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Modelling the dynamics of interactions: Application to the recognition of facial expressions

P. Gaussier

Cergy Pontoise University

K. Prepin, P. Andry, A. Revel, J. Nadel

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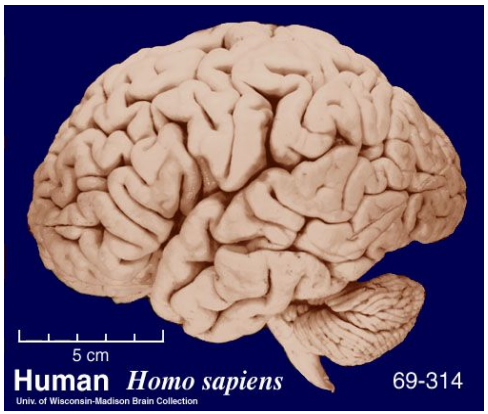
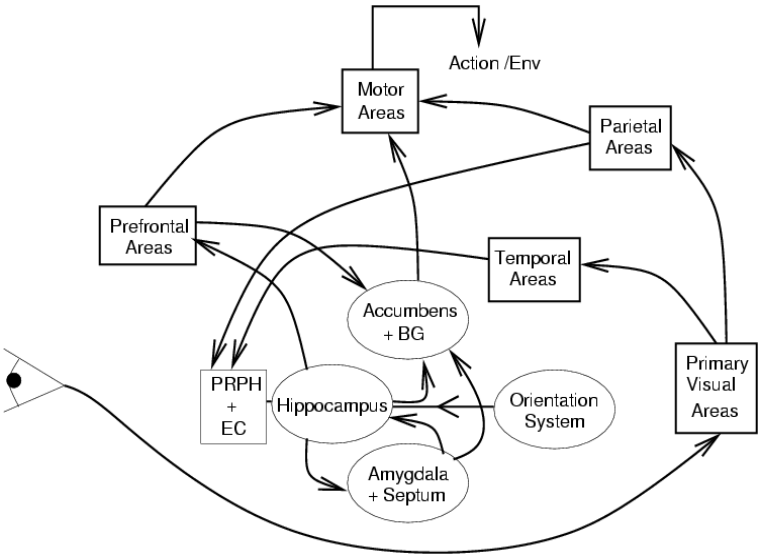
Cognition, brain, neurons...



-Development
-Social interactions



The limits of a reductionist approach….

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« Virtual » Laboratory

Joint works with

- Jean Paul Banquet (from Y. Burnod lab): neurobiological modeling

- Jacqueline Nadel
(inter-lab. association CNRS:
"imitation in robotics and development")

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Different levels of interest in emotion modelling

Importance of emotions both for individual and social development:

- Low level control (motivations, internal or essential variables...)
- Second order control (novelty or failure detection, internal emotional states, modulation of the controller activity...)
- Social communication

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Motivations and emotions for action selection and planning

Motivational Bias

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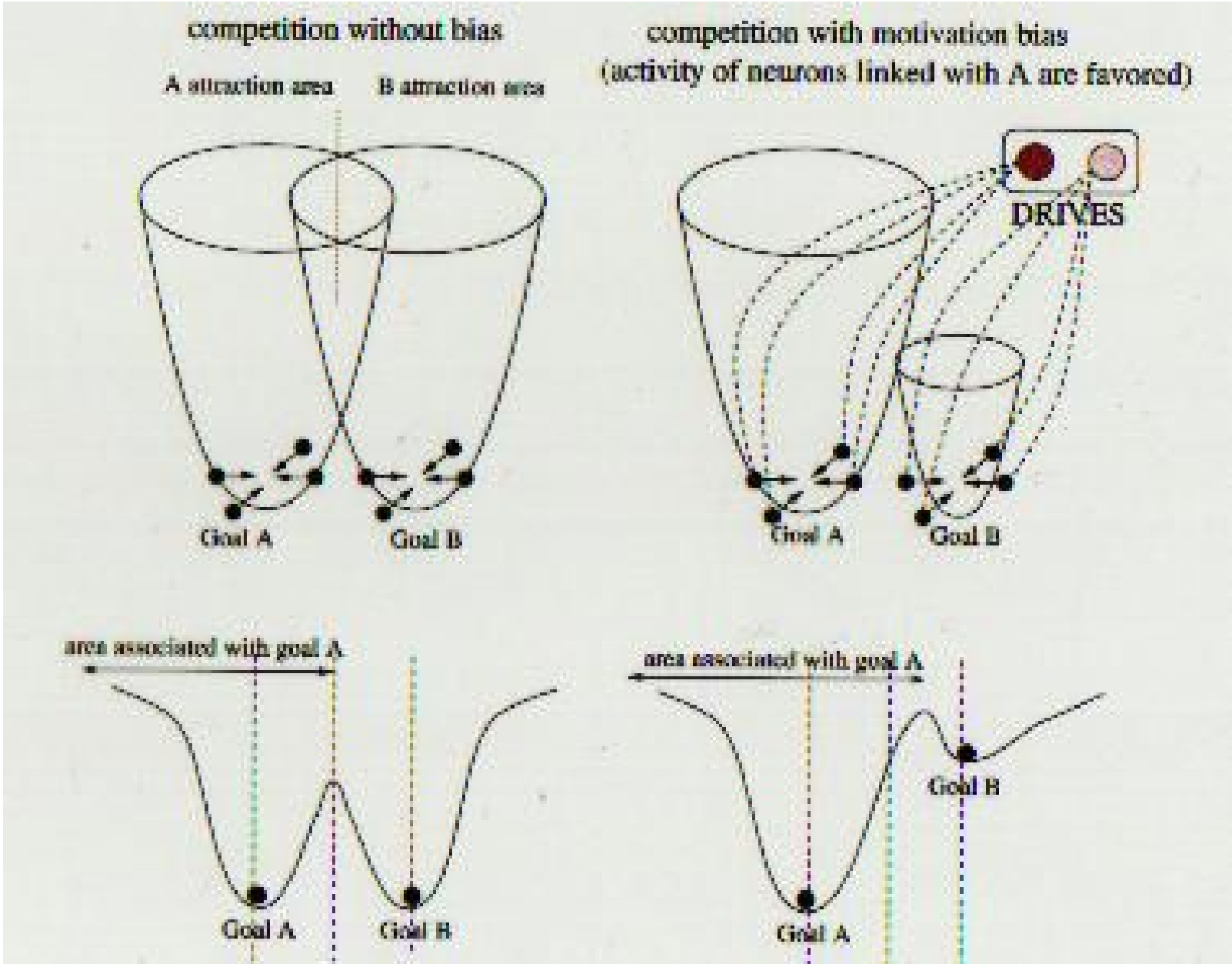
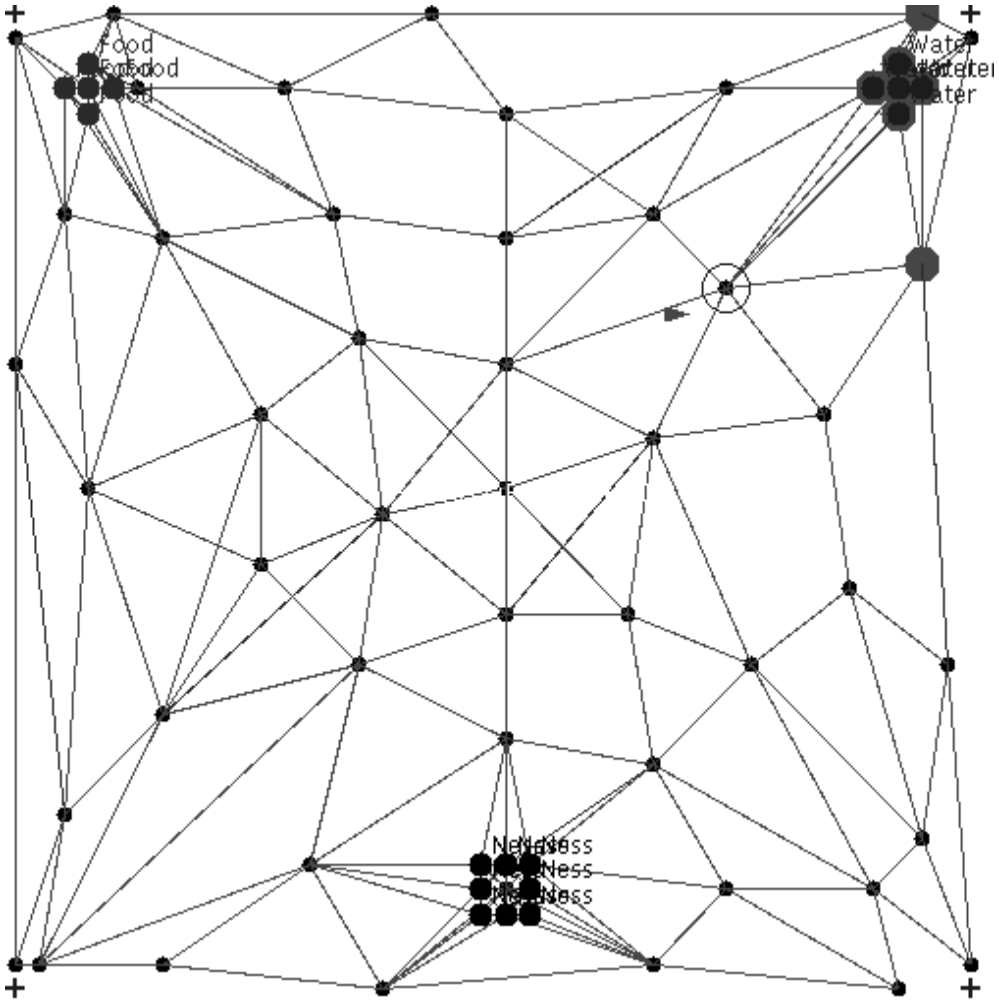


Adaptation of a cognitive map

Effect of decay and reinforcement on the connections



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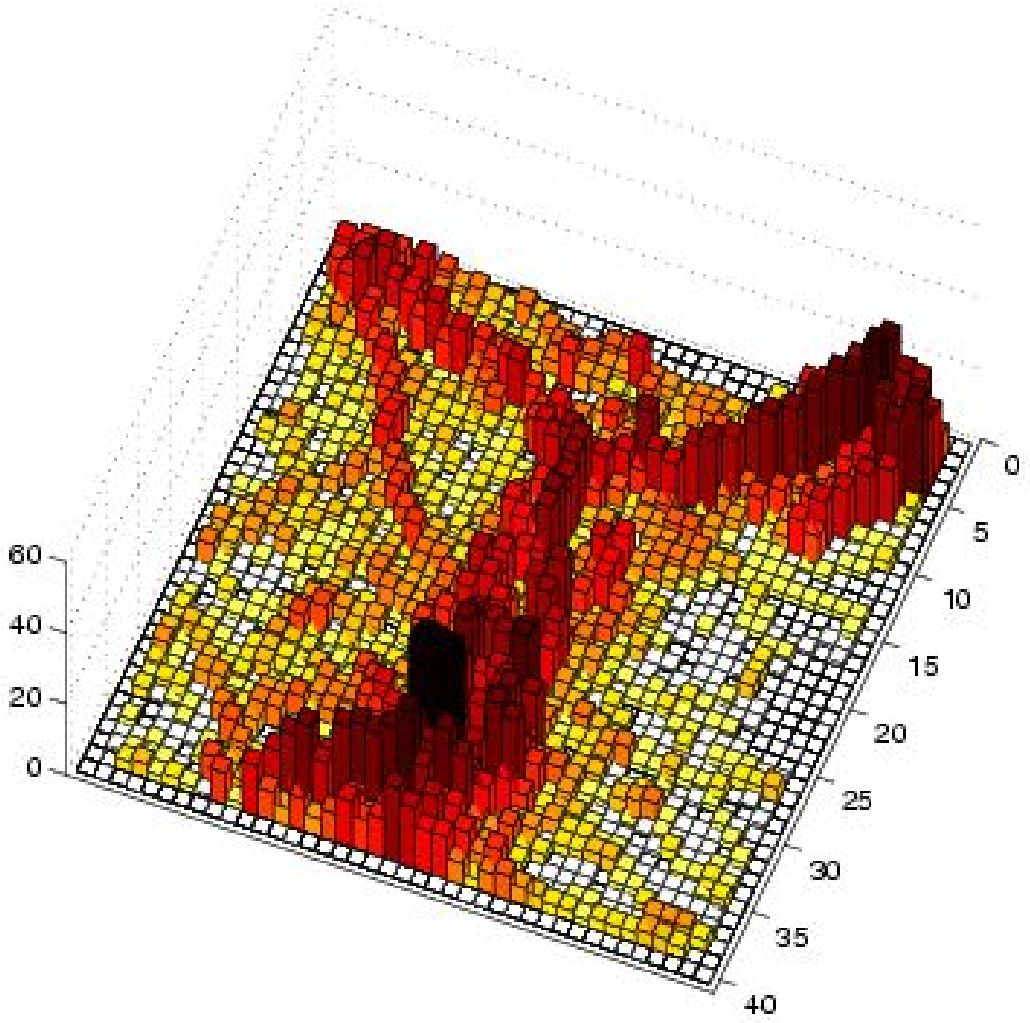
Reinforcement of the shortest pathway



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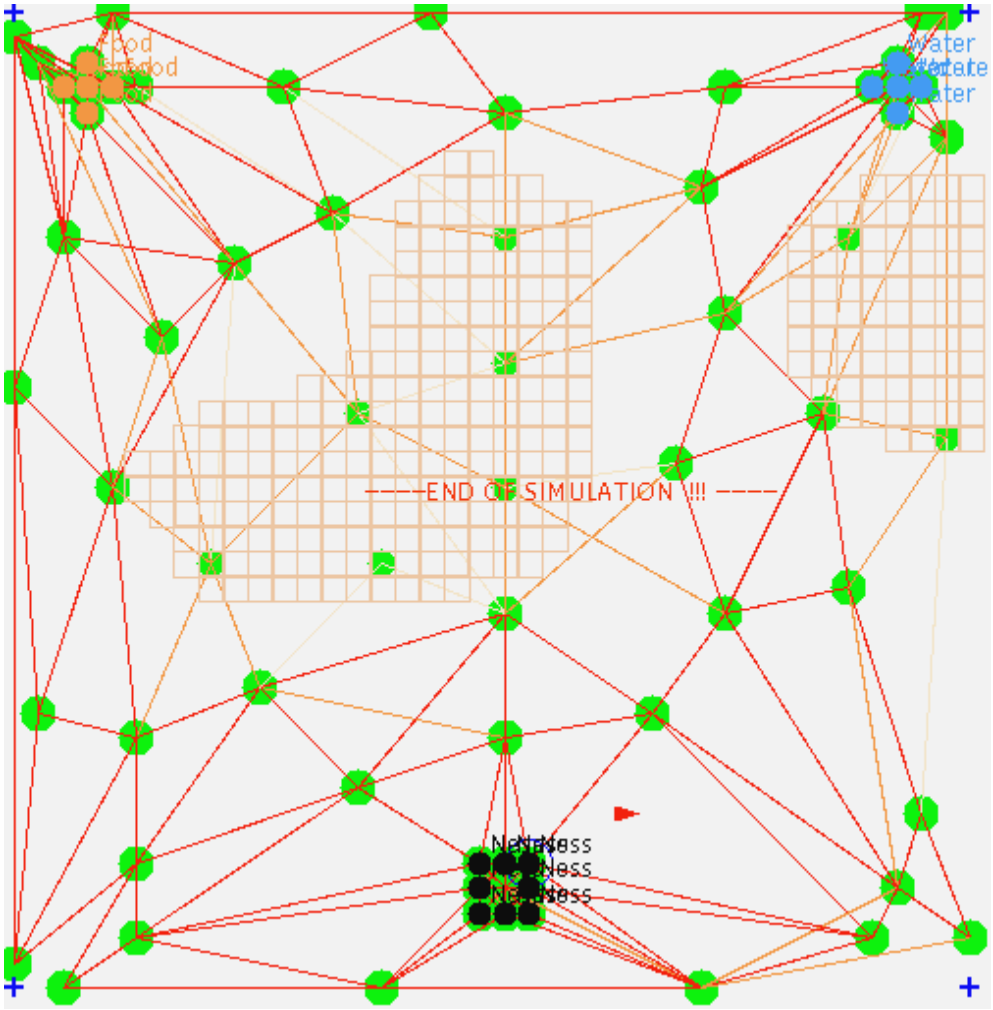
Learning to avoid dangerous areas



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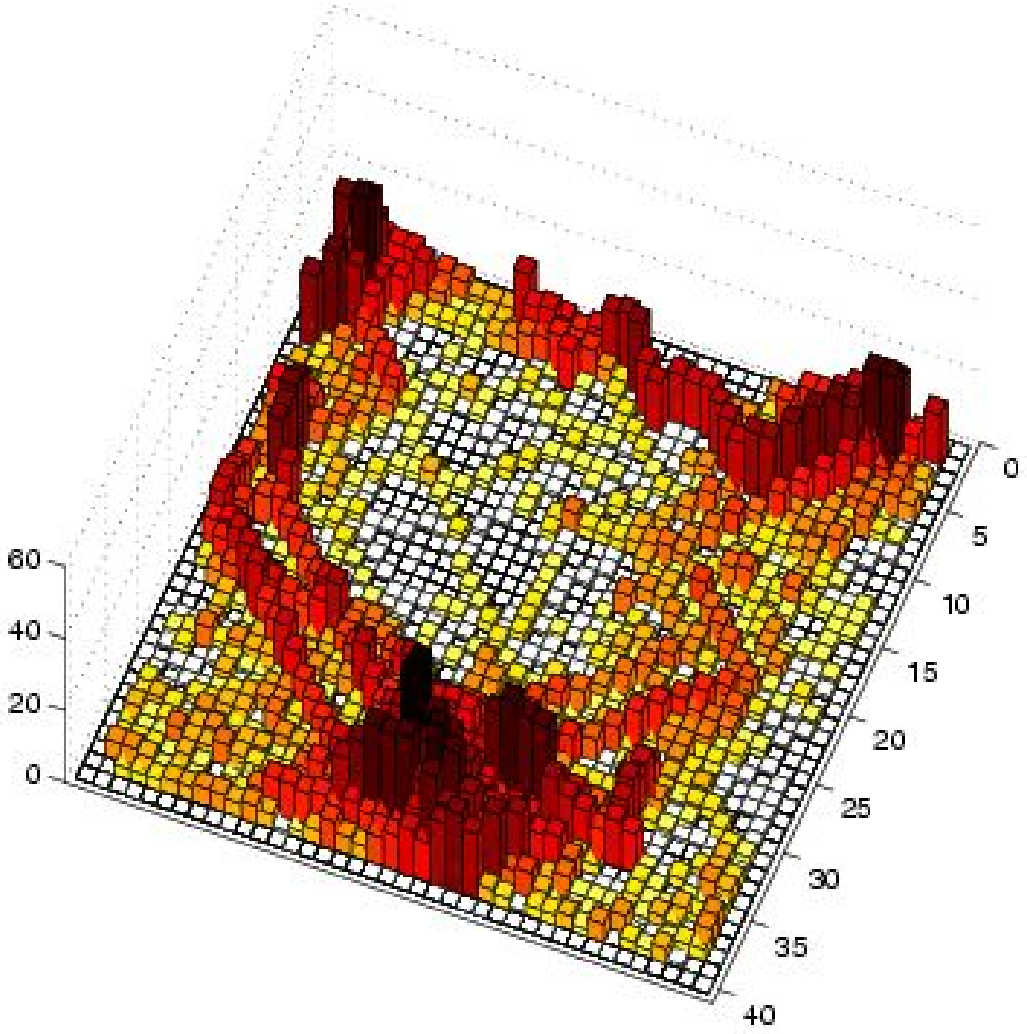
Adaptation of a cognitive map

Learning to avoid dangerous areas



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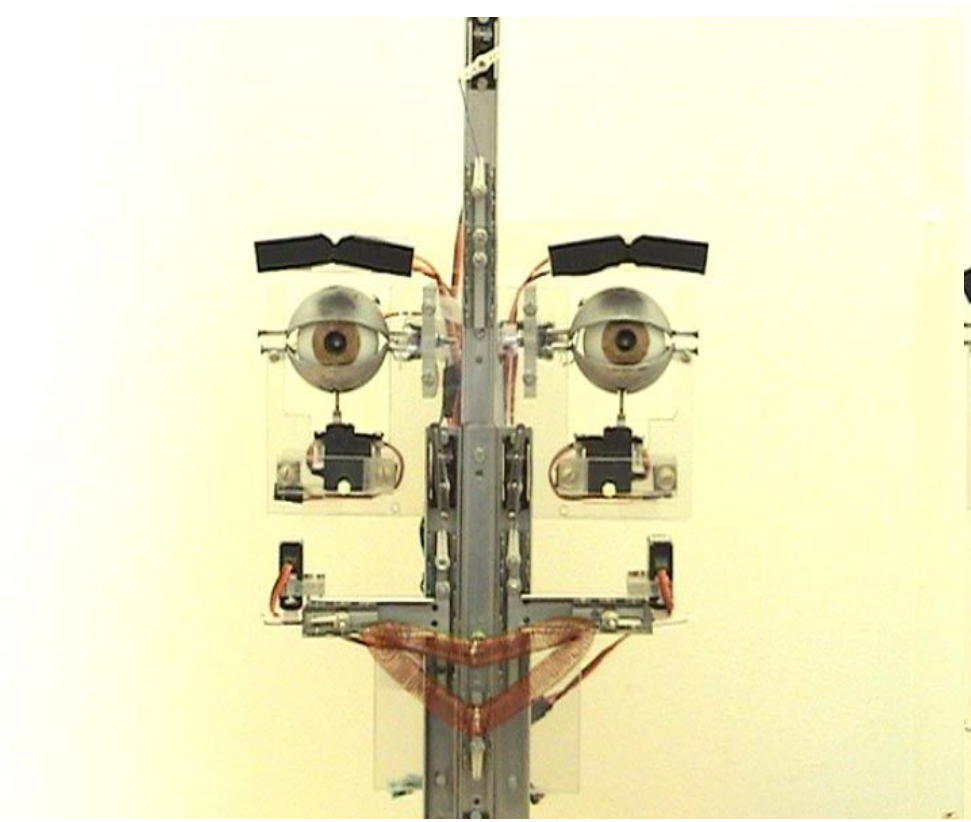
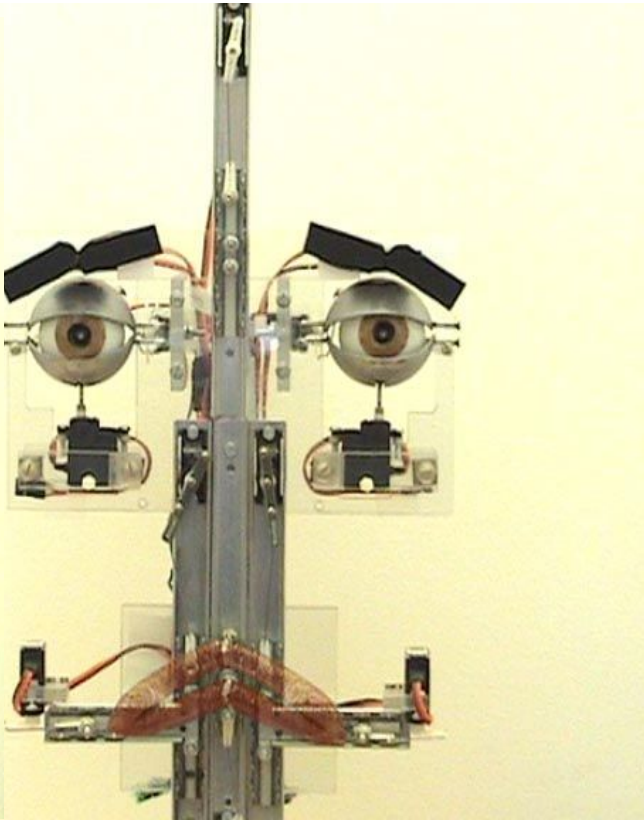
Emotions and communication





See M. Simon & J. Nadel ongoing work

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Theoretical studies of interacting systems

How to compare different models?
Do their belong to the same family?

I will try to show you on an example that:

It is possible to create a mathematical model to analyze a computation architecture and to predict its behavior
(learning in an interaction game)

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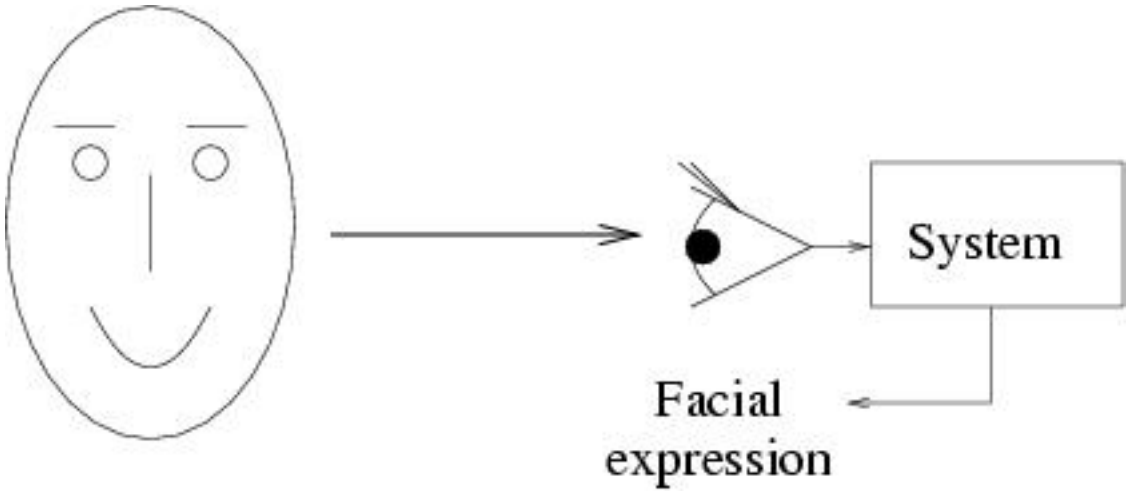
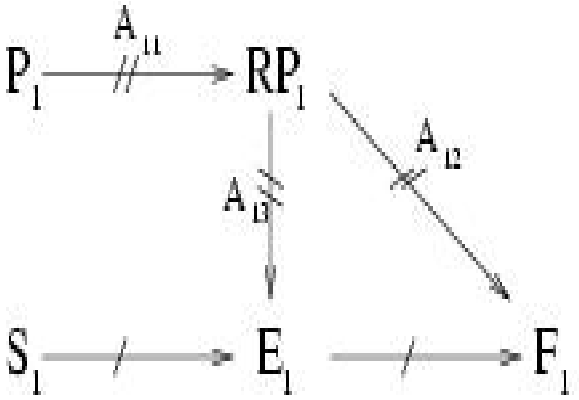
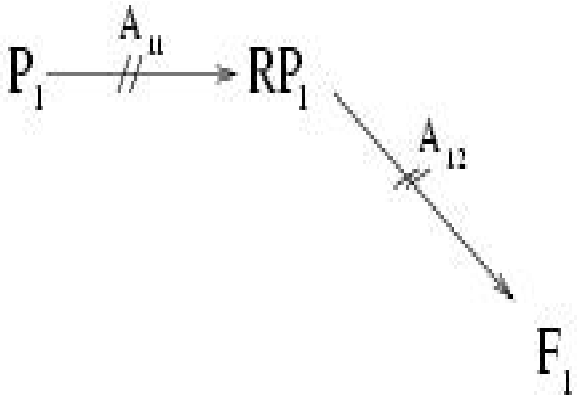
How to model baby learning?



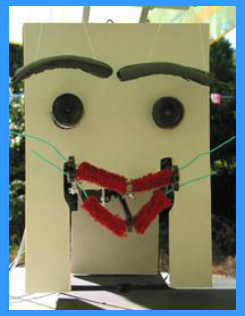
One possible architecture:



Desired solution:



(based only on sensori-motor loops)



Study of a dynamical interaction

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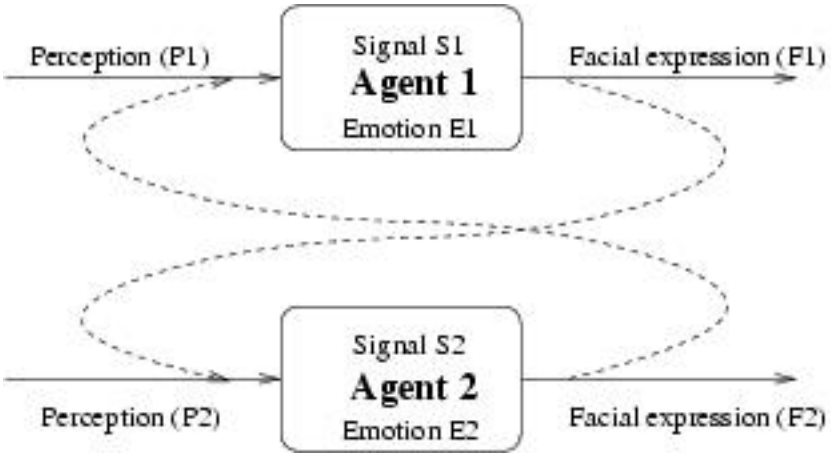
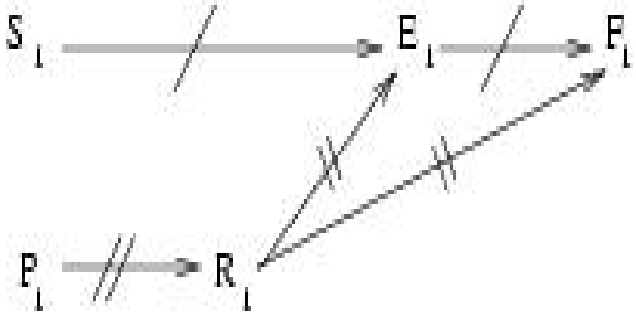
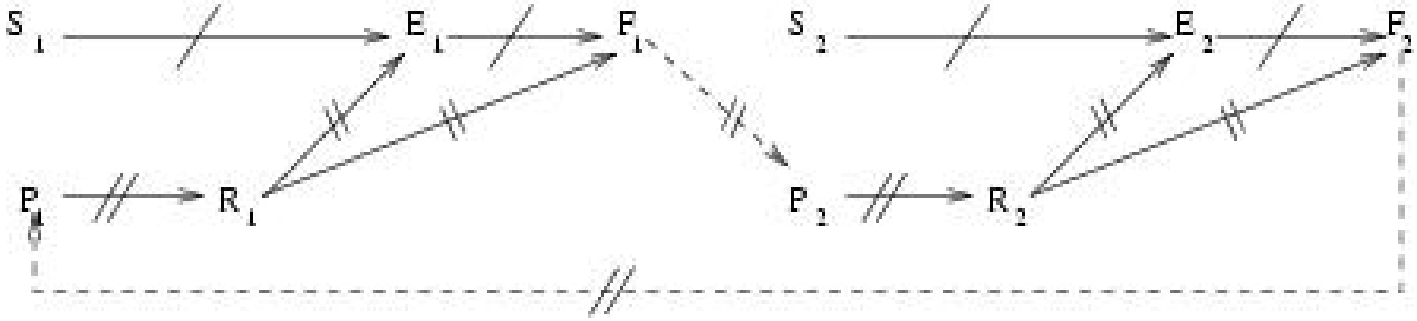
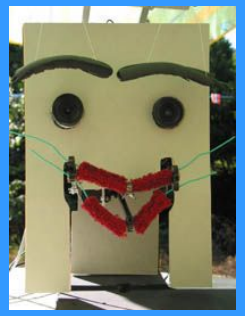


Agent architecture



Global system (both agents) :





Stable state of "perception"

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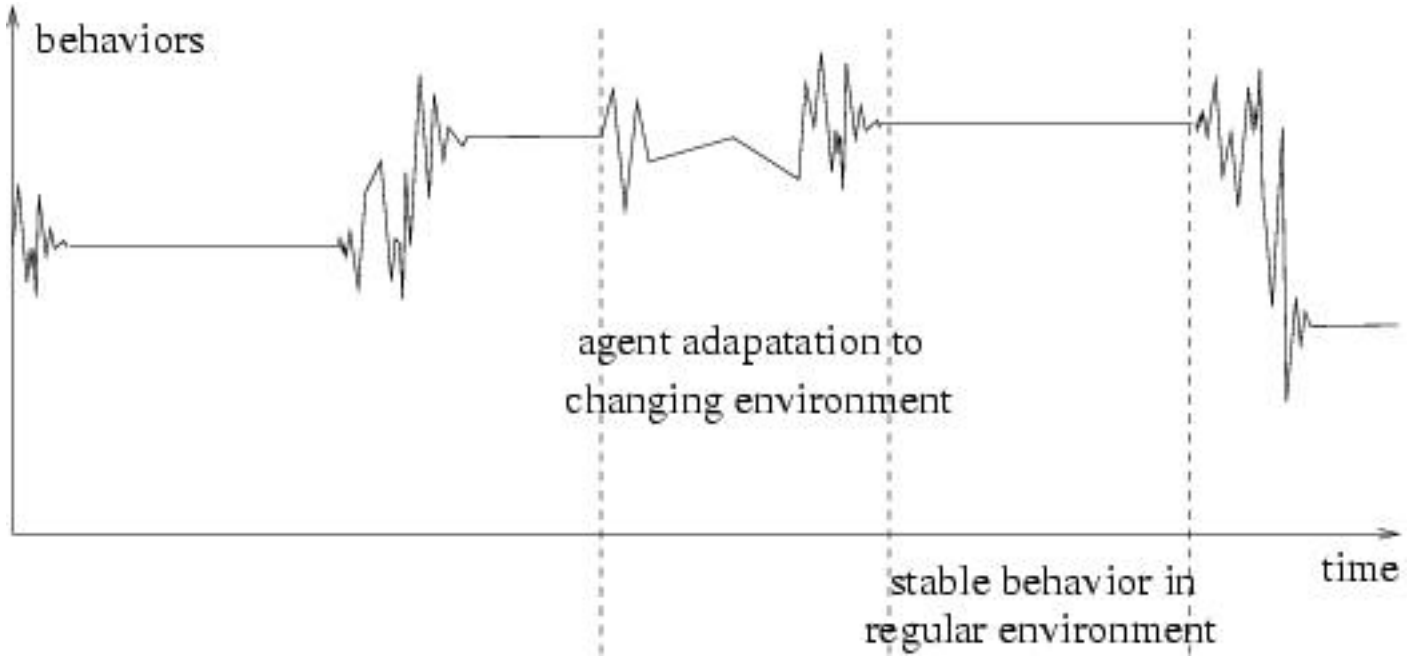
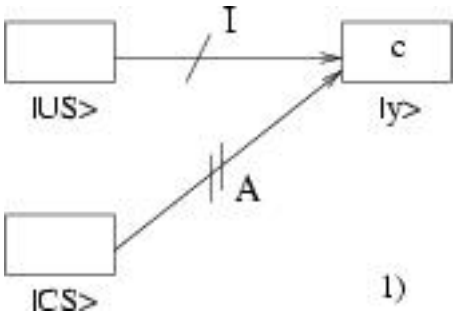
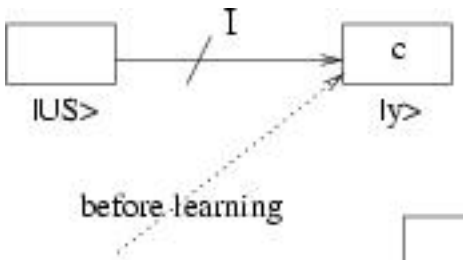
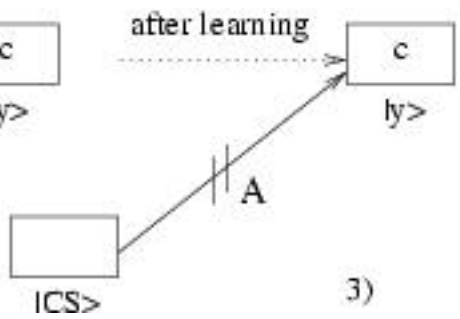
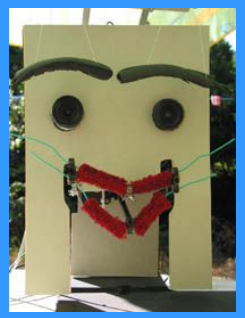


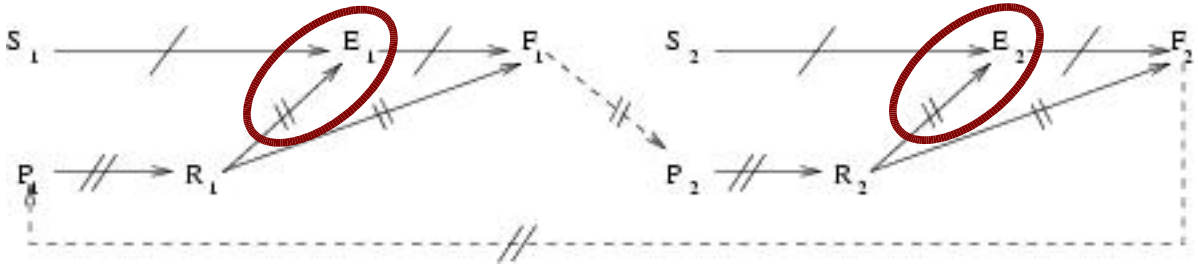




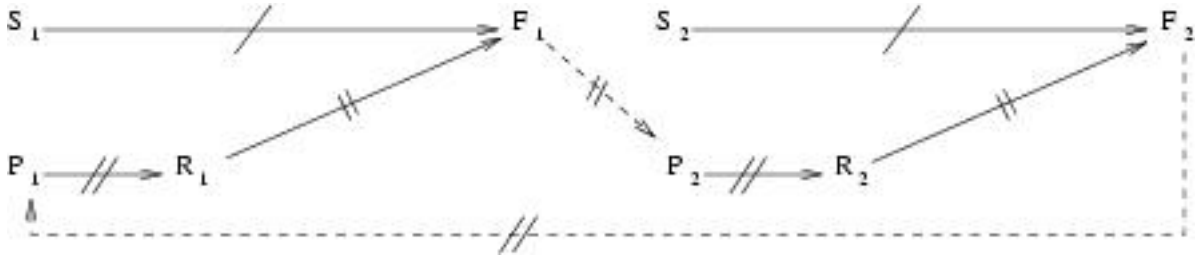


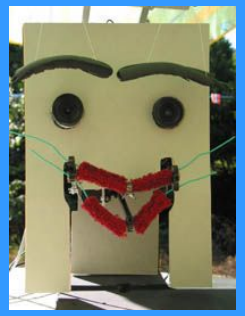


System simplification



First simplification if learning is possible:





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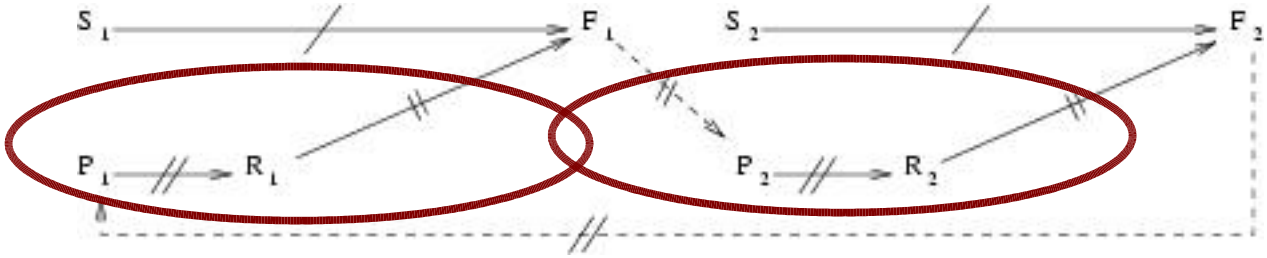
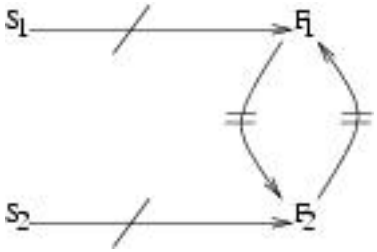
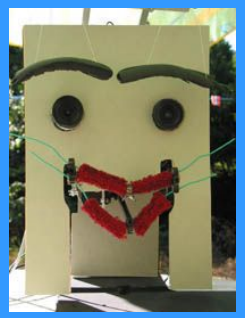
System simplification



Second simplification:





Stability condition

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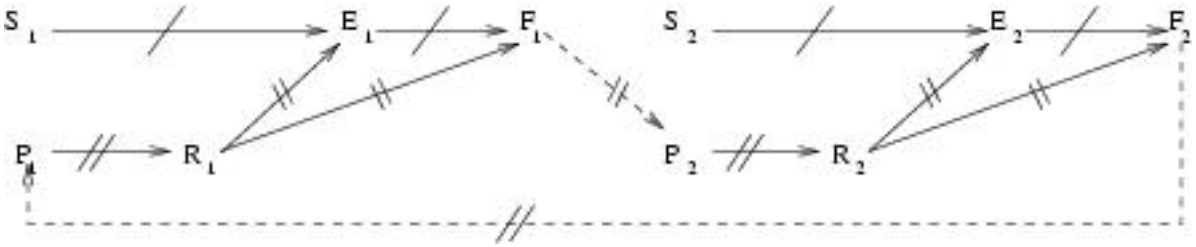
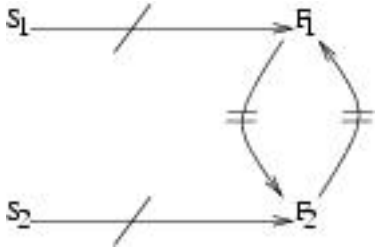
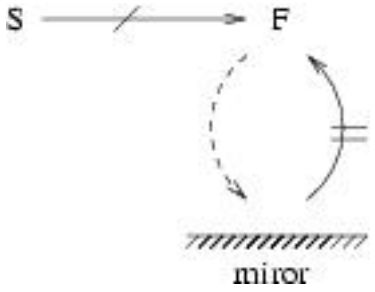
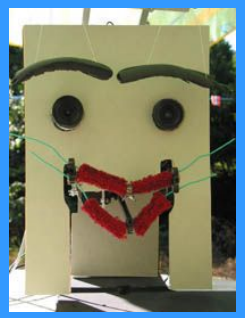




Condition for a stable association?





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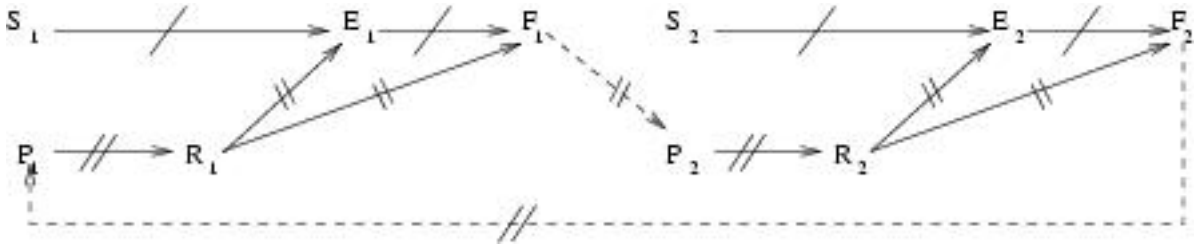
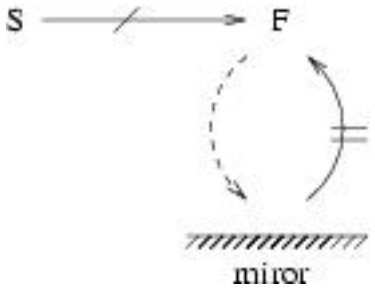
Solution for the stable state

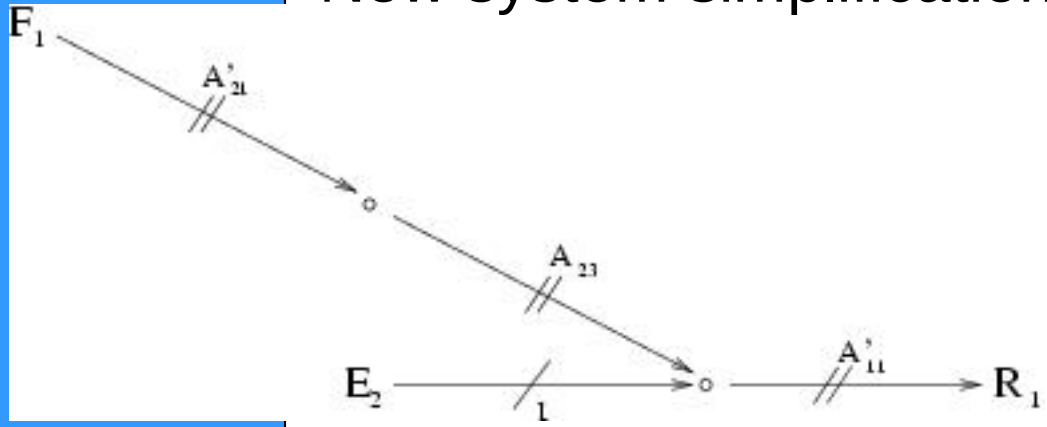
Initial system:



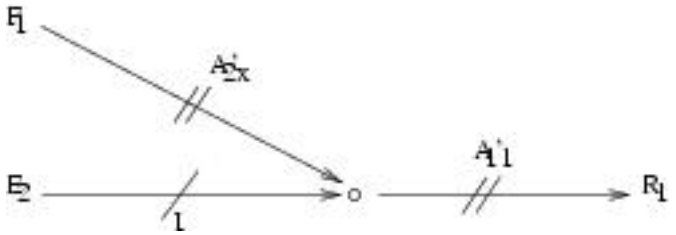
Condition for learning:



New system simplifications



Learned associations:



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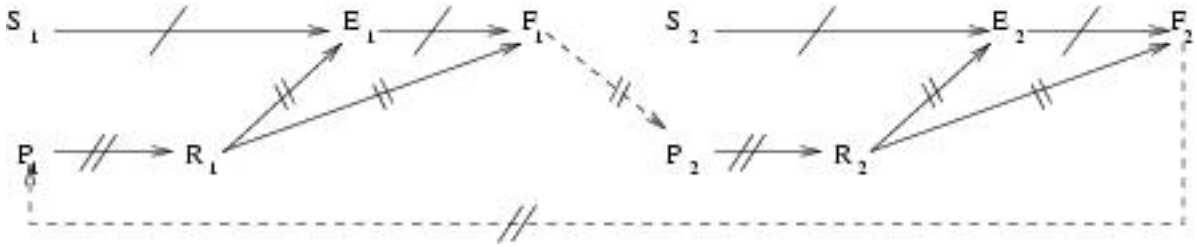
Solution for the stable state

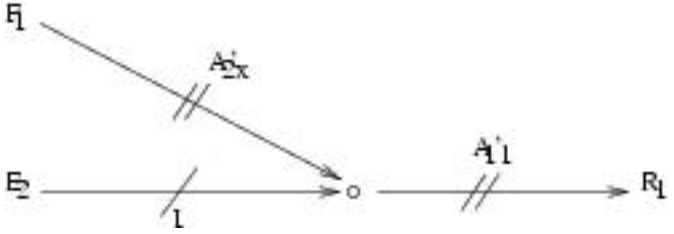
Initial system:



Learned associations:

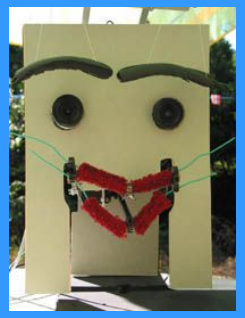
Baby facial expression

Parent emotional state



Baby face recognition

Sufficient condition for learning stability: the mother imitates the baby facial expressions ! At the end the correct associations are stabilized



More realistic architecture

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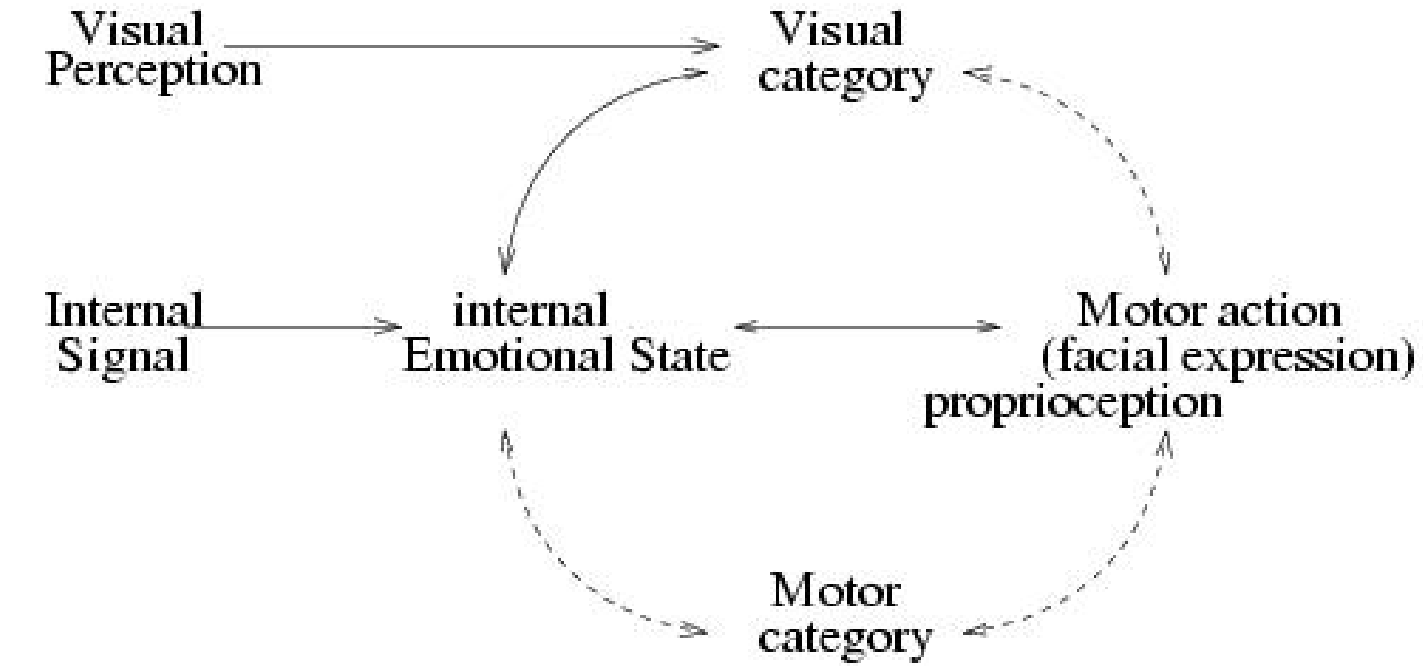

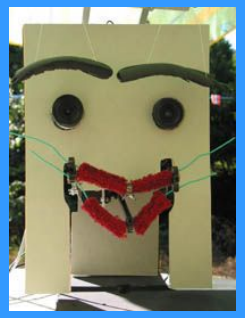

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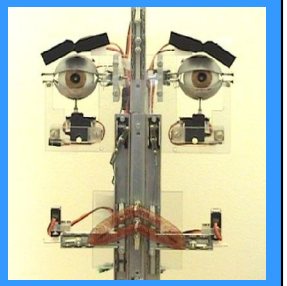
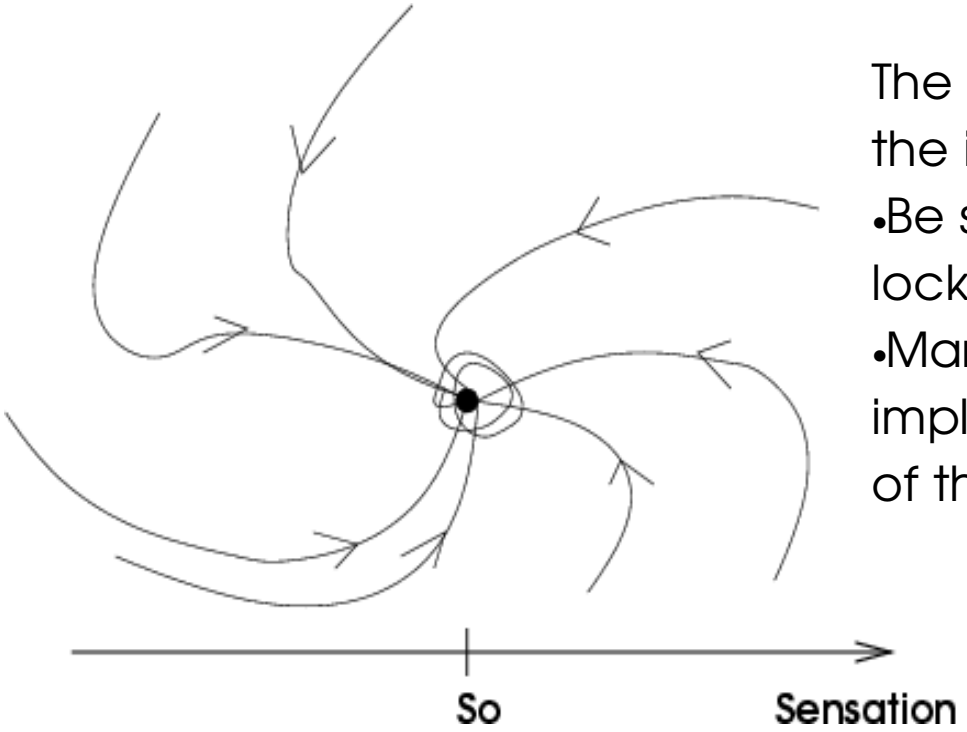


Limitations of our models

Dynamic of the interaction (and its perception) corresponds to a fixed point attractor



The demonstrator controls the interaction :

- Be sure of the visual locking ,
- Manage some explicit / implicit signals (begin/end of the exp.)

The innovation only comes from the other!

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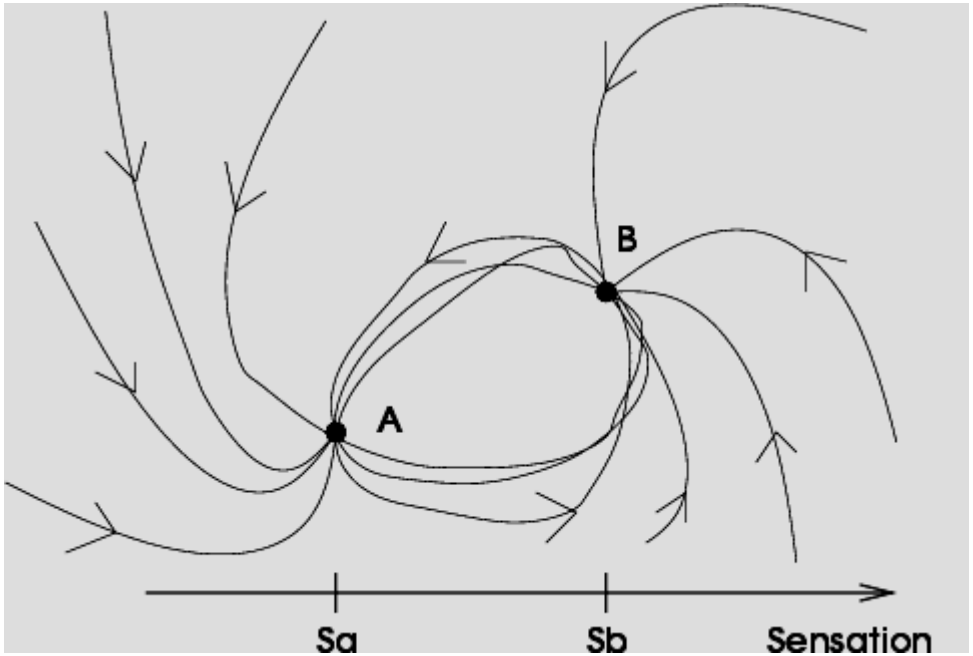
More complex Resonances

Need to introduce at least cyclic attractors:



Different levels:
- turn taking
- role switching

“Will” of interaction: a simple internal oscillator circuit?

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Conclusion

Need of an holistic approach to cognition :

Go from simple to more and more complex tasks to take into account the NL effects of the dynamics of the interactions with env.

Impossibility to decouple perception and action

Perception can be seen as a dyn. attractor

Possible mathematical analysis of embodied brain models (development, interactions…)

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Research groups:

- **Modelling the visual system**

  L. HAFEMEISTER, P. GAUSSIER, (J.-C. BACCON), M. MAILLARD, M. QUOY

- **Individual learning (navigation ...)**

  M. QUOY, P. ANDRY, N. CUPERLIER, P. GAUSSIER, C. GIOVANNANGELI, A. REVEL

- **Social interactions (imitation...)**

  A. REVEL, P. ANDRY, P. GAUSSIER, P. LAROQUE, K. PREPIN

- **Models and tools**

  Toward a neural programming language

The PerAc architecture

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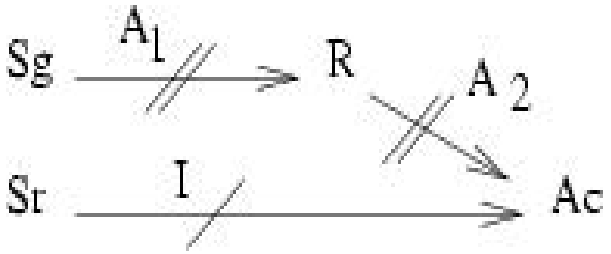
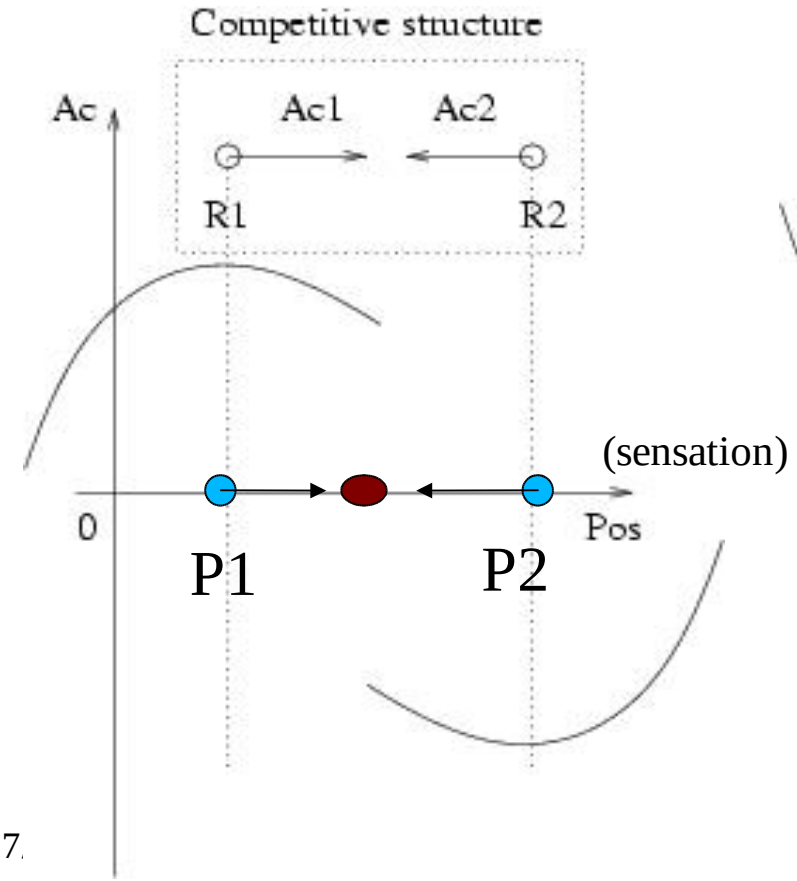
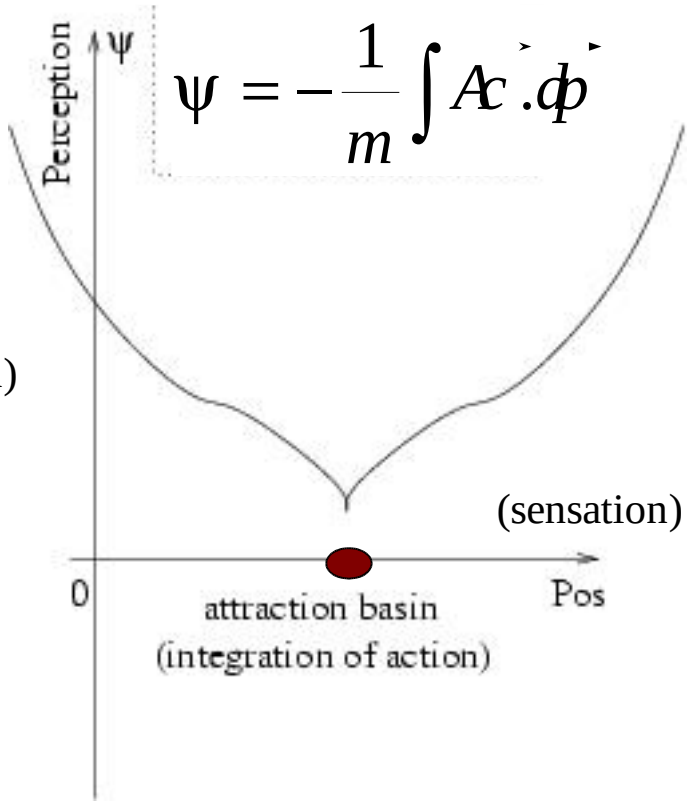
Associative pathway

Reflex pathway







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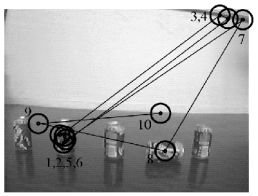
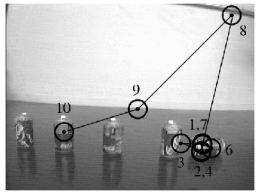
[Maillard05]

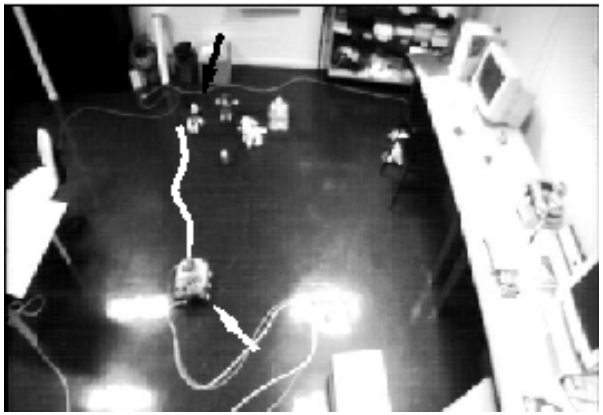


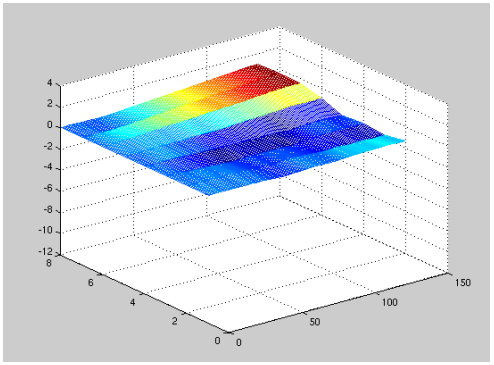
Perception

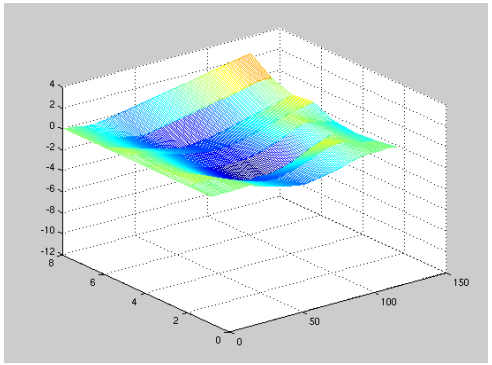


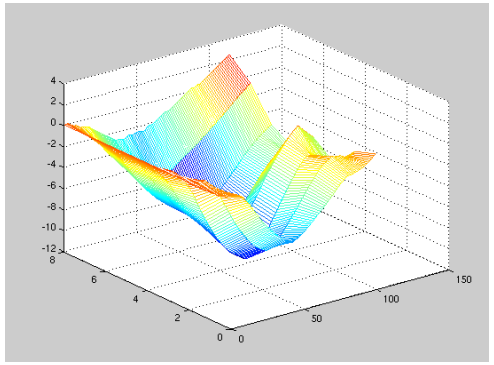
Perception : behavioral attraction basin
Learning sensori-motor invariants
(affordances/recognition)

Ac=-m.grad(Per)









Considered as recognition for the observer ?