A Little More, A Lot Better?
From Quantitative to Qualitative Change
in Language Emergence

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A **mosaic** evolutionary trajectory to language

❑ Many parameters seem to take part in the emergence of language (= human modern communication system)

  ➢ social cognition

  ➢ vocal tract control

  ➢ shared attention

  ➢ imitation

  ➢ memory

  ➢ complex rapid sequencing

  ➢ …

2 possible evolutionary pathways for language emergence

Discontinuity

Abrupt change in physiological devices / cognitive mechanisms / social settings

Possible explanations:

- macro-mutations?

- other mechanisms? (hard to conceptualize emergence)
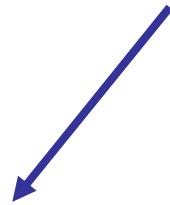
Continuity

Gradual evolution

No brand novelty, but rather quantitative evolution of pre-existing "devices"

Overview

❑ Comparative studies between humans and apes

❑ Computer modeling

Comparison between apes and humans

How do humans differ from their ancestors regarding the previous elements of the mosaic?

When humans are compared to apes, many of the previously thought human-specific features have to be reconsidered…

What does it means to be 98% chimpanzee?
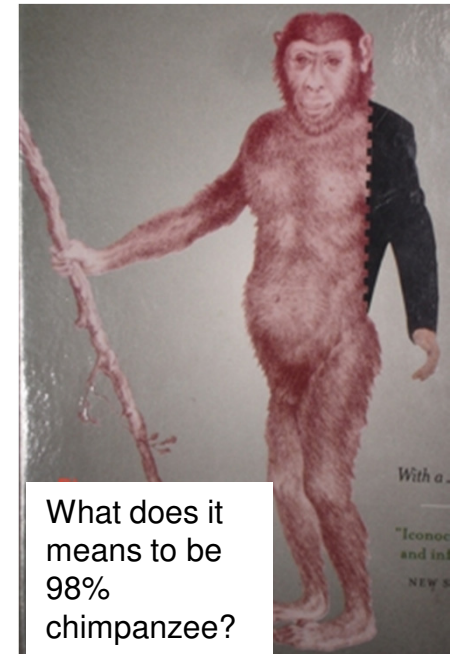
Genetic similarity

❑ Differences: 1.23% (single-nucleotide substitutions); 1.5% (with indels)

❑ Only a small subset of the observed gene differences is likely to be responsible for the key phenotypic changes in morphology, physiology and behavioural complexity between humans and chimpanzees

The Chimpanzee Sequencing and Analysis Consortium. Initial sequence of the chimpanzee genome and comparison with the human genome Nature 2005, 437: 69-87.
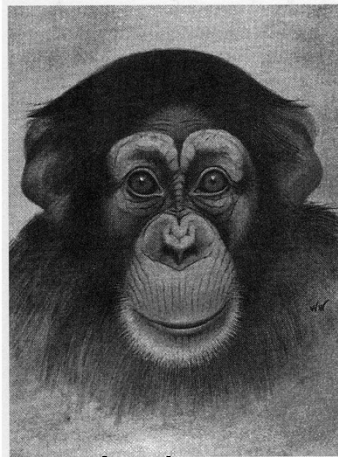
Behavioral similarity

The more we learn, "the more they seem similar to us as their genetic material implies". (de Waal 2005)

Field observations
Lab experiments
Enculturation

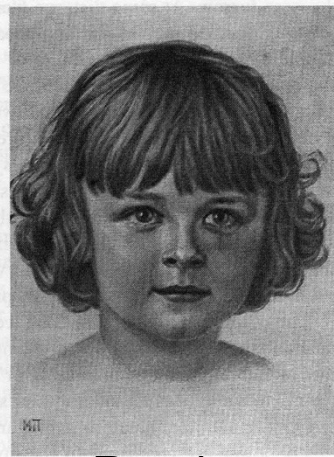90 years ago, a comparative study of chimpanzee and human infant (Ladygina-Kohts 1935) $\longrightarrow$ MC Kanzi in a night-club…
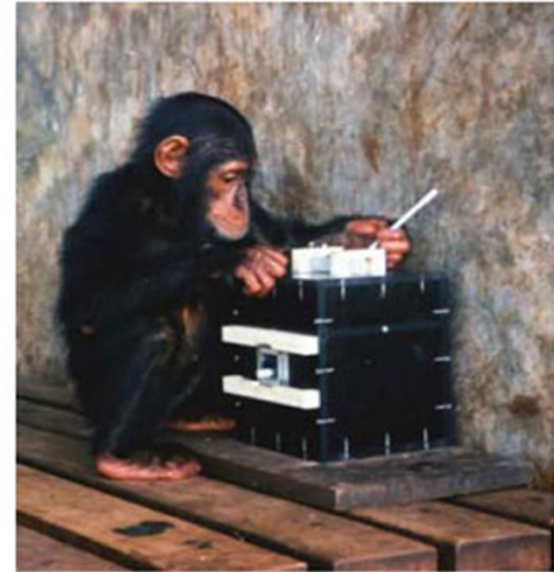
Joni   Roody

(a) *(b)*

Figure 2. The faces of the infant chimpanzee and the human child: (a) my chimpanzee Joni (age 4 years); (b) my son
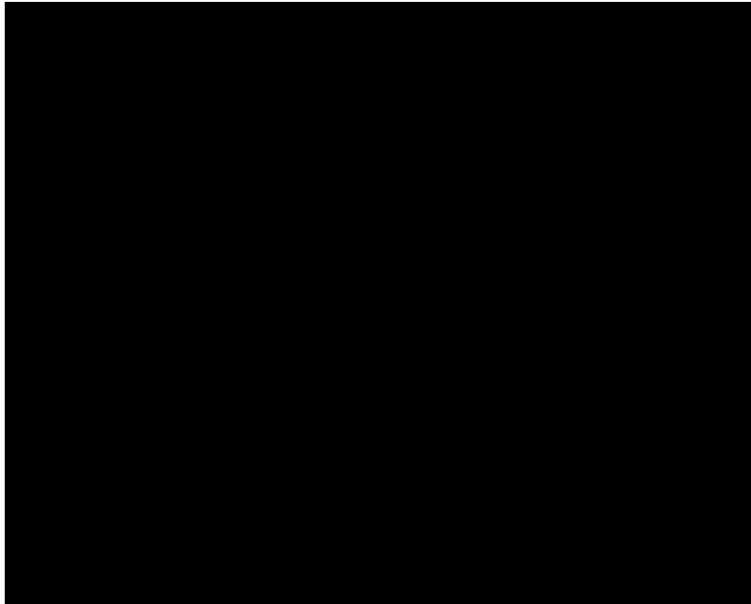
Imitation

(Ladygina-Kohts 1935)

(Horner & Whiten 2005)

Tool use

(Whiten 2005)

Symbolic communication
(Kanzi with S. Savage-Rumbaugh)

shared attention / reading intention
(Warneken and Tomasello 2006)

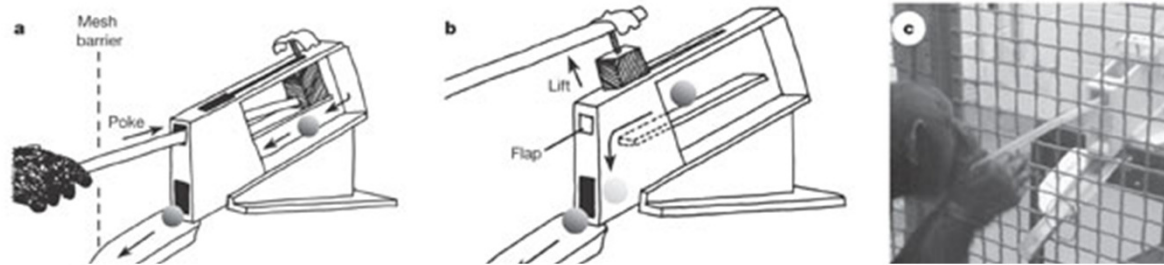Sequencing abilities (Terrace, 2002)

Statistical learning / detect recurrent patterns (Safran et al. 2004)
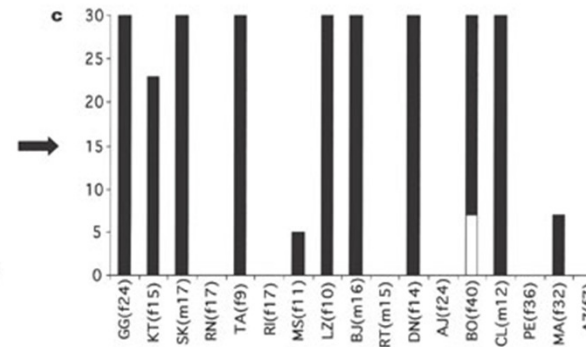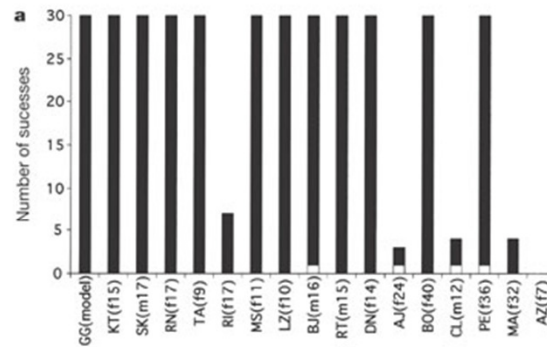
Sociality (power hierarchy, group membership, etc.)

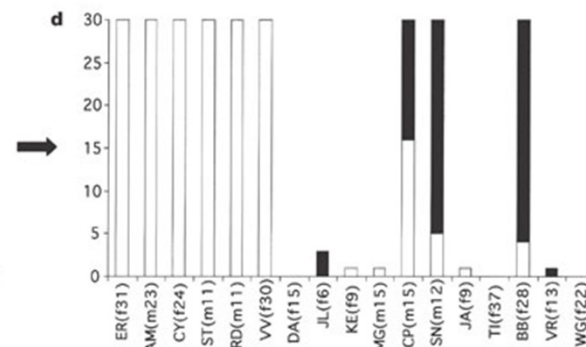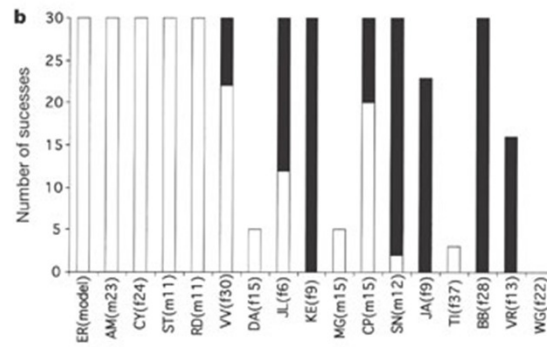(Cheney & Seyfarth, cf. Thursday's talk)

etc.

Cultural conformity & innovation

"poke" group

"lift" group

T1

T2 (2 months later)

Whiten, Horner and de Waal (2005). Conformity to cultural norms of tool use in chimpanzees, Nature 437, 737-740.

Summary of comparative studies

From the previous studies, most human abilities seem present in apes to a certain degree

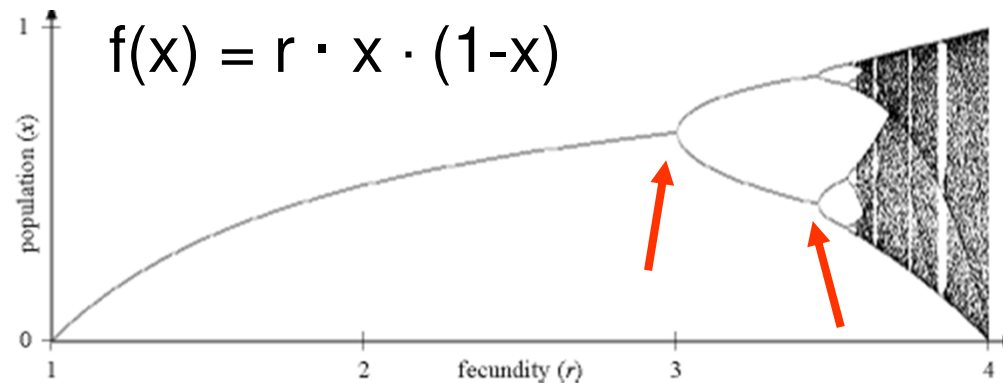→a continuous pathway between apes and humans seems likely

Question:

Only quantitative differences between abilities of humans and apes

However, a dramatic difference: language!

How to reconcile these two proposals?

From quantitative changes to phase transitions

Logistic map (Robert May, 1976)

$$f(x) = r \cdot x \cdot (1-x)$$

A small change of **r** results in a big change in the system dynamics

We may express the faculty of language as follows:

FL = f(intention reading, memory, pattern detection, vocal capacity…)

Interactions between parameters

"language sits at the crossroads of a number of small phenotypic changes in our species that interact uniquely to yield language as the outcome. Here, language is seen as a domain-specific outcome that emerges through the interaction of multiple constraints, none of which is specific to language."

TRENDS in Cognitive Sciences
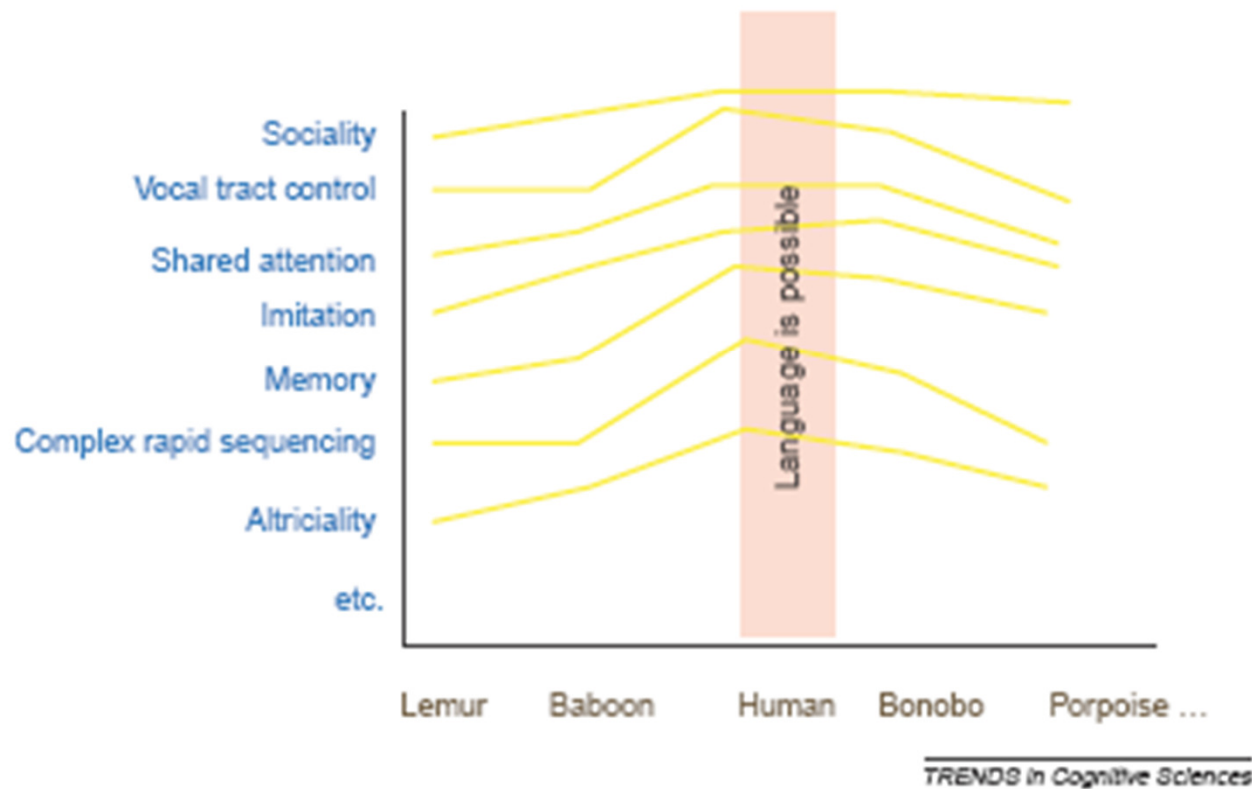
Elman, J.L. (2005). Connectionist models of cognitive development: Where next? Trends in Cognitive Science. 9/3:111-117.

How to observe phase transitions?

$\downarrow$

Simulation using computer models
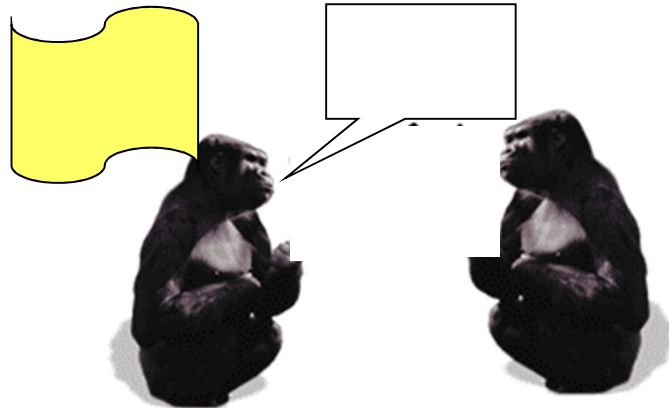
Computer model on language emergence

Two hypotheses:

A. **Synthetic** (Bickerton 1994, Jackendoff 1999)

   holistic signals → Ø → words → combination of words

B. **Holistic** (Wray 1998, Kirby 2000, Gong et al 2005)

   holistic signals → words extracted as recurrent patterns → compositional language
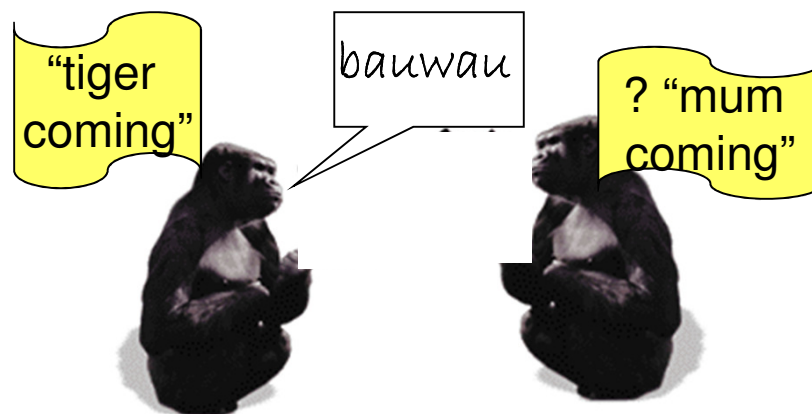
Agent-based model

Different from ILM:
- > 2 agents
- Horizontal transmission

• long term local interactions lead to the emergence of lexicon and simple word order

An interaction episode

"tiger coming"

bauwau

? "mum coming"

Speaker

Listener

• creates a novel holistic utterance, *or*
• find the existing holistic rule, *or*
•combines existing words to convey a meaning

• searches in holistic rule repertoire to interpret the utterance, *or*
• if possible, decomposes the utterance to interpret the meaning, *or*
• guesses a meaning from the given cue, copies the signal into his repertoire
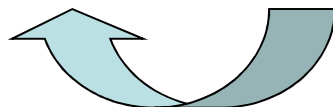
strengthen or weaken rules

Assumptions of the model

- Shared environment, similar conceptual world, e.g. "tiger", "coming"
- A small phonetic inventory, e.g. ma, pa
- A reasonable memory capacity
- Communication with intention
- Sequential ability (concatenating items in sequence)
- Imitation (forms, not necessarily with meaning)

- Detection of recurrent patterns and decomposition

- Shared attention (cue reliability)
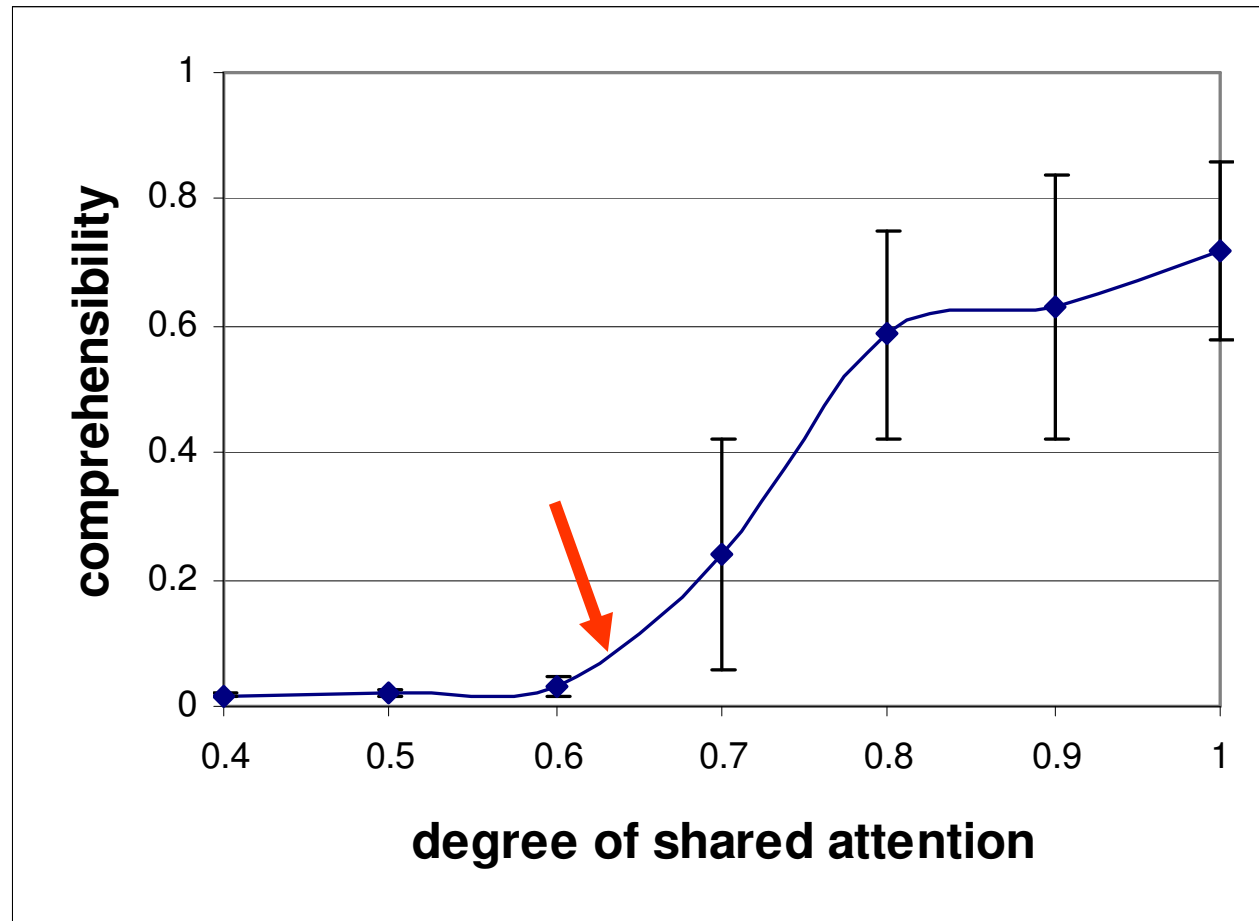
- Symbolization (creation and use of symbols)

chimpanzee ⟷ human

0   1.0
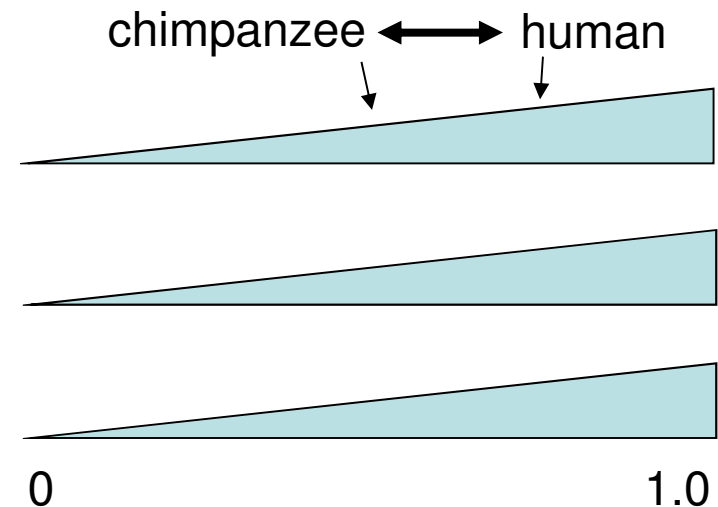
From holistic signals to compositional language
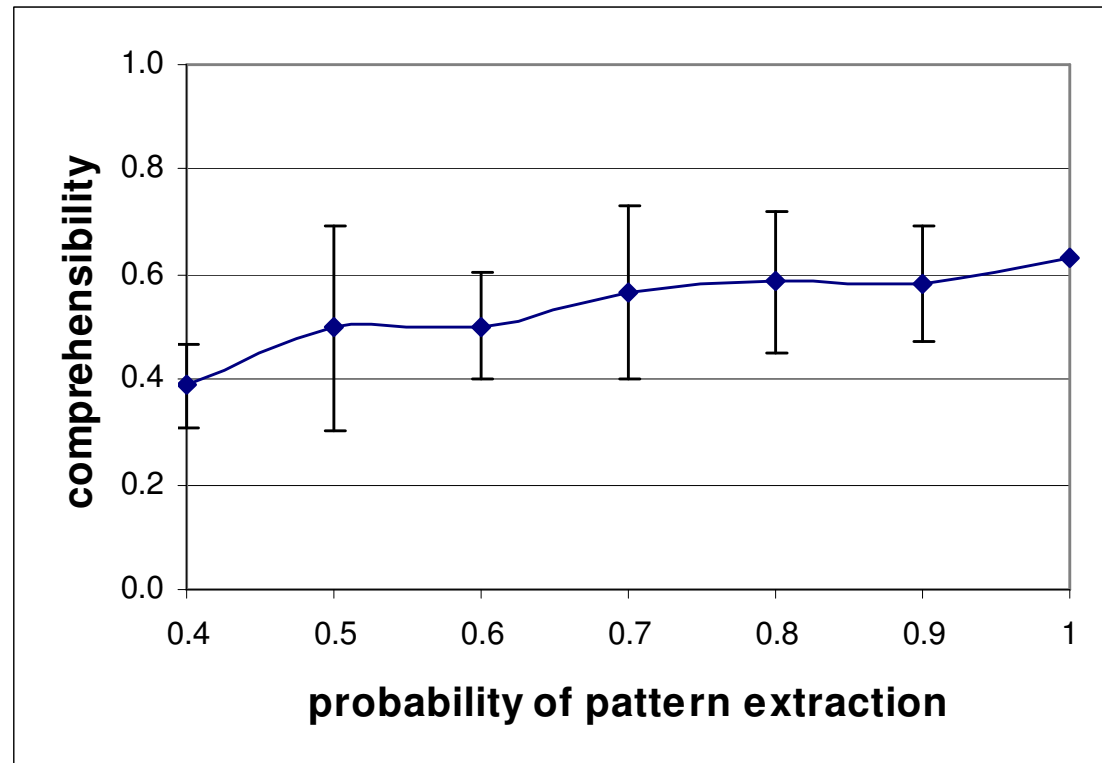
cp1.0 dr1.0 cr1.0
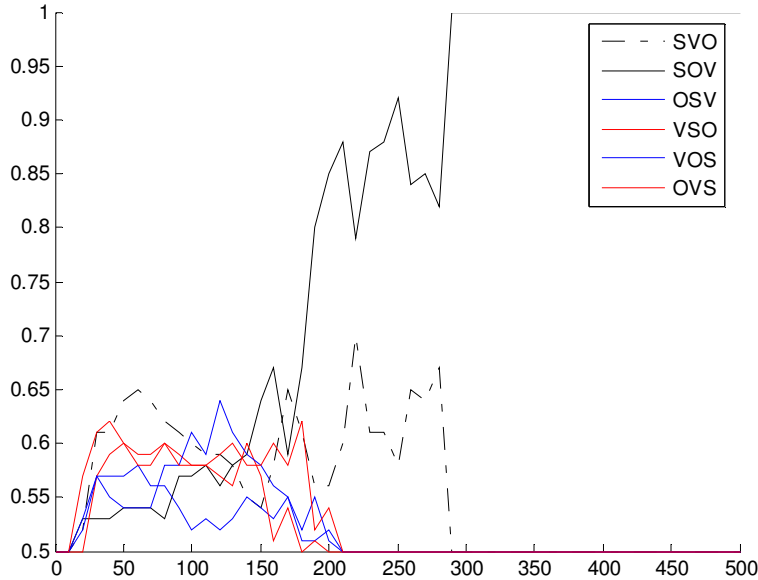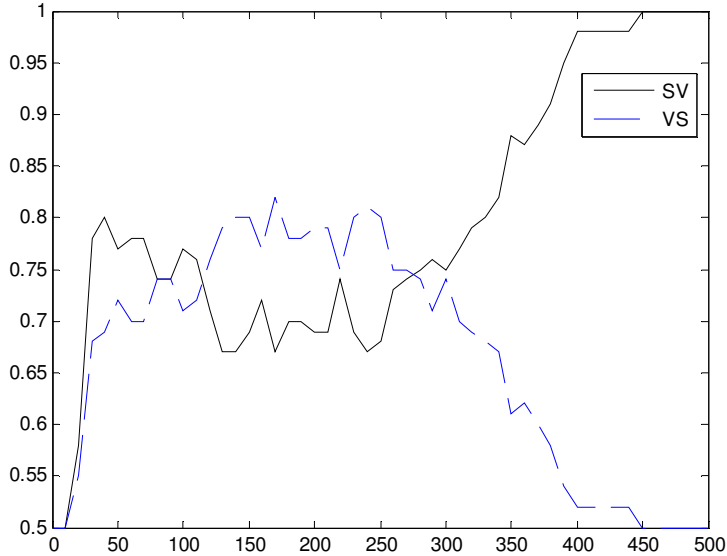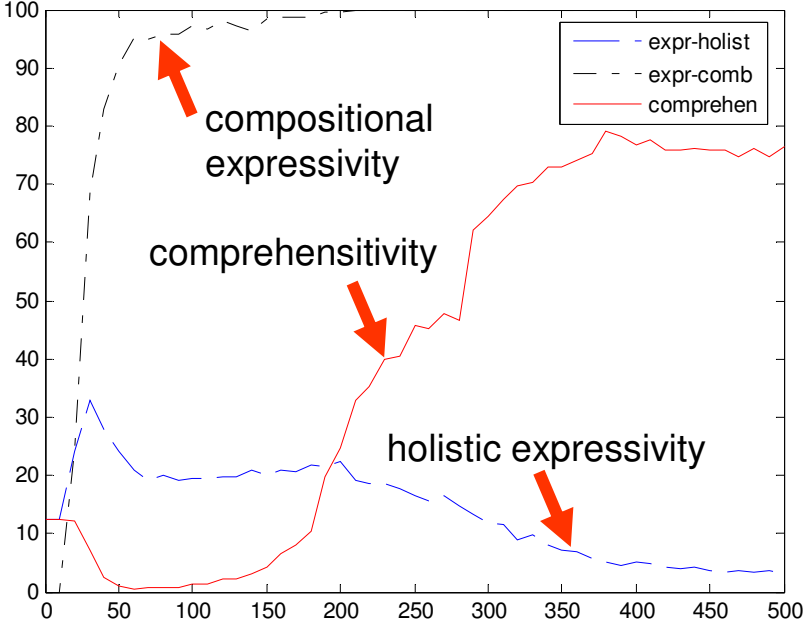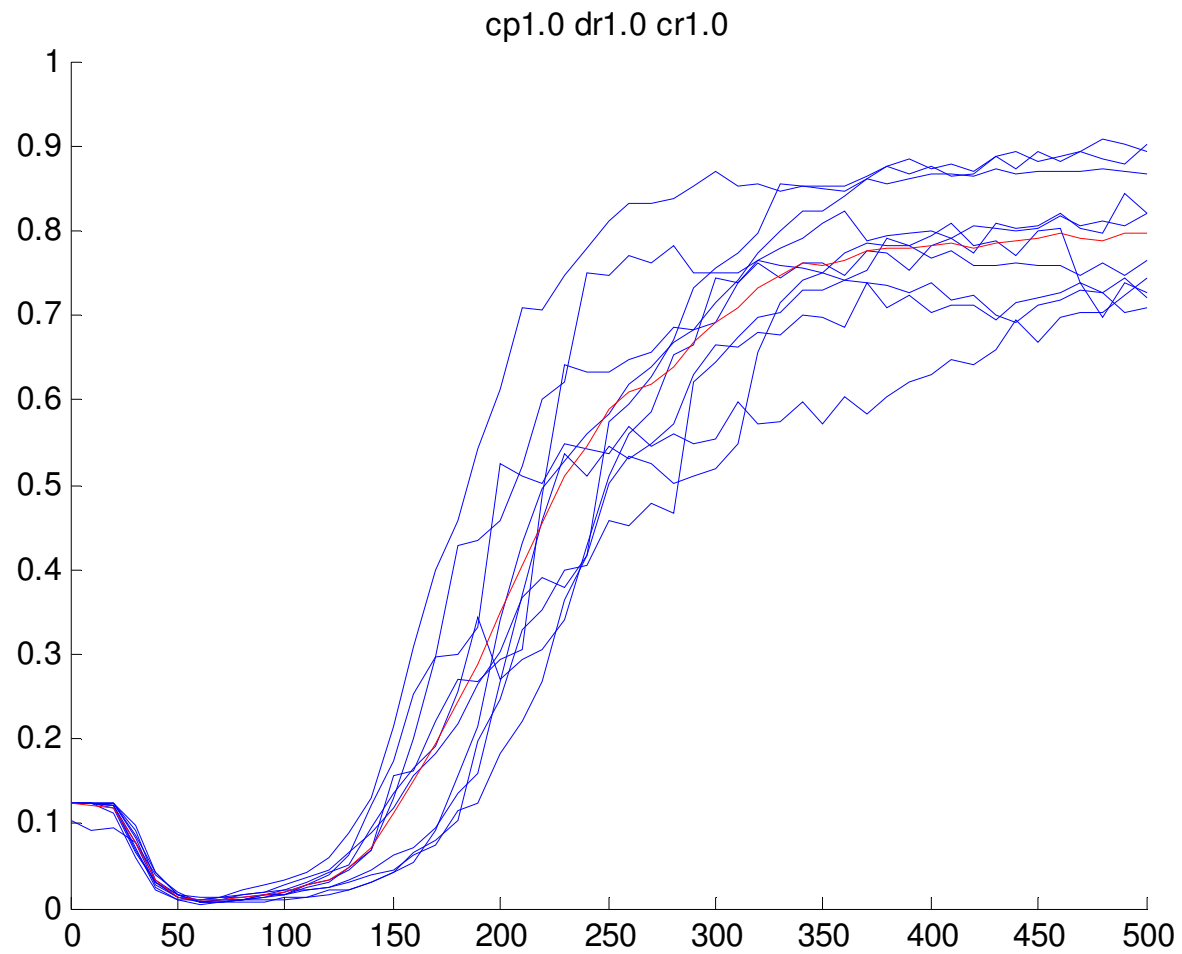
Convergence of a shared language in 10 runs

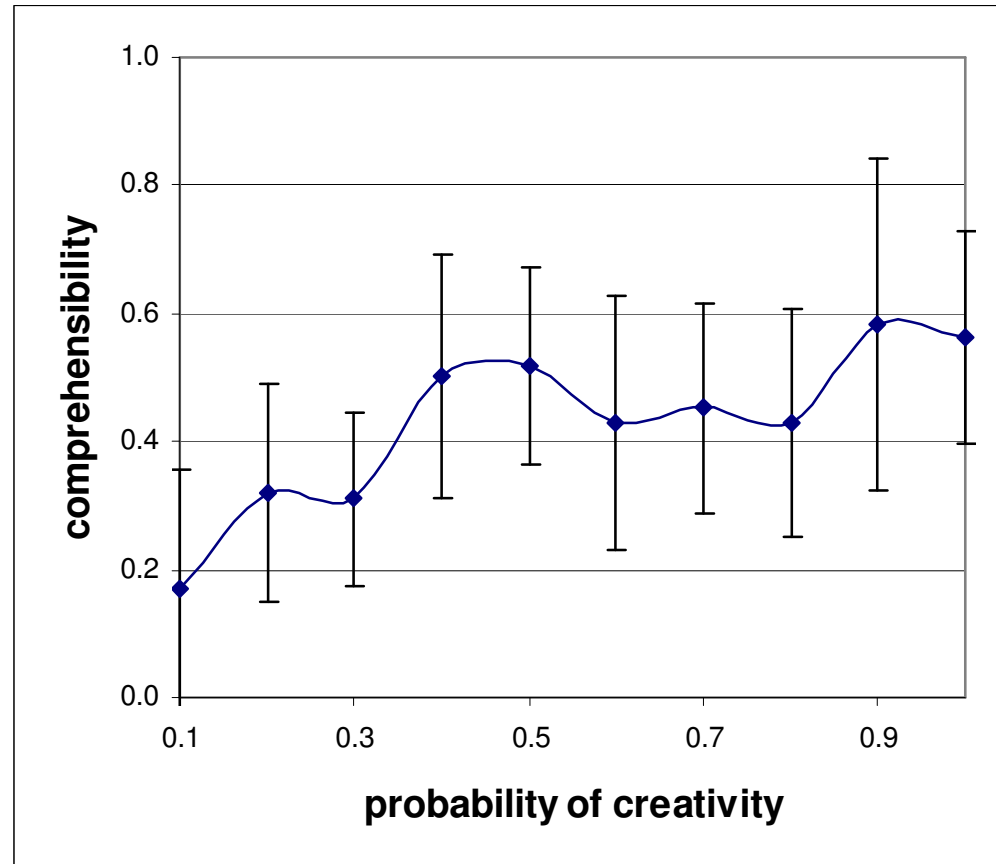# The effect of degree of shared attention

cp = 0.8; dp = 0.8

The effect of probability of pattern extraction

The effect of degree of symbolic creativity

Conclusions and work in progress

❑ Shared attention is a crucial factor; a small increase leads to a dramatic in the communicative efficiency.

❑ Other factors show more gradual effect (?)

Next steps:

❑ Effect of vertical transmission
❑ Interactions between the parameters
❑ Genetic algorithm to show the evolution of parameters

Thank you

Questions and comments welcome