Recursion Conference @ UMass, Amherst

The Design, Development, and Evolution of Unbounded Merge

Koji Fujita
Kyoto University

- Language evolution is an instance of biological evolution (and cultural evolution).

  → If one's theory of biological evolution fails to account for the evolution of language, then it needs a serious reconsideration.

Neo-Darwinism (Modern Synthesis)

- Adaptationist Program
  - Functionalism
- Natural Selection / Sexual Selection as the First Resort
- Gradualism

Neo-Neo-Darwinism (Expanded Synthesis)

- Non-adaptationist Program
  - Formalism
- Pluralism
  - NS/SS as the Last Resort
- Punctuated Equilibrium
- Exaptation

"… an evolutionary novelty may result from the combination of two pre-existing parts with unrelated functions." - M. Ridley

"Evolution has recruited for language purposes brains structures that performed other functions in non-human primates." - T. Deacon

To create is to *merge*.

"To create is to recombine." - F. Jacob

(1) Design ……..… Microgenesis

(2) Development … Ontogenesis

(3) Evolution ……. Phylogenesis

(1) Descriptive Adequacy ➡ <PHON,SEM>

↕

(2) Explanatory Adequacy ➡ I-Language

↕

(3) Evolutionary Adequacy ➡ UG

- Logical Problem of Language Evolution
- Logical Problem of Language Acquisition

- Arrival of the Fittest
- Survival of the Fittest

- The functions of the components that jointly constituted the language faculty later in the hominin evolution may have had nothing to do with the current (or even original) function(s) of language.
- Animal communication may have only an indirect bearing on language evolution.

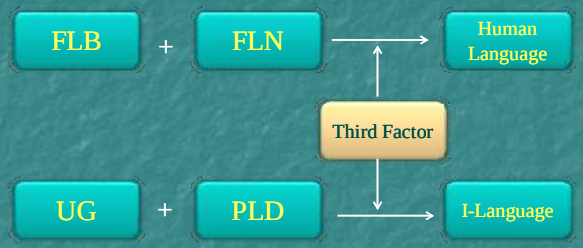
Strong Minimalist Thesis (SMT)

- Language is an optimal solution to legibility conditions.
- Unexplained elements of UG are zero.
- There is virtually nothing special about the origins and evolution of language.

- Language is uniquely human.
- Are its components uniquely human, too?
- Minimize the discontinuity elements in language evolution.

FLN: Recursion
(unbounded/recursive Merge)
Discontinuity

FLB: Sensory-Motor system
Conceptual-Intentional system
Continuity



"… unbounded Merge is not only a genetically determined property of language, but also unique to it."

"… for both evolution and development, there seems to be little reason to suppose that there were precursors to unbounded Merge."

- N. Chomsky

- … no clear evidence for languages that demonstrably lack recursion of any kind.
  (B. Heine & T. Kuteva)
- Recursion is absent in Pirahã. (D. Everett)
- Many languages have no, or very circumscribed recursion in their syntax.
  (N. Evans & S. Levinson)
- Recursion is just a theoretical artifact.
  (D. Bickerton)

- Derivational recursiveness:
  - Recursive Merge
- Representational recursiveness:
  - Self-embedding

(1) [CP C [TP T [*v*P *v* [VP V [CP C [TP T [*v*P *v* [VP V …

(2) [DP D [NP N [PP P [DP D [NP N [PP P …

(3) [TP T [*v*P *v* [VP V]]]

- Representational recursiveness is just one aspect of derivational recursiveness.

- Actual application of Merge is subject to a variety of constraints.
- If CP is never selected by a head, then there will be no clausal complementation in that language. (functional parametrization?)

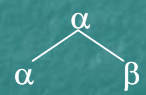
- Language evolution boils down to the emergence of:
  - Unbounded Merge
  - Interfaces
  - Lexicon

Labeling and `Embed`: Fukui (2008)

- Merge (α, β) = {α, β}:

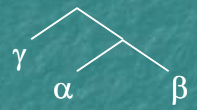
(no endocentricity)

- Embed (α, {α, β}) = {α, {α, β}}:

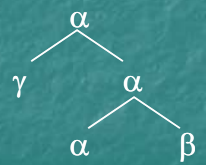


→ endocentricity

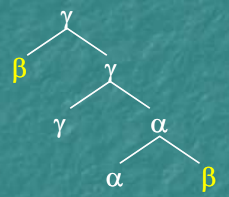
- Recursive Merge (without Embed)



- Recursive Embed



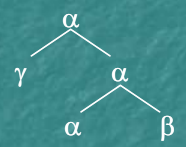
- Internal Merge (Move) + Embed



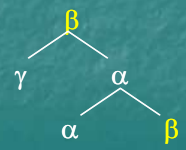
- Why not β for direct Embed without Move?

  Embed (β, {γ, {α,{α, β}}})

- Local Embed



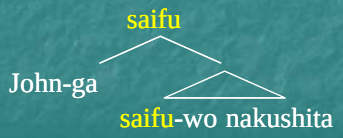
- Non-local Embed



→ exocentricity

- Internally-headed relatives:

(1) [John-ga saifu-wo nakushita no]-wo Mary-ga mitsuketa.
[John-Nom wallet-Acc lost Comp]-Acc Mary-Nom found
'Mary found the wallet John had lost.'

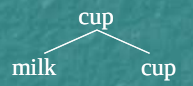


- Merge = Move = Embed (set formation)
- Embed is itself an instance of Merge applying recursively.
- No independent evolutionary/developmental scenario is necessary for Move and Embed.

Labeling Two Word Utterances

(1) no label

(2) endocentric



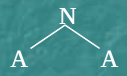
(3) *exocentric
&

(in the sense of 'milk & cup')

Recursive Merge is already fully operative at the two-word stage.
(see Roeper 2007)

But what about truly exocentric compounds?

(1) Tatemono-no takai-hikui-ga juuyoo da.
building-Gen high-low -Nom important is
'The height of the building matters.'



"Absolute categorial endocentricity"

S. Scalise, A. Fabregas & F. Forza 2009.

(1) [A N+N]:
Serbo-Croatian *ribòlik* 'fish+shape=fish-shaped'

(2) [A V+V]:
Turkish *yapis yapis* 'stick+stick=sticky'

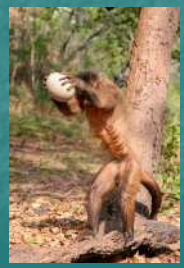
(3) [A V+N]:
French *lève-blocs* 'lift+block=block lifter'

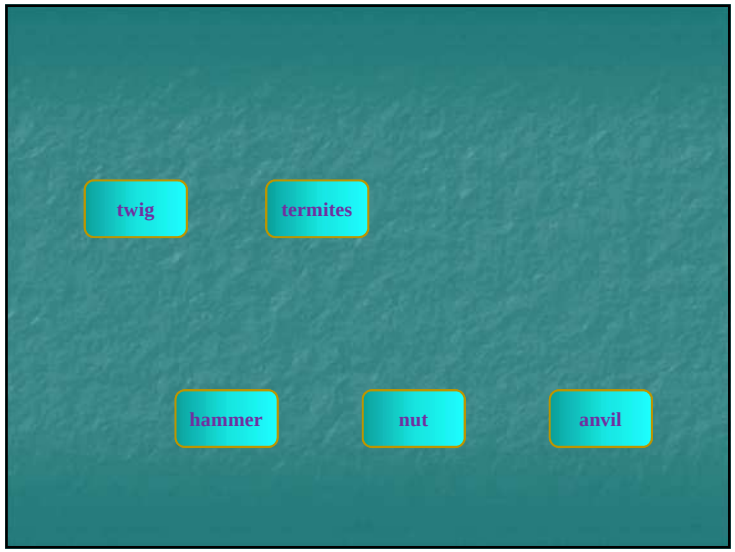
(4) [A N+V]:
Korean *neknek-hata* 'sufficiency+to be= sufficient'

Scalise et al.

Some Possible Precursors

- Syllable Structure
  - Birdsong
  - Music
- Social Intelligence
  - Theory of Mind (ToM)
  - Machiavellian Intelligence
- Navigation and Foraging
- Number
- Manual Dexterity, Motor Control
- Tool Using and Tool Making
  - Action Grammar





Action Grammar

- Pairing Method
- Pot Method
- Subassembly Method

P. M. Greenfield:
Language, tools, and brain: the ontogeny and phylogeny of hierarchically organized sequential behavior. *BBS* 14 (1991).
Language, tools, and brain revisited. *BBS* 21. (1998)

I. Pairing Strategy

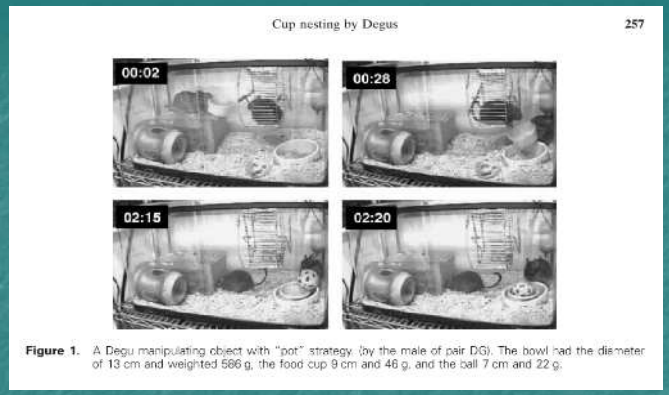
II. Pot Strategy

- Merge (saw, Mary) = {saw, Mary}
- Merge (John, {saw, Mary}) = {John, {saw, Mary}}

III. Subassembly Strategy

- Merge (saw, Mary) = {saw, Mary}
- Merge (the, boy) = {the, boy}
- Merge ({the, boy}, {saw, Mary})
  = {{the, boy}, {saw, Mary}}

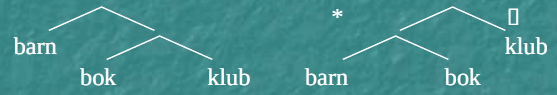
Subassembly strategy required



N. Tokimoto and K. Okanoya: Spontaneous construction of "Chinese boxes" by Degus (*Octodon degu*): A rudiment of recursive intelligence? *Japanese Psychological Research* 46 (2004).

Subassembly Strategy in Compounding

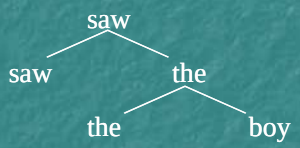
Swedish: barn bok klub:



English: child book club:

T. Roeper and W. Snyder. 2005. Language learnability and the forms of recursion.

- Subassembly-type Merge (S-Merge) is the genuine recursive device in human language.



What if the bare noun *boy* is already syntactically complex (*n*+BOY, etc.)?

Lexicon as a Conceptual Barrier

- To the extent that the lexicon belongs to FLN as a distinct component of grammar, language evolution becomes a harder topic.

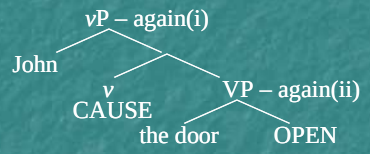
Anti-Lexicalism

- Words are also generated by recursive syntax.
- The (substantive) lexicon is decomposed into FLN (recursion) and FLB (SM/CI)
- The syntax-CI interface may be optimized.
- There is *virtually* no lexicon.

Syntactic Nature of 'Lexical' Verbs

(1) John opened the door again.
  i. repetitive reading
  ii. restitutive reading

(2)



(3) LCS: [*x* CAUSE [*y* OPEN again(ii)] again(i)]

Ditransitives

(1) a. John gave Mary a book.
  b. [$_{vP}$ John *v* [$_{VP}$ Mary V a book]]
  c. [*J.* CAUSE [*M.* HAVE *B.*]]

(2) a. John gave a book to Mary.
  b. [$_{vP}$ John *v* [$_{VP}$ a book V to Mary]]
  c. [*J.* CAUSE [*B.* GO to *M.*]]

- The mapping between syntactic structure and conceptual structure is straightforward.

Evidence from Developmental Data

CAUSE (2;0.4) ≥ HAVE (2;0.7) ≥
Double Obj verbs (2;1.6) >
GO (2;4.0) ≥ Dative Obj verbs (2;4.9)

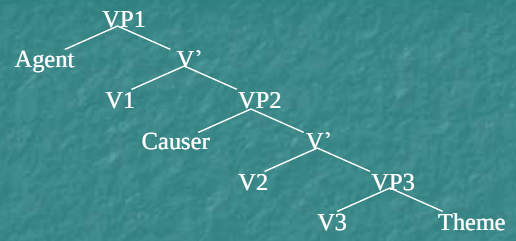
J. Viau 2006. *Give* = CAUSE + HAVE/GO: Evidence for early semantic decomposition of dative verbs in English child corpora. *BUCLD* 30.

Merge in Early Grammar

- "No verb is an island."
- "Children start to use Merge already with their very first word combinations."

A. Ninio. 2006. *Language and the Learning Curve*. OUP.

Three-Layered Split VP



cf. [x DO [x CAUSE [y BECOME …]]]

K. Fujita, Double objects, causatives and derivational economy, *LI* 27. (1996)

"Causes are realized in a position that is asymmetrically c-commanded by the Agent position."

L. Travis 2005. Agents and Causes in Malagasy and Tagalog, in *The Syntax of Aspect*. OUP.

- *tham/hây* causatives in Thai:

(1) *Saakhaa tham kracok tœœk dooy taŋcay.
Saka cause mirror break by intend

(2) Saakhaa hây dek win dooy taŋcay.
Saka have child run by intend

(3) Saakhaa tham hây kaw?ii lom dooy taŋcay.
Saka cause have chair fall by intend

R. Vichit-Vadakan 1976. The concept of inadvertence in Thai periphrastic causative constructions, in M. Shibatani ed. *Syntax and Semantics* 6: *The Grammar of Causative Constructions*. Academic Press.

(1) This glass breaks easily.
[TP this glass T [μP μ [VP1 IMP V1 [VP2 V2 [VP3 breaks this glass]]]]]

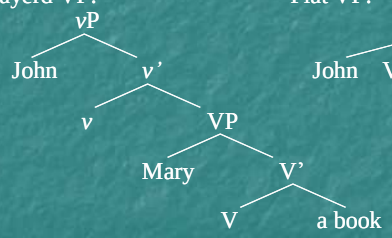
(2) This glass suddenly broke.
[TP this glass T [VP1 V1 [μP μ [VP2 IMP V2 [VP3 breaks this glass]]]]]

Middles	implicit Agent	Generically quantified	+stative
Ergatives	(implicit Causer)	Existentially quantified	+eventive

Simpler Syntax? (Culicover and Jackendoff 2005)

John gave Mary a book.
CS: [x CAUSE [y HAVE z]]

Layerd VP:



Flat VP:

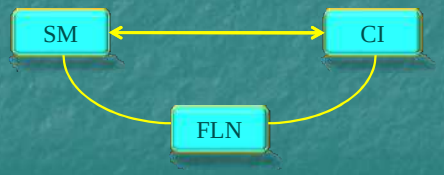
- Flat VP: optimal for SM-system
  - Language for communication
  - Lexicalism
- Layerd VP: optimal for CI-system
  - Language for thought
  - Anti-Lexicalism
- Symplicity is in the eye of the beholder!

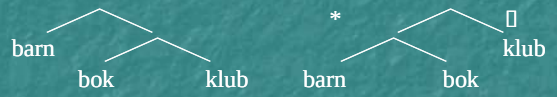
(1) John killed the cat on purpose.
(2) John caused the cat to die on purpose.

J. Fodor (1970)

(1`) [$_{vP}$ x CAUSE [$_{VP}$ y DIE]]
(2`) [$_{vP}$ x *v*(cause) [$_{VP}$ V [$_{TP}$ T [$_{vP}$ y *v*(die) [$_{VP}$ V]]]]]

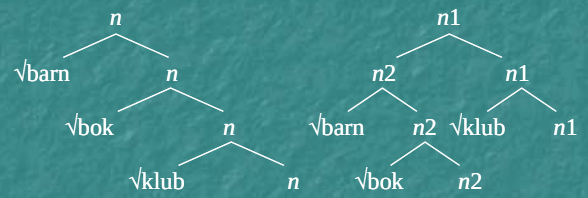
- From FLB to FLN:
- Recursive syntax could be an exaptation from the recursive CI-system.





Given that *bok* is syntactically complex, the right-branching compounding also requires S-Merge.

→ 'Root' compounding

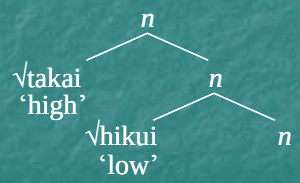


cf. M. Mukai, Recursive compounds. *Word Structure* 1 (2008).

- Exocentric compounds are in fact endocentric.

(1) A+A→N

(2) √ + √ + *n*→N



- The issue of whether protolanguage was holophrastic (à la Wray, Arbib) or synthetic (à la Bickerton, Tallerman) is largely irrelevant.
- Word-like elements in protolanguage (protowords) could exist in the absence of / prior to syntax.

From Pot to Subassembly
From Subassembly to Merge

	Merge	Action Grammar
Unbounded?	Yes	No/Yes
Symmetric?	Yes/No	No

- "Modularity, a biological approach that views organisms as the integration of partially independent, interacting units at several hierarchical levels, has been described as 'a conceptual framework for evo-devo', and 'a meeting place for evolutionary and developmental biologists'."

  B. K. Hall and W. M. Olson eds.: *Keywords & Concepts in Evolutionary Developmental Biology.*

Modular Architecture of the Mind

- Domain-Specificity
- Informational Encapsulation
- Autonomous
- Innate
- Mandatory
- Fast
- Deterministic
- Neural Localization
- Idiosyncratic Pathological Breakdown

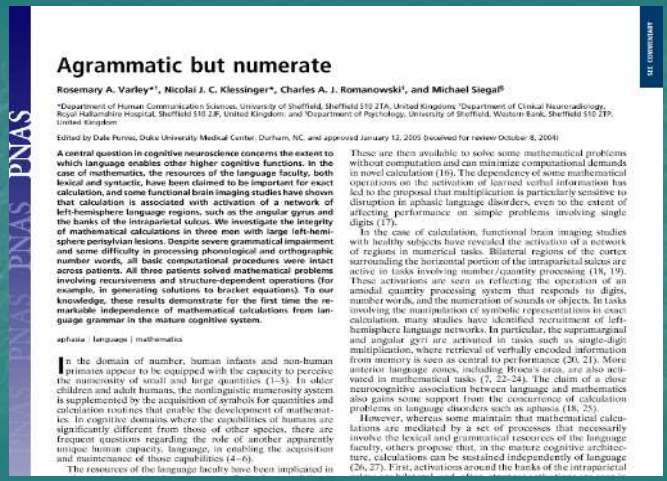
- Against Strong Innateness
- Departure from strong genetic determinism in *Evo-Devo* and in MP
- "The third factor" in general biological design

Merge to Successor Function?

Merge (1,1) = 2

Merge (2,1) = 3, etc.

Mathematical capacity is an abstraction from linguistic operations.



PNAS PNAS PNAS

SEE COMMENTARY

Agrammatic but numerate

Rosemary A. Varley*†, Nicolai J. C. Klessinger*, Charles A. J. Romanowski‡, and Michael Siegal§

*Department of Human Communication Sciences, University of Sheffield, Sheffield S10 2TA, United Kingdom; ‡Department of Clinical Neuroradiology, Royal Hallamshire Hospital, Sheffield S10 2JF, United Kingdom; and §Department of Psychology, University of Sheffield, Western Bank, Sheffield S10 2TP, United Kingdom

Edited by Dale Purves, Duke University Medical Center, Durham, NC, and approved January 12, 2005 (received for review October 8, 2004)

A central question in cognitive neuroscience concerns the extent to which language enables other higher cognitive functions. In the case of mathematics, the resources of the language faculty, both lexical and syntactic, have been claimed to be important for exact calculation, and some functional brain imaging studies have shown that calculation is associated with activation of a network of left-hemisphere language regions, such as the angular gyrus and the banks of the intraparietal sulcus. We investigate the integrity of mathematical calculations in three men with large left-hemisphere perisylvian lesions. Despite severe grammatical impairment and some difficulty in processing phonological and orthographic number words, all basic computational procedures were intact across patients. All three patients solved mathematical problems involving recursiveness and structure-dependent operations (for example, in generating solutions to bracket equations). To our knowledge, these results demonstrate for the first time the remarkable independence of mathematical calculations from language grammar in the mature cognitive system.

aphasia | language | mathematics

In the domain of number, human infants and non-human primates appear to be equipped with the capacity to perceive the numerosity of small and large quantities (1–5). In older children and adult humans, the nonlinguistic numerosity system is supplemented by the acquisition of symbols for quantities and calculation routines that enable the development of mathematics. In cognitive domains where the capabilities of humans are significantly different from those of other species, there are frequent questions regarding the role of another apparently unique human capacity, language, in enabling the acquisition and maintenance of those capabilities (4–6).

The resources of the language faculty have been implicated in

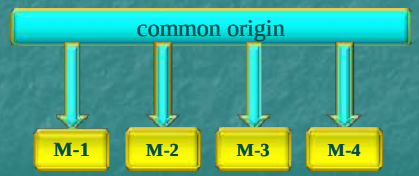
These are then available to solve some mathematical problems without computation and can minimize computational demands in novel calculation (16). The dependency of some mathematical operations on the activation of learned verbal information has led to the proposal that multiplication is particularly sensitive to disruption in aphasic language disorders, even to the extent of affecting performance on simple problems involving single digits (17).

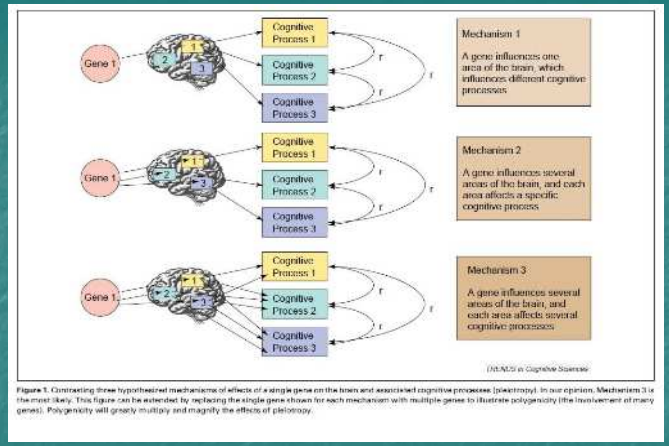
In the case of calculation, functional brain imaging studies with healthy subjects have revealed the activation of a network of regions in numerical tasks. Bilateral regions of the cortex surrounding the horizontal portion of the intraparietal sulcus are active in tasks involving number/quantity processing (18, 19). These activations are seen as reflecting the operation of an amodal quantity processing system that responds to digits, number words, and the numeration of sounds or objects. In tasks involving the manipulation of symbolic representations in exact calculation, many studies have identified recruitment of left-hemisphere language networks. In particular, the supramarginal and angular gyri are activated in tasks such as single-digit multiplication, where retrieval of verbally encoded information from memory is seen as central to performance (20, 21). More anterior language zones, including Broca's area, are also activated in mathematical tasks (7, 22–24). The claim of a close neurocognitive association between language and mathematics also gains some support from the concurrence of calculation problems in language disorders such as aphasia (18, 25).

However, whereas some maintain that mathematical calculations are mediated by a set of processes that necessarily involve the lexical and grammatical resources of the language faculty, others propose that, in the mature cognitive architecture, calculations can be sustained independently of language (26, 27). First, activations around the banks of the intraparietal

	Central System?	Adaptation?
Fodorian Module	No	No
Chomskyan Module	Yes	No
Darwinian Module	Yes	Yes

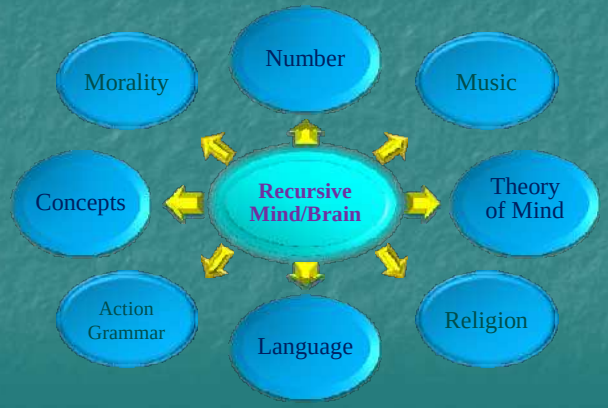
- G. Marcus (2006):
  descent-with-modification modularily
  (as opposed to sui generis modularity)





Y. Kovas and R. Plomin 2006. Generalist genes: implications for the cognitive sciences. *Trends in Cognitive Sciences* 10.

Recursion: *The* Generative Engine of the Mind



Some Conclusions (tentative!)

- Recursion should be understood derivationally.
- S-Merge makes human syntax possible.
- Syntax generates words.
- Linguistic structure is always endocentric.
- Action Grammar may be explored as a precursor to Merge.

Thank you.