Discussion

Koji Fujita / Kyoto U.

Strong Minimalist Thesis (SMT)

- Simplest Merge

- Language is an optimal solution to certain language specific constraints (LSCs).

# *Two Kinds of Minimalism*

- Formal Minimalism (Theory of language must be optimal.)

- Substantive Minimalism (Reality of language must be optimal.)

  - A scientific theory is an attempt to provide the simplest possible explanation of the complex real world.
  - Are we talking about FM or SM?

- Why language has a certain property X?

  - Because X is the simplest explanation of the relevant facts. (FM)
  - Because language, as part of nature, cannot be otherwise. (SM)
      cf. Miracle Creed

- Because X is the simplest solution to a certain LSC. (SMT)

Binary Nature of Merge

(a)

(b)
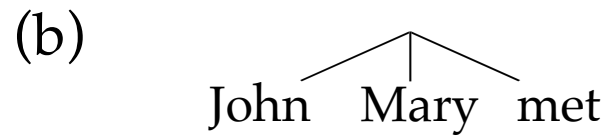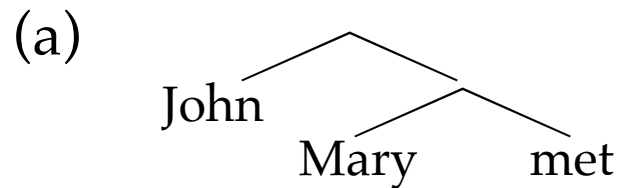
- Binary Merge is the optimal solution to linearization problem (LSC).

(1)

(2)
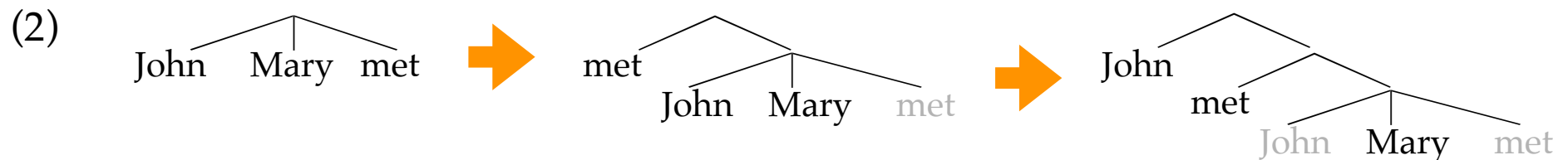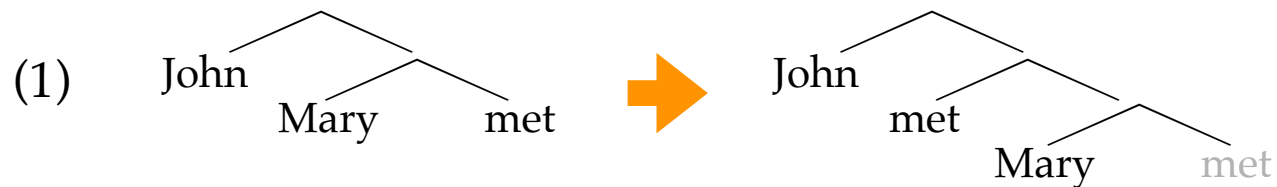
Universal Genetic Code

- nucleotides
- nucleotide triplets (codon)
- amino acids
- proteins

- phonemes
- morphemes
- words
- phrases & sentences

Biology and Physics

- "The physicist's problem is the problem of ultimate origins and ultimate natural laws. The biologist's problem is the problem of complexity."

- "The biologist tries to explain the workings, and the coming into existence, of complex things, in terms of simpler things. He can regard his task as done when he has arrived at entities so simple that they can safely be handed over to physicists." (R. Dawkins)

- From Biolinguistics to Physicolinguistics?

Language Evolution: Different Views

- Saltationism

- Gradualism

- 50～100kya

- 150～200kya

- 500kya～

frontiers in **PSYCHOLOGY**

HYPOTHESIS AND THEORY ARTICLE
published: 05 July 2013
doi: 10.3389/fpsyg.2013.00397

On the antiquity of language: the reinterpretation of Neandertal linguistic capacities and its consequences

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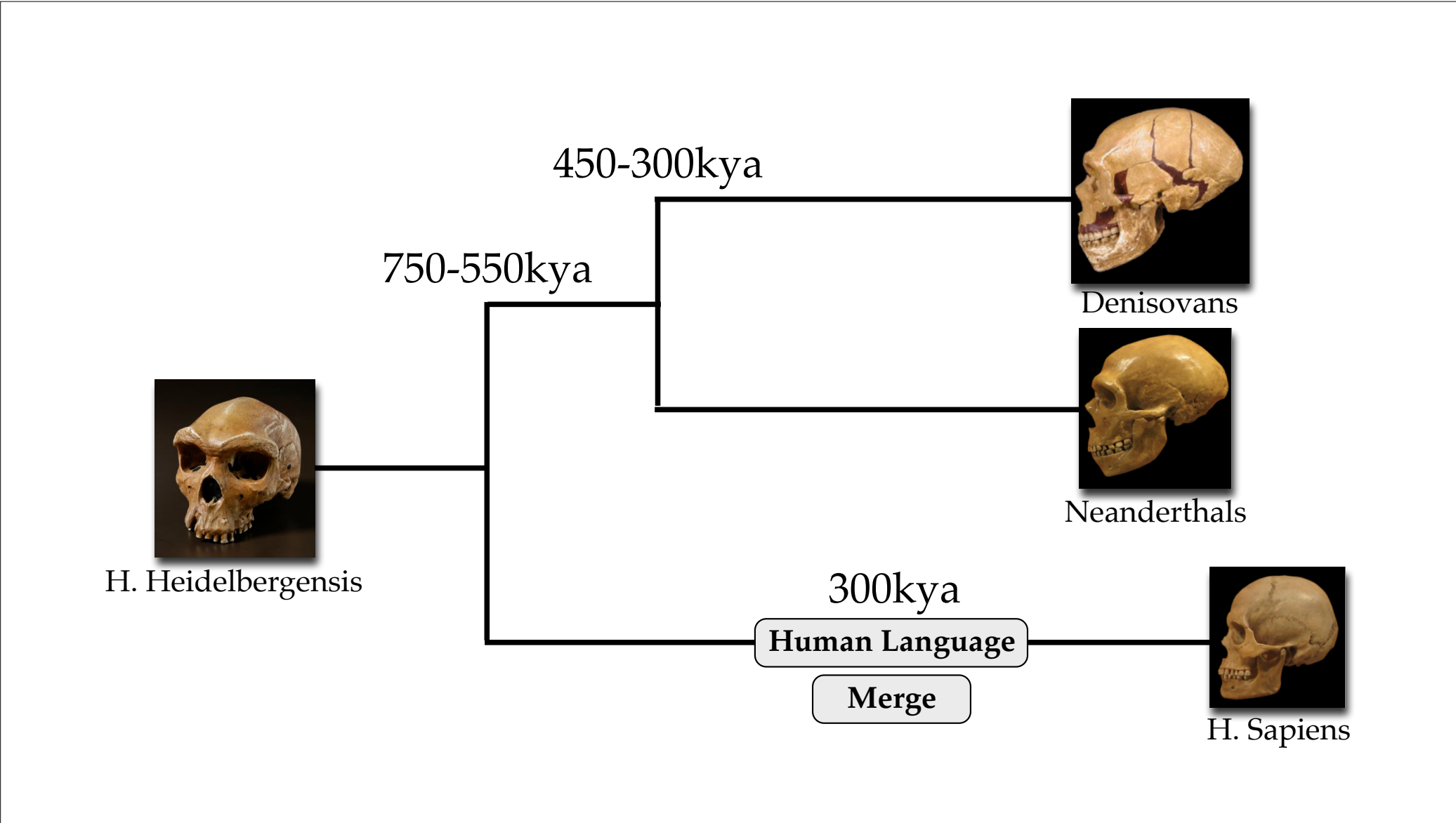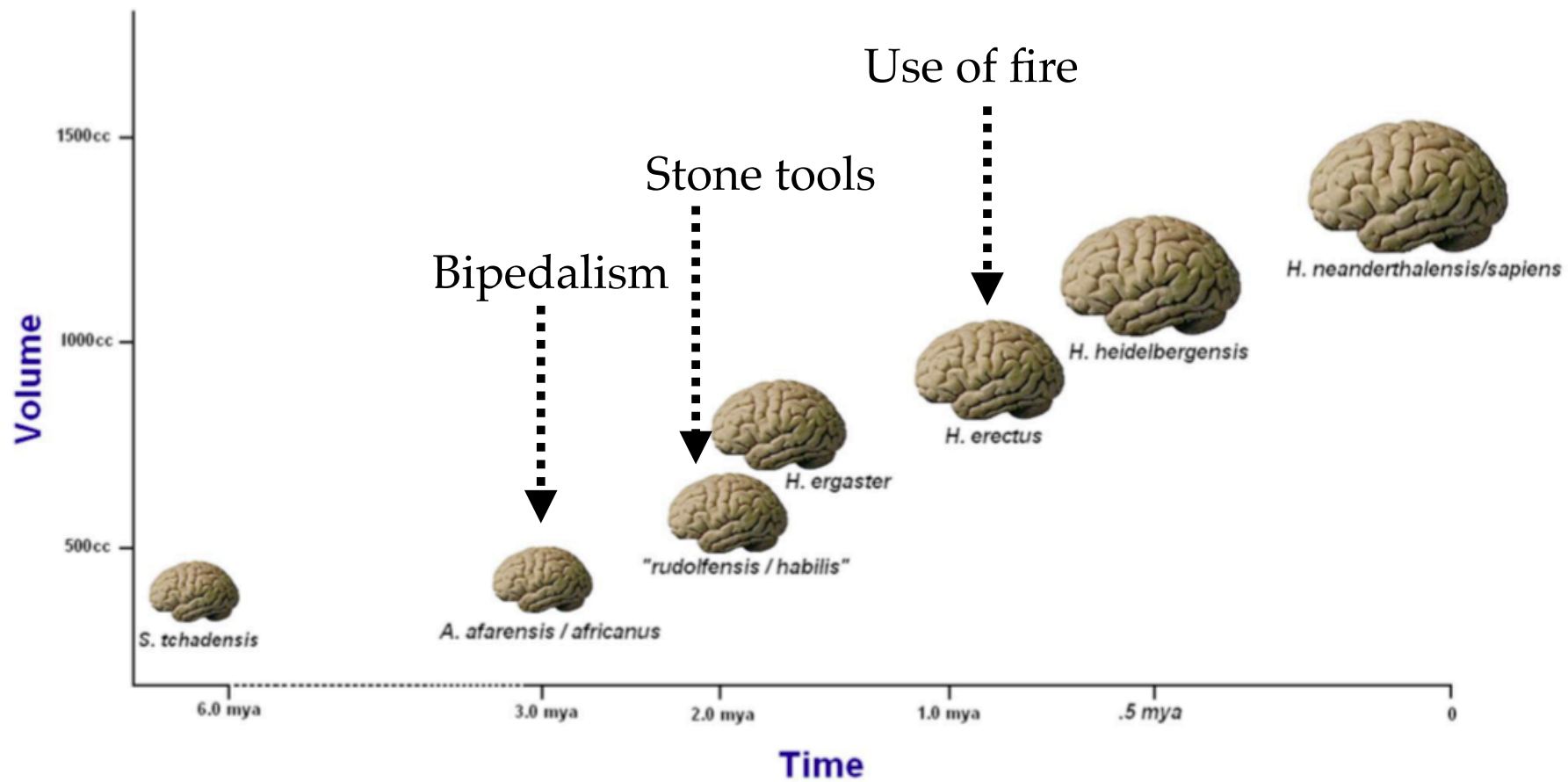Sonja A. E. Kotz, Max Planck Institute Leipzig, Germany

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[†] These authors have contributed equally to this work.

It is usually assumed that modern language is a recent phenomenon, coinciding with the emergence of modern humans themselves. Many assume as well that this is the result of a single, sudden mutation giving rise to the full "modern package." However, we argue here that recognizably modern language is likely an ancient feature of our genus pre-dating at least the common ancestor of modern humans and Neandertals about half a million years ago. To this end, we adduce a broad range of evidence from linguistics, genetics, paleontology, and archaeology clearly suggesting that Neandertals shared with us something like modern speech and language. This reassessment of the antiquity of modern language, from the usually quoted 50,000–100,000 years to half a million years, has profound consequences for our understanding of our own evolution in general and especially for the sciences of speech and language. As such, it argues against a saltationist scenario for the evolution of language, and toward a gradual process of culture-gene co-evolution extending to the present day. Another consequence is that the present-day linguistic diversity might better reflect the properties of the design space for language and not just the vagaries of history, and could also contain traces of the languages spoken by other human forms such as the Neandertals.
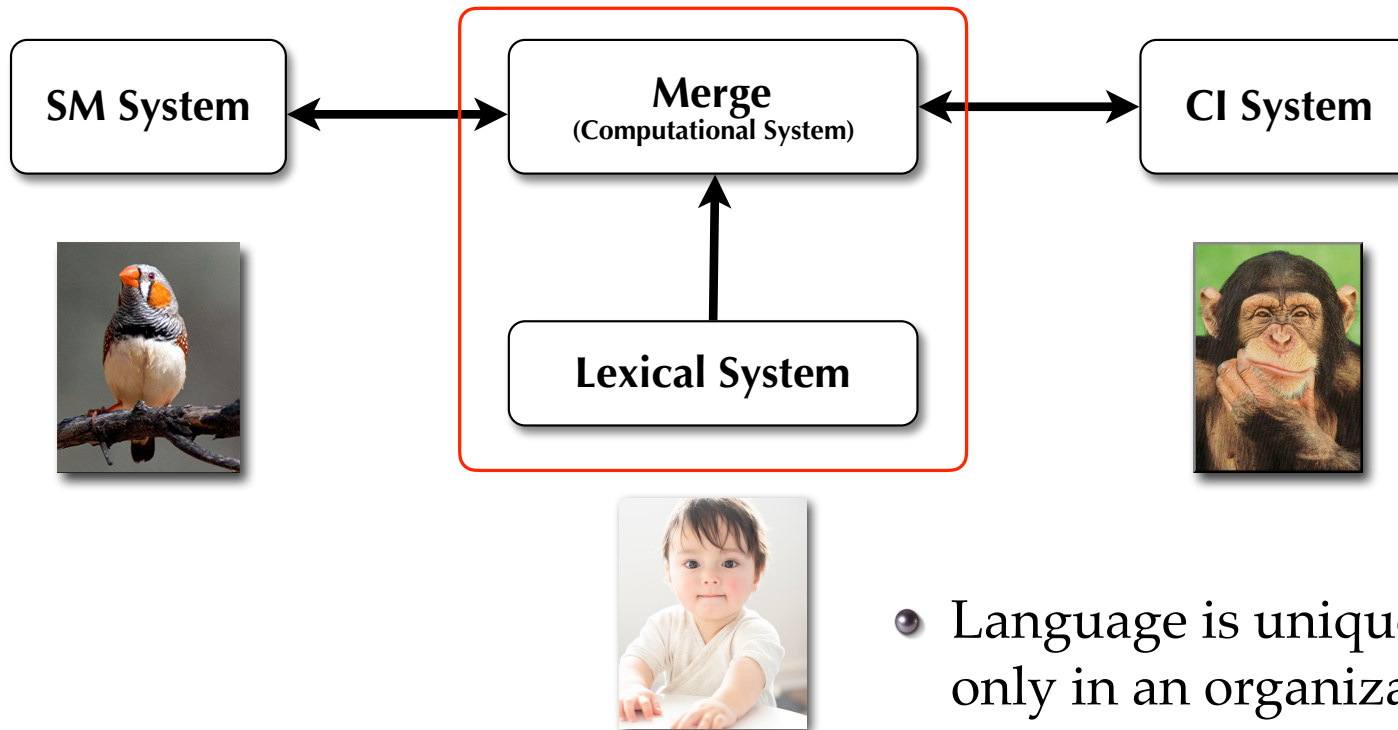
450-300kya

750-550kya

Denisovans

Neanderthals

H. Heidelbergensis

300kya

Human Language

Merge

H. Sapiens

Use of fire

Stone tools

Bipedalism

1500cc

1000cc

500cc

Volume

H. neanderthalensis/sapiens

H. heidelbergensis

H. erectus

H. ergaster

"rudolfensis / habilis"

A. afarensis / africanus

S. tchadensis

6.0 mya   3.0 mya   2.0 mya   1.0 mya   .5 mya   0

Time

Bolhuis, J.J. et al. *PLoS Biology* 12(8). 2014.

A Multicomponential View

convergent evolution   **autapomorphy (?)**   **homology**

SM System ⟷ Merge (Computational System) ⟷ CI System

Lexical System

- Language is uniquely human only in an organizational sense.
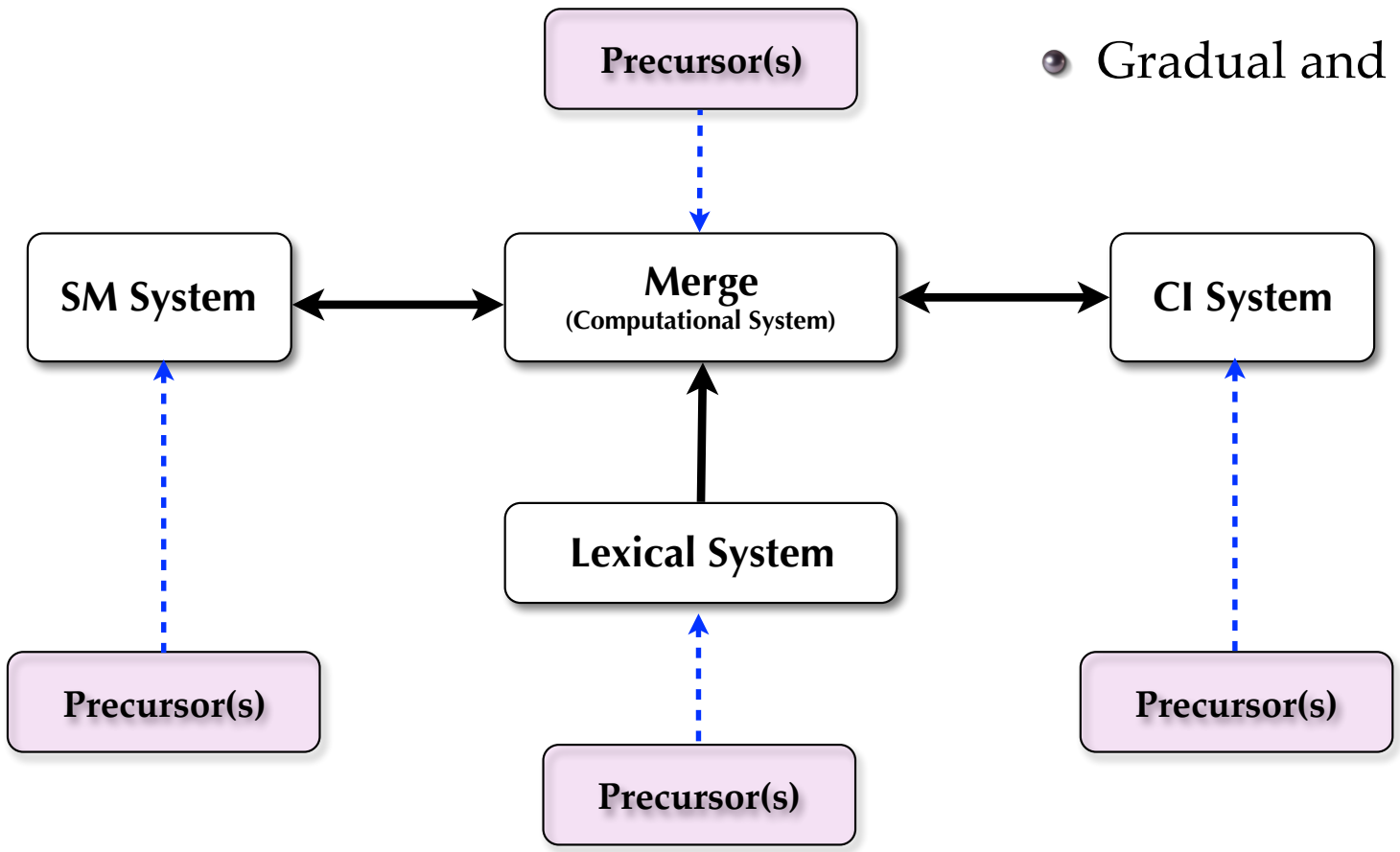
- UG makes no sense except in the light of evolution.

Evolutionary Adequacy (beyond Explanatory Adequacy)

- Evolutionary Continuity
  - Language evolution is continuous with the evolution of other human and nonhuman capacities.
- Descent with Modification
  - The "humaniqueness" of language is a result of modification of non-humanique traits.

  - Evolutionary plausibility / Evolvability (cf. Learnability)

Evolutionary Continuity
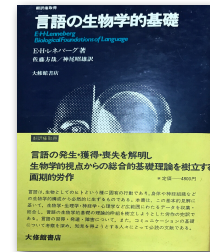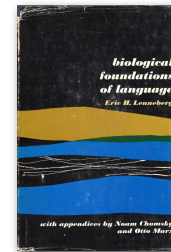
- "He (=Lenneberg) contrasted continuous versus discontinuous approaches to language's evolution, arguing for the discontiuous position …"

  R.C. Berwick and N. Chomsky. 2016. *Why Only Us.*

- "I stressed discontinuity only from a synchronic viewpoint, not to be confused with a diachronic one. Everything in biology is continuous from the perspective of natural history. For everything results from transformation of preexisting conditions, and language is no exception."

  E. Lenneberg. 1967. *Biological Foundations of Language.* Preface to the Japanese translation.

- 「筆者が不連続性を考えているのは，共時的な観点に立ってのことであり，これらを通時的観点と混同してはならないのである．自然史という見地から眺めるならば，生物学におけるすべては，連続的であると言えよう．なぜならば，あらゆるものは，以前の状態が変換を遂げて出来上がった結果であり，言語もまた例外ではありえないからである．」

- Each subfunction (inc. Merge) evolved gradually in other species independently of language. (Gradualist)

- These subfunctions combined into the human Faculty of Language in a relatively short time. (Saltationist)

- The FLN/FLB distinction is an illusion.

- "All creatures are endowed with recursive motor machinery …"

- "In animal minds, this recursive system is locked away in the motor regions of the brain, closed off to other brain areas.

- "… a critical step in acquiring our own distinctive brand of thinking was not the evolution of recursion as a novel form of computation but the release of recursion from its motor prison to other domains of thought."

M. Hauser. Origin of the mind. *Scientific American*. 2009 (9).

Darwinian Evolution

- Variation
- Selection
- Heredity

Chomskyan Evolution

- Disruption by mutation, etc.
- Nature (Miracle Creed)
- Natural selection

N. Chomsky. 2023. Language and the miracle creed.

- "... the snowflake's delicate sixfold symmetry tells us that order can arise without the benefit of natural selection."   S. Kauffman. 2002. *Investigations*.
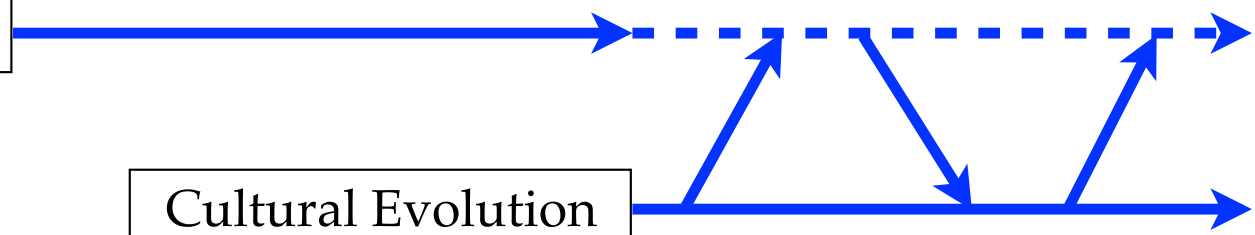
No Protolanguage?
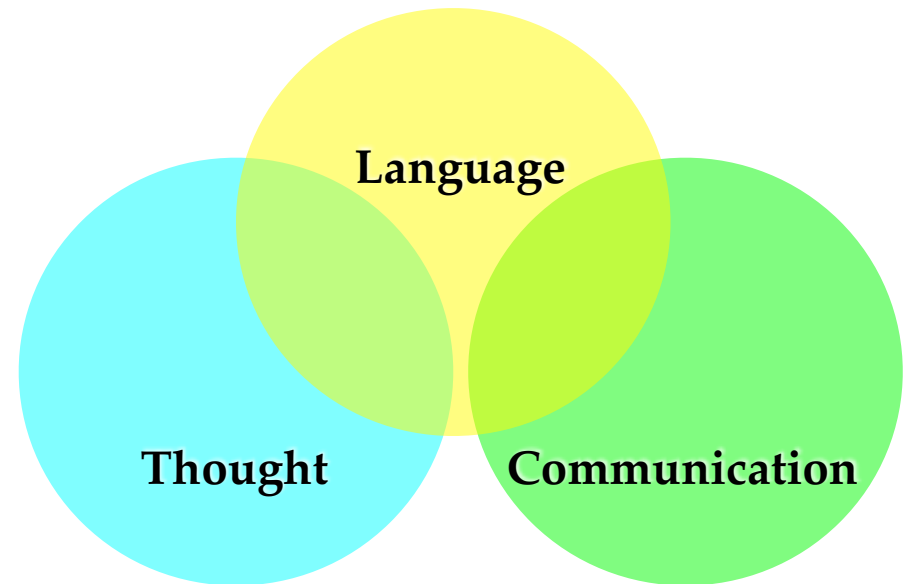
1.8mya〜 H. erectus   **300kya〜 H. sapiens**

Protolanguage(s) → Human Language → Particular Languages

Biological Evolution ————————————————▸

Cultural Evolution ————————————————▸

Thought or Communication?

- Language is a primary tool for human thought and communication.

- Language ≠ Thought
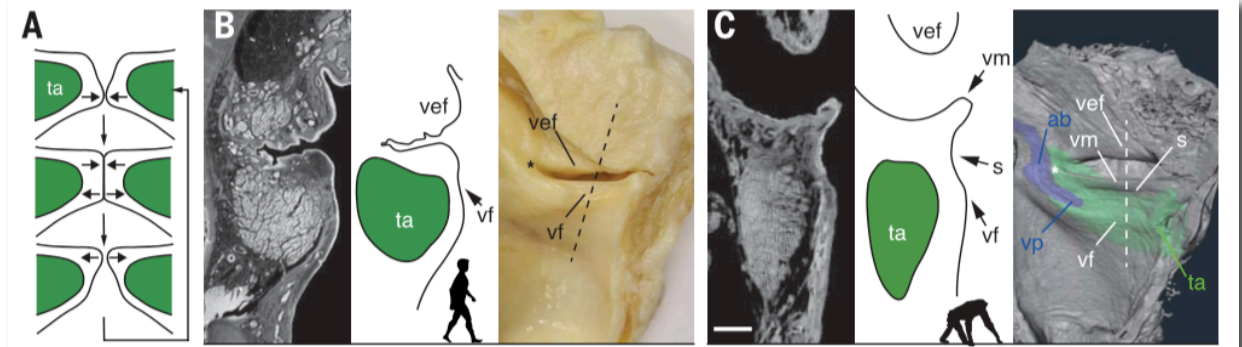- Language ≠ Communication

- Original Function vs Current Utility

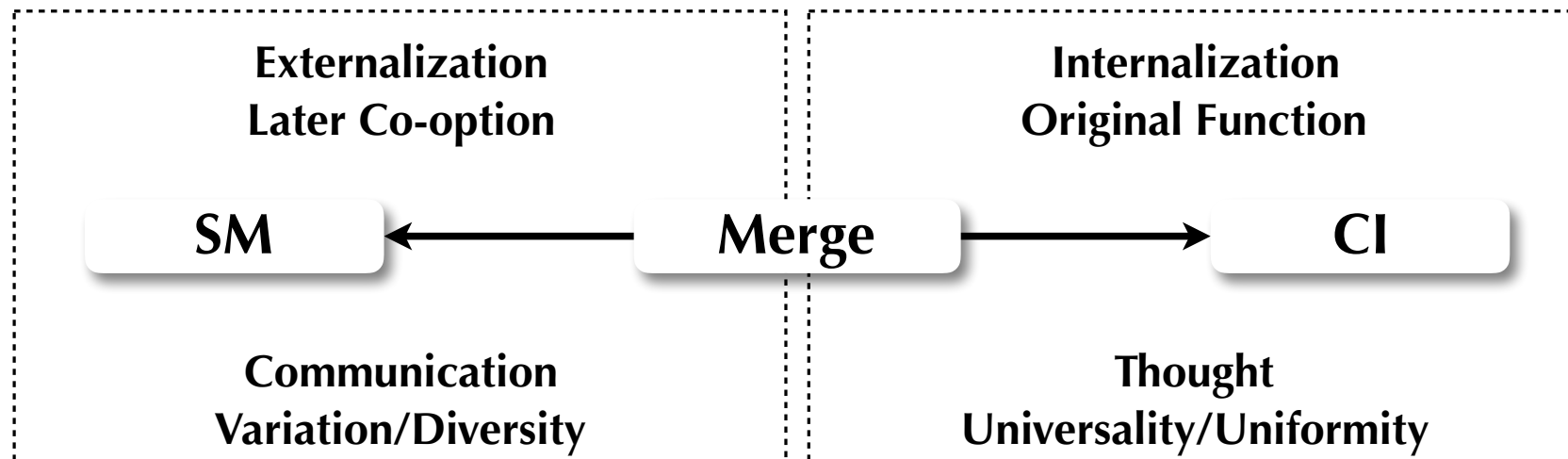# Evolutionary loss of complexity in human vocal anatomy as an adaptation for speech

Takeshi Nishimura[1,2]*, Isao T. Tokuda[3], Shigehiro Miyachi[1,2], Jacob C. Dunn[4,5,6], Christian T. Herbst[1,6], Kazuyoshi Ishimura[3], Akihisa Kaneko[1,2], Yuki Kinoshita[1,2], Hiroki Koda[1]†, Jaap P. P. Saers[5], Hirohiko Imai[7], Tetsuya Matsuda[7], Ole Næsbye Larsen[8], Uwe Jürgens[9], Hideki Hirabayashi[10], Shozo Kojima[1], W. Tecumseh Fitch[6,11]*

Human speech production obeys the same acoustic principles as vocal production in other animals but has distinctive features: A stable vocal source is filtered by rapidly changing formant frequencies. To understand speech evolution, we examined a wide range of primates, combining observations of phonation with mathematical modeling. We found that source stability relies upon simplifications in laryngeal anatomy, specifically the loss of air sacs and vocal membranes. We conclude that the evolutionary loss of vocal membranes allows human speech to mostly avoid the spontaneous nonlinear phenomena and acoustic chaos common in other primate vocalizations. This loss allows our larynx to produce stable, harmonic-rich phonation, ideally highlighting formant changes that convey most phonetic information. Paradoxically, the increased complexity of human spoken language thus followed simplification of our laryngeal anatomy.

Science 377, 2022

A Thought-First View

Externalization
Later Co-option

Internalization
Original Function

SM ← **Merge** → **CI**

Communication
Variation/Diversity

Thought
Universality/Uniformity

- Externalization for communication is more costly.
- Communication is a later, subsidiary function of language, and the original function of language was thought.

- "... the role of language as a communication system between individuals would have come about only secondarily ..."

<div align="center">

F. Jacob. 1977. Evolution and tinkering. *Science* 196.

</div>

- "The point is that the same processes that are needed for speech - concept formation, predication, and the recognition of relationships between concepts - are needed also for thought. The necessary mental abilities may have evolved in the first instance for thinking, rather than communication, or at least for thinking as well as communication."

<div align="center">

J. Maynard Smith & E. Szathmáry. 1995. *The Major Transitions in Evolution.*

</div>

MORE THAN A TOOL FOR COMMUNICATION

By **Pamela J. Hines** *and* **Peter Stern**

October 19, 2019

"Language is central to our existence as humans."

Science 366 (6461), 2022

Perspective

Language is primarily a tool for communication rather than thought

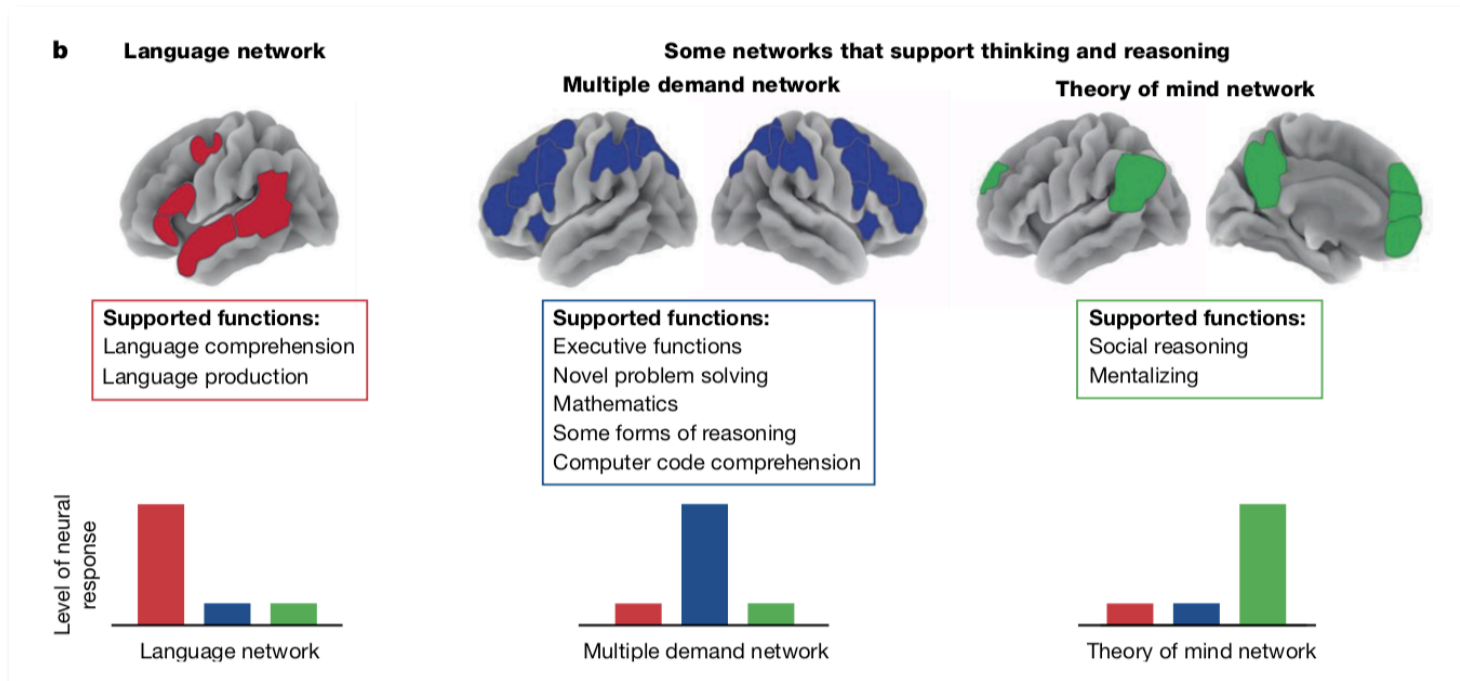Evelina Fedorenko[1,2 ✉], Steven T. Piantadosi[3] & Edward A. F. Gibson[1]

Language is a defining characteristic of our species, but the function, or functions, that it serves has been debated for centuries. Here we bring recent evidence from neuroscience and allied disciplines to argue that in modern humans, language is a tool for communication, contrary to a prominent view that we use language for thinking. We begin by introducing the brain network that supports linguistic ability in humans. We then review evidence for a double dissociation between language and thought, and discuss several properties of language that suggest that it is optimized for communication. We conclude that although the emergence of language has unquestionably transformed human culture, language does not appear to be a prerequisite for complex thought, including symbolic thought. Instead, language is a powerful tool for the transmission of cultural knowledge; it plausibly co-evolved with our thinking and reasoning capacities, and only reflects, rather than gives rise to, the signature sophistication of human cognition.

b Language network

Some networks that support thinking and reasoning

Multiple demand network

Theory of mind network

Supported functions:
Language comprehension
Language production

Supported functions:
Executive functions
Novel problem solving
Mathematics
Some forms of reasoning
Computer code comprehension

Supported functions:
Social reasoning
Mentalizing

Level of neural response

Language network

Multiple demand network

Theory of mind network

- "no unequivocal empirical support for any form of thinking requiring linguistic representations (words or syntactic structures)."

- "We would expect a system designed for the conditions of speech communication to be somehow adapted to the load on memory. In fact, grammatical transformations characteristically reduce the amount of grammatical structure in phrase-markers in a well-defined way, and it may be that one consequence of this is to facilitate the problem of speech perception by a short-term memory of a rather limited sort."

N. Chomsky. 1967. The formal nature of language.

- Move/IM may be a later innovation for communication.
- Duality of semantics
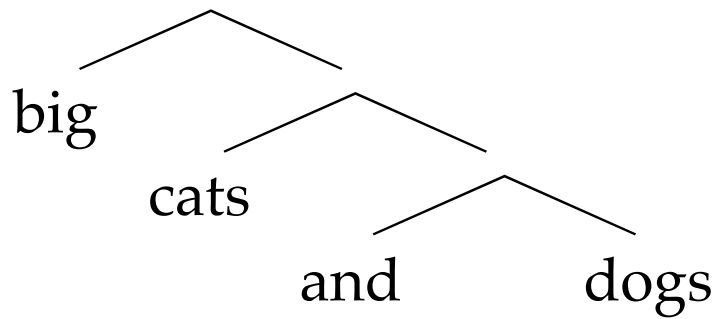
Structure Dependence / Structural Ambiguity

(1) green tea cup
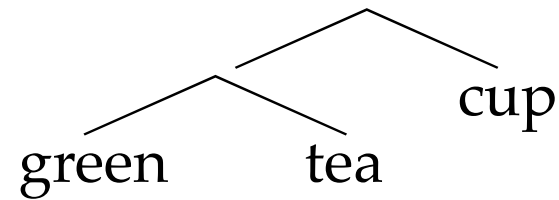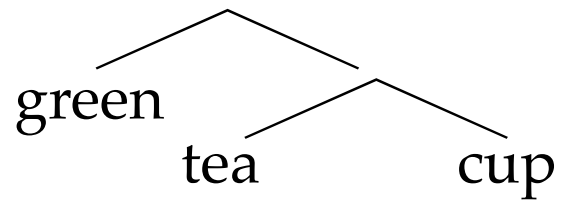
(1') Japanese green tea cup shop map

- Apparently dysfunctional for efficient communication.

(2) unfoldable

```
        /\
      un  /\
        fold  able

              /\
            /\   able
          un  fold
```

(3) big cats and dogs
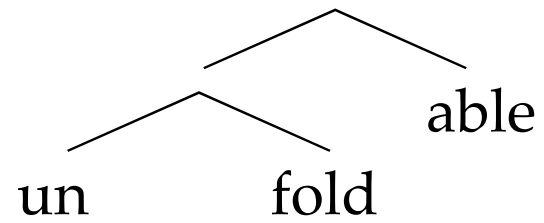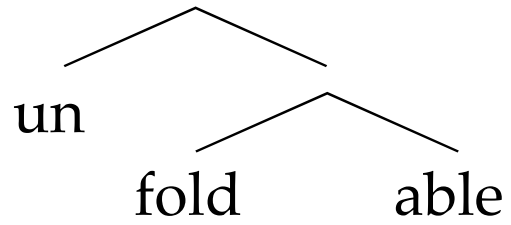
```
      /\
    big  /\
      cats  /\
          and   dogs

            /\
          /\    /\
        big cats and dogs
```
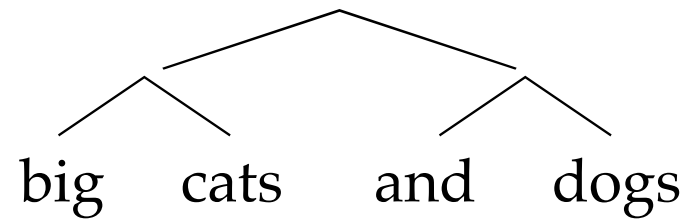
- Ambiguity is useful for communication. (Fedorenko et al.)

- Lexical and structural ambiguity are a result of morphology and linearization (part of externalization).

- Externalization is also useful for thought.

- Which part of language is more or less useful for thought and communication?

Limits of AI

英語（自動検出） ⌄   ⇄   日本語 ⌄   用語集

The horse raced past the barn fell.   ✕   馬は納屋が倒れたところを駆け抜けた。

DeepL

KF 次の英語を日本語に訳してください
The dog the cat the rat chased ate died.

「犬は猫を追いかけ、それを食べ、そして死んでしまった」

原文をそのまま訳すと、おおよそこのようになります。ただし、意味としては、ちょっとおかしいように感じられるかもしれません。もしも、お話したい内容が分かりにくい場合は、もう一度お話したいことをお伺いするか、もしくは、違う表現を試させていただけると、より明確な回答ができるかもしれません。

chatGPT

Co-evolution of Thought and Communication

- Externalization determines the binary nature of Merge (optimization of linearization).

- Thought and communication enhance each other, evolving in parallel.
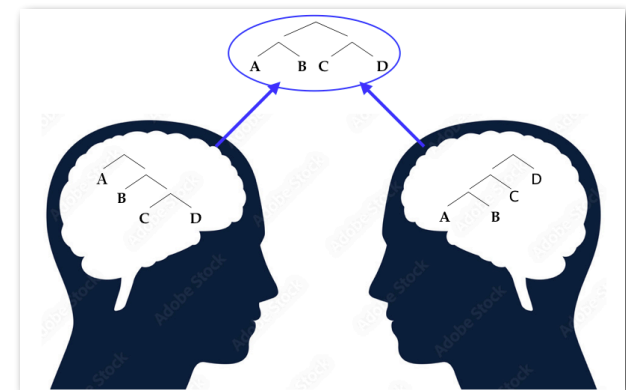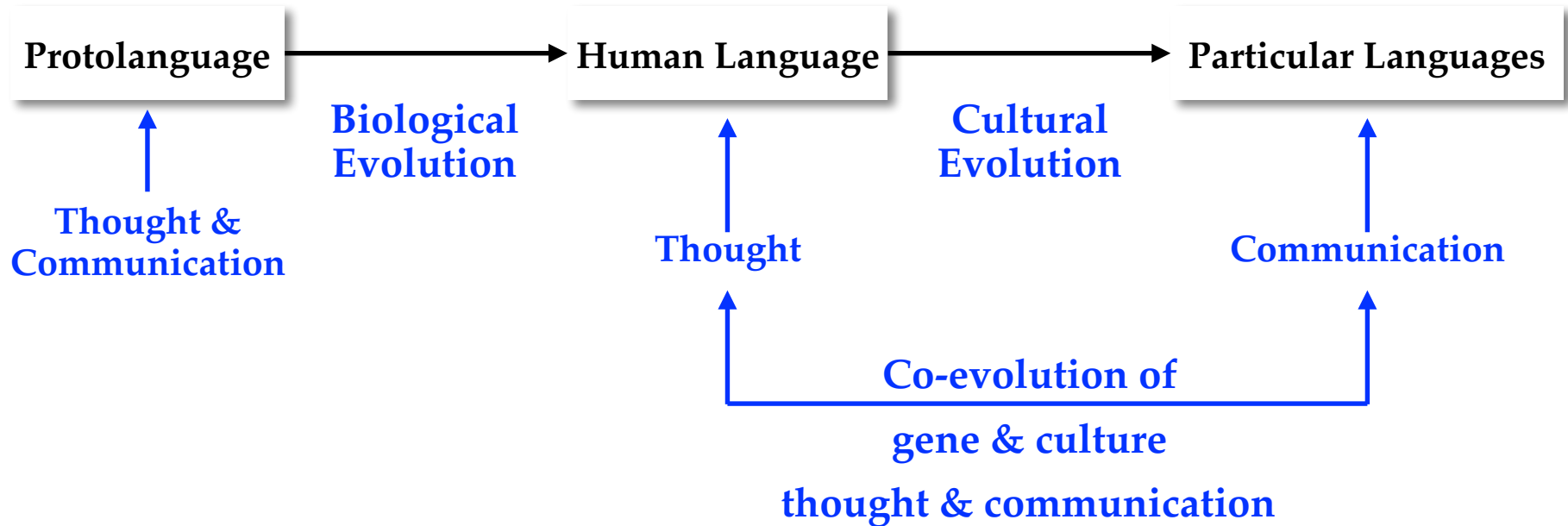
- No teleology: Evolution has no purpose. No goal-directedness.

- Language did not evolve for the purpose of thought or communication. Rather, language evolved, and then it was used for thought and communication (and others).

- Teleonomy: Apparent goal-directedness in living organisms as a consequence of a program, such as natural selection.
- Teleomaticity: Apparent goal-directedness as a consequence of natural laws.
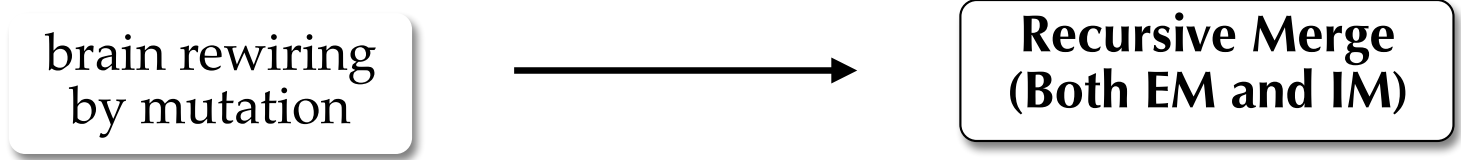
cf. E. Mayr. 1988. *Toward a new philosophy of biology.*
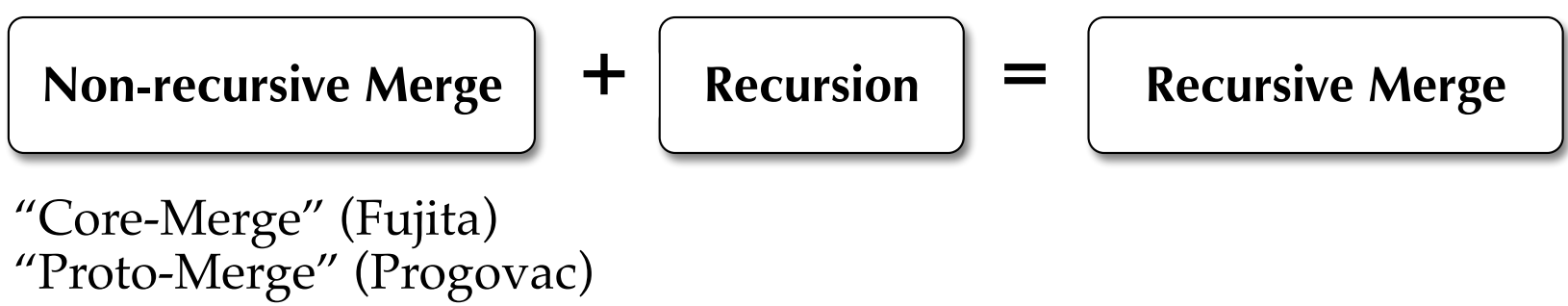
Linear Grammar · Hierarchical Grammar

Protolanguage → Human Language → Particular Languages

Biological Evolution · Cultural Evolution

Thought & Communication · Thought · Communication

Co-evolution of gene & culture thought & communication

- Protolanguage was already adaptive for thought and communication.

- Saltationist view

| brain rewiring by mutation | ⟶ | **Recursive Merge (Both EM and IM)** |

- Gradualist view

Non-recursive Merge + **Recursion** = **Recursive Merge**

"Core-Merge" (Fujita)
"Proto-Merge" (Progovac)

Article

Experimental evidence for core-Merge in the vocal communication system of a wild passerine

Toshitaka N. Suzuki [1,2] ✉ & Yui K. Matsumoto[2,3]

One of the cognitive capacities underlying language is core-Merge, which allows senders to combine two words into a sequence and receivers to recognize it as a single unit. Recent field studies suggest intriguing parallels in non-human animals, e.g., Japanese tits (*Parus minor*) combine two meaning-bearing calls into a sequence when prompting antipredator displays in other individuals. However, whether such examples represent core-Merge remains unclear; receivers may perceive a two-call sequence as two individual calls that are arbitrarily produced in close time proximity, not as a single unit. If an animal species has evolved core-Merge, its receivers should treat a two-call sequence produced by a single individual differently from the same two calls produced by two individuals with the same timing. Here, we show that Japanese tit receivers exhibit antipredator displays when perceiving two-call sequences broadcast from a single source, but not from two sources, providing evidence for core-Merge in animals.
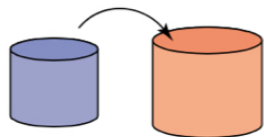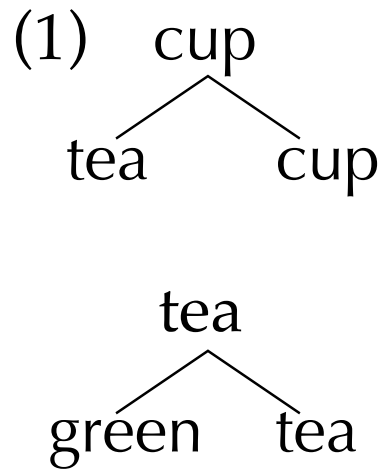
- Gradualist view 2

```
┌─────────────┐     ┌─────────────┐     ┌─────────────┐
│ Core-Merge  │ ──▶ │  Pot Merge  │ ──▶ │  Sub-Merge  │
└─────────────┘     └─────────────┘     └─────────────┘

┌───────────────────────────────────────────┐     ┌─────────────┐
│              External Merge               │ ──▶ │     IM      │
└───────────────────────────────────────────┘     └─────────────┘
                      ▲                                    ▲
                      │                                    ┊
┌───────────────────────────────────────────────────────────────┐
│   Domain-general, Species-general, Generic Merge              │
└───────────────────────────────────────────────────────────────┘
```
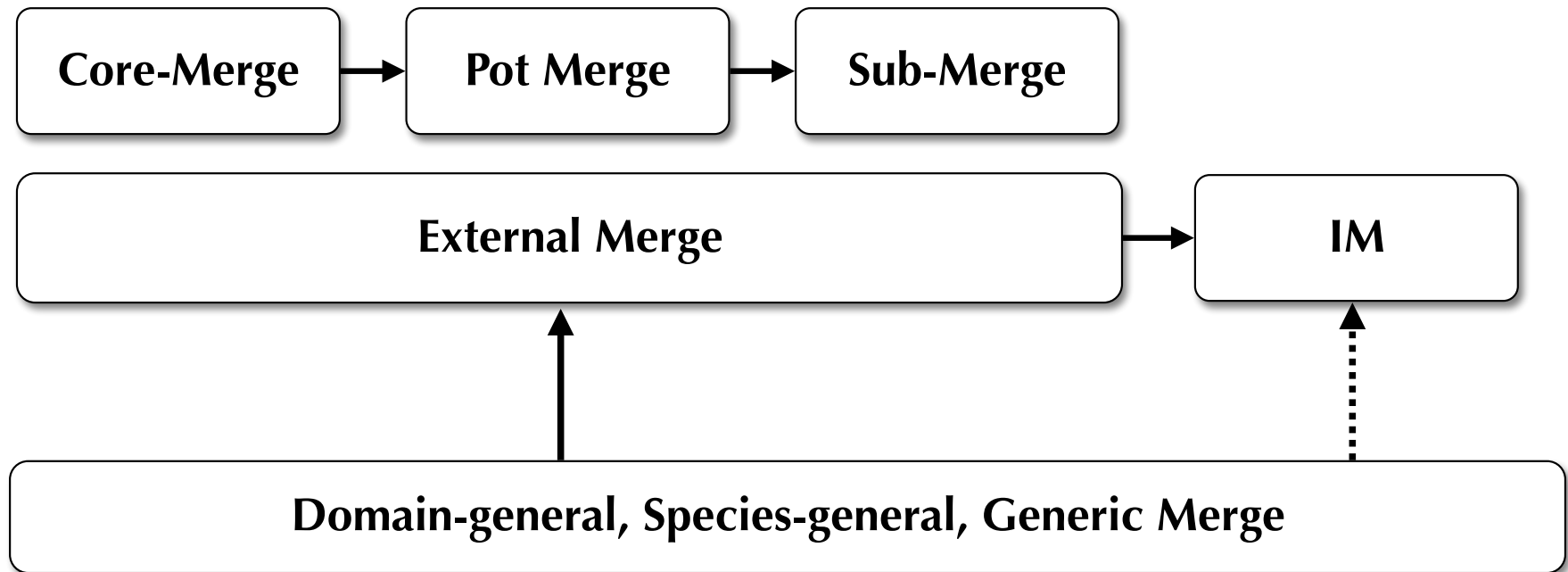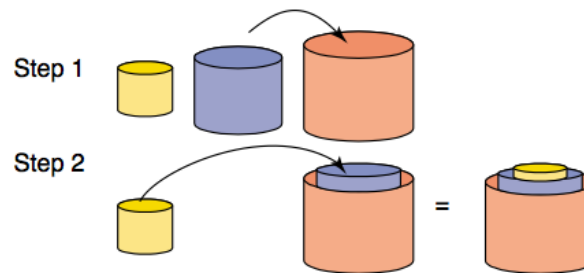
- Internal Merge: can be species-specific, but not domain-specific
- External Merge: neither species-specific nor domain-specific

Core-Merge

(1)
```
        cup
       /   \
     tea    cup

        tea
       /   \
   green   tea
```
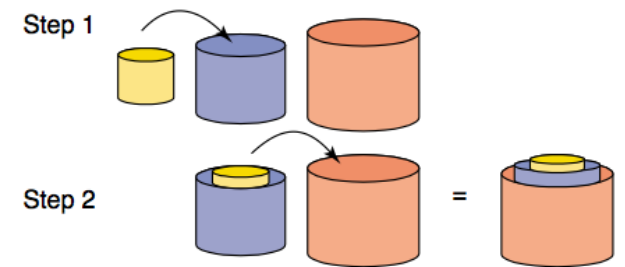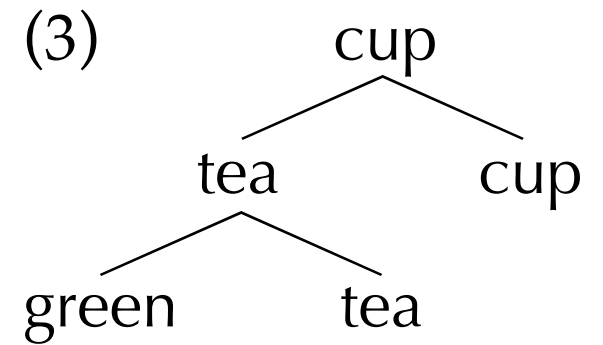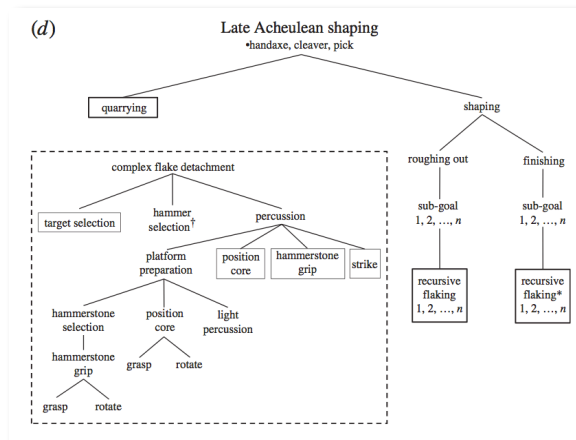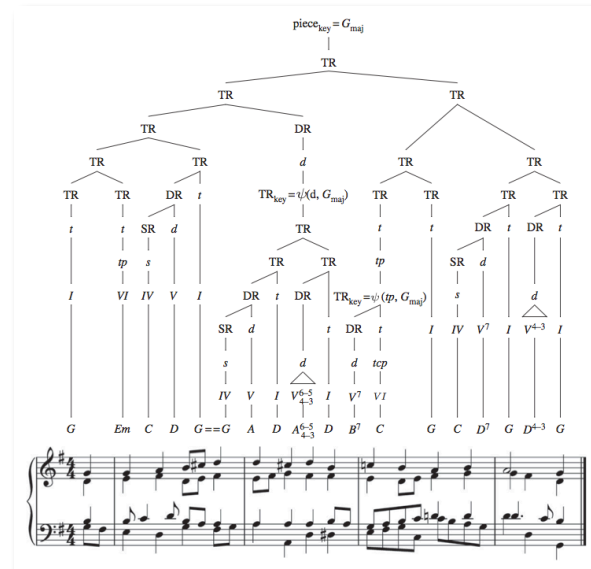
Pot Merge

(2)
```
        cup
       /   \
   green    cup
           /   \
         tea    cup
```
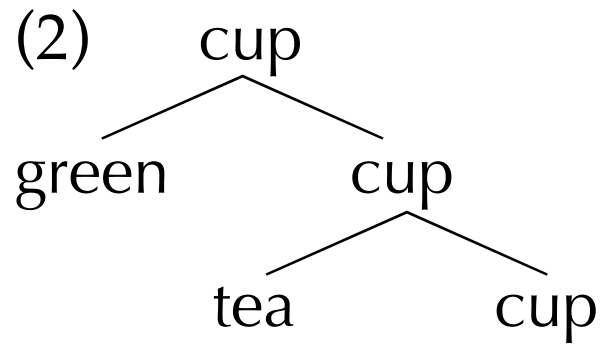
Subassembly Merge

(3)
```
            cup
           /   \
         tea    cup
        /   \
   green    tea
```
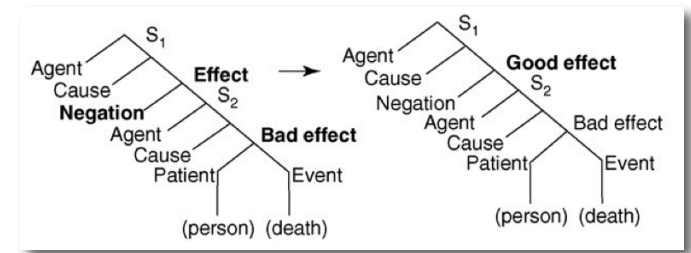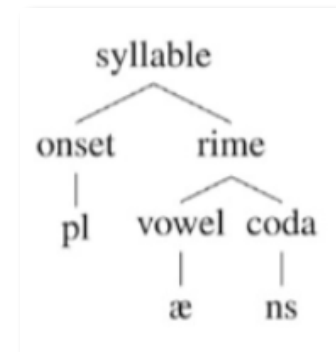
Hierarchy Everywhere

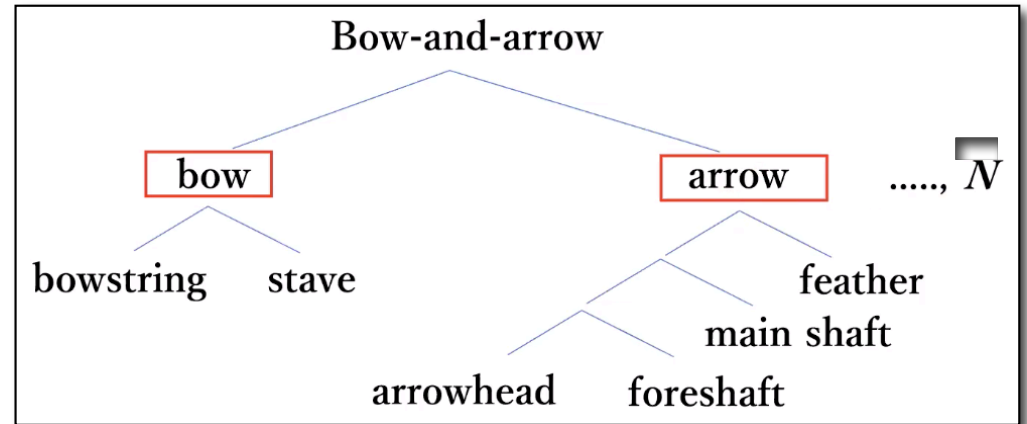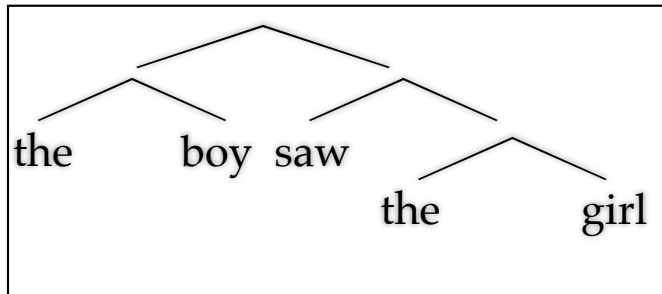
Stone tool making (Stout 2011)

Tonal harmony (Rohrmeier et al. 2015)

Morality (Mikhail 2007)

Syllable structure (Yang et al. 2011)

the boy saw the girl

Bow-and-arrow

bow — bowstring, stave

arrow — arrowhead, foreshaft, main shaft, feather

....., N

courtesy of K. Sano, Tohoku U.

70kya〜 Bow-and Arrow technology

Bow-and-arrow hunting
Bow stave
Bowstring
Arrow shaft
Adhesive
Arrowhead
Arrow feather
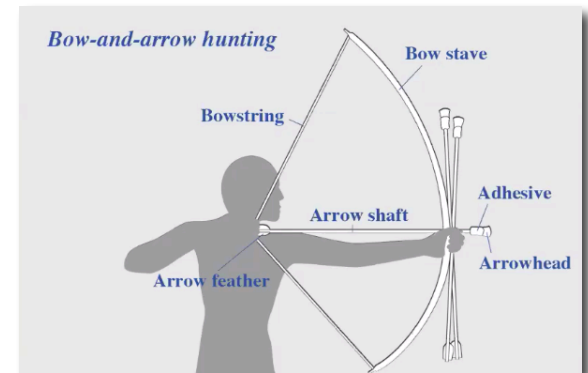
- Linguistic Merge evolved from pre-linguistic combinatorial capacities, neither human-specific nor language-specific.
- Linguistic Merge is an instance of domain-general Merge (generic Merge) recycled in the linguistic domain (exaptation).
- What may have evolved is Generic Merge, not Linguistic Merge. (→Strongest Minimalist Thesis?)
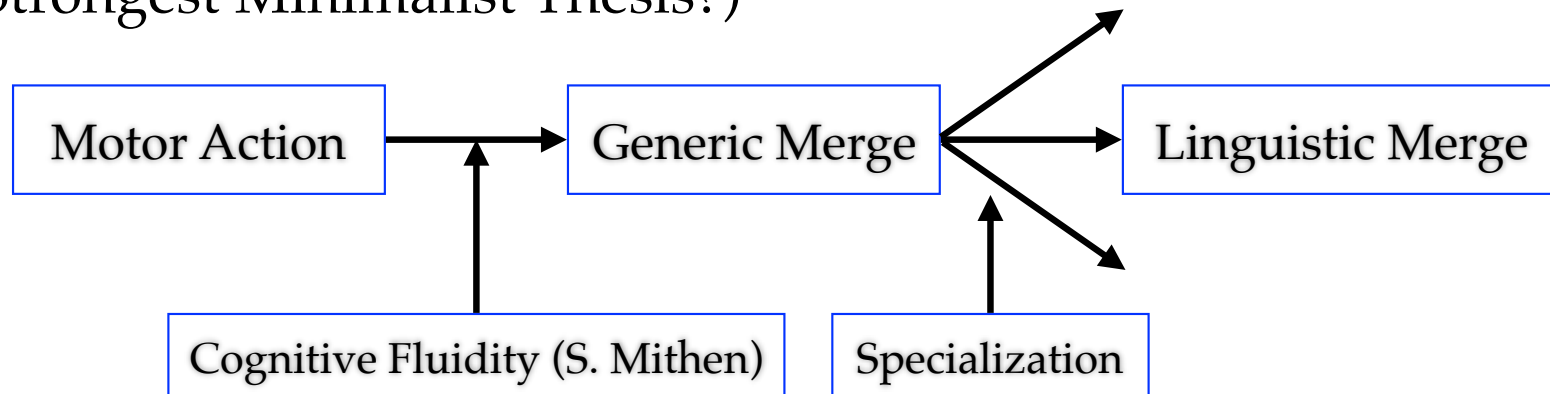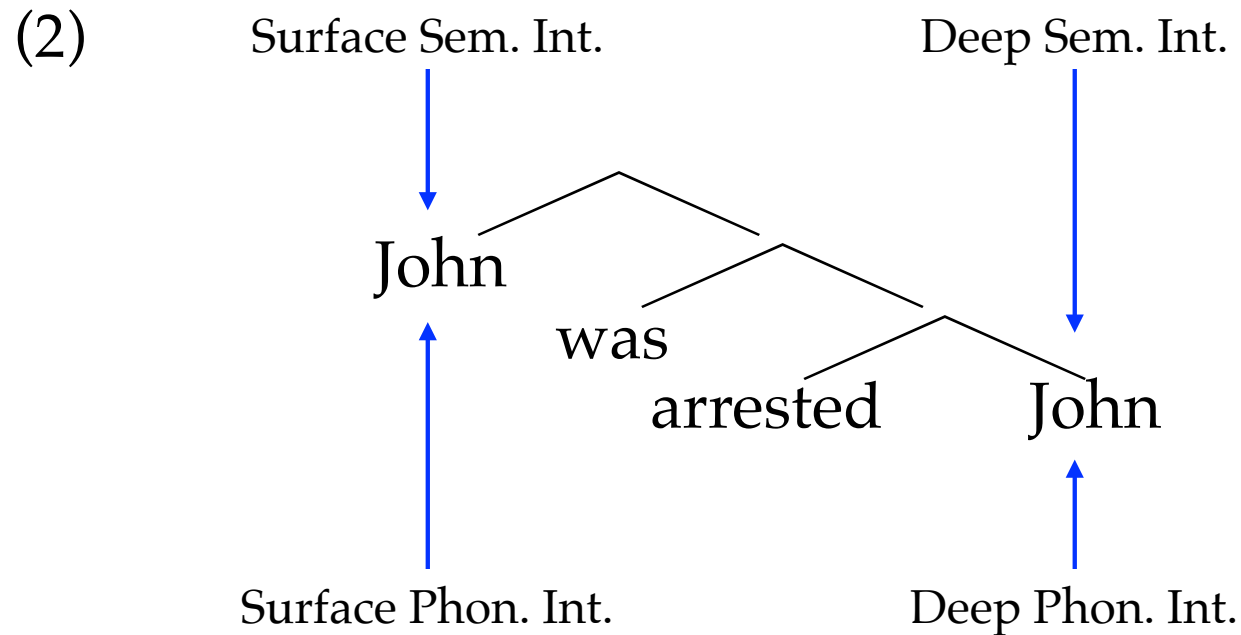
Unbounded Linguistic Merge?

- "Syntactic Merge is unbounded but motor action is bounded."

- At the competence level, both are unbounded.

- At the performance level, both are bounded.

- Invalid objection based on comparing language and action on a different level.
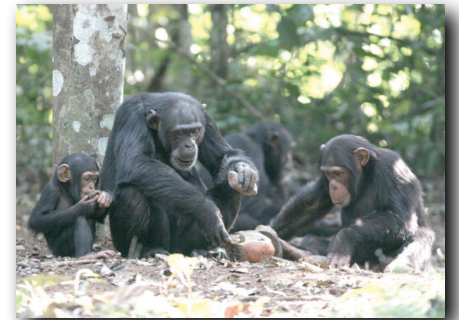
Duality of Semantics and Phonology

(1) John was arrested.

(2)

Multiple Attention

Limiting Subtypes of Merge

	Set-Merge	Pair-Merge
External Merge	√	**?**
Internal Merge	**?**	**?**

IM reduced to EM?

(1) { was, arrested, John }
(2) { was { arrested John}} → Copy {John} and IM {John2}
(3) { John2 { was { arrested John}}

(4) { was, arrested, John } → Duplicate {John} and EM {John1}
(5) { was { arrested John1}} → EM {John 2}
(6) { John2 { was { arrested John1 }}

- Duplication before entering a WS creates a repetition.
- Duplication inside a WS creates a copy.

Resumptive Pronoun Strategy

(1)   Who did you meet (*him)?

(2)   the girl who you would do anything if you could marry *(her)

- Processing efficiency overrides computational complexity?

Derivational θ-Marking

(1) The train arrived (the train) late.
      -θ   θ

(2) The boy arrived (the boy) late on purpose (to avoid his father).
      the boy = agentive theme

(3) the boy [(the boy) v^* [arrived (the boy)]]
    -θ   θ   θ

• Also obligatory control by movement?