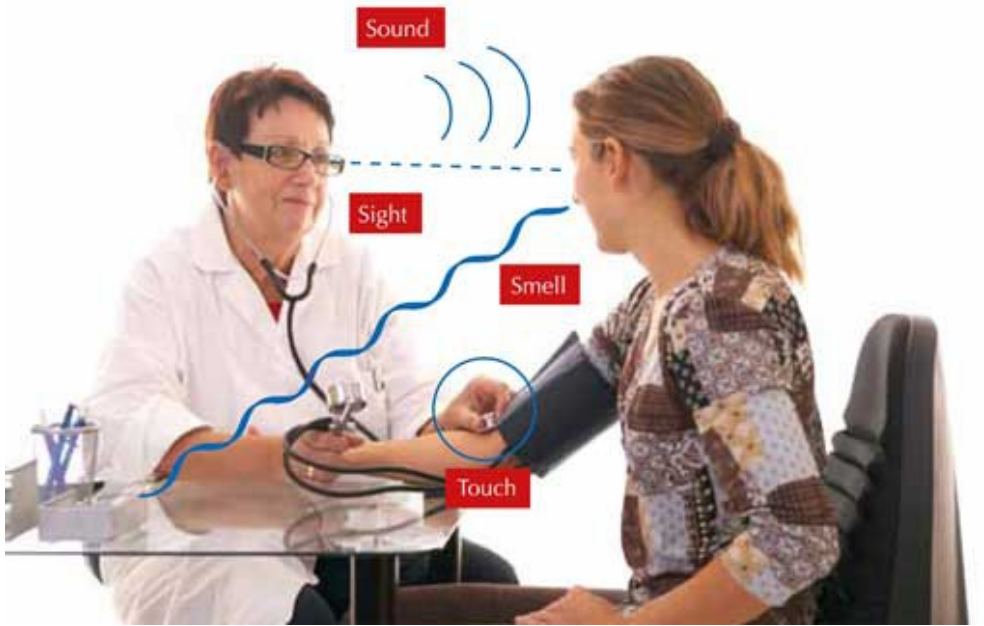
- Durant l'éveil, les connexions excitatrices à longue distance sont renforcées, tandis que les connexions latérales inhibitrices sont diminuées (du fait même qu'elles sont efficaces).
- Durant le sommeil lent, il y a synchronisation locale des neurones et donc renforcement de toutes les connexions à courte distance (inhibitrices, fonction de l'usage diurne).
- Durant le sommeil paradoxal, il y a réactivation des connexions à longue distance (x20).

Les placebo sont efficaces pour :

- la dépression, l'hyperactivité ou les déficits d'attention, l'épilepsie, les troubles du sommeil, l'hypertension artérielle, les troubles de l'érection, la frigidité, les phobies, l'addiction au jeu, le mal de tête, la migraine, la douleur, l'asthme, la nausée, la maladie de Parkinson, la toux...
- la lutte contre les allergies, les ulcères d'estomac, l'herpès, le cancer, la maladie de Crohn, la sclérose en plaques...

Variations d'efficacité du placebo

- Selon les individus (son vécu, mais pas sa personnalité).
- Les effets dépendent de la taille, de la couleur, du nombre de pillules, du prix.
- Les effets dépendent du pays, du contexte, de la publicité, de la date de commercialisation, des conseils associés lors de la délivrance.

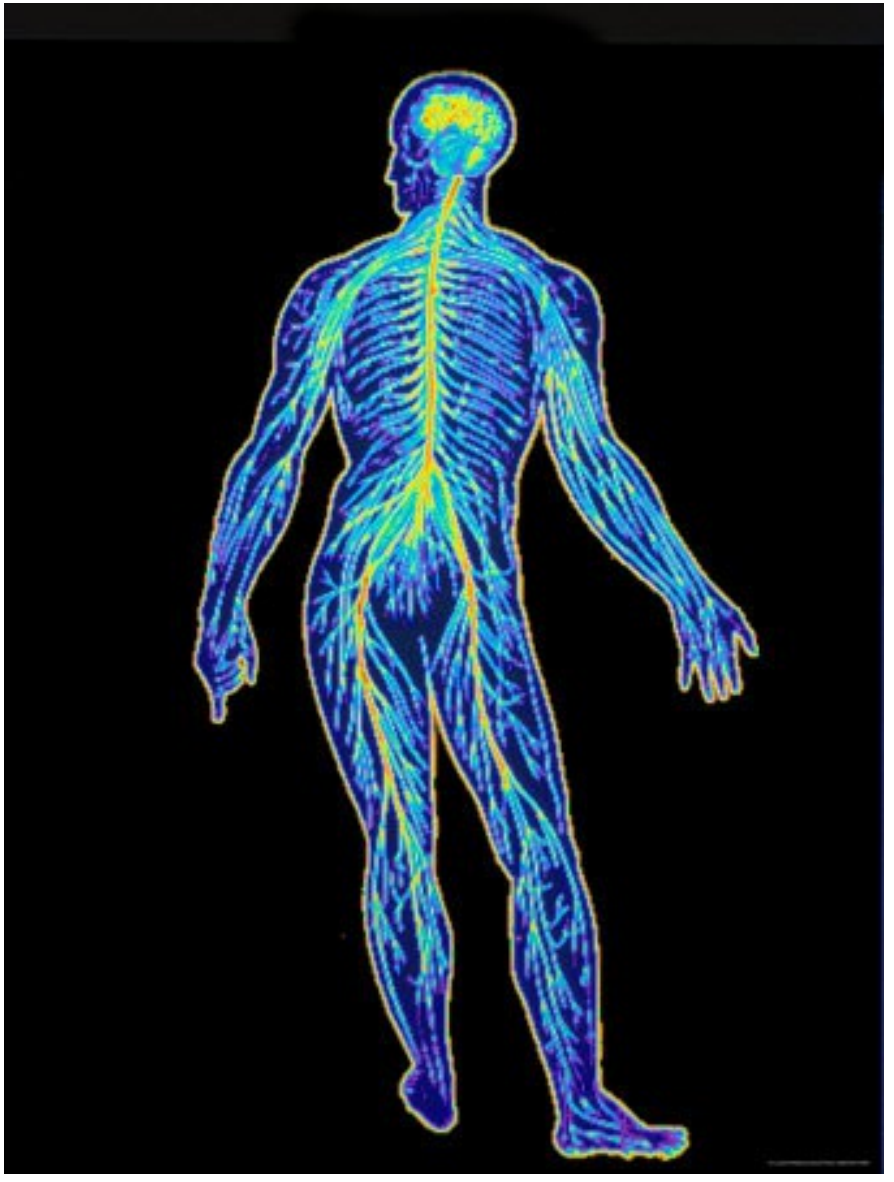


L'effet placebo

L'état de « bonne santé »

Tout notre corps est sous le contrôle de nos neurones, y compris le système hormonal et le système immunitaire.

L'apprentissage des réseaux de neurones engendre obligatoirement l'homéostasie (équilibres).



Les états de «mauvaise » santé

Médecine évolutive : souvent les symptômes, qui nous font nous sentir mal(ade), sont créés par notre corps (nos neurones) pour lutter contre l'infection ou le déséquilibre (perte d'appétit, élévation de la température, toux, perte d'entrain, diarrée, etc.).

D'autres symptômes disparaîtront avec la mise en oeuvre des mécanismes de défense (système immunitaire).

Ce qu'il faut retenir :

Connexions neuronales multi-niveaux et loi de Hebb