Arbitrary signs
and the emergence of language

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Basic questions

Question 1: How and why did language evolve in humans but not in other species?

Question 2: How and why did language evolve with the properties that we observe rather than some other set?
Two unique linguistic properties

(i) Signs

(ii) Recursive syntax
The linguistic sign (Saussure)

Seven parts of a sign:

**Cognitive:** chunk of cognition

**Form:** l1d1 star

**Physical:** particular sound waves

**Meaning:** [Property LITTLE] [TYPE: STAR]

**Link 1:** ||  ||

**Link 2:** ||  ||

**Link 3:** ||  ||
Reformulated questions

a) How did elements from domains of such different natures—concepts and perceptual forms—get to meet in the brains of humans?

b) Why can’t these elements meet in the brains of other animals?

c) What are the biological foundations of these signs?
**Key proposal**

Language is NOT defined through its purpose (communication, thinking)

Language is NOT defined through its recursivity and “efficiency”

These functionalities both follow from design properties of the sign
The design properties of the sign are ultimately due to three factors

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<tbody>
<tr>
<td>a)</td>
<td>neuronal systems unique to humans which can link percepts and concepts to form signs</td>
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<td>b)</td>
<td>pre-existing properties of the human physical make-up involved in signifiers</td>
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<td>c)</td>
<td>pre-existing properties of the human cognitive make-up involved in meanings</td>
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A design feature of the human physical make-up:

**segmentation**

a) **natural oscillations** (Poeppel)

b) **articulatory factors for categorical perception**
   (Stephens 1972, Ménard)

c) **vocal imitation as a preadaptation for sexual selection** (Darwin)
A design feature of the human cognitive make-up:

segmentation

The world, events are digitized (Hurford)

a) magical number 4

b) discrete chunks, action packages (1-4 sec.)
The human adaptive suite
Premack 2004; Fedor et al. 2009

Human-specific cognitive traits

1) language: signs and syntactic combinations
3) developed Theory of Mind (Flavell 1992, Povinelli 2000)
4) understanding of cause and effect (Penna & Povinelli 2007)
5) efficient teaching
6) social trust and collaboration
7) pointing, shared attention, deictic reference
8) detachment from immediate situation, episodic memory (of noncurrent scenes and events) (Gärdenfors & Osvath 2005)
The human adaptive suite

**Human-specific neurological traits**

9) large brain
10) ApoE4 (*apolipoprotein E4*) (provides better synaptic interactions) (Bufill & Carbonell 2004)
11) plasticity of the brain for several functions (Fedor et al. 2009, Hagoort 2009)
12) offline brain systems (OBS)
   ("offline" activations, inhibiting input or output) (Hurley 2008)
The human adaptive suite

**Human-specific physiological traits**

13) bipedalism
14) fine control over vocal tract
15) fine control over hand and finger movements
The human adaptive suite

**Human-specific behavioral traits**

16) long dependency during infancy
17) art, culture
18) tool use
c) What are the biological foundations of signs?

1- A **large brain** with a huge cortex offers a highly increased potential for synaptic interactions

2- **ApoE4** greatly improves synaptic repair, hence dramatically increases synaptic interactions  
   (Bufill & Carbonell 2004)

3- The **long dependency** during infancy feeds more cultural material to these additional brain capacities
Answers to the questions

c) What are the biological foundations of signs?

- Large brain
- + ApoE4
- + long dependency

= Offline Brain Systems (OBS)

A small step with gigantic consequences:
OBSs give rise to the “Human-specific Adaptive Suite”
Answers to the questions

a) How did elements from domains of such different natures—meanings and perceptual forms—get to meet in the brains of humans?

A vocal element can enter into the brain in a way exclusive to humans: as an offline activation by an OBS.

A “mentalized” vocal element can be linked to a meaning because they have a similar mental nature.

Vocalizations processed independently from any external stimulus can become symbolic (linked to any concept).
Three basic levels of mapping in human brains:

*primary representational system:*
from reality to sensory perception; simple representations with almost nothing between stimulus and response

*mapping from sensory perception to categorization:*
neural linking of similar results from various sensory input;
ex.: a leopard’s spots, roar and smell

*mapping from categories to concepts:*
abstracted from any sensory input, any immediacy;
a category used offline in OBSs
b) Why can’t these elements meet in the brains of other animals?

Because only humans have Offline Brain Systems that can appropriately mentalize perceptual elements, detached from any external stimulus.
How did the specific properties of signs emerge?

Perceptual forms: phonemes and phonological combinations

Meanings/concepts

Linkings between forms and meanings
How did the specific properties of signs emerge?

Order out of chaos: (Prigogine)
self-organization due to frequency and accumulation
Perceptual forms

Phonemes: discrete elements in a continuum

A chaotic system: there are infinitely many incrementally different vocal forms that we can produce and perceive.

Production: some vocalizations are easier to pronounce and require less energy: this favors their use and frequency (Lindblom 1992).

Perception: our perceptual system sets upper bounds on the vocal distinctions which we can perceive (Nowak et al. 1999).

These self-organizing constraints maximize contrastive dispersion and create clusterings in a few particular “hot spots”.

8 discrete regions of a tube like the vocal tract which correspond to places of articulation in natural languages (Oudeyer 2005, Ménard).
Perceptual forms

Phonological combinations

The usual story:

- vast (maybe infinite) number of potential meanings
- very small number of actual phonemes in any language

The solution to this “problem”: the vocalizations become compositional

Where do the compositional processes of come from?
Universal material properties of vocal units (phonemes):
- occur in time, so appear in an order, with some juxtaposed
- can have various intonations
- can be shortened or elongated
- can be stressed or unstressed

These properties are percepts already in the stock of our perceptual system. They can be represented by an OBS.

Phonological compositional processes are simply functional uses of preexisting material properties, such as order and juxtaposition
In a system of arbitrary signs, a vocal signifier can be any element among those recognized by the perceptual system:

- a phoneme
- a juxtaposition of phonemes
- a tone on a phoneme, etc.

As a result of various material constraints, a limited number of discrete phonemes and their combinations emerged from self-organization in the chaotic system of the speech sounds represented by OBSs.

They constitute the potential signifiers.
Meanings/concepts

Where do meanings come from?

**Ontology:** our perceptual attentional systems treat the world as containing two basic kinds of entities: (Hurford 2007)

1) Objects ("something is there")

2) Properties of these objects ("what is there")

These two kinds of entities correspond to two separate neural pathways in the visual system.
Meanings/concepts

Where do meanings come from?

Extremely large number of potential concepts:

- vast number of objects and situations
- untold number of possible concepts due to detachment, offline activation
- various perspectives on them (Quine indeterminacy)
- countless possible ways to partition the conceptual substance by a given language (Saussure’s radical arbitrariness vs Plato’s nomenclature)

Any of these elements can be a meaning. This introduces another unprecedented sort of chaotic system in the brain.
Meanings/concepts

Where do meanings come from?

Meanings: clusters form in the mass of the conceptual substance as a result of frequency and accumulation due to relevance/usefulness:

- high relevance of some situations for organisms → accumulations self-organize on general categories which are of greater usefulness (Locke 1690)

- pragmatic inferences from ToM and context → accumulations self-organize on general meanings because they are sufficiently precise (Bouchard 1995; Origgi & Sperber 2004)

- optimal compromise between informativeness and distinctiveness → accumulations self-organize on basic level concepts (Rosch et al. 1976)
Linking meanings and forms

Where do the links between forms and meanings come from?

The random high frequencies of some meaning clusters and of some vocal clusters increase the probability of links involving them.

So these links tend to accumulate and crystallize.

As the accumulations grow, this leads to contrastive dispersals of the links, reaching strongest distinctivity, i.e., mutual exclusivity:

the forms and meanings of a language tend to be in a one to one relationship.
Linking meanings and forms

Where do the links between forms and meanings come from?

The link is an instance of the basic relation of predication that holds between ontological entities: a property is attributed to an object.

*A sign* is a reciprocal predication: the systematic attribution of a vocal form and a meaning to one another.

Since any link is possible, signs are potentially infinite.
Syntax

Where do the tools that build sentences come from?

Syntax combines signs. So the combination of two signs operates simultaneously on their meaning and form.

**Meaning:** \([\text{Property LITTLE]} \rightarrow R(CI) \rightarrow \text{[TYPE: STAR]}\)

**Link:** \(\| \rightarrow \| \rightarrow \|

**Form:** \(\text{IDLI} \rightarrow R(SM) \rightarrow \text{star}\)

Syntactic relations are COMBINATORIAL SIGNS
Syntax

Where do the tools that build sentences come from?

Syntactic compositional processes are not an innovation: they are simply functional uses of universal preexisting properties of vocal sounds [R(SM) signifiers] and of our cognitive system [R(CI)] (Bouchard 1996, 2002).

Universal traits of the vocal forms of words:

- occur in time, so appear in an order, with some juxtaposed

- can have various intonations
Syntax

Where do the tools that build sentences come from?

1. syntactic ordering: head and object, phrase and modifier adjunct, etc.
2. syntactic intonation: emphatic focus, question, exclamation, etc.
3. dependent marking by order: case affixes in Latin, German
4. dependent marking by tone: case tones in Rendille
5. head marking by order: object marking on verb in Mohawk
6. head marking by tone: on the verb to mark tense or aspect in Ngiti
Syntax

**Where do the tools that build sentences come from?**

Combinatorial sign:

Its meaning is predication, in the broad sense that one element adds its denotation as a restriction on another:

- the subject gets the property of the predicate
- the topic gets the property of the comment
- the verb gets the property of the direct object
- the noun gets the property of the adjective
Syntax

Where do the tools that build sentences come from?

Combinatorial sign:
Its meaning is predication
Its form is juxtaposition or intonation
Why this meaning and these forms?

Predicative relation: by far the most frequent meaning in our cognitive system.
Juxtaposition and intonation: always present, so the most frequent elements in the perceptual system.

These elements create accumulation points in their respective domains that are so dominant that they increase the frequency of links between them to a degree that these links inevitably accumulate and crystallize.

Order-out-of-chaos predicts that, when we develop signs, we inevitably develop combi-signs.
Syntax

Where do the tools that build sentences come from?

Why is there Type-recursion in language?

In addition to combinatorial signs which produce complex signs, you need three additional properties to have Type-recursion:

- labels

- heads

-endocentricity (the phrase inherits the category of its head)
Syntax

Where do the tools that build sentences come from?

These syntactic properties derive from prior properties:

**Labels:** the basic categories N and V derive from the two basic kinds of entities (objects and properties); other categories derive from N and V.

**Heads:** Asymmetries in syntactic relations, such as head vs dependent, come from the fact that predication — the meaning of combi-signs — is asymmetrical (Bouchard 2002; early GG: Venneman 1974, Keenan 1978).

**Endocentricity:** derives from object permanence. In the world, an object to which you attribute a property remains an element of the same type.
Syntax

**Where do the tools that build sentences come from?**

Why is there Type-recursion in language?

Parsimonious assumption: the only primitives are lexical signs and combinatorial signs.

**Endocentricity Theorem:** the category of a complex sign is the category of the formative sign to which the predication of the combi-sign applies.

**Type-recursion** occurs when a restraining sign or one of its elements happens to be of the same type as the head of the complex sign.
Plato’s problem: how can we know so much with so little evidence?

We don't have to know that much to use a language: its signs and combi-signs.

Their properties follow from prior properties.

Language acquisition is canalized by these properties, not by a L-specific UG list of unexplained properties.

There is an alternative to a computational model: learned fragments (not of templates for phrases or sentences) but combi-signs.
The mutation towards offline activation of some neurons makes sense in evolution.

Language developed as part of a complex human adaptive suite. Many of these traits developed in parallel because they all come from the same micro-anatomical brain structures with offline potential.

Because this genetic change provides a pleiotropic advantage in several domains, its evolvability is high.
The capacity to form signs is the only aspect of language which is new and unprecedented in the primate lineage.

Offline Brain Systems provide the crucial property that got language started: meanings and forms can meet in the brain through their "representations".

Material canalization leads to combi-signs (syntax) made of the same “substances” as uni-signs.
Thank you!