



Modeling concurrent development of speech perception and production in a Bayesian framework

Marie-Lou Barnaud, Raphaël Laurent, Pierre Bessière, Julien Diard, Jean-Luc Schwartz

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Background : theories of speech perception

The invariants of speech perception

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Auditory theories :

The invariants are
acoustic properties.

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Motor theories :

The invariants are the intended phonetic gestures of the speaker.

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Auditory theories :

The invariants are acoustic properties.

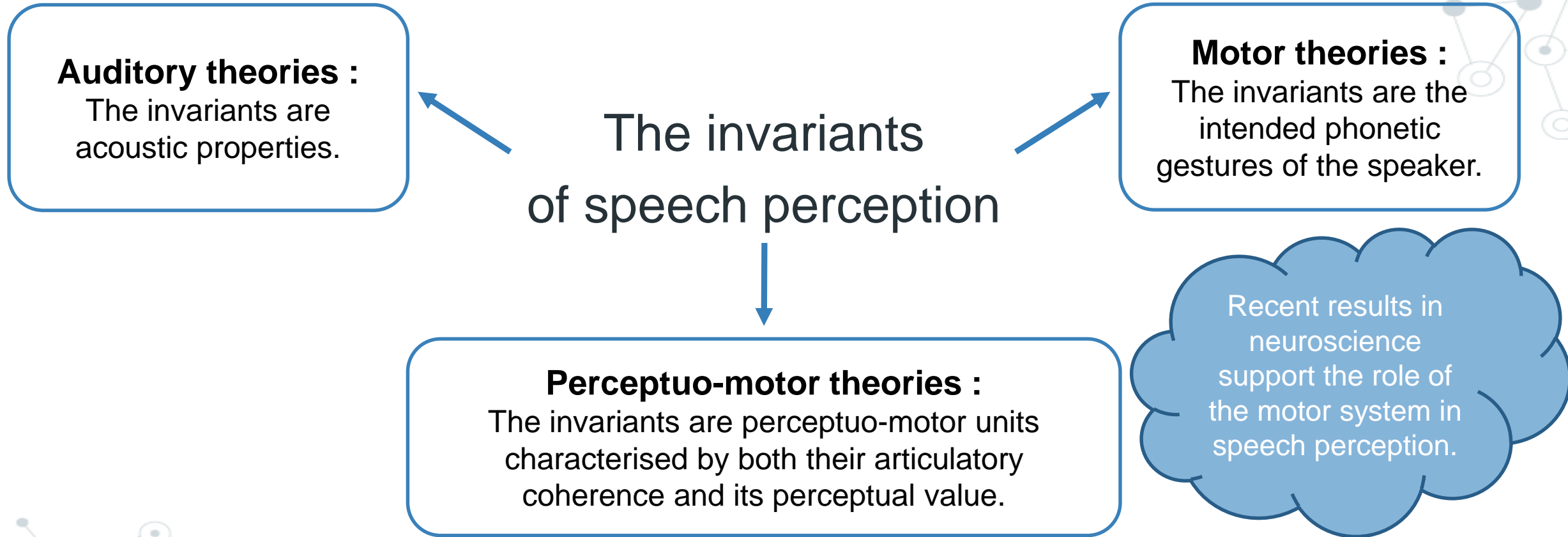
The invariants
of speech perception

Motor theories :

The invariants are the intended phonetic gestures of the speaker.

Recent results in neuroscience support the role of the motor system in speech perception.

Background : theories of speech perception



Background : theories of speech perception

Perceptuo-motor theories :

The invariants are perceptuo-motor units characterised by both their articulatory coherence and its perceptual value.

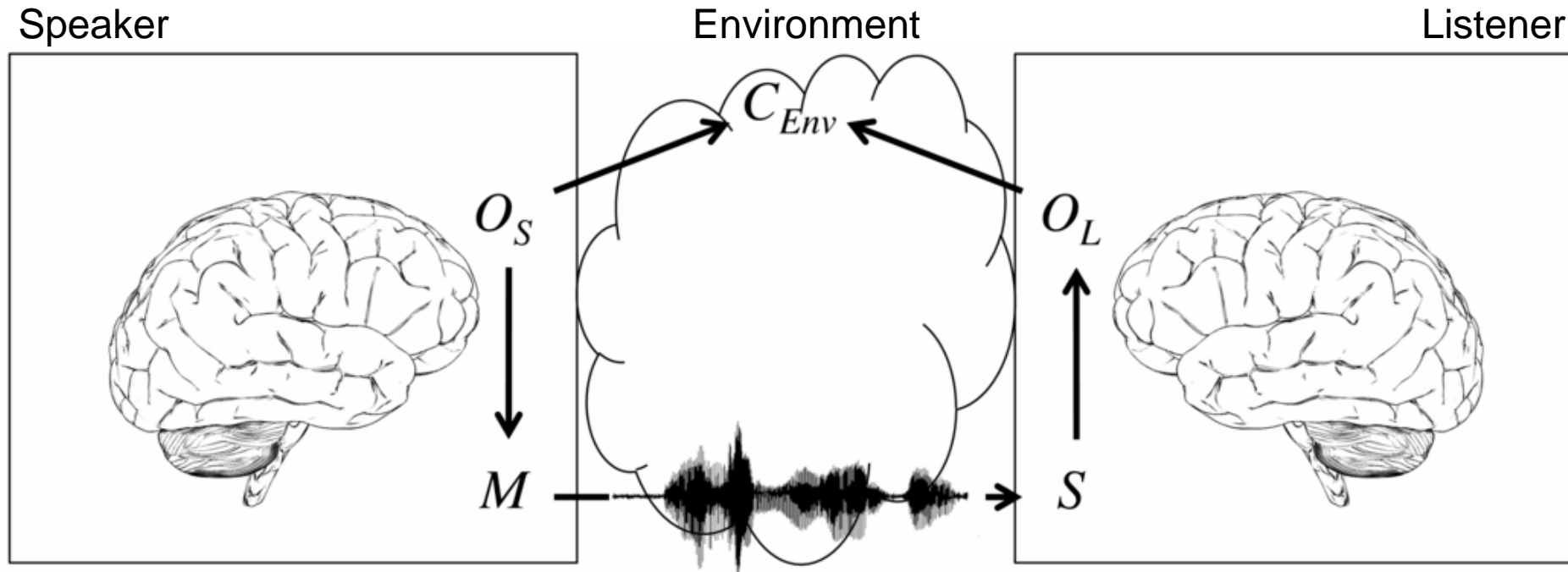
Question of interest

Why would we use perceptuo-motor units ?

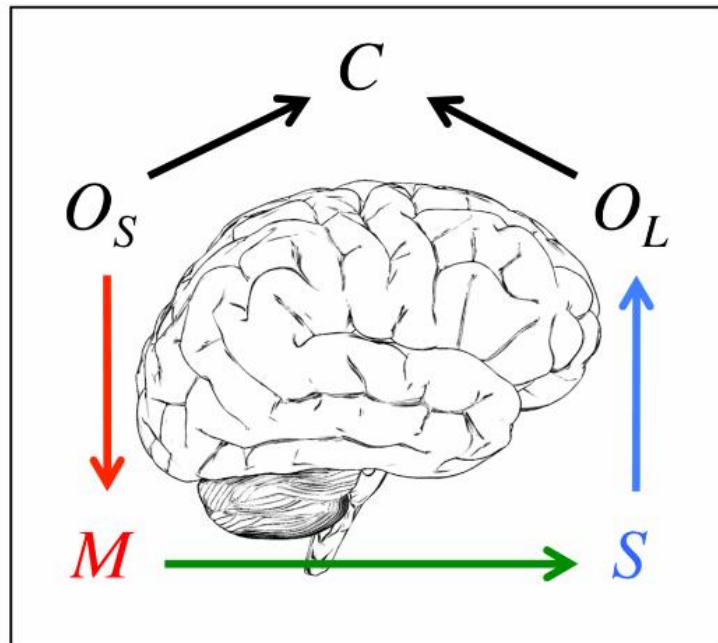
Hypothesis

The auditory and the motor systems would be complementary.

COSMO : A model of communication



COSMO : Internalization



$$P(C \ O_S \ S \ M \ O_L) =$$

$$P(O_S) \times P(M \mid O_S) \times P(S \mid M) \times P(O_L \mid S) \times P(C \mid O_S \ O_L)$$

Prior on the objects

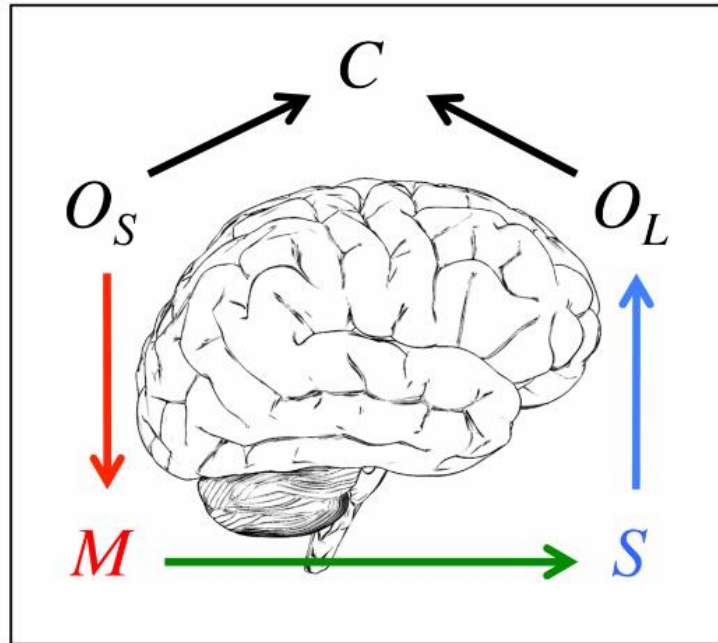
Motor system

Auditory system

Validation system

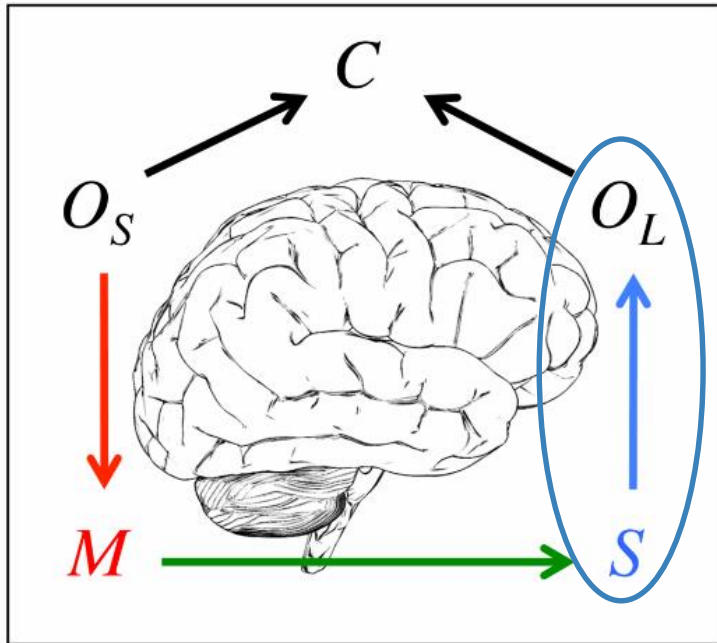
Sensori-motor system

COSMO : Inferences



Speech perception task

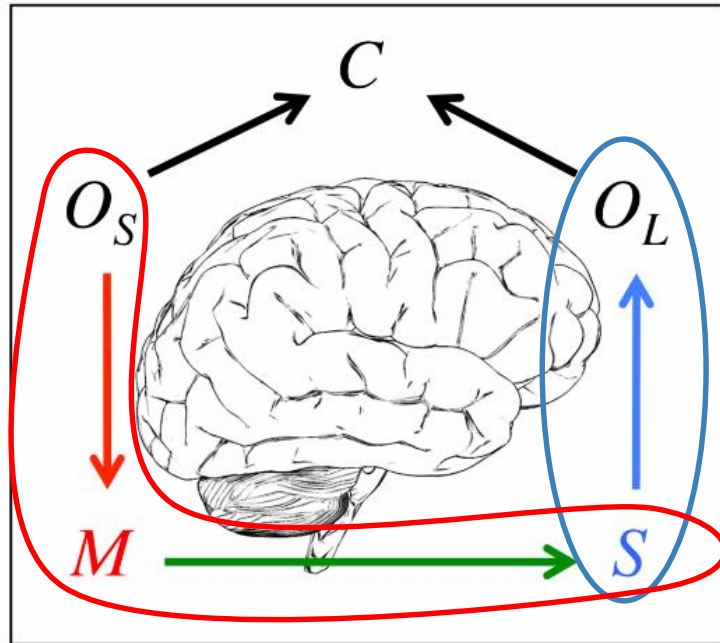
COSMO : Inferences



Speech perception task

- Sensory identification $P(O_L | S)$

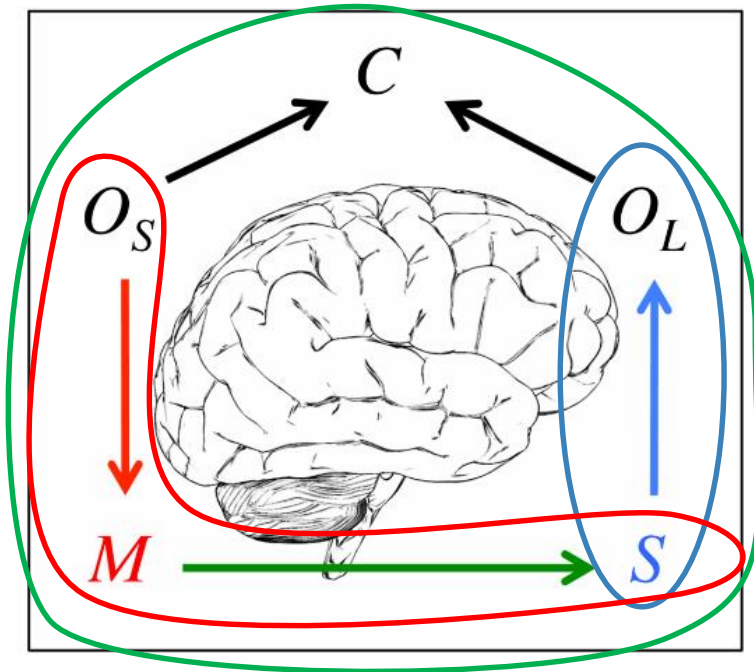
COSMO : Inferences



Speech perception task

- Sensory identification $P(O_L | S)$
- Motor identification $P(O_S | S)$

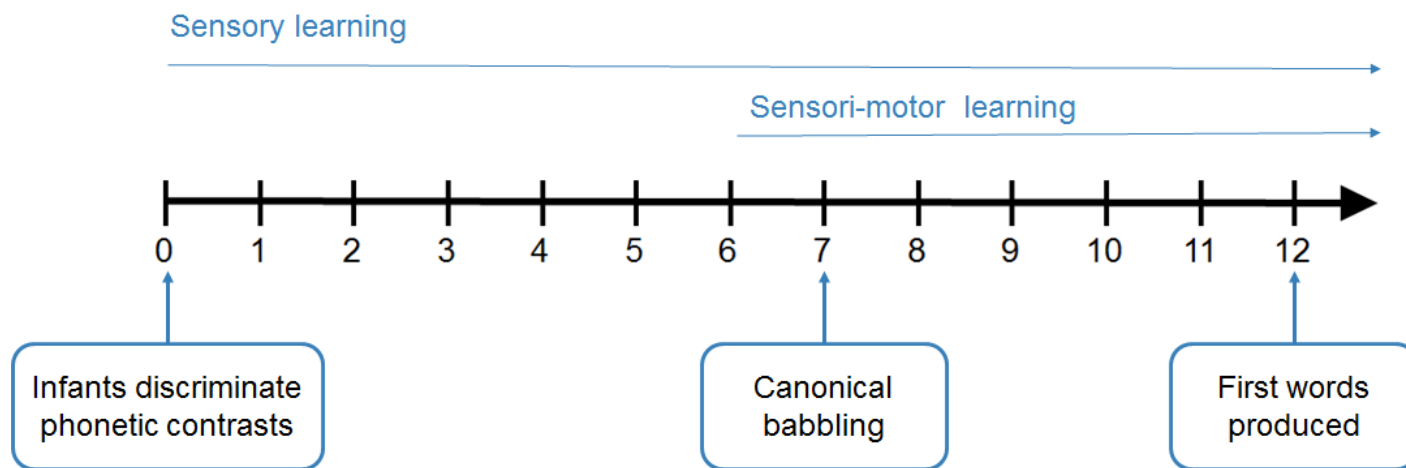
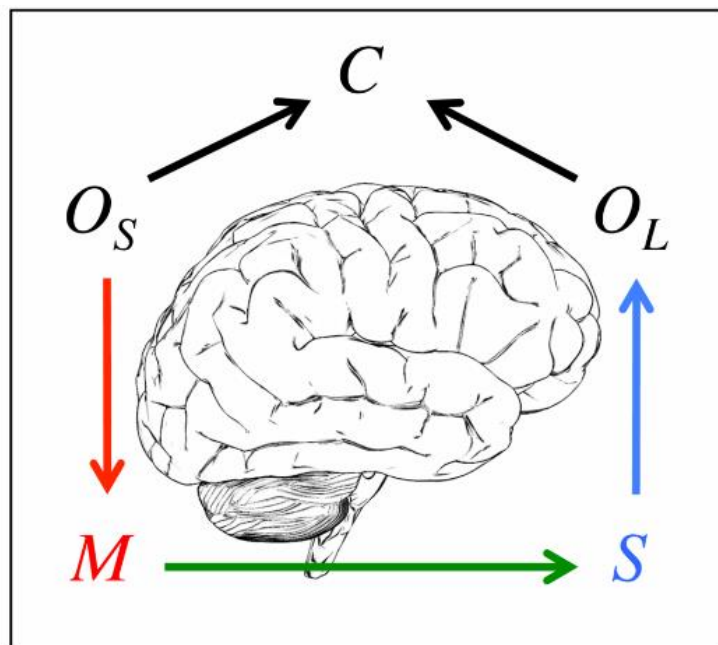
COSMO : Inferences



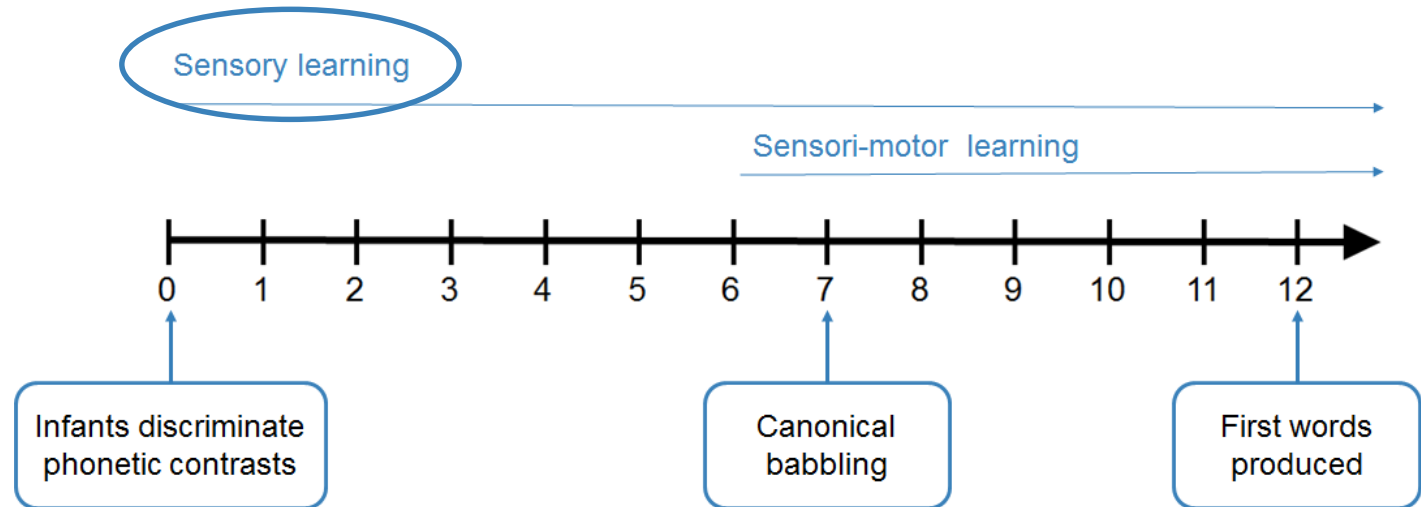
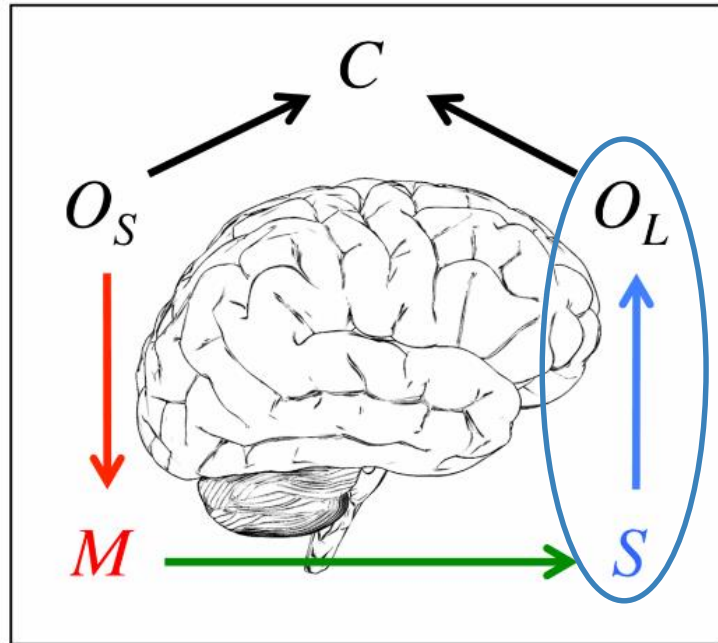
Speech perception task

- Sensory identification $P(O_L | S)$
- Motor identification $P(O_S | S)$
- Perceptuo-motor identification $P(O_L O_S | S [C=1])$

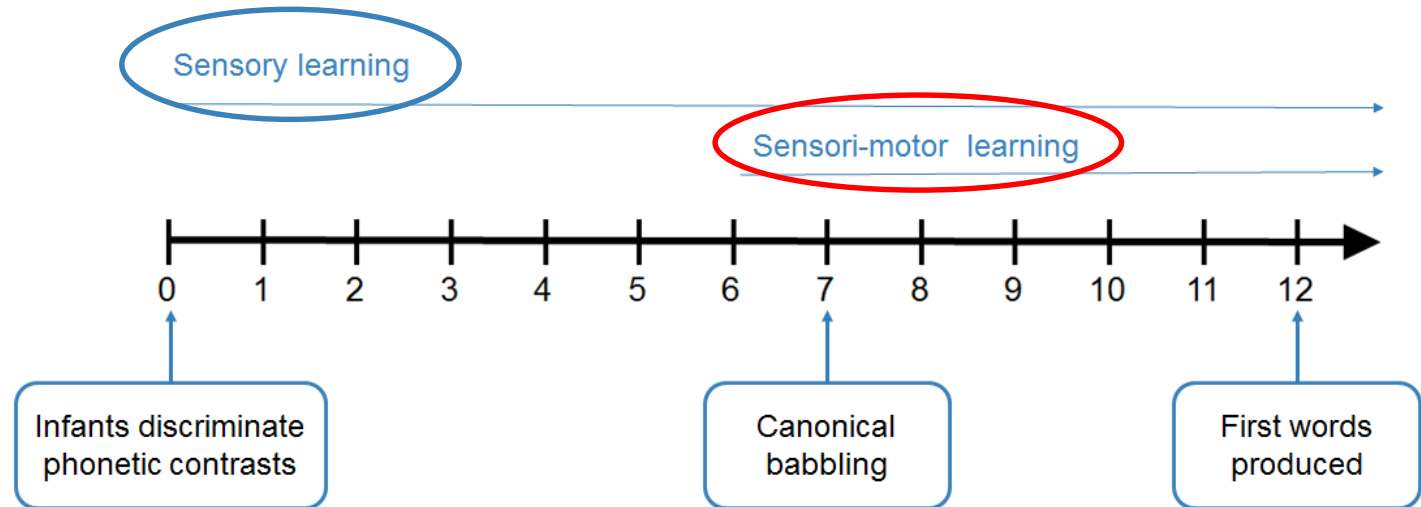
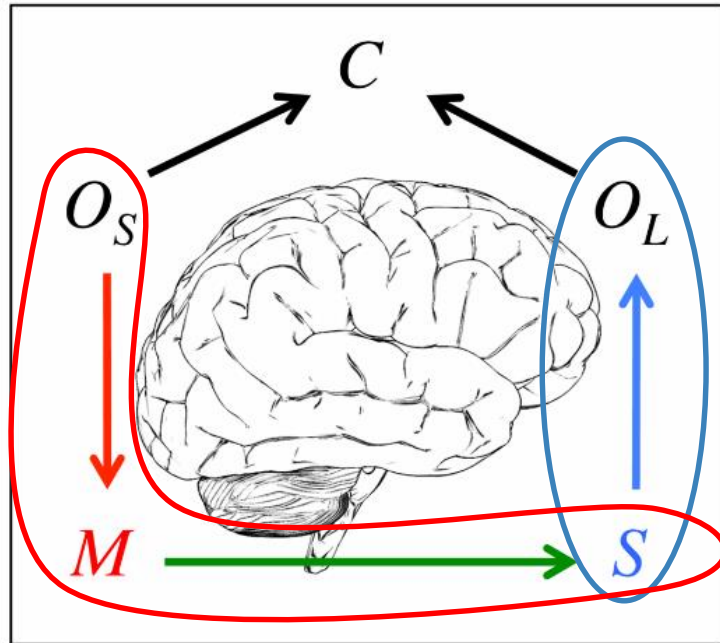
COSMO : Learning



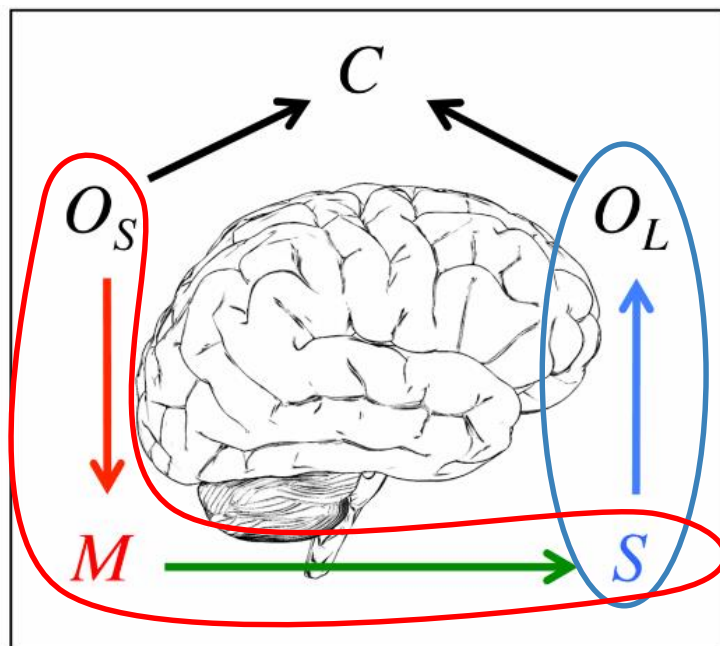
COSMO : Learning



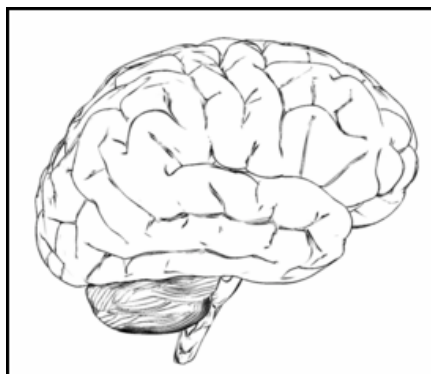
COSMO : Learning



COSMO : Learning

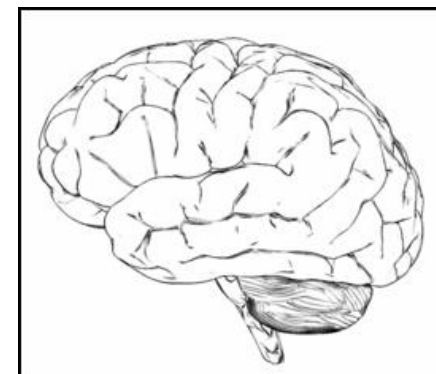


Master

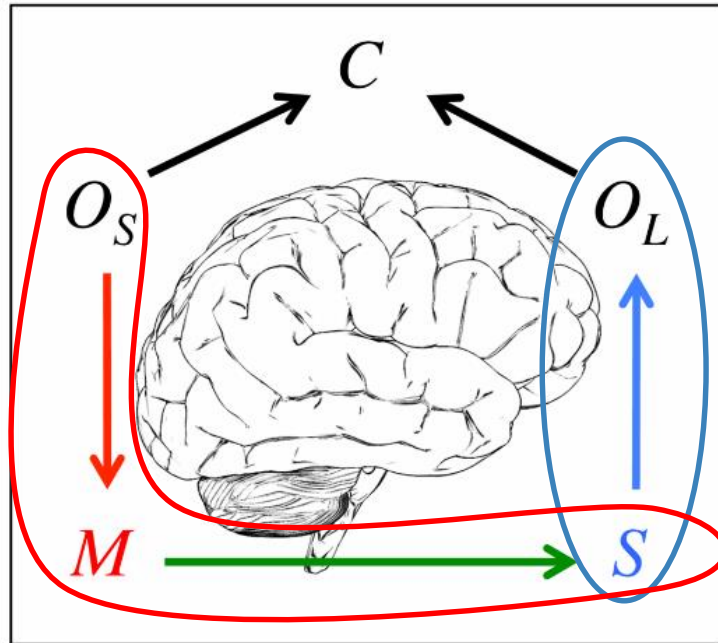


Sending of a
sound s and
an object o

Learning agent

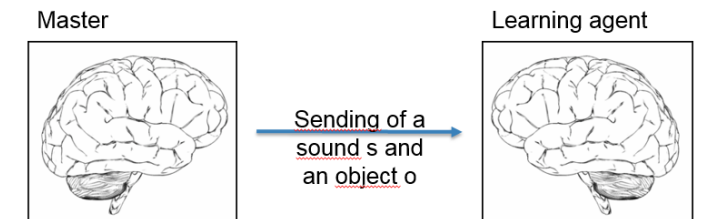
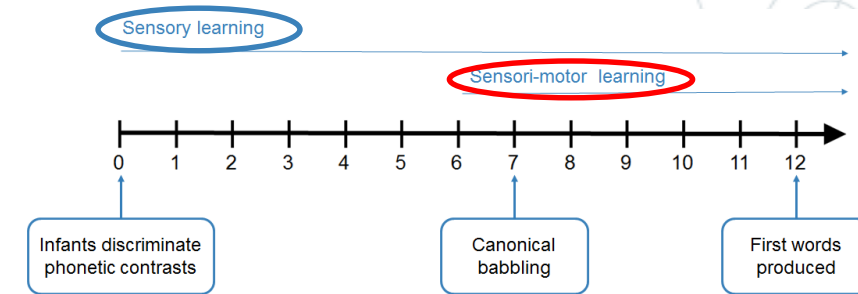


COSMO : Learning

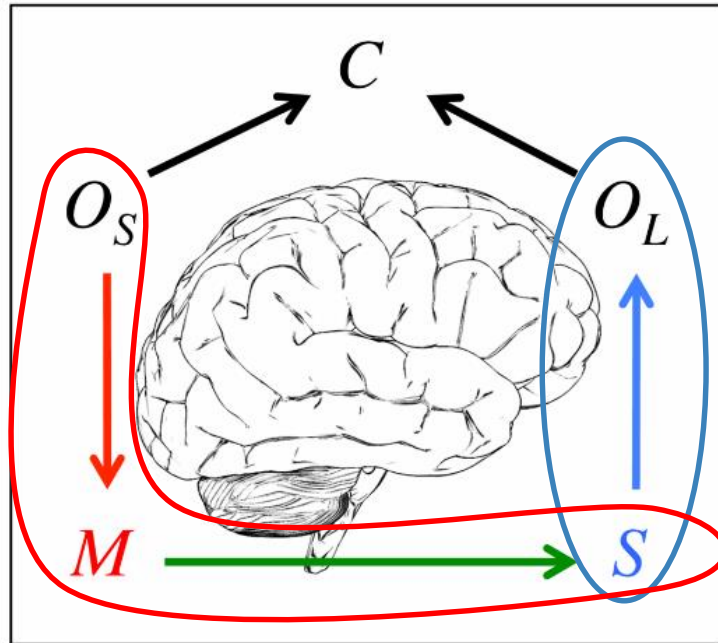


Summary

- **Sensory learning**
 - Simple structure
 - Fully supervised
- **Motor learning**
 - More complex structure
 - Not fully-supervised

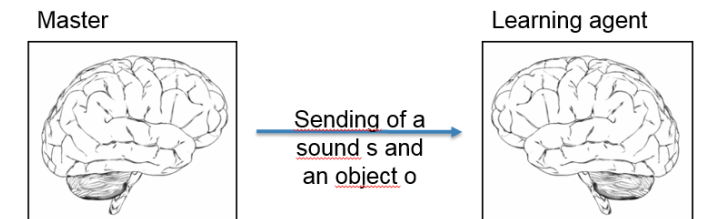
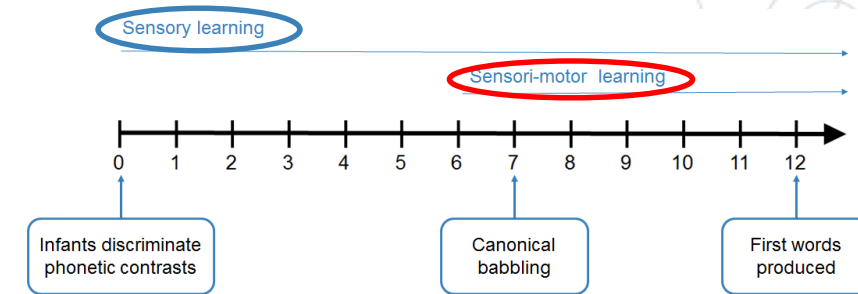


COSMO : Learning

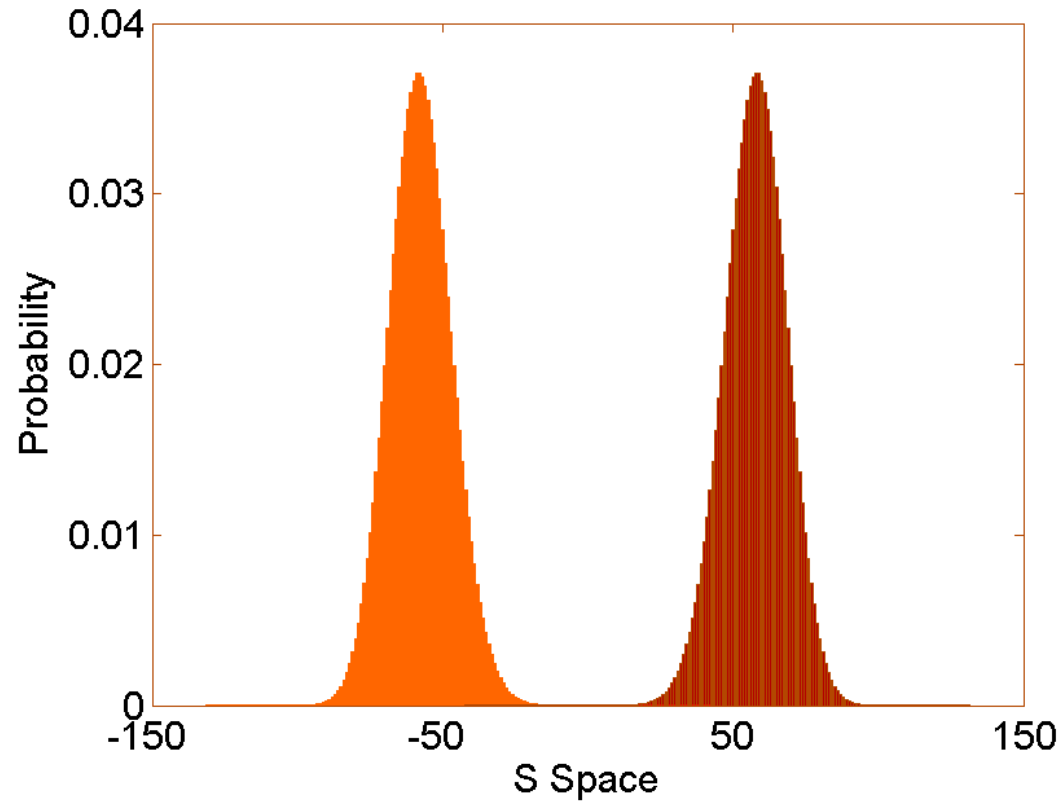


Assumptions

- **Sensory learning**
 - More focused
 - Better for learned stimuli
- **Motor learning**
 - More wandering,
 - Better for non-learned stimuli

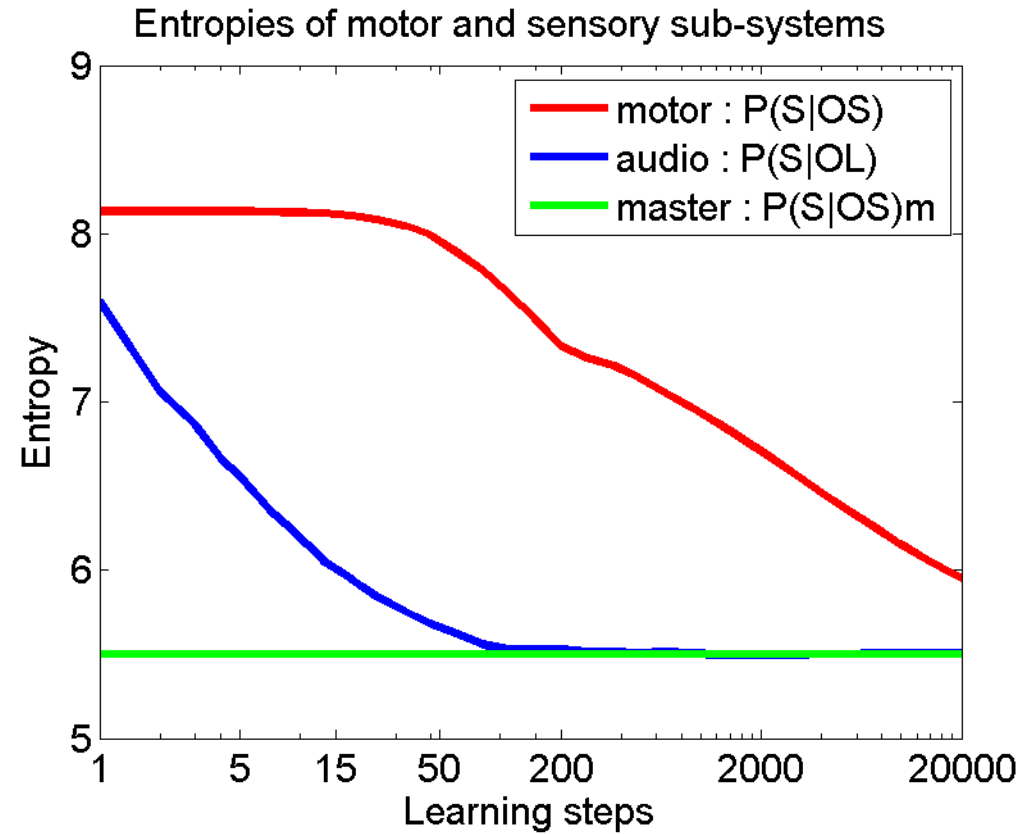


Simulations



- 2 objects O_1 and O_2
 - For instance : /ba/ for O_1 and /da/ for O_2
- Spaces S and M in one dimension
 - For instance : S is voicing, M is the tongue position.

Results : Learning speed

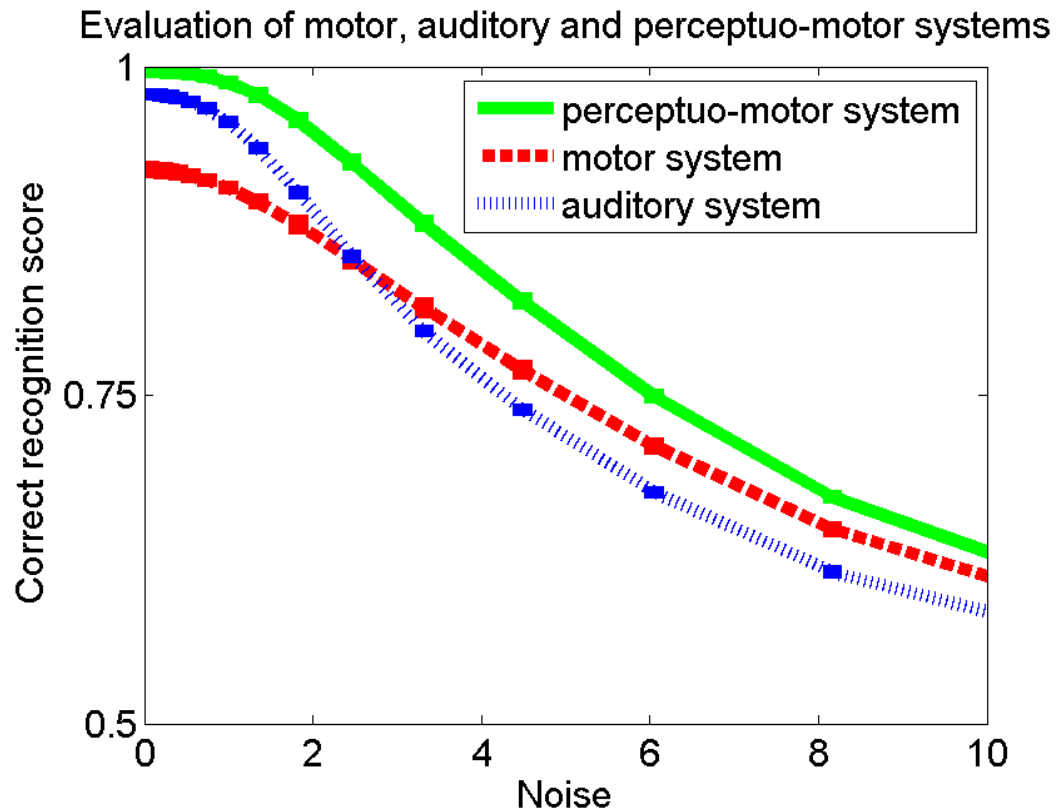


Auditory learning
- Fast

VS

Motor learning
- Slow

Results : Categorization in noise



Auditory learning

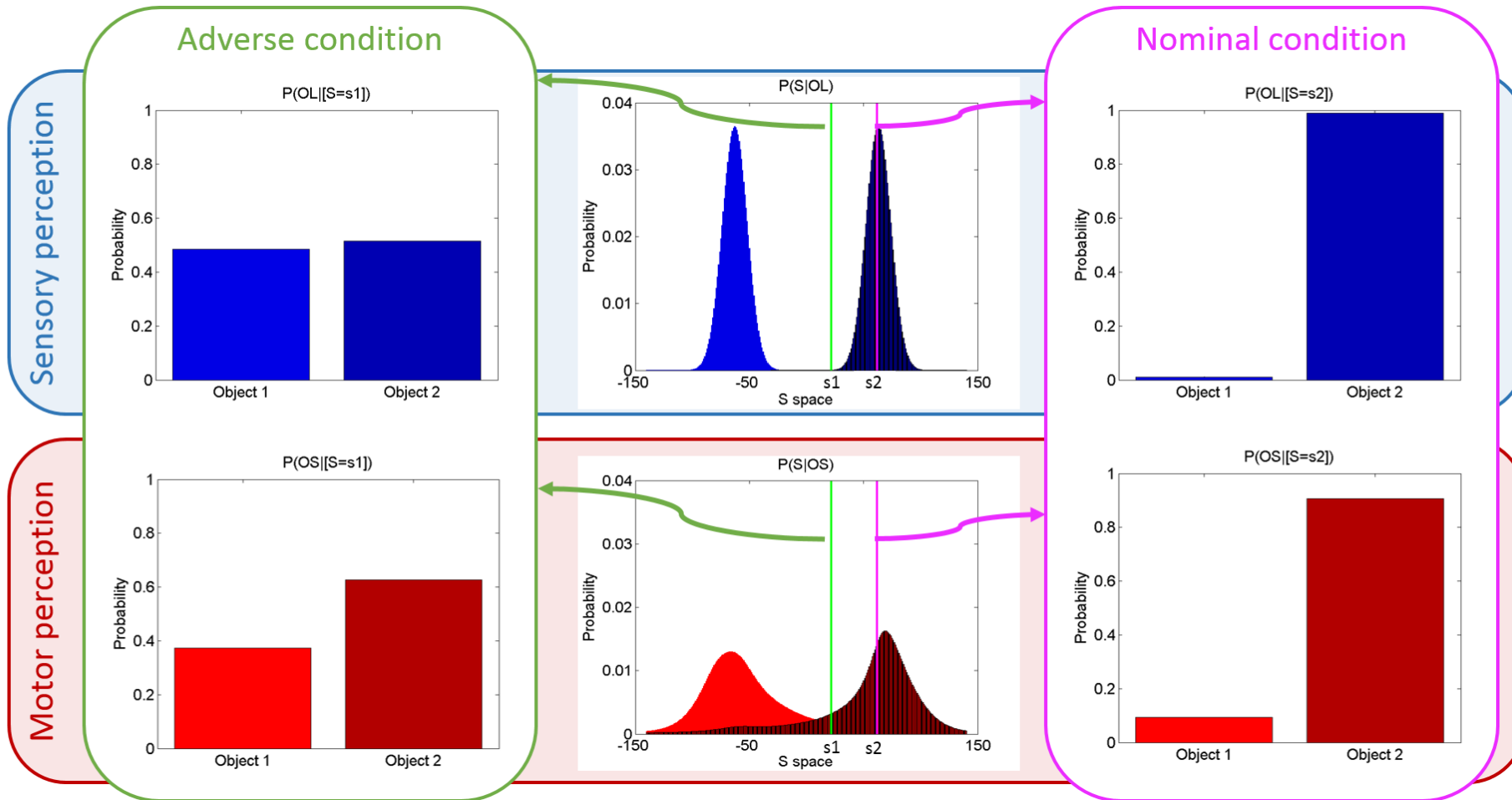
- Fast
- Better in nominal conditions

VS

Motor learning

- Complex => slow
- Better in adverse conditions

Comparison in adverse and nominal conditions



Conclusion / Perspective

- ◎ Conclusion : differences in development lead to different roles
 - The auditory system acts as a narrowband
 - The motor system acts a wideband

- ◎ Perspective (ongoing)
 - More realistic simulations (syllables , vowels, etc)
 - More complex learning



Thanks for your attention !