Morphological Complexity and Computation
1st Lecture

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Outline

Minimalism and I-morphology
  Complexity as choice points / indeterminacy
  Composition and recursion in I-morphology
  Asymmetry as reducing complexity

2. Exploring asymmetry effects in I-morphology
  Argument/adjunct asymmetry in deverbal compounds
  Internal/external aspect asymmetry in prefixed verbs

3. Two approaches to morphological complexity
  I-complexity, E-complexity
  Behavioral and computational results

4. Morphological variation, symmetry breaking and reduction of complexity
  Language development
  Development of prepositions in phylogeny
1. Minimalism and I-Morphology

We aim to understand grammar on the basis of notions that have been shown to shed light on the dynamics of complex systems such as biology and physics, namely the notions of symmetry, asymmetry and symmetry-breaking.

These notions, we claim, ensure essential conceptual unification between language and biology. They are also crucial for the understanding of the reduction of the complexity (choice points / indeterminacy) generated by the operations of the language faculty.

Thus we ask how these properties of relations help us understand what is a morphological object, how it is computed by the human brain/mind and how it is possible to simulate this computation by computers.
**Minimalism**

I adopt the Minimalist program, which aims to reduce the technical apparatus of the grammar to the bare minimum.

- Genetic endowment and the computational procedure of the language faculty in the narrow sense;
- experience and language variation;
- complexity and the principles reducing it. (Chomsky 2005)

Discussions on the computational procedure and factors ensuring efficient computation have mainly targeted syntactic expressions.

Minimize the search space (derivation by phase)
Minimize the externalization (pronounce the minimum)
Minimalism leads to question theories

- in which morphological computations fall outside of the operations of the Language Faculty: Composition + recursion & interfaces;
- that reduce morphological complexity to a SM phenomena;
- that view words as evolutionary prior to syntax.

Minimalism leads

- to distinguish internal/intentional properties of morphological expressions from their external/extensional properties;
- to consider morphological complexity brought about by the Language Faculty in the narrow sense (FLN);
- to view the computation of words to emerge with FLN.
I-morphology/E-morphology

Assuming the distinction between I-language (intentional and internalized) and E-language (extensional and externalized) (Chomsky 1986, 1997, 2001), I take the notion of I-morphology to denote the properties of I-language devoted to the computation of morphological expressions. I-Morphology is opposed to E-morphology, whose investigation leads to consider the extensional properties of morphological expressions.

The investigation of I-morphology and E-morphology leads to consider the properties of the core operations of the FL and raises the question of their emergent or gradual development. It also leads to consider the notion of morphological complexity and raises the question of how the complexity of morphological computations is reduced within the architecture of FL. (Di Sciullo 2012)

My proposal: Minimize symmetrical relations (preserve asymmetry)
**I-Morphology computation**

Morphological expressions are derived by FLN computation.

Di Sciullo and Williams (1987) ‘lexeme’ to denote a lexical word, ‘morphological object’ to denote a grammatical word and ‘syntactic word’ to denote a word that has internal syntactic phrasal structure.

Di Sciullo (2005) asymmetry is hard coded in morphology, which operations may apply to structures, including Minimal trees, morphological phases provide feature valuing.

- TAG (combining minimal and already computed trees)
- Asymmetric Agree (feature valuing)

Predictions:
- units of morphological computation and phase transfer
- Only certain combinations of affixes and roots qualify as morphological objects
- Morphological and syntactic structure are subject to TRANSFER
- Strict ordering of the constituents / strict scope
  - Only one order of the components of morphological objects is possible
  - No scope ambiguity is possible
- Conceptual interpretation / externalization
  - Entities and predicates / truth values
  - Compound stress rule / nuclear stress rule
The adviser of Paul (*by John).
This student is a dreamer. #Trains are arrivers.
the rider on the shore; the fighters in the ring
#the puter of the letter in the mail vs. the sender of the letter

a desirable and affordable book
#a putable book on this shelve;
a sitable chair; #a leaveable place
#Rain is fallable. #Gentlemen are standable in trains.

a formalized theory; a computerized accounting system
#This equalizes the results.; #It’s hard to friendize with him
a simplified problem; #an enviousified neigboor
Unicorns are impressive (*of/for people).

(A-Spec) : -er
(A-Compl) : -ize, -if
(A-Spec, A-compl) : -able, -ee, -ive
Feature asymmetry

- able
  a. Selects for A-Spec & A-Compl
  b. Links to A-Compl

- er
  a. Selects for A-Spec
  b. Links to A-Spec

- ize/-ify
  a. *sisterize/*friendize/*equalize
     (root: A-Spec & A-Compl)
  b. solidify/certify/liquify
     (root: no A-Spec)
  c. unionize/computerize/systemize
     (no A-Spec nor A-Compl)

- able
  a. washable/lovable
     (root: A-Spec & A-Compl)
  b. *fallable/*arrivable
     (root: no A-Spec)
  c. *shinable/*snorable
     (root: no A-Compl)

- er
  a. Selects for A-Spec
  b. Links to A-Compl

- able
  a. killer/hitter/producer
     (root: A-Spec & A-Compl)
  b. swimmer/boxer/dreamer
     (root: no A-Compl)
  c. *faller/*arriver/*departer
     (root: no A-Spec)
Where is Morphology?

Modularity of the Language Faculty - Mind/Brain
Primitives of Language Faculty in the narrow sense
Operations deriving the discrete infinity of language
Mapping to the external systems
Principles reducing complexity
In Chomsky (1995), Merge is asymmetric and projects a Label. The asymmetry lies in whether one or the other object undergoing the operation, $\alpha$ or $\beta$, projects its label, and the objects undergoing Merge can be the result of previous computation, given the recursive procedure that is associated to this operation.

* **Merge** (Chomsky 1995)*

  Target two syntactic objects $\alpha$ and $\beta$, form a new object $\Gamma \{ \alpha, \beta \}$, the label $\text{LB}$ of $\Gamma(\text{LB}(\Gamma)) = \text{LB}(\alpha)$ or $\text{LB}(\beta)$.

```
  δ
   \  /\
  β   α
```

```
  *  

  a.  

  b.  
```
Implementation of Merge

The implementation of Merge under this view implies:

a) a Numeration: the set of lexical items with their features.
b) SELECT: an operation that selects items from the numeration and inserts them into the workspace.
c) a workspace: the space where the derivation unfolds and which will eventually contain the output of the recursive application of Merge.

For Zwart (2000) Merge is asymmetrical wrt the timing of this operation.
Asymmetric Agree

Asymmetric Agree limits the choice of the pairs of elements undergoing morphological merger to those whose set of features are in a proper inclusion relation. (Di Sciullo 2005)

Given the following Numeration:

Numeration: { computable: [V]. -able: [A, uV]. un- : [A, uA], - ity : [N, uA]}

the order in which items in the Numeration must be Merged is determined by the proper inclusion relation.

```
 N
   |  -ity
   | [uA, N]
   |
 un-  |
[uA, A]
   |
 compute  -able
[V]  [uV, A]
```

Given the proper sub-set requirement on the sub-procedure SELECT, un- can only merge with compute-able. It cannot merge to compute-able-ity:

1. Merge (compute [V], -able [uV, A])
2. Merge (compute able [A], -ity [uA, N])
3. *Merge (computability [N], -un [uA, A]) (no proper inclusion)

Asymmetry, as a factor reducing complexity, constrains the order of application of morphological merger and thus provides a constrained approach to I-morphological computation.
Asymmetric Merge

Core syntactic derivations are detailed in Di Sciullo and Isac (2008), where Merge is asymmetric in the sense that it applies to the elements of a Numeration whose set of features are in a proper inclusion relation. Asymmetric Merge predicts the ‘right’ order of Merge for interface legibility.

Asymmetry of Merge (Di Sciullo and Isac (2008: 268)

Merge is an operation that applies to a pair of elements in the Numeration whose sets of features are in a proper inclusion relation.

\[ N = \{C, T, \{D, \text{Num}, N, v, V, D, \text{Num}, N\}\} \]

Step 1. Select an item from Numeration that has interpretable features only

\[ \Rightarrow \text{Select N \{[N]\}} \]

Step 2. Select an item from Numeration that properly includes N

\[ \Rightarrow \text{Select Num \{[Num], [uN]\}} \]

Step 3. External-Merge N with Num.

Step 4. Select an item that properly includes Num

\[ \Rightarrow \text{Select D \{[D], [uNum]\}} \]

Step 5. External-Merge D to the workspace and check uninterpretable features, as enforced by the Earliness Principle.
**I-morphology is not I-syntax**

Under the assumption that affixes and roots like LI are specified for categorical features, Merge combines different sets of categorical features when applied in morphological vs. syntactic derivations. The syntactic feature specifications for the category N, as well as for the categories D, V, tense and C from Di Sciullo and Isac (2008), here in (a), do not extend to morphology. Different sets of features are at play in the merger of affixes and roots, as discussed in Di Sciullo (2014).

a. N: [N]
   Indefinite D: [Num] [uN]
   Definite D: [D] [uNum] wh-D: [D] [uNum] [wh]

b. UnergativeV: [V]
   Transitive V: [V] [uD]
   Unaccusative V: v [v] [uV] [uD] [uTense] Unaccusative v: [v] [uV], [uTense]

c. Tense : [Tense], [uv] [uD] [EPP] [uClauseType: ]
   C1 : [D] [ClauseType] [uTense]
   C2 : [D] [ClauseType] [uTense] [wh]
**I-morphology is not I-syntax**

N affixes (e.g., -ity, -ion, -ade) would be specified for [uA], [uV], [uN], which is not the case for syntactic Ns, see (9a).

V affixes (e.g., -ize, -ify) would be specified for [uN] (e.g., union-ize) and [uA] (e.g., formal-ize), but not [uD] and [uTense], as it is the case for syntactic Vs, see (9b).

Tense affixes, (e.g., -ed) would not be specified for [uD] [EPP] and [uClauseType:], (e.g., formalized), as it is the case for the syntactic category Tense, see (9b).

Thus, SELECT applies to elements with different sets of features in morphological derivations as opposed to syntactic derivations.

According to I-Morphology however, affixes and roots are not specified for categorial features, but with argument, aspect and operator-variable features. According to this theory, the set of features of the objects undergoing morphological merger is distinct from the set of features of LI which undergo syntactic merger.

See Di Sciullo (2014) for discussion.
**I-morphology and I-syntax**

Share properties of the operations that combine: binarity, recursion, asymmetry

Differ with respect to
  i) the properties of the objects they combine: features and structures
  ii) what counts as a phase
  iii) phase impenetrability
  iv) the nature of the interface where the derived expressions are interpreted.
Summary of section 1

1. Morphology and computation
2. Minimalism and I-morphology
3. Configurational and feature asymmetry
4. I-morphology and I-syntax in the Language Faculty
Intermezzo

Consequences for language development

The distinction between I-morphology and E-morphology relates to the emergent vs. the gradual views on the development of language and on the derivation of words, as discussed in Di Sciullo (2013).

It has been argued that a more elementary form of Merge or Proto-Merge preceded full fledged Merge, in the evolution of language. Recent works argue that compounds are derived by Proto-Merge.
**Merge and Proto-Merge**

Proto-Merge and Merge are recursive operations; that is they may apply to their own outputs. However,

i) Merge is a binary operation, Proto-Merge is not.

ii) Merge creates hierarchical structure, this is not the case for Proto-Merge.

Proto-Merge = recursive n-ary operation concatenating n elements and deriving a flat/adjunction structure (Jackendoff 1999, 2002).

iii) Merge applies to structured elements to derive more complex structured elements. It can also be defined as a concatenation operation, which applies to strings and derives a single string (Logic, theory of computation).

To claim that a language includes expressions from a pre-syntactic stage of that language is to assert that both Proto-Merge and Merge contribute to the derivation of linguistic expressions.

Given minimalist assumptions, a theoretical issue is the fact that complexity arises from the co-presence of Merge and a more primitive form of Merge (Proto-Merge) for the derivation of linguistic expressions.
Emergent vs. gradual development of language

According to the emergent view of language evolution (Chomsky 2008, 2011, a.o.), there is no Proto-Language, nor a preceding pre-syntactic (one word) stage in language evolution. The Faculty of Language emerged late in historical development. According to this view, language did not start from something simpler, and it did not evolve from simpler stages.

In the gradualist view of language development (Bickerton 1990, 1998, Jackendoff 1999, 2002, 2011) proto-language is an intermediate step in the historical development of language:
-pre-syntactic (one-word) stage > proto-syntax (two-word) stage > modern syntax
In the gradualist view, E-morphology (words, simplex and complex) are viewed as being derived by Proto-Merge.
**Fossils of proto-language**

Jackendoff (1999, 2002) proposed that the relatively flat (non-hierarchical) structure of adjuncts, as well as the raw concatenation of compounds, still retains a bit of proto-linguistic flavor, and can be analyzed as syntactic ‘fossils’ of a previous stage of syntax.

For Jackendoff (1999, 2002), minimal syntactic specification and extensive involvement of pragmatics are the hallmarks of what have been proposed to be syntactic fossils.

-Fossils of proto-language = constructions dating back to a proto-syntactic stage, now co-existing with more complex syntactic constructions.
Different views of Proto-Language

For Bickerton (1990, 1998), proto-language is a kind of communication system with no syntax. According to Bickerton, although words may have been uttered in short sequences, there were no rules defining well-formedness of strings, and therefore words in proto-language could not be said to belong to separate syntactic classes, such as Noun or Verb.

According to Hurtford (2001) proto-thought had something like predicate calculus, but had no quantifiers or logical names. Other theories take proto-language to be limited to concatenation of predicates only.

For Gil (2011), proto-language relates to the development of subject-predicate relations.
Empirical support for fossils of Proto-language

i) Conjunction
   - atomicity
   - violation of syntactic constraints
   Cowart et al. (2011)

ii) VN compounds
    -not recursive
    -the nominal element may in some cases be interpreted as the complement or the subject of the predication
**VN exocentric compounds**

Exocentric compounds are found in several languages. (Progovac 2011)

**English**

scare-crow, kill-joy, pick-pocket, cut-purse, spoil-sport, scatter-brain, turn-coat, hunch-back, dare-devil, wag-tail, tattle-tale, saw-bones, rattle-snake, cry-baby

**German**

Tauge-nichts, be.worth-nothing, ‘good-for-nothing’
Habe-nichts ‘have-nothing’

**Serbian**

cepi-dlaka, split-hair ‘hairsplitter’
ispitutura, empty-flask ‘drunkard’
muti-voda, muddy-water ‘who muddies waters’
pali-kuća, burn-house ‘who burns houses’
priši-petlja, sow-loop, ‘who clings onto another’
vrti-guz, spin-butt, ‘restless person, fidget’
deri-koža, rip-skin ‘who rips you off’
jejbi-vetar, screw-wind ‘charlatan’
pali-drvce, ignite-stick ‘matches’
podvi-rep, fold-tail ‘who is crestfallen’
aspikuća, waste-house, ‘who spend’
vucibatina, pull-whip, ‘good-for-nothing’

**Tashelhit Berber, Morocco**

slm-aggrn, suck.in-flour, ‘butterfly’
ssum-sitan, suck-cow, ‘insect, 
ssum-izi, suck-fly ‘thifty person’

**Asante Twi, Ghana**

Atoto.botom, dip.in pocket, ‘pickpocket’
Nom-mmodža, suck blood, ‘vampire’
Wodi.nii, kill person, ‘killer’
Kukru.bin, roll feces, ‘beetle’
Hierarchical structure

The properties of exocentric compounds in Romance languages provide evidence that these constructs are articulated on the basis of the merger of functional structure.

a. limpia botas ‘shoeshine’ (Sp)
b. mozzafiato ‘breath-taker’; spaccatimpani ‘ear-drum-breaker’ (It)
c. gagne-petit ‘small win’, couche-tard ‘night-owl’, saute-dessus ‘jump above’ (Fr)

Exocentric compounds in French may include complements or adjuncts, as well as phrasal functional structure. These facts show that they are hierarchical structures derived by Merge and not flat structures, derived by Proto-Merge.
Computation of exocentric compounds

X-bar theoretical analysis of exocentric compounds is formulated in Di Sciullo (1982), on the basis of French data. Nominalization of phrasal structure is proposed therein and in Di Sciullo and Williams (1987), who analyze these expressions as ‘syntactic words’.

\[
\begin{align*}
    &a. \quad N \rightarrow VP \\
    &b. \quad N \rightarrow XP
\end{align*}
\]

A reduced restricted relative clause analysis for exocentric compounds is found in Panini’s work on Classical Sanskrit, as well as Tollemache (1945), Coseriu (1978), Bok-Bennema and Kampers-Mahne (2005), Franco (2010), a.o. The merger of an unpronounced nominal constituent with a CP derives a reduced relative clause analysis for these compounds.

c. Merge (NP, CP)

If the structure of exocentric compounds is that of a reduced relative clause, and thus is derived by the recursive application of Merge, it is expected that phrasal complements and adjuncts can be generated in these constructs. See Di Sciullo (2013) for discussion.

\[
\begin{align*}
    &d. \quad [NP \ [CP \ [FP \ F \ [vP \ v \ [vP \ V]]]]]
\end{align*}
\]
Summary of intermezzo

Minimalism leads to reconsider basic biolinguistic questions on the development of language, emergence vs. evolution, as well as the properties of the core operation of the Faculty of Language.

Words, simplex and complex, are seen as prima-facie natural candidates for the evolutionist view of language development, including proto-language.

Exocentric compounds cannot be derived by concatenation or Proto-Merge, they do not provide empirical support for Proto-language within language.
2. Recursion in I-Morphology

Recursion is the property of a rule to be able to reapply to its own output.

According to Chomsky, Hauser and Fitch (2002) recursion is unique to the human language faculty.

We qualify this statement as follows:
Indirect recursion is a distinctive property of the operations of the language faculty.

Theoretical support comes from the Asymmetry Theory.
Biolinguistic support comes from neuroimaging and human-animal studies. Empirical support comes from morpho-syntax.
Direct and indirect recursion

**Direct recursion**: the property of an operation (Merge) to reapply to its own categorical output.

a. an interesting, observable phenomenon
b. ununfold; rerecode; redishish

Direct recursion brings about complexity (choice points / indeterminacy)

**Indirect recursion**: the property of a rule to reapply indirectly to its own categorical output via the merger of a functional head

a. John’s father’s hat
b. lexic-o-semantics

The asymmetry brought about by indirect recursion limits the complexity of the recursive computation of I-morphology (Di Sciullo 2014).
Recursion is a property of the basic combinatorial operation of the Language Faculty. Recursion can also be thought of as replication of the same categorial structure. Differences between free Merge and asymmetric Merge (Di Sciullo & Isac 2008a, b). Asymmetric Merge derives the order of application of the operations and gives indirect recursion for free.

**Free Merge**

a. \( N = \{\text{Mary, v, saw, Wolfram, in, Venice}\} \)

b. \( \text{Mary} \longrightarrow v \longrightarrow \text{Mary} \)

c. \( \text{v} \longrightarrow \text{Venice} \)

**Asymmetric Merge**

\[
\begin{align*}
\text{C}^0 & \quad \text{TP} \\
\text{[uTense]} & \quad \text{TP} \\
\text{[uD]} & \quad \text{DP}_{sa} \\
\text{[uTense:Decl]} & \quad \text{[uTense:Pres]} \\
\text{[u]} & \quad \text{[u]} \\
\text{[uD] + [EPP]} & \quad \text{[u]} \\
\text{[uTense:Decl]} & \quad \text{[uTense:Pres]} \\
\text{[u]} & \quad \text{[u]} \\
\text{[u]} & \quad \text{[u]} \\
\text{D} & \quad \text{NumP} \\
\text{[uNum/deg]} & \quad \text{Num} \\
\text{[D]} & \quad \text{NP} \\
\text{[uN]} & \quad [N]
\end{align*}
\]
Recursion in NN compounds

i) head-initial compounds (It)

\[\begin{align*}
\text{a.} & \quad \begin{array}{c}
\text{N} \\
\text{controllo} \\
\text{N} \\
\text{passaporto}
\end{array} \\
\text{b.} & \quad \begin{array}{c}
\text{N} \\
\text{punto} \\
\text{N} \\
\text{controllo} \\
\text{N} \\
\text{passaporto}
\end{array}
\end{align*}\]

ii) Head-final compounds (En)

control passport
passport control
point passport control
passport control point passport control

Shortcomings:
i) Multiple derivations are possible since nothing restricts the merger of two LI from the numeration.

\[\text{NUM: \{ punto: [N], contollo: [N], passaporto :[N]\}}\]

ii) The order of application of Merge does not follow in any principled way.
Nothing forces External Merge or Internal Merge to apply.
Derivation of compounds and indirect recursion

Given Asymmetric Merge, SELECT cannot merge two constituents with matching features, the proper sub-set requirement ensures that the merger is asymmetrical.

NUM: { punto: [[N], [uF]], controllo: [[N], [uF]], F : [[F], [uN]], passaporto :[N] }
The F head pronounced in Brazilian Portuguese compounds
Head-complement & modification relations

A) Head-complement relation:

a. **controle de passaporte** (BP)
   controllo passaporto (It)
   control passport
   'passport control'

b. **empregado de banco** (BP)
   impiefato banca (It)
   employee bank
   'bank employee'

a. **ponto de controle** de passaporte (BP)
   punto controllo passaporto (It)
   point control passport
   'passport control point'

b. **sala de funcionários de viagem** (BP)
   sala personale viaggiante (It)
   room staff traveling
   'traveling staff room,'

B) Modification relation:

a. **coleta privata** de lixo tóxico (BP)
   Raccolta privata rifiuti tossici (It)
   collection private waste toxic
   'toxic waste private collection'

b. **legislação municipal** sobre **coleção privada** de lixo tóxico (BP)
   delibera comunale raccolta privata rifiuti tossici (It)
   regulation municipality collection private waste toxic
   'toxic waste private collection municipality regulation'
Merge and asymmetrical relations

Why must there be a functional head, here a preposition, between the phrasal constituents of BP deverbal compounds?

The properties of compounds follow, from the asymmetry of Merge, which is, according to our hypothesis, a distinctive feature of the core operator of the Language Faculty.

The obligatory presence of a preposition in BP deverbal compounds is the consequence of the basic asymmetry of the morphology, whereby two constituents cannot be merged together. Each constituent must first merge with a functional head.
Summary

Composition
We distinguished I-morphology from E-morphology (Di Sciullo 2014)
We focused on I-morphology
We presented evidence that the computations in I-morphology are distinct from the computations in I-syntax as they apply to different sets of features and configurations, and are interpreted as different kinds of objects at the interfaces with the external systems.
In addition to structural asymmetry, feature asymmetry limits the complexity of I-morphology composition.

Recursion
Hauser, Chomsky and Fitch (2002) argue that recursion sets human language apart from animal communication.
We qualified this statement as follows: indirect recursion is specific to human language.
Evidence comes from the properties of compounds in different languages, as discussed in Di Sciullo (2005-2014).
Independent evidence comes from complex numerals, as discussed in Di Sciullo (2012).

Asymmetry limits the complexity of the recursive computation of I-morphology.
Selected references


