"Investigating the emergence of linguistic signs"

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1. Introduction

- **Linguistic signs do not refer directly to objects of the world, they only refer via a mental representation of these objects (a concept)**

- **We assume that it has not always been like this and that linguistic signs underwent an evolution from direct to indirect reference**

1. Introduction

➢ **We propose to study the emergence of language through the development of symbolic capacities emphasizing two independent and crucial processes :**

i) Convention :

Process leading from individual to collective "knowledge"

ii) Segmentation :

Process leading from direct to indirect reference

2. Convention

Convention means that individuals share the knowledge that a particular "sign" is associated with a particular "object" of the world. This requires two important conditions to be verified :

i) Quasi invariance of the "sign" in order to be recognized as identical through its different occurrences

ii) A specific part of the brain is selected for the identification of such recurrent sign-object pairs

2. Convention

➢**Regarding condition i) :**

At an early stage, signals must have been "iconic" with what they referred to, maybe because of a natural bound between them and their "referent"

➢**Regarding condition ii) :**

We propose that mirror neurons are the cognitive equipment which lead to the emergence of convention

As a link between perception and production they are able to structure the relation between stimulus and response

3. Segmentation

Segmentation can be defined as the process allowing the association of different signs in a structured linear relation

Translated in evolutionary terms, segmentation coincides with the emergence of paradigms and syntagmatic relations as identified in the "sign-object" pairs.

Those relations were probably confined at the beginning, to causal, spatial and / or temporal relations

4. Deacon's hierarchy

i) Iconic level :

Individuals are able to notice similarities between objects

ii) Indexical level :

Individuals recognize the correlation between two objects (causal link, spatial and/or temporal contiguity). Dependent on the iconic level

iii) Symbolic level :

Symbols refer to an object through the relations it has with other symbols

5. Evolutionary scenario

Properties

Cognition

1

Reflex stage
iconic signs

- **situation-specific**
- **signal**
- **no level of representations**

Stereotyped behaviors
Stimulus / response

Integration of low level sensory input

Convention

2

Natural symbolization
"simple" signs

- **situation-specific**
- **vocalizations**
- **global perception of message**
- **closed set of symbols**

Structured mental representations
Learning device

Integration of high level sensory input

Segmentation

3

Artificial symbolization
"complex" signs

- **non situation-specific**
- **CV**
- **constituency**
- **open set of symbols**

Internalization
Reflexive system

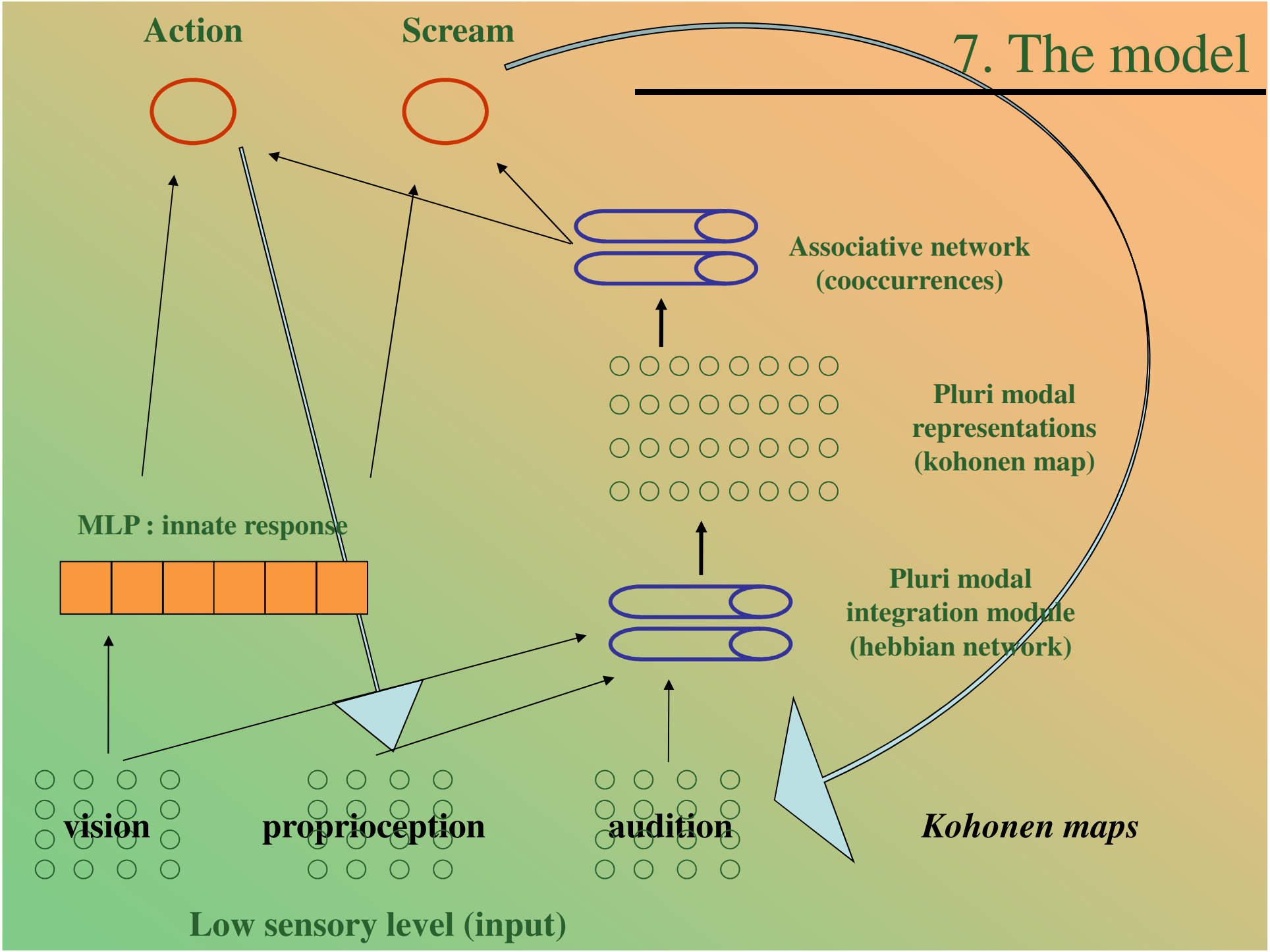
6. Simulation

Our simulations are concerned with alarm calls

The environment is composed of 9 predators gathered in 3 categories. To each category correspond a special scream and a specific escape action. Each agent, when seeing a predator has an "instinctive" escape response and will emit a scream as well. An agent has the possibility to see a predator and to simultaneously hear a scream from someone else, or just to hear a scream.

The main goal is to see whether or not the scream from the others, when it is the only stimulus, can trigger the escape response.

7. The model


Action
Scream
Associative network
(cooccurrences)
Pluri modal
representations
(kohonen map)
MLP : innate response
Pluri modal
integration module
(hebbian network)
vision
proprioception
audition
Kohonen maps
Low sensory level (input)

8. Results

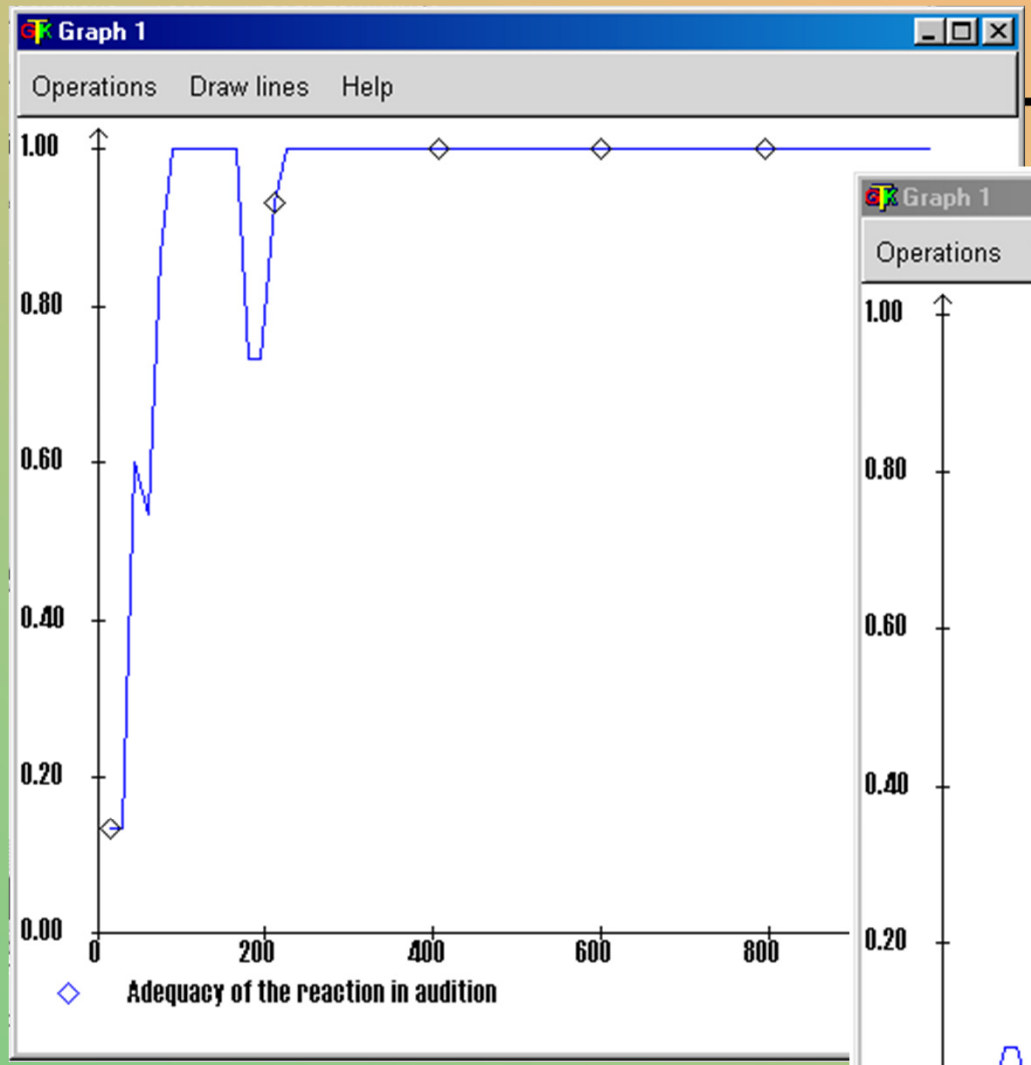
At a low sensory level, each perceptual stimulus is treated in an autonomous modality

A plurimodal integration then takes place, that computes the modal "context" of a specific input. Contexts are determined when several perceptions are present simultaneously

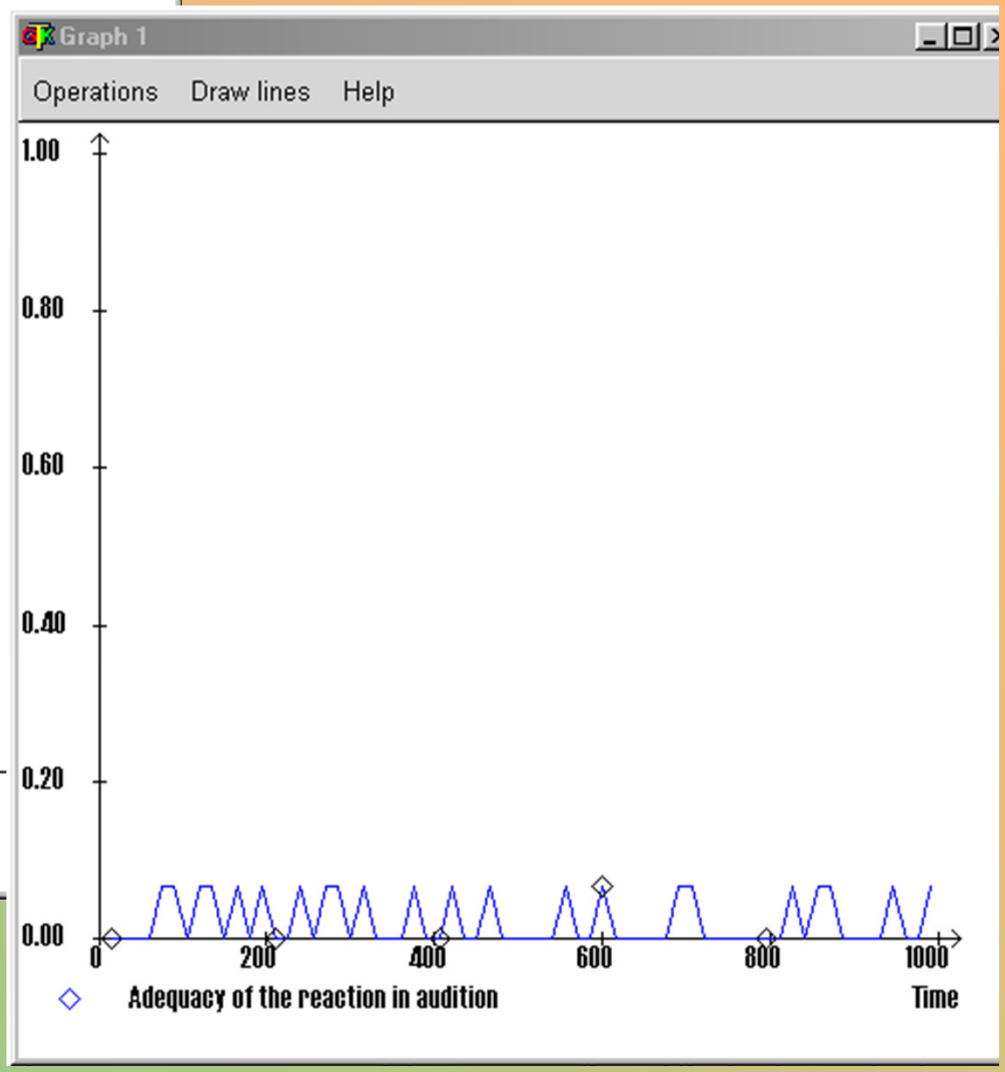
A kohonen map will then structure the different contexts generated by the different inputs.

The contextual "representations" are finally correlated with the innate response of the agent when it sees a predator

8. Results



Rate of escape response with only scream stimulus ("iconic")



Rate of escape response with only scream stimulus (non "iconic")

8. Results

Each innate responses are reentered into the agent's cognitive system, so cooccurrences between vision of a predator, scream and motor neural pattern can be computed

After a learning period, if the screams produced by agent X are similar enough to the ones produced by agent Y, the latter will "interpret" these screams as his.

As a scream and a motor neural pattern will share the same context (a set of predators); they will correspond to the same contextual representation, and the neurons coding for this representation will fire both for the production and the perception of the scream, and also when the animal escapes from the corresponding predator => mirror neurons (?)

9. Interpretations

In this simulation it appears that :

i) A kind of communication (language) emerged independently of any fitness consideration. We believe language is more of an aptation

ii) Altruism, here, appears as a total epiphenomenom. The sharing of information is involuntary, not the result of a choice

iii) Consequently, the search for coalition in order to increase fitness seems not useful for language emergence. In this simulation, it is exclusively dependent on the evolution of brain capacities

10. Conclusion

Our model seems to confirm our different hypotheses :

i) iconicity of the ‘ancestors’ of signs

ii) Mirror neurons could be a providential shortcuts that identifies heared signals with produced ones