

# The Role of Iconicity & Embodiment to the Evolution of Human Communication

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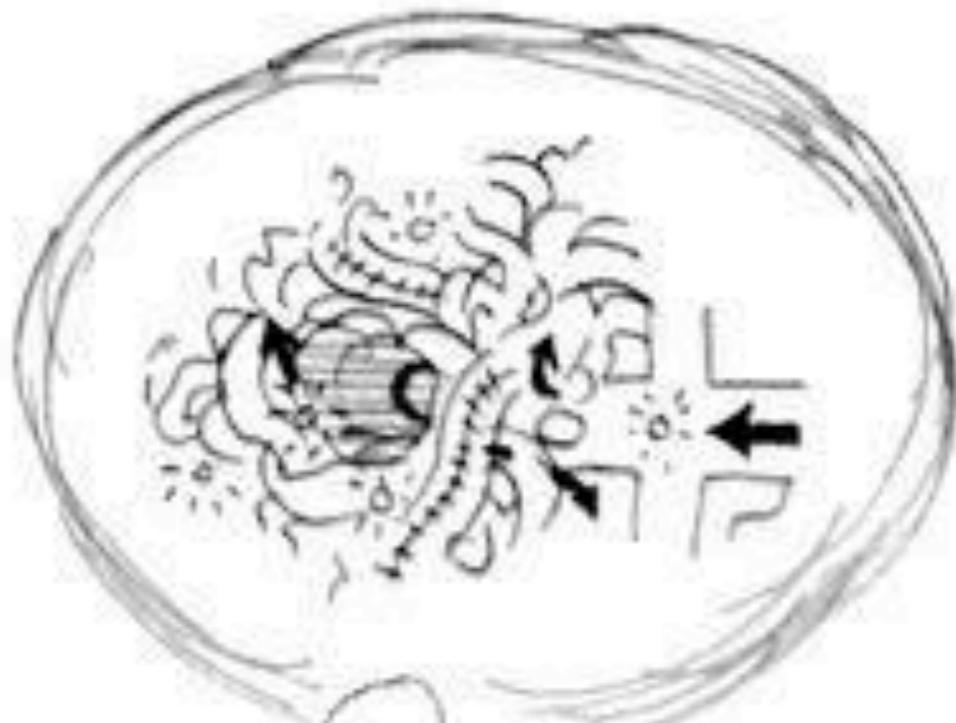


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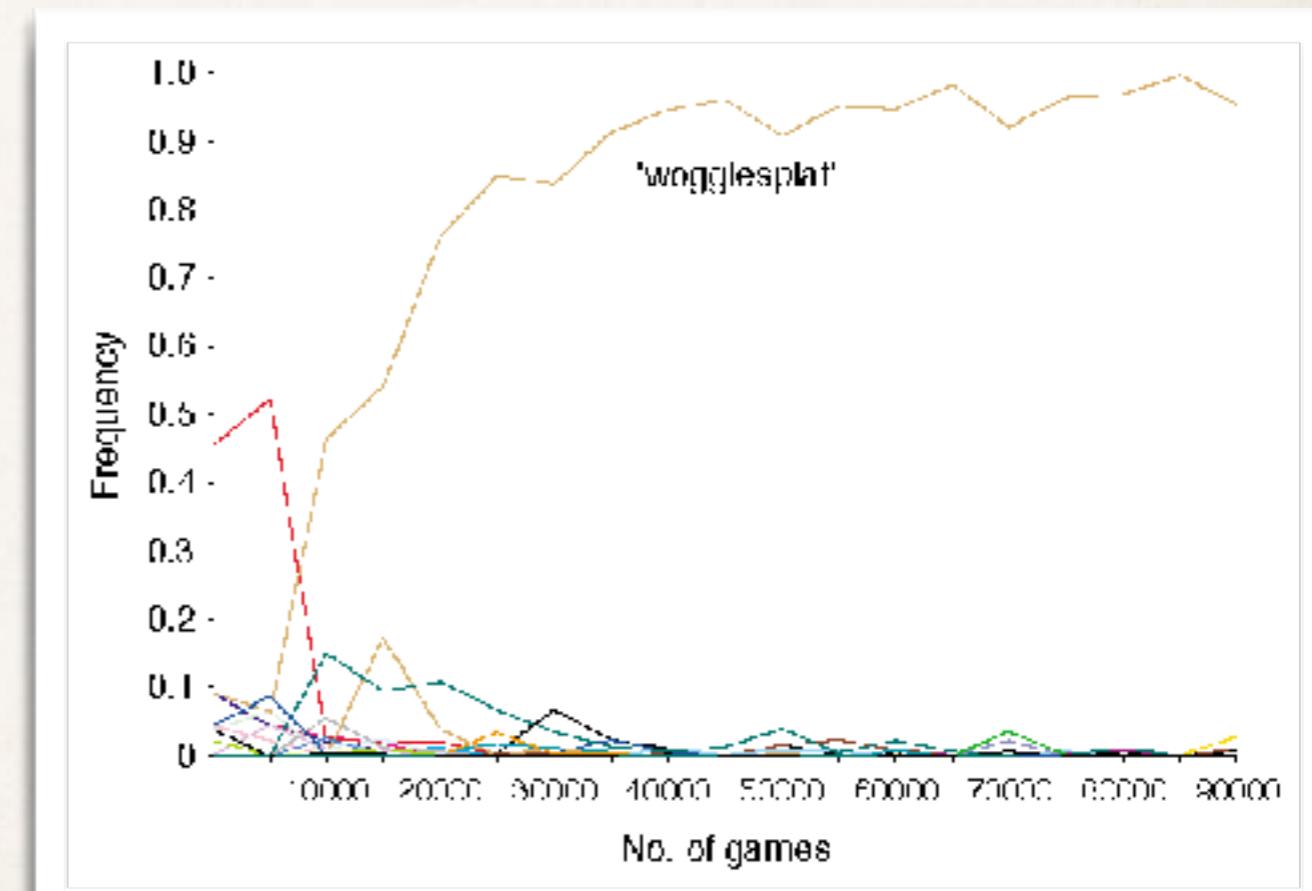
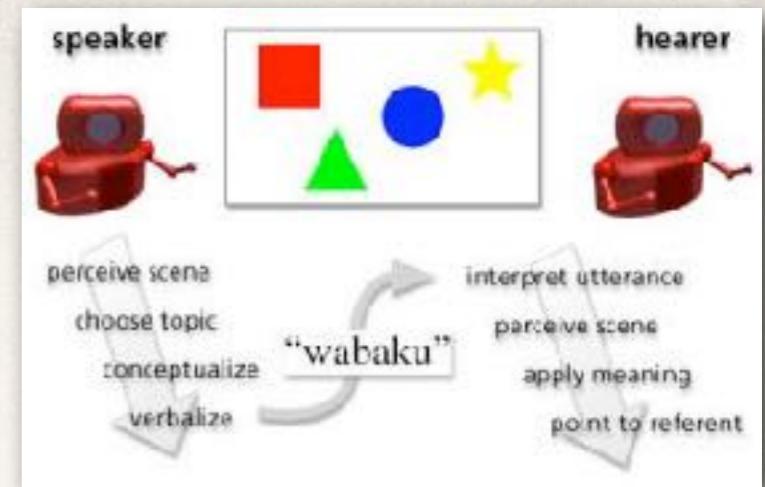




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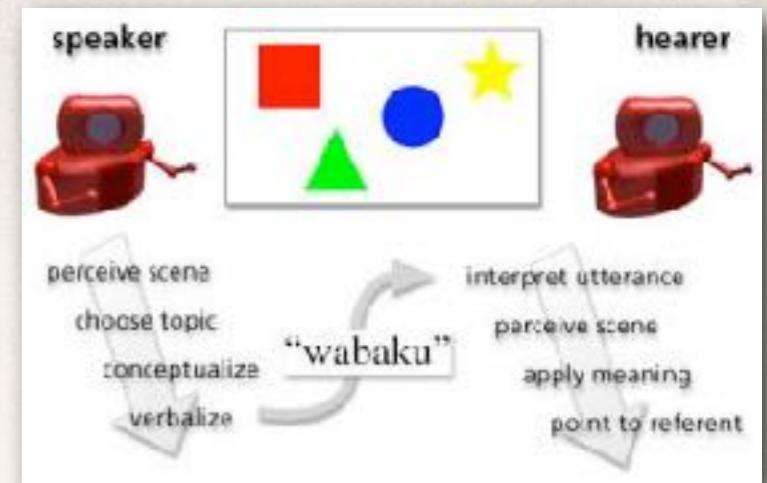
# Talking Heads Expt.

Steels (2006)



# Talking Heads Expt.

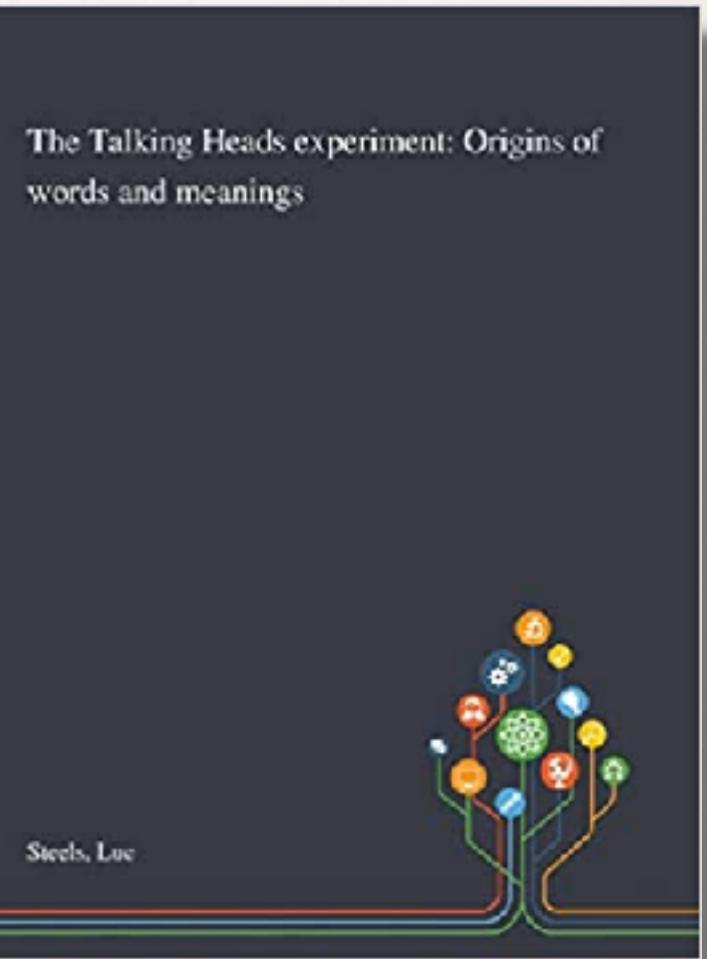
## Steels (2006)



- ✿ Groups can form linguistic conventions **bottom-up**

- ✿ Assumptions:

1. Symbols can ground shared symbols (**Forms**)
2. Learning via reinforcement learning (**Dynamics**)
3. Interactive feedback via pointing (**Embodiment**)



# Forms

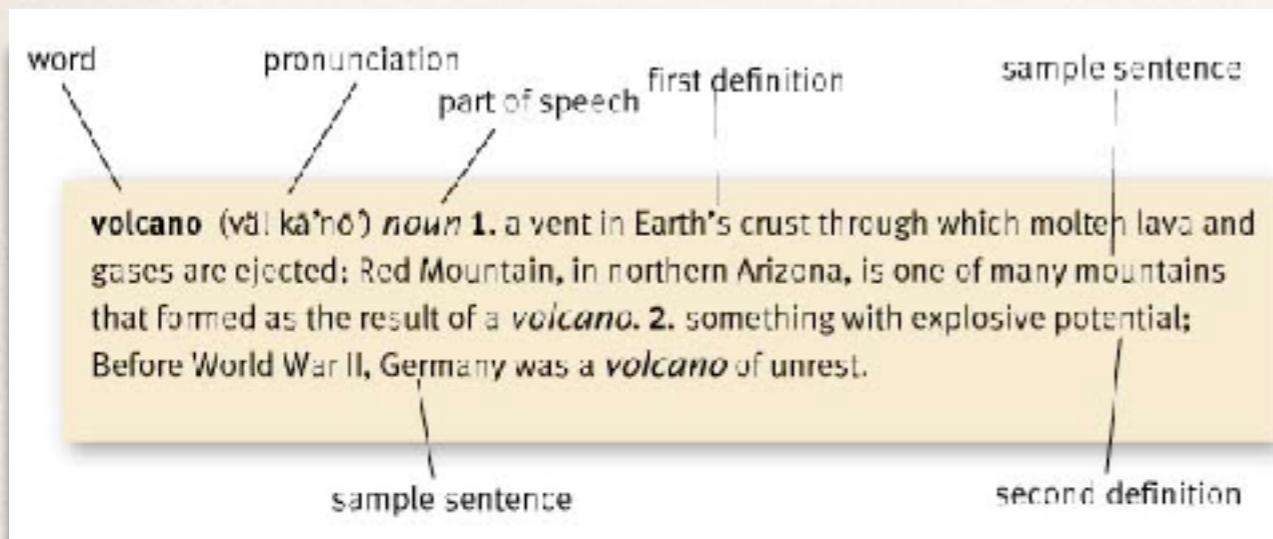
## Assumption 1: Symbols can ground shared symbols

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### The Symbol Grounding Problem (Harnad, 1990)

“Words would seem to have been necessary to establish the use of words”

Rousseau (1755/1964)



“Symbols grow. They come into being by development out of other signs, particularly from **icons**, or from mixed signs partaking of the nature of icons and symbols.”

Peirce (1893)

# Forms: The Experimental Task

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- ✿ To study language evolution in the laboratory we need the right task!
- ✿ A Task that:
  1. Prohibits the use of Ps' existing language system
    - ✿ forces Ps to create a new communication system from scratch
  2. Ps play several times
    - ✿ to track the evolution of the communication system

# Forms

## Garrod, Fay, Lee, Oberlander & MacLeod (2007)

- \* Theatre
- \* Art Gallery
- \* Museum
- \* Parliament
- \* **Robert De Niro**
- \* Arnold Schwarzenegger
- \* Clint Eastwood
- \* Drama
- \* Soap Opera
- \* Homesick
- \* Cartoon
- \* Television
- \* Computer Monitor
- \* Microwave
- \* Loud
- \* Poverty

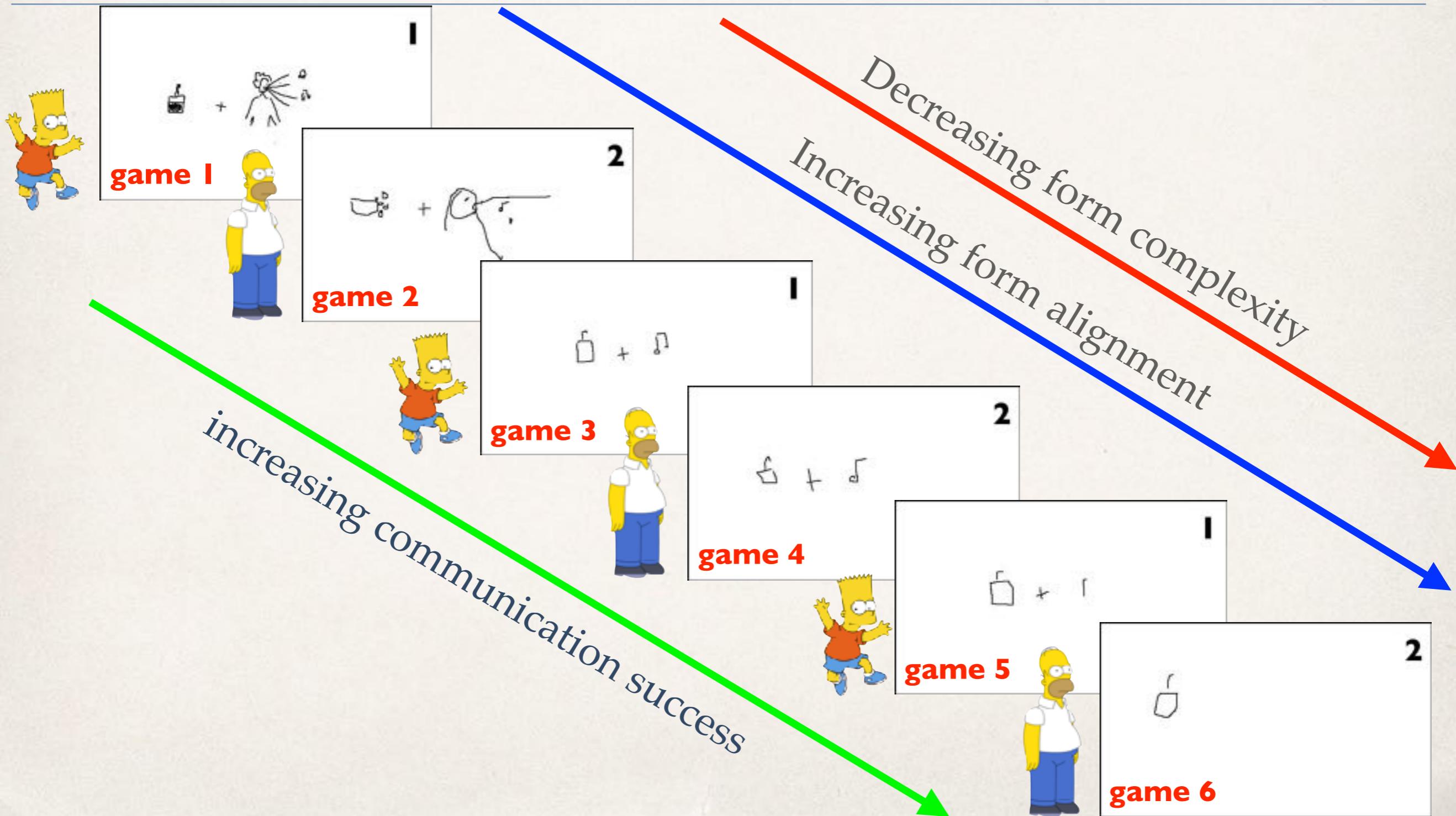


Drawer

Matcher

# Forms

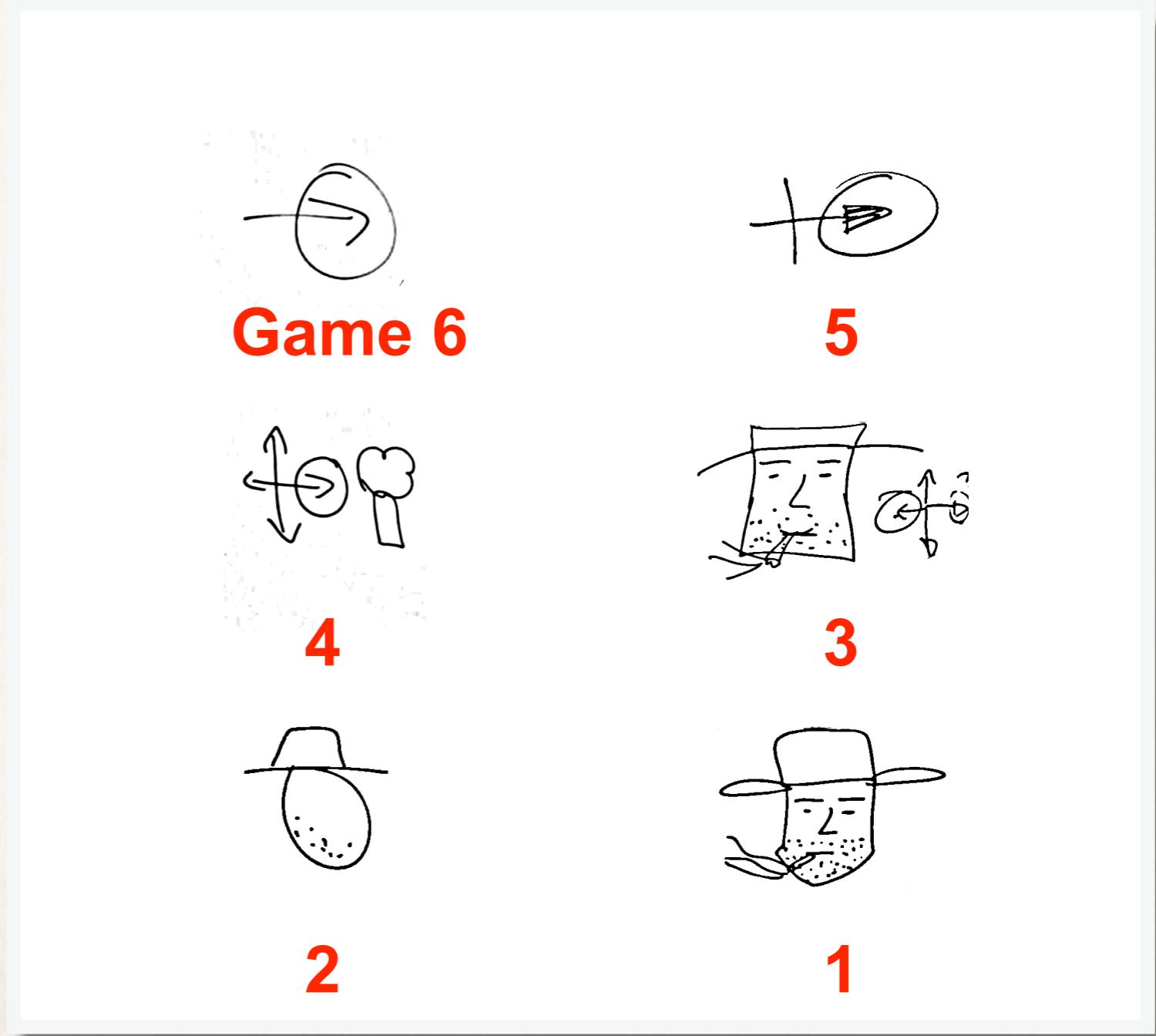
Garrod, Fay, Lee, Oberlander & MacLeod (2007)



# Forms

Garrod, Fay, Lee, Oberlander & MacLeod (2007)

- ❖ Theatre
- ❖ Art Gallery
- ❖ Museum
- ❖ Parliament
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- ❖ Poverty

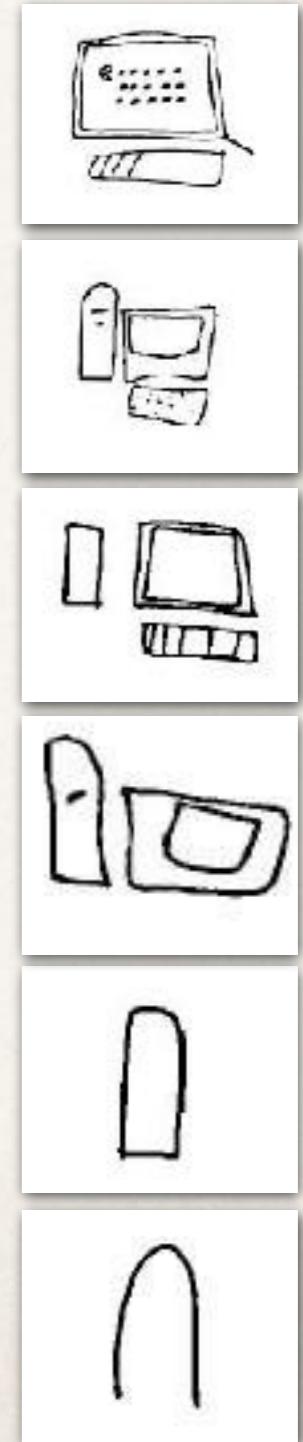


# Forms

## Assumption 1: Symbols can ground shared symbols

- ✿ Assumption not supported
- ✿ Icons ground shared meanings
- ✿ Social Interaction drives form refinement & symbolisation (**Peirce, 1893**)
- ✿ Similar **Icon-to-Symbol** transition seen in the evolution of writing systems

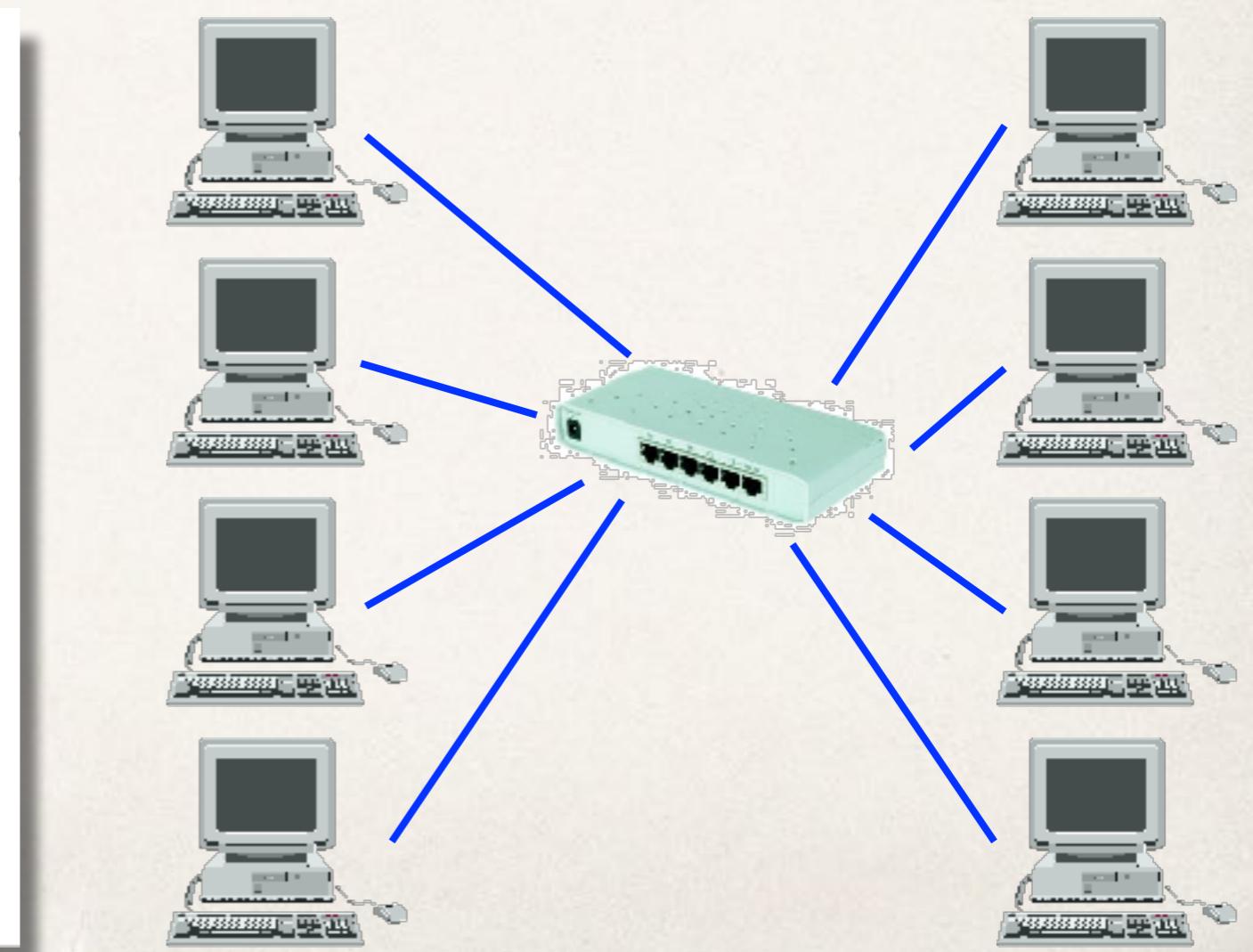
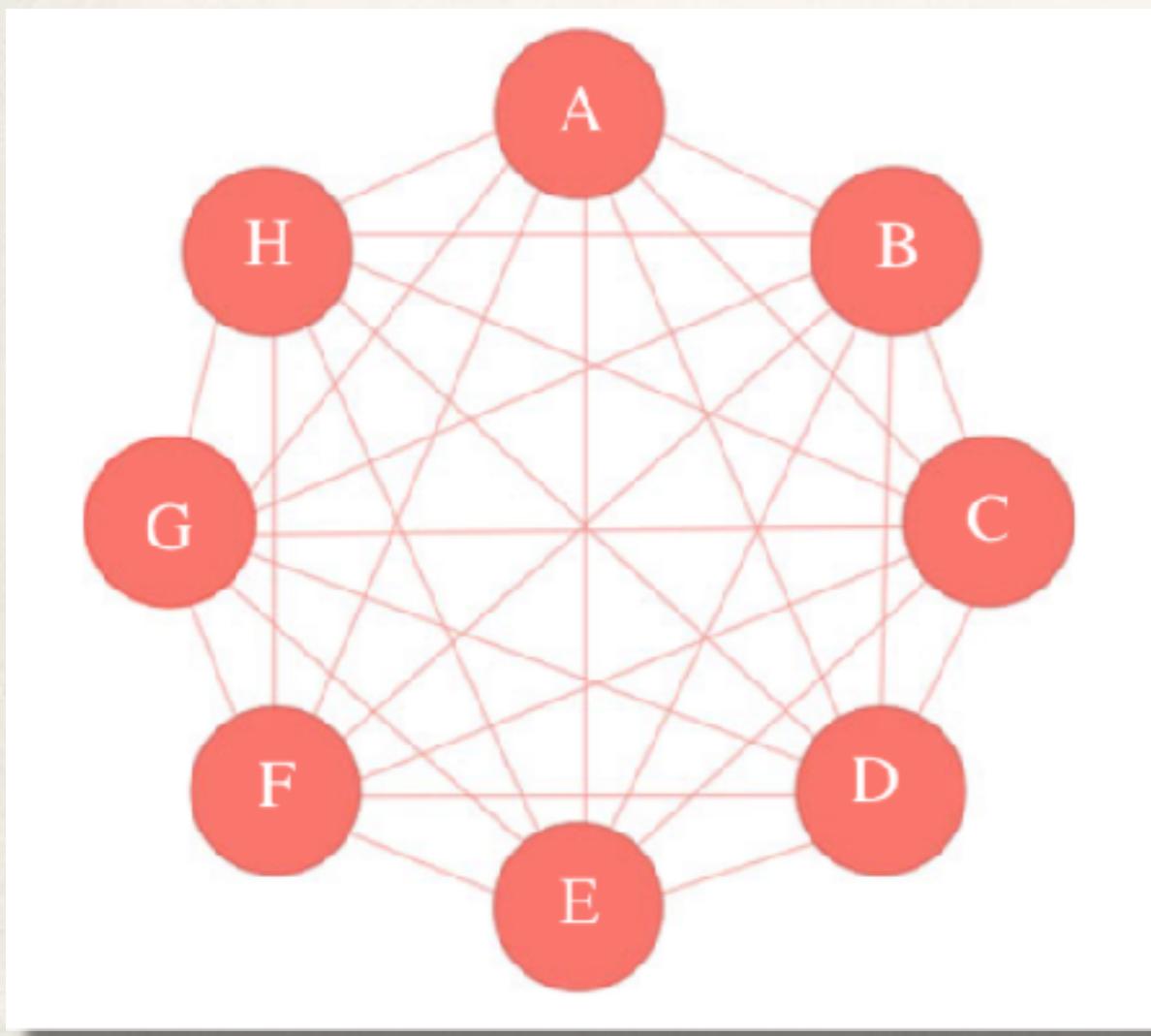
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GATE	門	門	門	門	門	門	𠂇

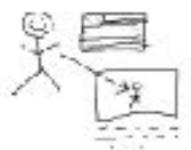
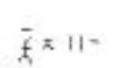
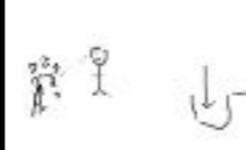
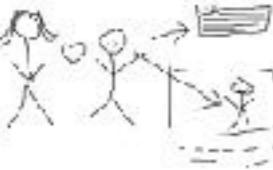
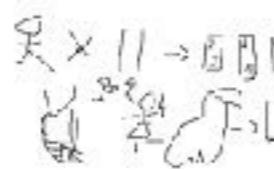
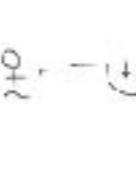
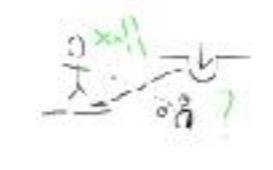
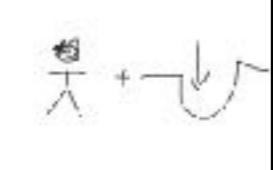
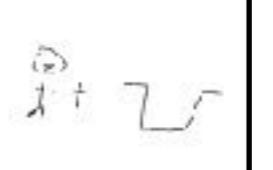
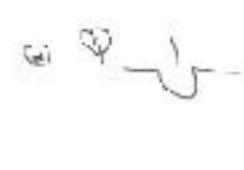
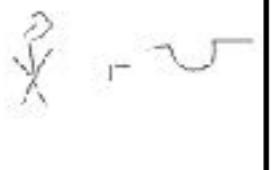
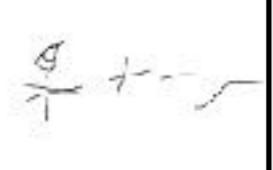
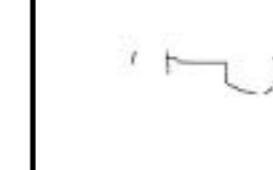
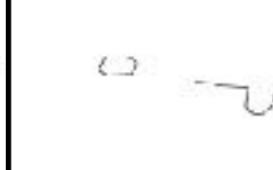
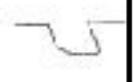
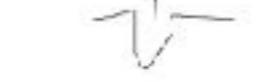
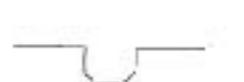


# Dynamics

## Assumption 2: Learning via Reinforcement Learning

- ❖ Use experimental micro-societies to study how groups form linguistic conventions



	P1	P2	P3	P4	P5	P6	P7	P8
G1								
G2	A	A	B	B	C	C	D	D
G3								
G4	A	B	B	A	C	D	D	C
G5								
G6	A	B	C	D	C	D	A	B
G7								
	A	B	C	D	A	B	C	D

	P1	P2	P3	P4	P5	P6	P7	P8
G1								
	A	A	B	B	C	C	D	D
G2								
	A	B	C	D	D	C	A	B
G3								
	A	B	C	D	B	A	C	D
G4								
	A	B	B	A	C	D	C	D
G5								
	A	B	C	D	C	D	B	A
G6								
	A	B	C	D	A	B	D	C
G7								
	A	B	A	B	C	D	C	D

# Functional Adaptation Production & Comprehension by Next Generation

PHILOSOPHICAL  
TRANSACTIONS  
OF  
THE ROYAL  
SOCIETY B

*Phil. Trans. R. Soc. B* (2008) **363**, 3553–3561  
doi:10.1098/rstb.2008.0130  
Published online 17 September 2008

## The fitness and functionality of culturally evolved communication systems

Nicolas Fay<sup>1,\*</sup>, Simon Garrod<sup>2</sup> and Leo Roberts<sup>1</sup>

<sup>1</sup>The University of Western Australia, Crawley, Australia

<sup>2</sup>The University of Glasgow, Glasgow, UK

This paper assesses whether human communication is adaptation seen in animal communication systems and compared the fitness of ad hoc sign systems created under different population sizes. In a task involving two interacting communities, a series of signs evolve that facilitate efficient decoding. No such benefits are found for signs evolved in isolated pairs of interlocutors. Experiments 2 and 3 showed that the fitness of community evolved signs cannot be attributed to superior memory. Experiments 4 and 5 revealed that naïve overseers were better able to identify community evolved signs than isolated pair developed signs. Hence, the fitness of community evolved signs arises from their greater residual iconicity. As populations increase, communication systems undergo a process of communicative selection and evolution. This results from the interplay between sign diversity and efficiency. The pairwise interaction between sign diversity and efficiency in the selection of signs for each referent reveals that the sign-meaning mapping for each referent applies selection pressure. The results show that the fitness of communication systems depends on the size of the population.

**Keywords:** graphics; communication; signs

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## The Cultural Evolution of Human Communication Systems in Different Sized Populations: Usability Trumps Learnability

Nicolas Fay\*, T. Mark Ellison

School of Psychology, University of Western Australia, Perth, Australia

### Abstract

This study examines the intergenerational transfer of human communication systems. It tests if human communication systems evolve to be easy to learn or easy to use (or both), and how population size affects learnability and usability. Using an experimental semiotic task, we find that human communication systems evolve to be easier to use (production efficiency and reproduction fidelity), but harder to learn (identification accuracy) for a second generation of naïve participants. Thus, usability trumps learnability. In addition, the communication systems that evolve in larger populations exhibit distinct advantages over those that evolve in smaller populations: the learnability loss (from the initial signs) is more muted and the usability benefits are more pronounced. The usability benefits for human communication systems that evolve in a small and large population is explained through guided variation reducing sign complexity. The enhanced performance of the communication systems that evolve in larger populations is explained by the operation of a content bias acting on the larger pool of competing signs. The content bias selects for information-efficient iconic signs that aid learnability and enhance usability.

**Citation:** Fay N, Ellison TM (2013) The Cultural Evolution of Human Communication Systems in Different Sized Populations: Usability Trumps Learnability. PLoS ONE 8(8): e71781. doi:10.1371/journal.pone.0071781

# Cultural selection drives the evolution of human communication systems

Monica Tamariz<sup>1</sup>, T. Mark Ellison<sup>2</sup>, Dale J. Barr<sup>3</sup> and Nicolas Fay<sup>2</sup>

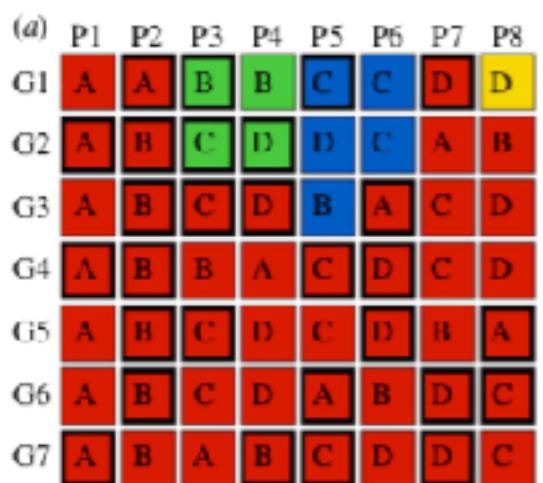
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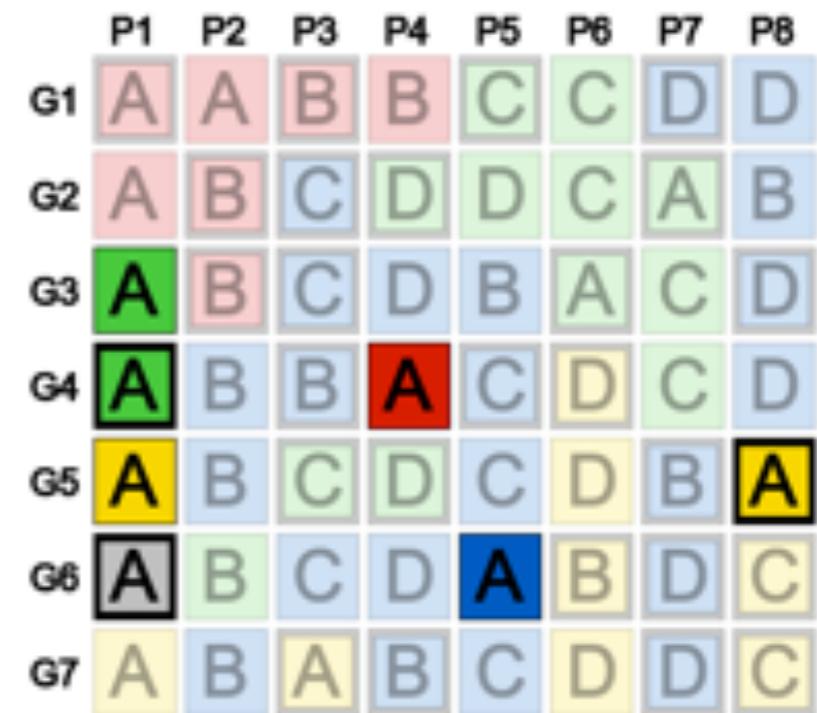
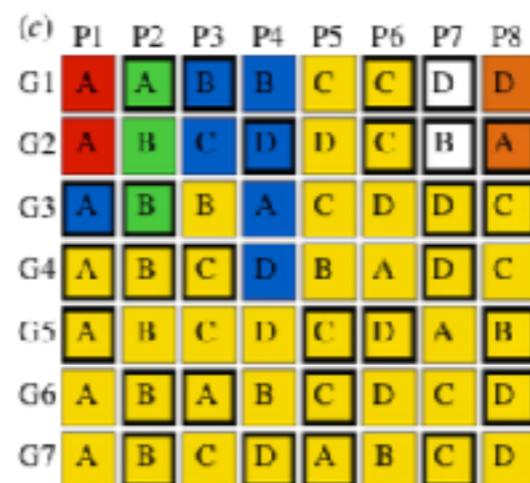
<sup>3</sup>Institute of Neuroscience and Psychology, University of Glasgow, Glasgow G12 8QB, UK

type	variable	no. levels	levels
explanatory	content bias	11	$b = 0.0$ to 1.0 in steps of 0.1 $\tau = 1, 2, 3, 4, 5, 6, 7, 8$
explanatory	coordination bias	11	$c = -1.0$ to 1.0 in steps of 0.2
control	memory	4	$m = 2, 4, 6, 8$
control	mutation	1	$\mu = 0.02$

*Microwave Example*

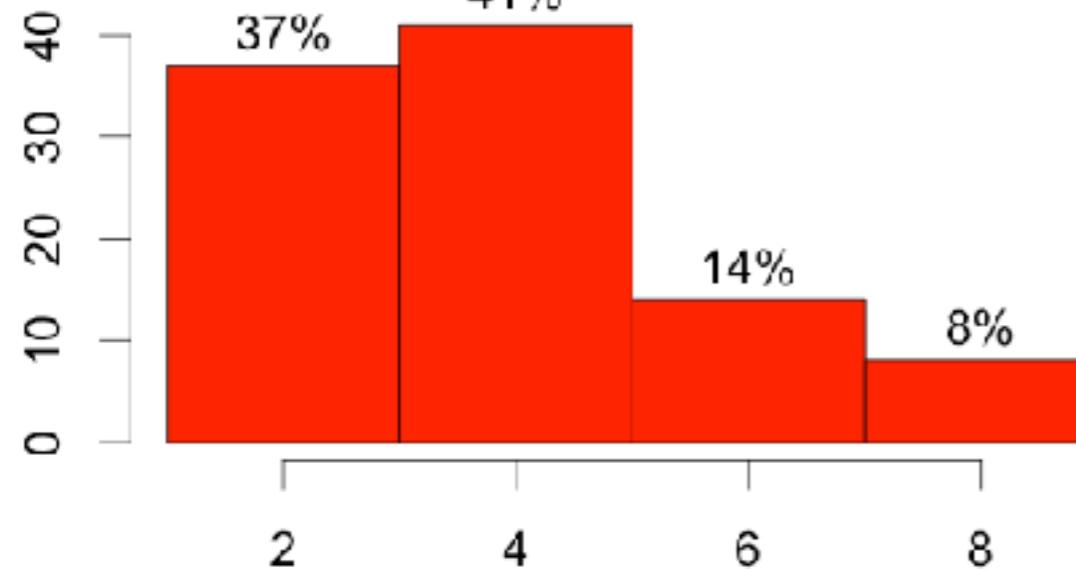


*Brad Pitt Example*



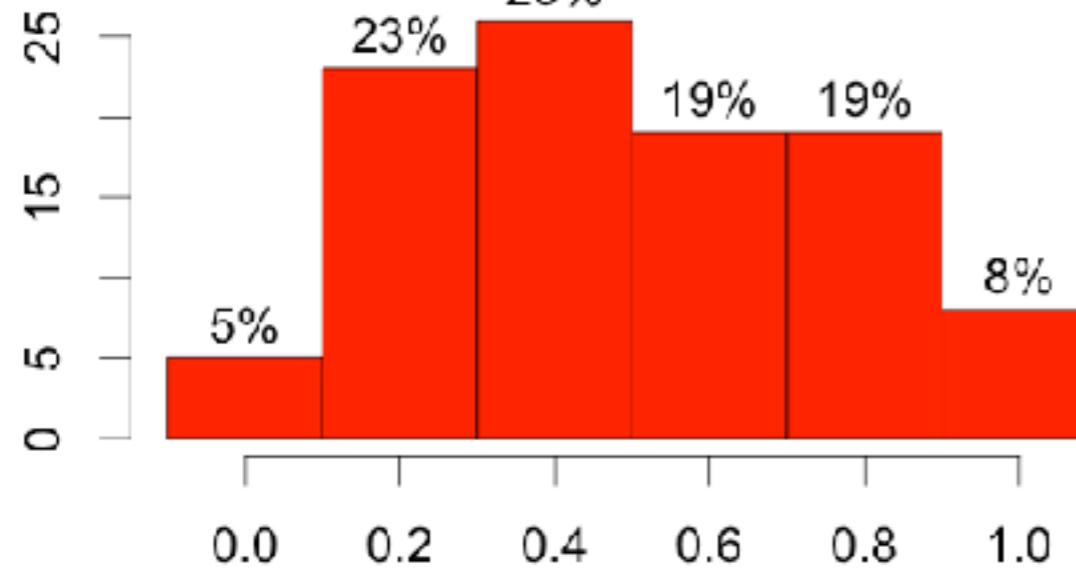
Percentage of Data Structures

### Memory Size



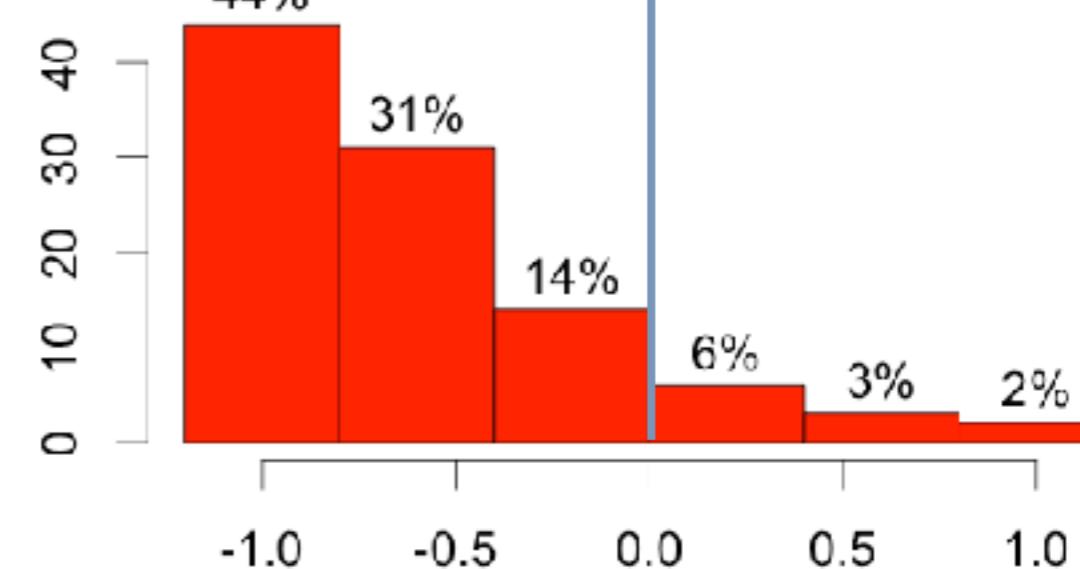
Percentage of Data Structures

### Content Bias



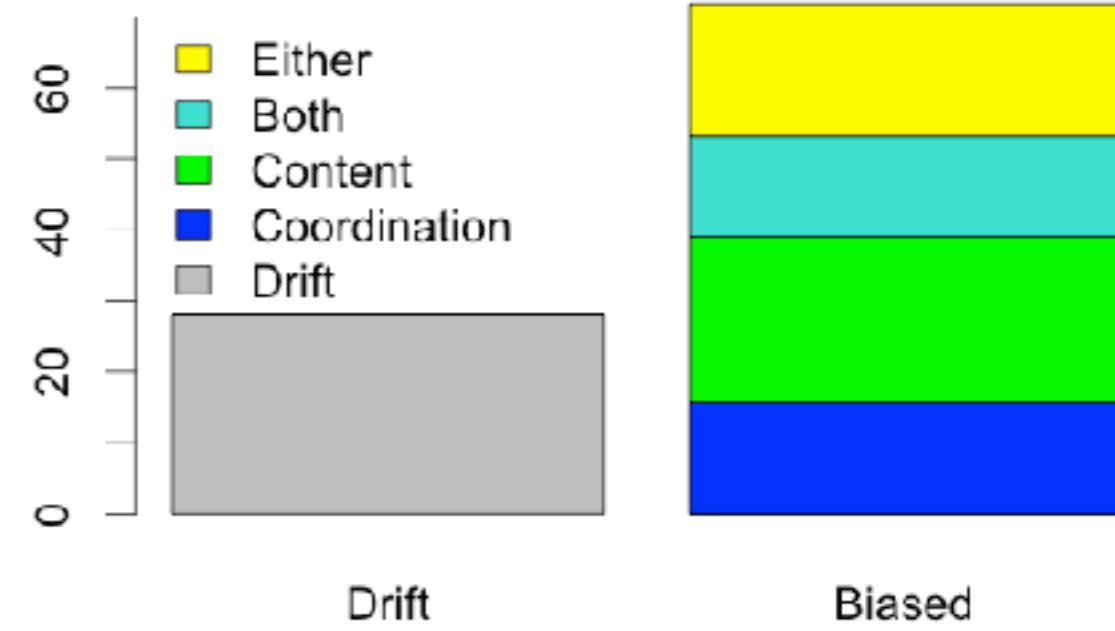
Percentage of Data Structures

### Coordination Bias

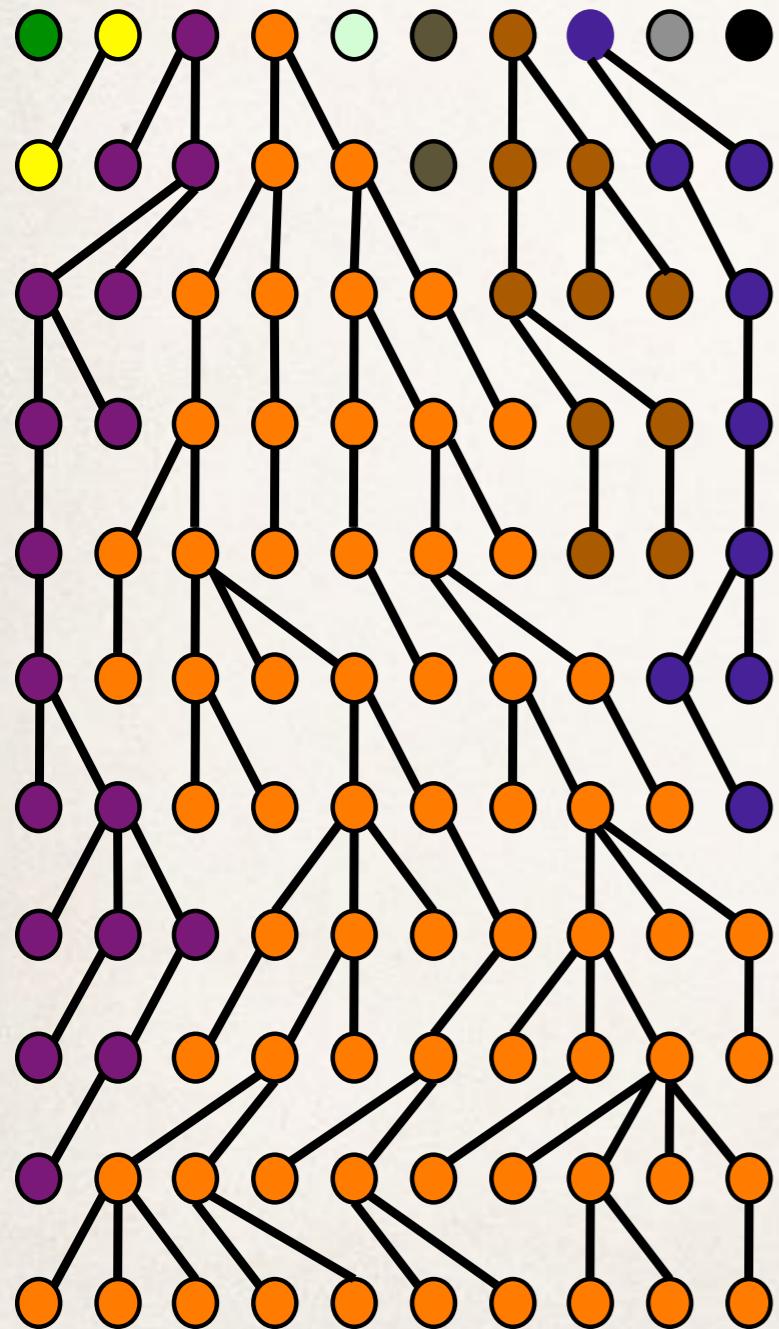
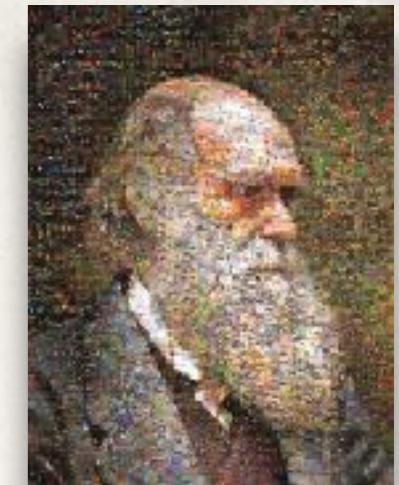


Percentage of Data Structures

### Evidence of Bias



# Dynamics Cultural Selection



- ✿ 72% of data structures \*required\* a biased account
  - ✿ **Content-Bias & Egocentric-Bias**
- ✿ **Cultural Selection** is operating on the communication system
- ✿ **Assumption 2:** Learning via reinforcement learning
- ✿ **Findings support Assumption 2, but add nuance**

# Embodiment

Assumption 3: Embodiment is important to language creation

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# Language Origin: Vocal- or Gesture-First?

## Comparative Evidence is Mixed

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### ✿ Evidence for Gesture-First Account:

- ✿ > flexibility in primate gesture compared to vocal calls
- ✿ > success in teaching primates sign language compared to vocal language
- ✿ Striking similarities in gestures produced by young children & chimpanzees



### ✿ Evidence for Vocal-First Account:

- ✿ primates use vocal calls to convey specific information (about predators) to conspecifics
- ✿ vocal calls more flexible than first thought
- ✿ vocal calls combined to make new meanings



# Language Origin: Vocal- or Gesture-First? Experimental Approach

- ❖ Similar to the Pictionary task
- ❖ Communication restricted to (non-linguistic) **Vocalisation or Gesture**
- ❖ Cross-Cultural Study: Australian or Ni-Vanuatu *Producers*
- ❖ Cross-Experiential Study: Sighted or Blind *Producers*
- ❖ Signals video-recorded & Interpreted by another group of Ps

## PROCEEDINGS B

royalsocietypublishing.org/journal/rspb

### Research

Cite this article: Fay N, Walker B, Blinn TM, Blundell I, De Kleine N, Gunde M, Lister O, Goldin-Meadow S. 2021 Gesture is the primary modality for language creation. *Proc. R. Soc. B* 288: 20210666  
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Subject Category:  
Behaviour

Subject Areas:  
behaviour, cognition, ecology

Keywords:  
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Electronic supplementary material is available online at <https://doi.org/10.1098/rspb.2021.0666.supp>.

THE ROYAL SOCIETY  
PUBLISHING

## Gesture is the primary modality for language creation

Nicole Fay<sup>1</sup>, Bradley Walker<sup>2</sup>, L. Mark Ellison<sup>3</sup>, Zachary Blundell<sup>1</sup>, Naomi De Kleine<sup>4</sup>, Murray Gunde<sup>1</sup>, Lucy J. Lister<sup>1</sup> and Susan Goldin-Meadow<sup>4</sup>

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How language began is one of the oldest questions in science, but theories remain speculative due to a lack of direct evidence. Here, we report two experiments that generate empirical evidence to inform gesture-first and vocal-first theories of language origin; in each, we tested modern humans' ability to communicate a range of meanings (995 distinct words) using either gesture or non-linguistic vocalisation. Experiment 1 is a cross-cultural study with signal Producers sampled from Australia ( $n = 30$ ,  $M_{\text{age}} = 32.63$ ,  $s.d. = 12.43$ ) and Vanuatu ( $n = 30$ ,  $M_{\text{age}} = 32.40$ ,  $s.d. = 11.76$ ). Experiment 2 is a cross-experimental study in which Producers were either sighted ( $n = 10$ ,  $M_{\text{age}} = 39.60$ ,  $s.d. = 11.18$ ) or severely vision-impaired ( $n = 10$ ,  $M_{\text{age}} = 39.81$ ,  $s.d. = 10.03$ ). A group of undergraduate student Interpreters guessed the meaning of the signals created by the Producers ( $n = 140$ ). Communication success was substantially higher in the gesture modality than the vocal modality (sighted vs. high overall, 61.7% versus 29.0% success). This was true within cultures, across cultures and even for the signals produced by severely vision-impaired participants. The success of gesture is attributed in part to its greater universality (i.e. similarity in form across different Producers). Our results support the hypothesis that gesture is the primary modality for language creation.

### 1. Introduction

People of all cultures gesture while they speak [1,2], blind people gesture [3], and hearing adults and children can successfully use gesture as their sole means of communication at the request of experimenters [4–6]. Furthermore, sophisticated animal languages, with the same expressive range as spoken languages [7], emerge naturally in populations of deaf children [10,11]—and even among individual deaf children living in hearing households [12]—or in communities with a high incidence of deafness [13]. The ubiquity of gesture, and its capacity to rapidly evolve into language, has led to the proposal that language originated in manual gestures rather than in vocal calls [14,15]. The present study tests this proposal with two experiments.

The gesture-first theory of language origin dates back to the eighteenth century [14,15], but has recently gained in popularity [16–20]. Consistent with a gesture-first theory, comparative studies have demonstrated greater flexibility in non-human primates' (hereafter: primates) gesture compared to vocal calls [21], more success in teaching primates sign language than vocal language [22–24], and striking similarities between the non-motor gestures produced by young children and by chimpanzees [25]. Support for the vocal-first theory of language origin [26–28] includes comparative evidence indicating that primates use vocal calls to convey species-specific information to conspecifics [29], primate vocal cells are more flexible than first thought by gesture-first proponents [30], and

# Embodiment & Evidence for Gestural Universals

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- ✿ **Hypothesis:** Gesture > Vocal (**comm. success**)
- ✿ **Explanation:**
  - ✿ Greater **iconicity** for gestured signals
  - ✿ Greater **universality** of gestured signals
- ✿ **Embodiment:** body & its interaction in the environment important to cognition
  - ✿ embodiment opportunity in gesture
  - ✿ no embodiment opportunity in vocal
- ✿ **Embodiment** gives rise to universality
- ✿ **Hypotheses:** 1) > Universality in gesture &  
2) Universality predicts comm. success



# Embodiment

## Cross-Cultural Study



Please select the concept you think is being communicated.

possible full year swim square chain kettle order cover danger

money rain bag stick sick committee

# Embodiment

## Cross-Cultural Study



Please select the concept you think is being communicated.

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# Embodiment

## Cross-Cultural Study



Please select the concept you think is being communicated.

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# Embodiment

## Cross-Cultural Study



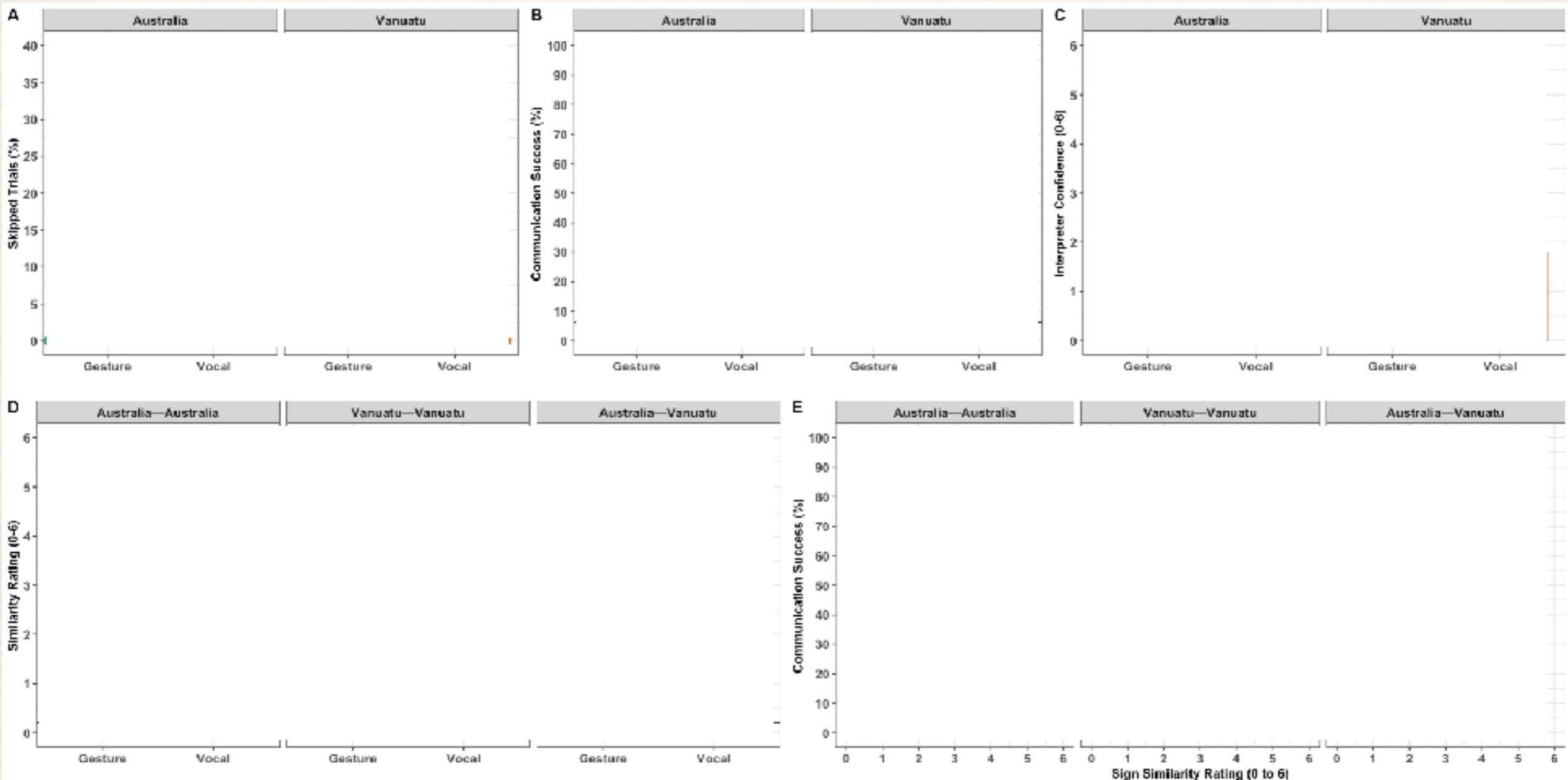
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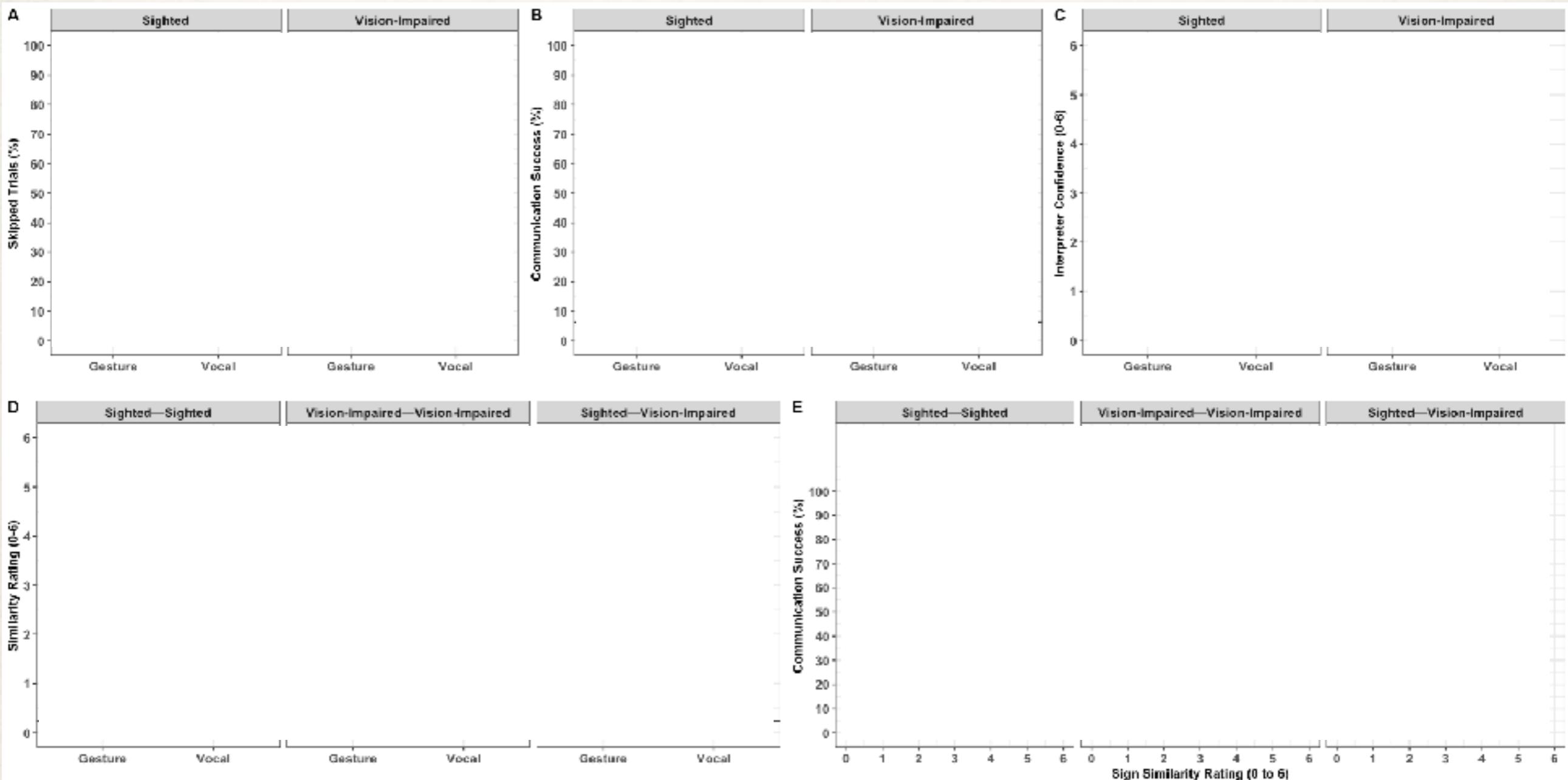
# Embodiment: Results

## Cross-Cultural Study



# Embodiment: Results

## Cross-Experiential Study



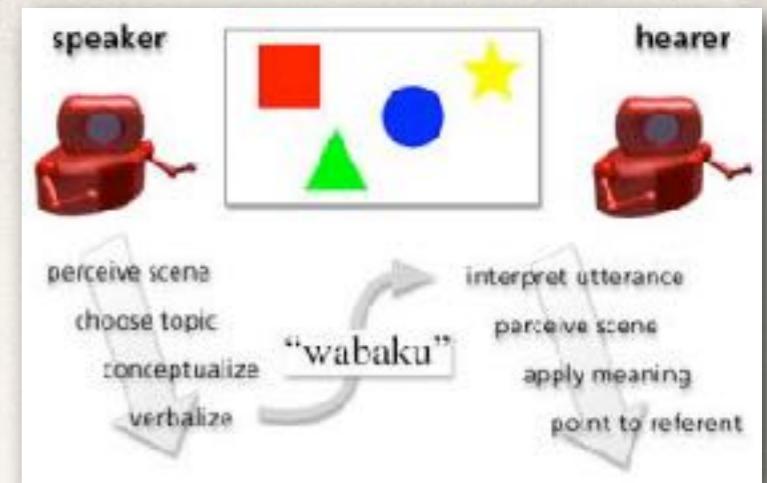
# Embodiment

Assumption 3: Embodiment is important to language creation

- ✿ **Embodiment:** we understand the world via our physical interactions
- ✿ Gesture offers substantial scope for **embodiment**
  - ✿ Leads to stronger **universality** in gesture modality
  - ✿ Contributes to the **communication success** of gesture
- ✿ Benefits even seen among **blind** people who have access to the vocal world but not the visual world...
- ✿ **Assumption 3 supported**



# To Conclude



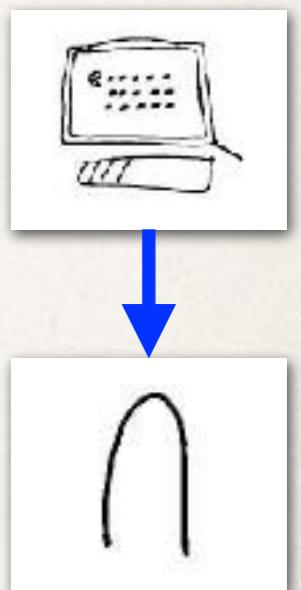
- ✿ Groups can form linguistic conventions  
**bottom-up**

- ✿ Process:

- 1. Forms:** Icons ground shared meanings

- 2. Dynamics:** Learning guided by content-bias & egocentric-bias

- 3. Embodiment:** Embodiment drives signal universality & communication success



*The End*