**Putting Protowords Together**

*The Leopard Call (anterior cingulate cortex and brainstem):*
- The instinctive call is equivalent to
  There is a leopard nearby. Danger! Danger! Run up a tree to escape

*Hypothetical Protowords that “go further” (the lateral brain of, perhaps, Homo erectus):*
- One protoword is equivalent to
  There is a dead leopard – let’s feast upon it.
    is embellished by pointing
- The other protoword is equivalent to
  There is a leopard – let’s hunt it so we can feast upon it.
    is embellished by pointing and pantomime of hunting strategies

Items begin to be put together, but the protowords are still holophrases (unitary utterances) – there is, e.g., no word for leopard common to both of them.

**From Holophrases to Language**

**Hypothesis:**

a) The protolanguage of *Homo erectus* and early *Homo sapiens* was composed mainly of holophrases

b) Commonalities between two structures could yield
- the isolation of that commonality as a gesture or vocalization betokening some shared aspect of the event, object or action denoted by each of the two structures
  - Wray 2000: how this might have operated in protohumans
  - Kirby 2000: a related computer model
- This could in time lead to the emergence of a construction for “putting the pieces back together”, with the pieces becoming instances of a widening class of slot fillers

Pantomimic example: Holophrases for “open door” versus “close door” may precede the invention of a word for “door.”
Complex Imitation Revisited

**Recall: Complex imitation combines**

- The ability to recognize another's performance as a set of familiar movements
- The ability to use this recognition to repeat the performance, and
- More generally: the ability to recognize that another’s performance combines variants actions to approximate the performance on this basis, with increasing practice yielding increasing skill.

Mechanisms serving inventing and acquiring a language

Complex imitation makes fractionation possible:

- For protohumans: this could lead to the invention of new (proto)words and constructions.
- For the modern child: this provides the basis for understanding that sound patterns can be dissected into strings of words, and that these words can be grouped by constructions.
- The constructions become of greater or more focused applicability
  - on a historical time-scale as new words and constructions are invented over the course of many generations
  - on a developmental time-scale as the child has more experience of using fragments of the ambient language to understand and be understood.
Many further ways of expressing relationships were discovered piecemeal by *Homo sapiens*. Possibilities include:

- Adjectives, conjunctions such as *but, and, or and that, unless, or because, etc.*, might well have been “post-biological” in their origin.
- The one word *sour* halves the number of fruit names to be learned.
- Separating verbs from nouns allows one to learn only $m+n$ words to be able to form $m^*n^*m$ of the most basic utterances.

The result: A spiraling co-evolution of communication and representation, extending the repertoire of achievable, recognizable and describable actions.

And recall (CIEL-5) SHEN Jiaxuan on “Nouns and Verbs: Evolution of Grammatical Forms.”

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**Acquiring a Language**

Jane Hill (1983) showed that the child may first acquire what the adult perceives as two-word utterances as holophrases (e.g., “want-milk”) prior to developing a more general construction (e.g., want $x^*$) in which “$x$” can be replaced by the name of any “wantable thing.”

Further experience will yield more subtle constructions and the development of word classes like “noun” defined by their syntactic roles in a range of constructions rather than their meaning.

Classes of slot fillers may be semantic, “semantico-syntactic” or syntactic.
Ontogeny does not recapitulate Phylogeny

Adult hunters and gatherers had to communicate about situations outside the range of a modern 2-year old.

Protohumans were not communicating with adults who already used a large lexicon and set of constructions to generate complex sentences.

Nonetheless, I argue that protolanguage and language emerged through the invention of an increasingly subtle interweaving of (proto)words and (proto)constructions, and that the same basic mechanisms may have served both protohumans inventing language and modern children acquiring the existing language of their community.

Phonology Emerging
Duality of Patterning

In speech

- *meaningful* units are composed from a smaller set of *meaningless* units as when discrete sounds combine to form words
- words combine to form phrases which combine to form sentences

Definition: The *phonology* of a language comprises a fixed set of meaningless units together with the “rules” whereby they can be constructed into meaningful units

Stokoe (1960) demonstrated that a *sign language* also has duality of patterning – meaningless handshapes, locations, and movements combine to form a large set of lexical items. This provides the basis for *sign phonology*

The Emergence of Phonology

Pantomime does not need phonology

- we may vary the pantomime of opening a door in many many ways
- Conventionalization of such a pantomime will capture aspects of one of the many possible performances rather than being built from constituents.

Early utterances of protospeech might

- echo the movements of a protosign; or
- come closer to the vocalization of a cat than the “meow” that invokes the phonology of English.

But as Hockett (1987) says:

- “If a vocal-auditory [or gestural-visual] system comes to have a larger and larger number of distinct meaningful elements, those elements inevitably come to be more and more similar to one another in sound [or appearance, respectively]”
- and this would provide the pressure for segmenting protowords into pieces which could then be replaced by an increasingly conventionalized system of “meaningless units”
Fractionation: Emergence of Shared Components

We hypothesized that “semantic fractionation” can define new meaningful elements and the constructions that combine them.

We now add that the same mechanisms could yield “motor fractionation” (whether manual or vocal) that defines new meaningless elements as the basis for phonology.

Observation: The components are “emergents” of this process and further the move away from iconicity.

Variation in Al-Sayyid Bedouin Sign Language (ABSL) Signs “close” to pantomime

Aronoff et al. (2008) find an unexpectedly high degree of inter-signer variation in Al-Sayyid Bedouin Sign Language.

- e.g., “tree” “dog” and “banana” remain close to pantomime though the signs within a family may be similar.

suggesting that linguistic proficiency can occur without duality of patterning

- a (sign) language can occur without phonology
Computational Modeling of the Brain: Action, Perception, Communication

Alstermark's Cat – Flexible Action Patterns and their Rapid Reorganization

From Alstermark et al. (1981)
**Two Key Ideas**

*Motor schema activation determined by executability and desirability:*

- **Desirability** – Based on drives/goals & subgoals/the internal state; dynamically updated via reinforcement learning
- **Executability** – Determined by affordances /the external state and probability of action’s success; dynamically updated by end-state of actions

*A New Role for Mirror Neurons: What Did I Just Do?*

- An observation/execution matching (mirror) system may contribute to rapid reorganization of motor programs in the face of disruption when a known schema can be recognized as “filling the gap” for disrupted schemas

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**The Augmented Competitive Queuing (ACQ) system**

[Diagram of the Augmented Competitive Queuing (ACQ) system]

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Dyadic Brain Modeling

Interacting agents, yes: But where brain and body of each agent are crucial to the investigation:

Learning from Primate Communication

Klaus Zuberbühler: Acquired mirroring and intentional communication in primates

[This is the first slide referring to titles and authors of commentaries in Language and Cognition 2013, 5(2-3)

“primate studies show … that non-linguistic vocalisations are governed by psychological experiences, perhaps similar to what underlies and governs linguistic communication.

“One of course, it is not possible for a chimpanzee to explain to another what it had for breakfast, but it can indicate the location of food, inform others about danger, or choose to remain silent if social conditions are unfavourable.”

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“One of course, it is not possible for a chimpanzee to explain to another what it had for breakfast, but it can indicate the location of food, inform others about danger, or choose to remain silent if social conditions are unfavourable.”
Ontogenetic Ritualization of Gesture in Apes

Group-specific gestures have been observed in ape populations, suggesting a role for social learning. (Another Controversy)

Tomasello, Call et al proposed *ontogenetic ritualization* as a means whereby (some) ape gestures could emerge:

(i) Individual A performs praxic behavior X and individual B consistently reacts by doing Y
(ii) Subsequently, B anticipates A’s overall performance of X by starting to perform Y before A completes X.
(iii) Eventually, A anticipates B’s anticipation, producing a ritualized form X^R of X to elicit Y

A Hypothetical Example: Beckoning

1) **Child reaches out, grabs, and tugs on Mother**, leading Mother to move towards Child as a response.
2) Child reaches out, grabs, and begins to tug on Mother, but Mother moves sooner towards Child.
3) Child reaches out and makes contact with Mother as if to grab Mother, and Mother quickly moves towards Child.
4) Child reaches out towards Mother— intending to make contact with her— and Mother responds by moving towards Child before contact.
5) Child reaches out towards Mother, and Mother quickly responds by moving towards Child.
6) **Child beckons Mother** to move towards her.

A Model:

Computational Comparative Neuroprimatology: Each Brain Script Extends the ACQ Model in the same way

Comparing the Macaque and Human Brain

Leonardo Fogassi, Gino Coudé, and Pier Francesco Ferrari: The extended features of mirror neurons and the voluntary control of vocalization in the pathway to language

Marco Tettamanti: A research program in neuroimaging for an evolutionary theory of syntax

Francisco Aboitiz: How did vocal behavior ‘take over’ the gestural communication system?