The SMT Parser:

where Merge and Perception meet

Abbr./Glossary

Slides here!

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Slides 1–42/119

SMT: *Strong Minimalist Thesis*

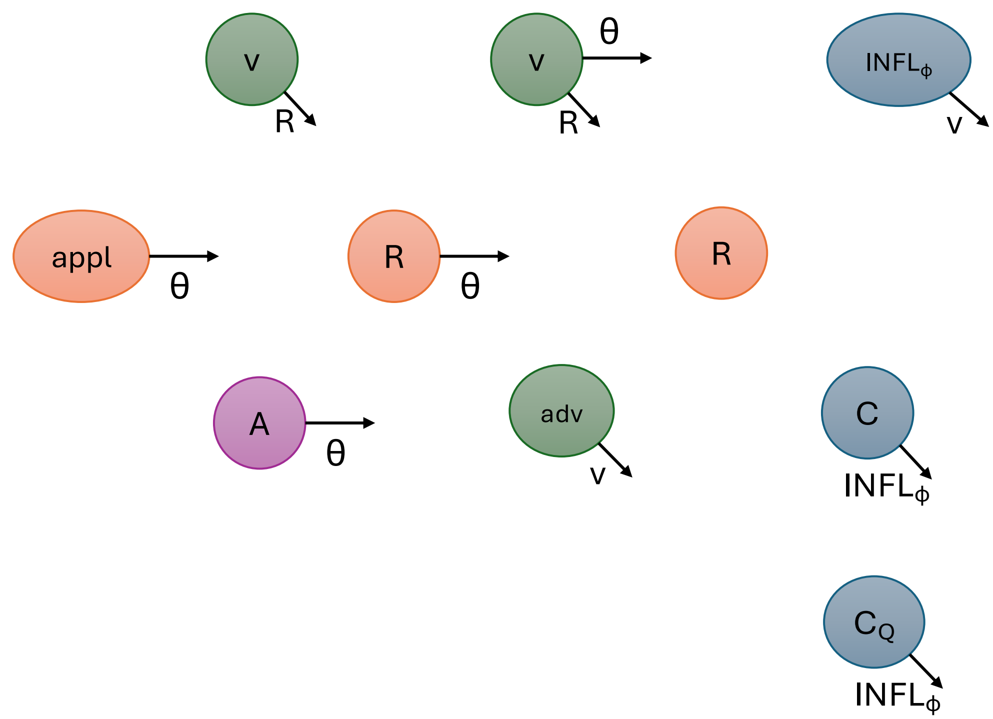
Outline:

- **Introduction**: atoms and molecules of syntax
- **SMT Parser**: system architecture
- **Theory and Computation Model**: some highlights
- **SMT**: motivating optimal simplicity

`Website: sandiway.arizona.edu`

θ-configurations: *from atoms to molecules*

- A small inventory of *syntactic* atoms, e.g.:
  - v (little v)
  - R (verbal root)
  - appl (Applicative)
  - N (nominal)
  - A (adjective)
  - adv
  - $INFL_{\phi}$ (inflection)
  - C
  - neg
  - *etc.*



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  - N (nominal) { *deverbals* / *A -ness*
  - A (adjective)
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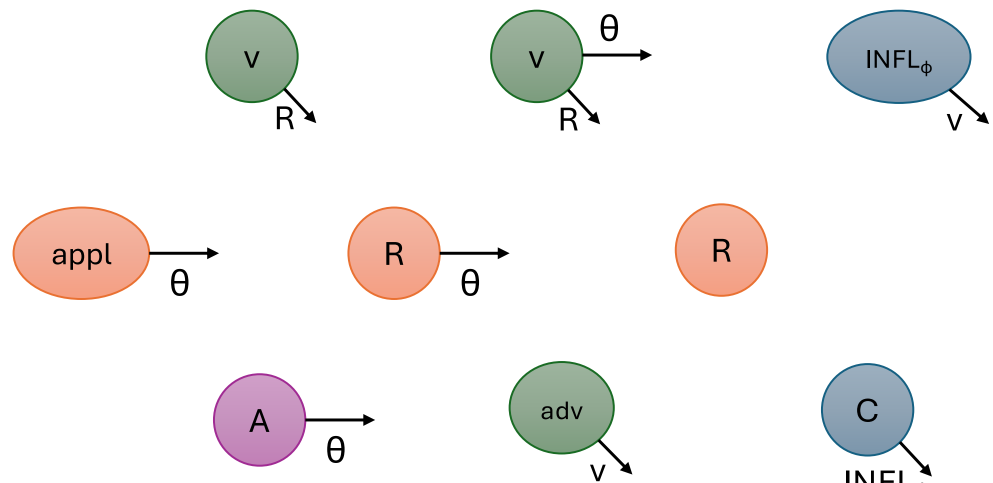
  - C
  - neg
  - *etc.*

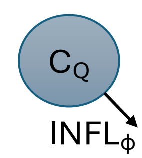
{n, R}

A -*ly*

morphemic atoms

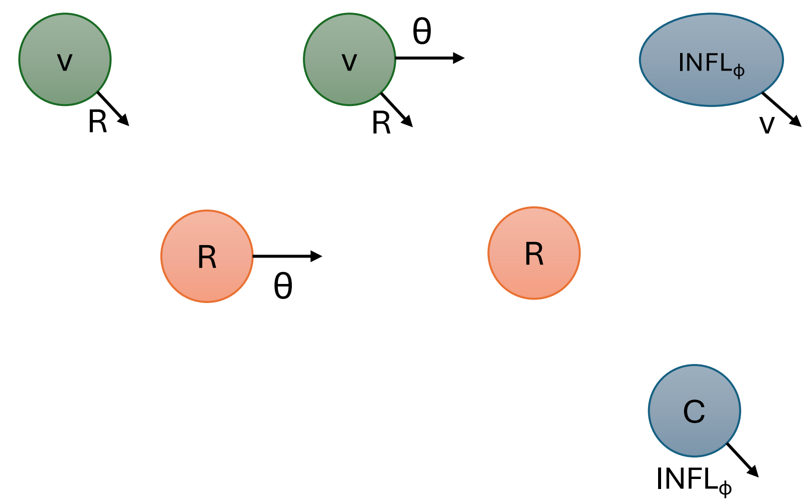


Can ask serious questions:
- How complex can a θ-configuration get?
- Are all combinations attested?
- *etc.*



θ-configurations: *from atoms to molecules*

- Form molecules (**Merge**):



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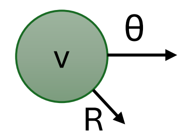
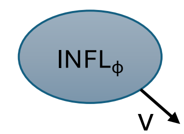
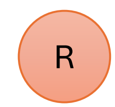
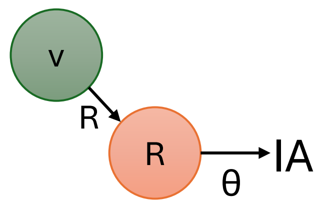
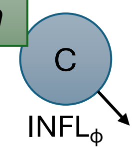








- $\{v_R, \{R_\theta, \quad IA\}\}$ *propositional domain*
- pst *arrive train*$_a$ (*arrived a train*)
- pres *llegar tren*$_{un}$ (*llega un tren*)



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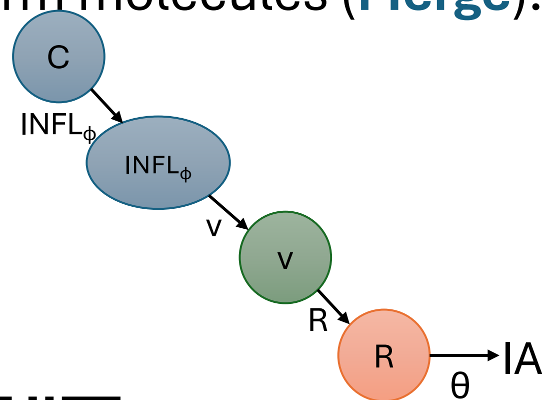

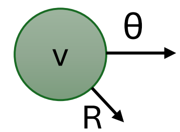

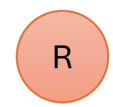

- $\{v_R, \{R_\theta, \quad IA\}\}$ ⇐ *propositional domain*
- pst *arrive train*$_a$ (*arrived a train*)
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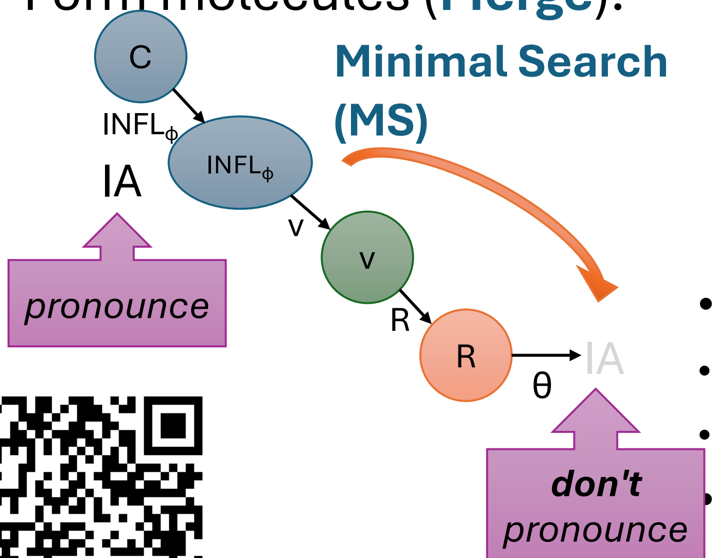
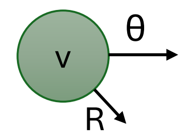
- $\{C, \{INFL_\phi, \{v_R, \{R_\theta, \quad IA\}\}\}\}$ ⇐ *clausal domain*
- *3sg* *pst* *arrive* train$_a$
- *arrived* train$_a$ ⇐ *Amalgamation*

θ-configurations: *from atoms to molecules*

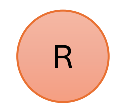
- Form molecules (**Merge**):



- **EXT** (Externalization) options:



  - *a train arrived* / **arrived a train*
  - ***there*** *arrived a train* (expletive)
  - *un tren llega* / *llega un tren*
  - *dos trenes llegan* / *llegan dos trenes*



- $\{v_R, \{R_\theta, \ IA\}\}$ ← *propositional domain*
- pst *arrive train$_a$* (*arrived a train*)
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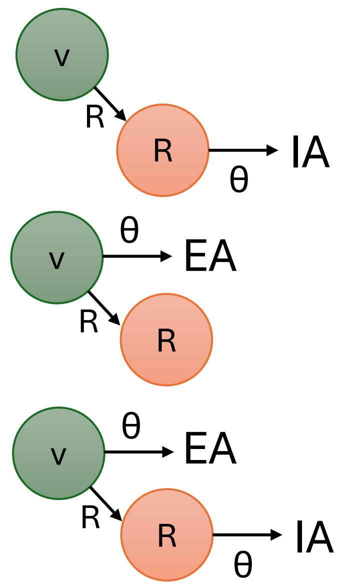
- $\{C, \{INFL_\phi, \{v_R, \ \{R_\theta, \ IA\}\}\}\}$ ← *clausal domain*
- *3sg* *pst* *arrive* train$_a$
- *arrived* train$_a$ ← *Amalgamation*

θ-configurations: *standard molecules*

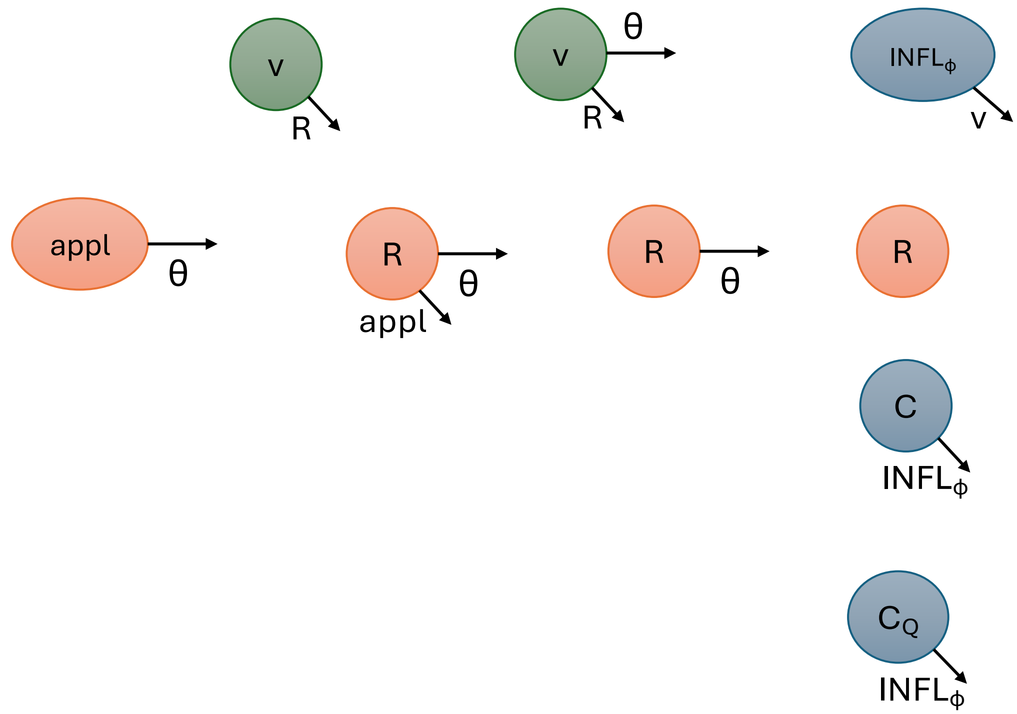
- There's a set of *legible* molecules wrt. **INT** (Interpretation)
  - limited set of molecules
  - information stored in **LEX** (Lexicon)
  - mapping from *words* to atoms/molecules acquired by hearer



- Unaccusative
  - $\{v_R, \{R_\theta,\ IA\}\}$
  - e.g. *arrive / fall*
- Unergative
  - $\{EA, \{v_{R:\theta}, R\}\}$
  - *dance / walk*
- Transitive (simple)
  - $\{EA, \{v_{R:\theta}, \{R_\theta,\ IA\}\}\}$
  - *like / kick*

θ-configurations: *standard molecules*

- Low applicative
  - e.g. *gustar* (cf. *like*)
  - *Él* ***le*** *gusta a ella*
  - "She likes him"



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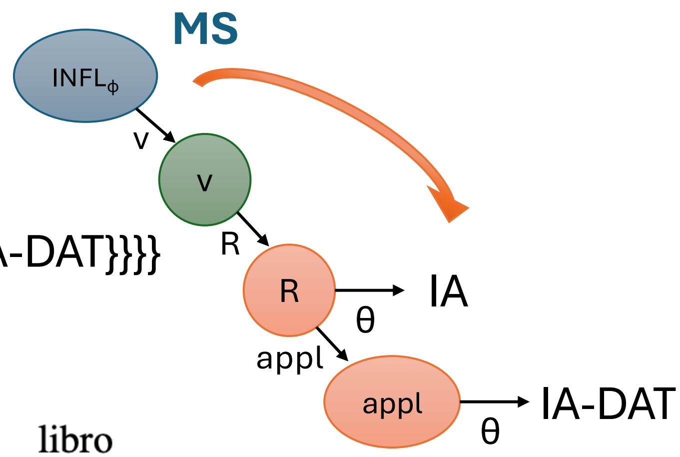


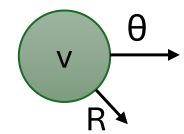
- Low applicative
  - e.g. *gustar* (cf. *like*)
  - $\{v_{appl}, \{IA, \{R_{appl:\theta}, \{appl_\theta, IA\text{-}DAT\}\}\}\}$

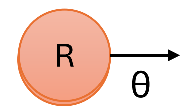
Agreement (MS):

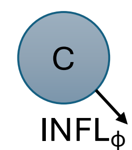
Me	gusta	el	libro
me.SG.DAT	please.SG.PRES	the.SG.M	book.SG.M

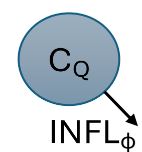
Me	gustan	los	libros
me.SG.DAT	please.PL.PRES	the.PL.M	book.PL.M

"I like the book/books"



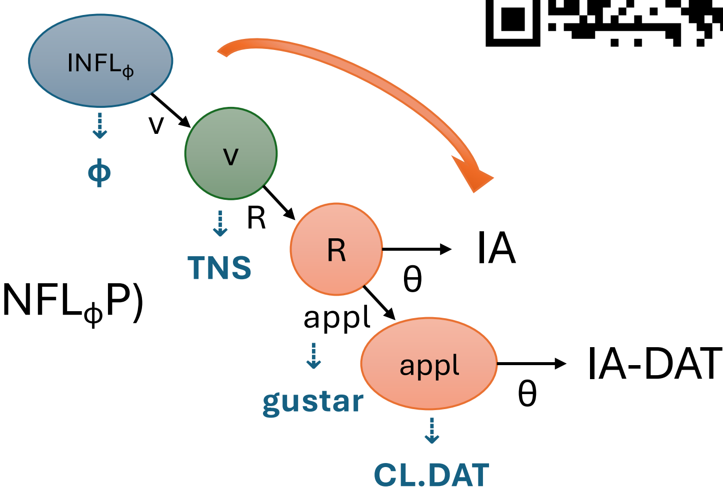






θ-configurations: *standard molecules*

- *gustar* (cf. *like*)
  - $\{v_{appl}, \{IA, \{R_{appl:\theta}, \{appl_{\theta}, IA\text{-}DAT\}\}\}\}$
- **EXT** options:
  - *Él* ***le*** *gusta a ella* (IA edge of $INFL_{\phi}P$)
    he CL.DAT please DAT her
    "*She likes him*"
  - ***Le*** *gusta él a ella* — *in situ*
  - ***Le*** *gusta a ella él* — *perhaps* RP-internal scrambling
  - *A ella* ***le*** *gusta él* — IA-DAT edge of $INFL_{\phi}P$
  - ***Le*** *gusta él* — pro drop



Clitic doubling obligatory in standard Spanish

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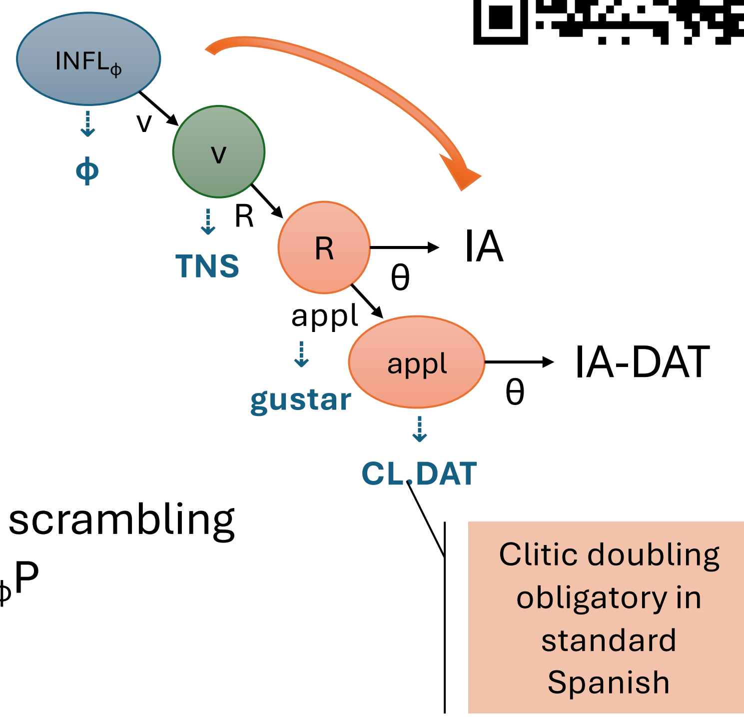

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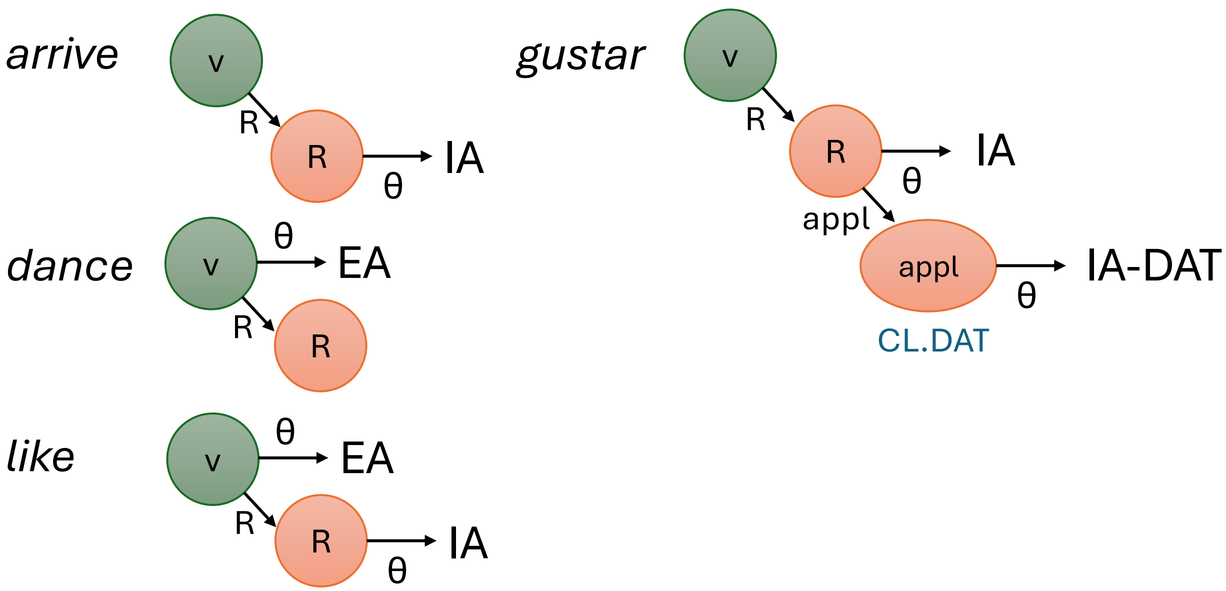

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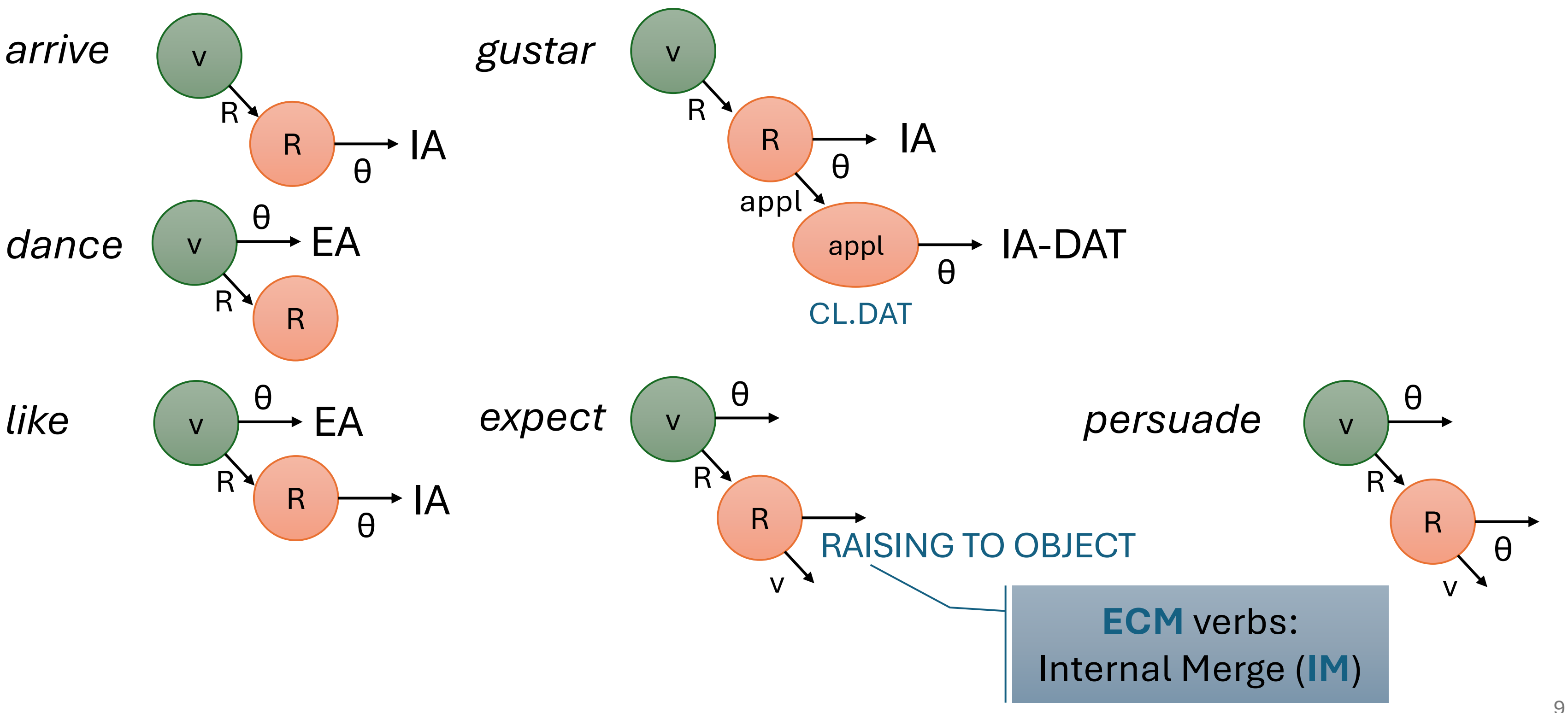
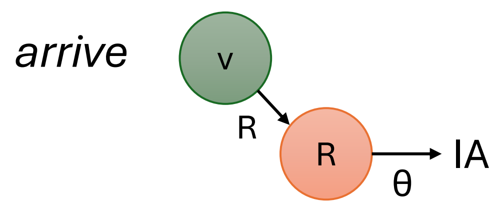


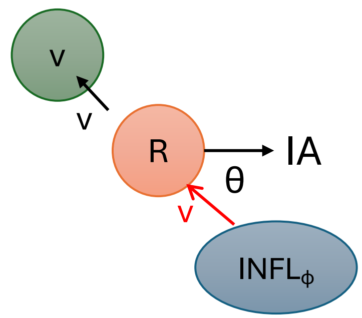
θ-configurations: some *impossible molecules*

- Can't stack in the wrong order



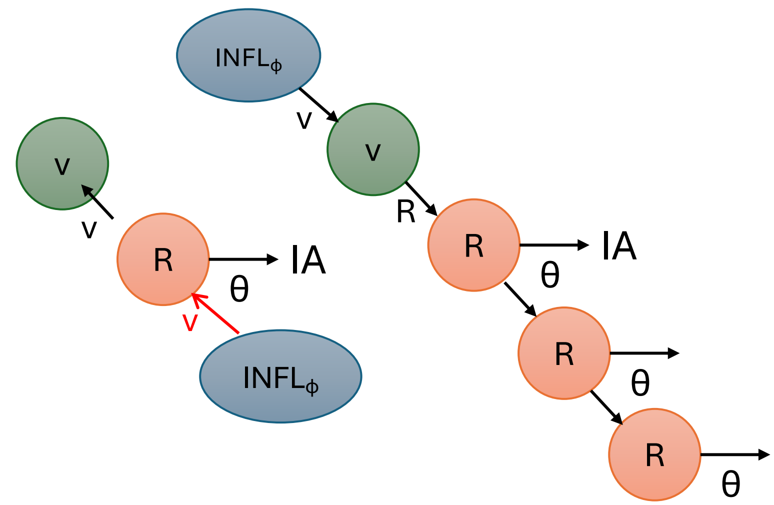
θ-configurations: some *impossible molecules*

- Can't stack in the wrong order
  - *{IA, {R_θ, v_R}}



θ-configurations: some *impossible molecules*

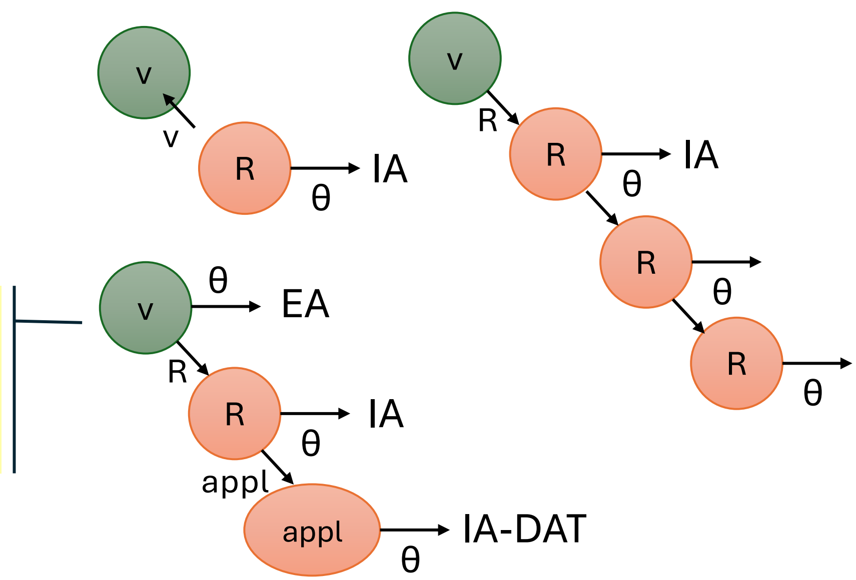
- Can't stack in the wrong order
  - *{IA, {R_θ, v_R}}
- Can't build arbitrary large molecules
  - *{v_R , {IA, {R_θ, {IA, {R_θ, {R_θ, IA}}}}}}



θ-configurations: some *impossible* *molecules*

- Can't stack in the wrong order
  - *$\{IA, \{R_\theta, v_R\}\}$
- Can't build arbitrary large molecules
  - *$\{v_R, \{IA, \{R_\theta, \{IA, \{R_\theta, \{R_\theta, IA\}\}\}\}\}\}$
  - $\{EA, \{v_{R:\theta}, \{IA, \{R_{appl:\theta}, \{appl_\theta, IA\text{-}DAT\}\}\}\}\}$

Largest θ-configuration: *3 arguments*



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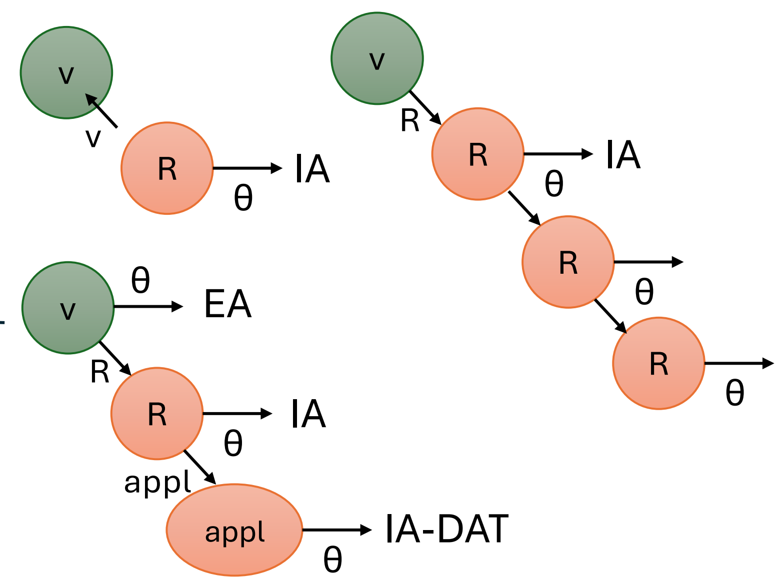
  - $\{EA, \{v_{R:\theta}, \{IA, \{R_{appl:\theta}, \{appl_\theta, IA\text{-}DAT\}\}\}\}\}$
- **Note**: ∃ non-θ-introducing atoms:
  - *be* prog
  - *have* perf
  - *be* passive
  - *le* (了) ASP
  - *can/could etc.* modals
  - neg
  - adv / PP

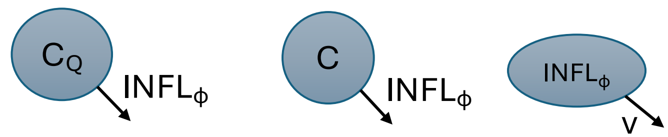
Largest θ-configuration: *3 arguments*



- **Note**: serial verbs (mono-clausal)
  - e.g. $\{EA, \{v_{R:\theta}, \{\{R_\theta, R_\theta\}, IA\}\}\}$ or $\{EA, \{v_{R:\theta}, \{\{R_\theta, IA\},\{R_\theta, IA\}\}\}\}$
  - argument sharing is required (*still can't violate molecule θ-limits*)
  - uses **FormSet** (**SBO**)
  - (*unpublished*) joint work with J. Ginsburg, H. Terada & M. Matsumoto

Clausal domain: *molecules*

- Form clausal molecules (Merge):
  - *A train arrived / There arrived a train*
  - *Did a train arrive*? yes-no Q
  - *Did there arrive a train*?
  - *What arrived*? *wh*-Q



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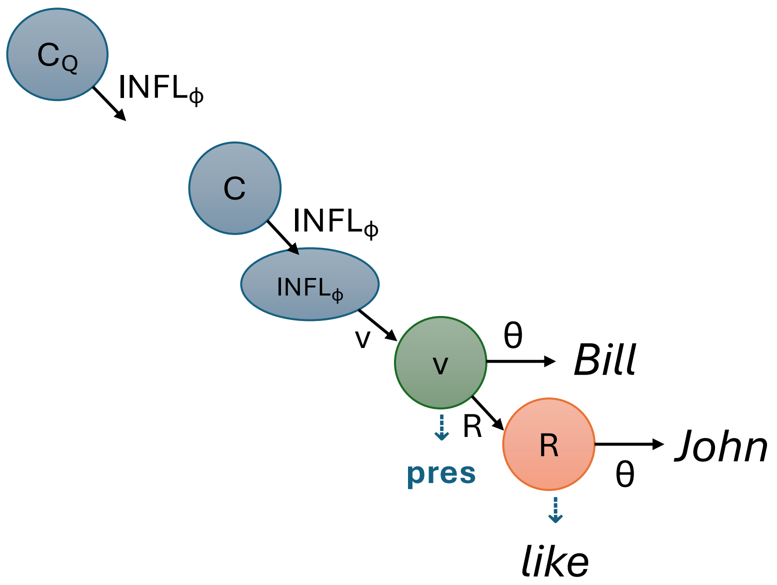
  - *Bill likes John*
    - {C, {$INFL_{\phi}$, {Bill, {$v_{R:\theta}$, {R_{θ}, John}}}}}



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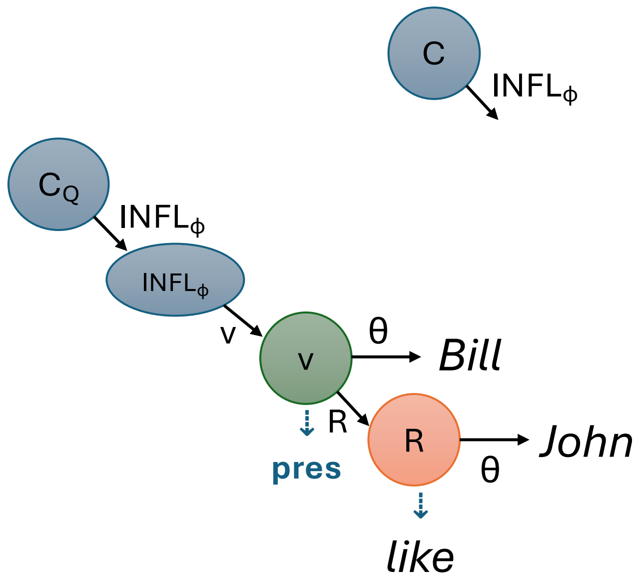

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  - *Did Bill like John*? yes-no Q
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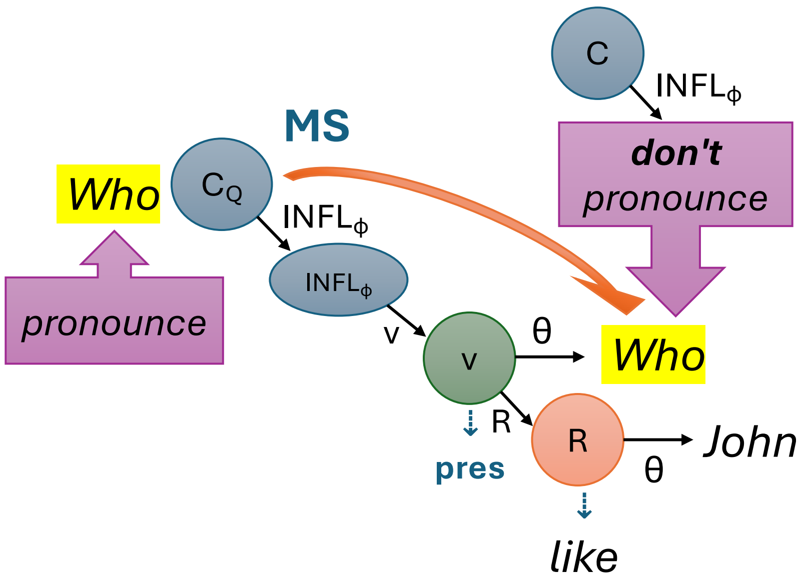
  - *Who likes John*?
    - {C$_Q$, {INFL$_\phi$, {who, {v$_{R:\theta}$, {R$_\theta$, John}}}}}



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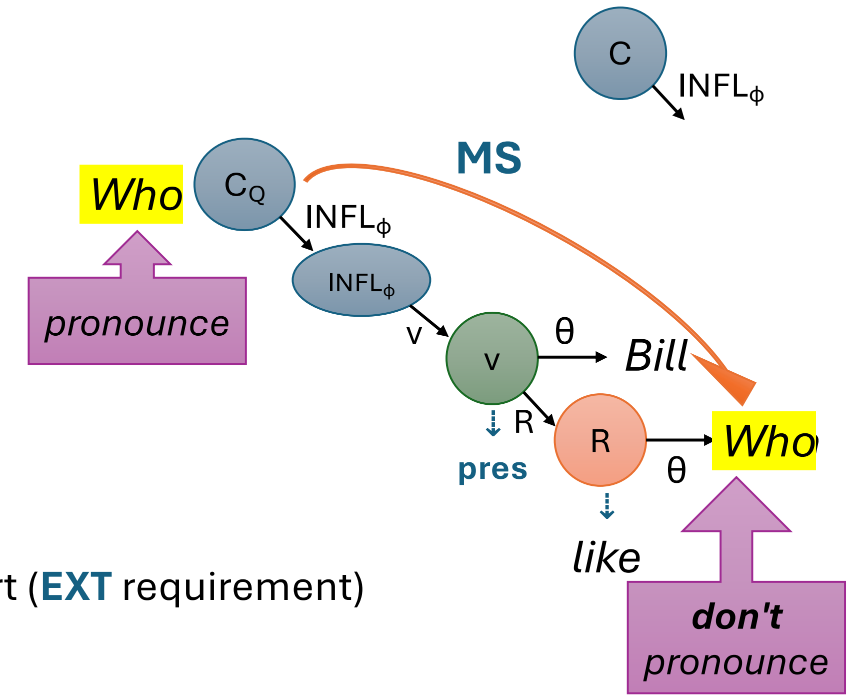
  - *Who **did** Bill like?* *do*-support (**EXT** requirement)
    - $\{C_Q, \{INFL_\phi, \{Bill, \{v_{R:\theta}, \{R_\theta, who\}\}\}\}\}$



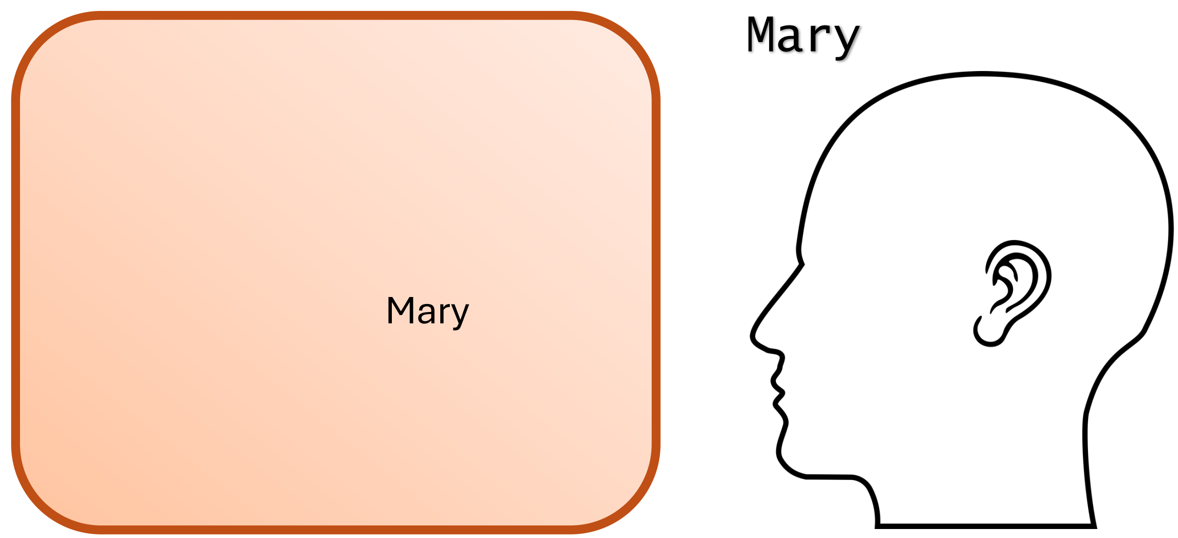
SMT: *Strong Minimalist Thesis*

Outline:

- **Introduction**: atoms and molecules of syntax
- **SMT Parser**: system architecture
- **Theory and Computation Model**: some highlights
- **SMT**: motivating optimal simplicity

Parser Model: *view* #1

- Workspace (**WS**):
  - **SBO** space
  - atoms inserted from **LEX**



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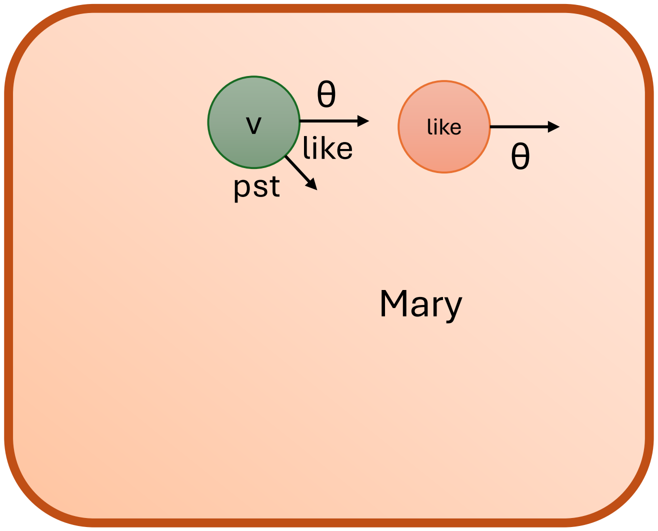

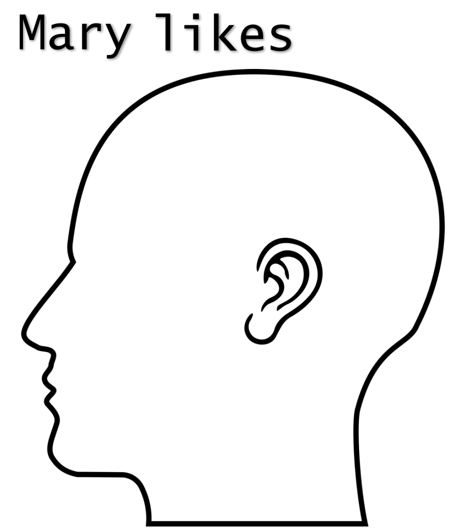

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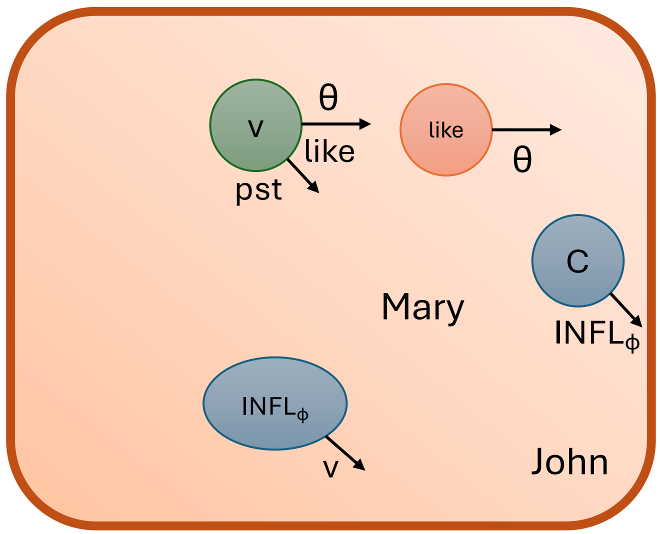

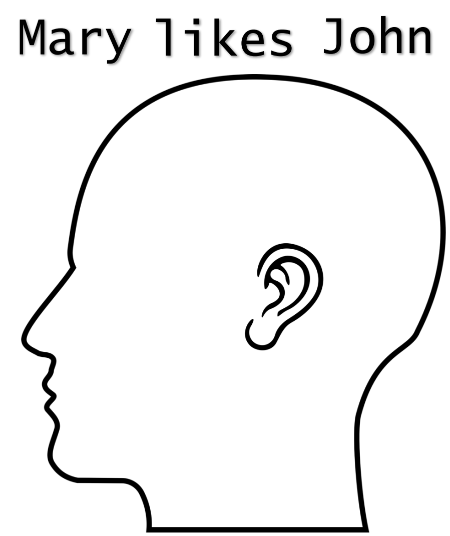

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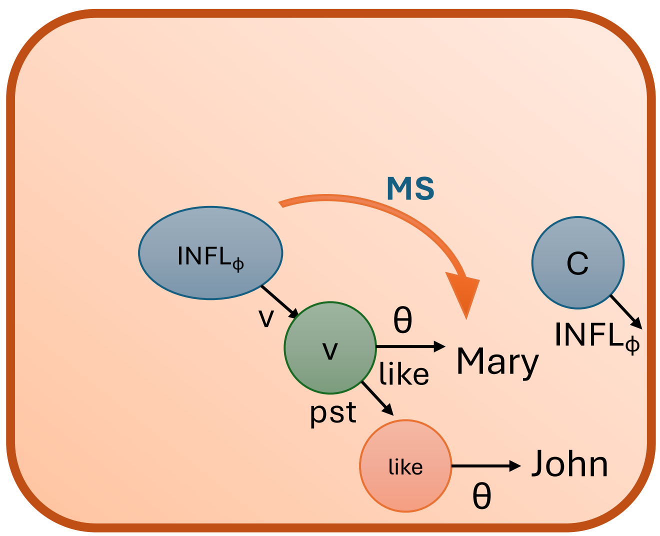

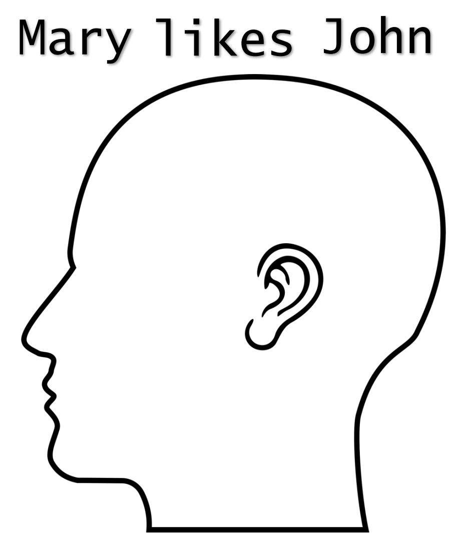

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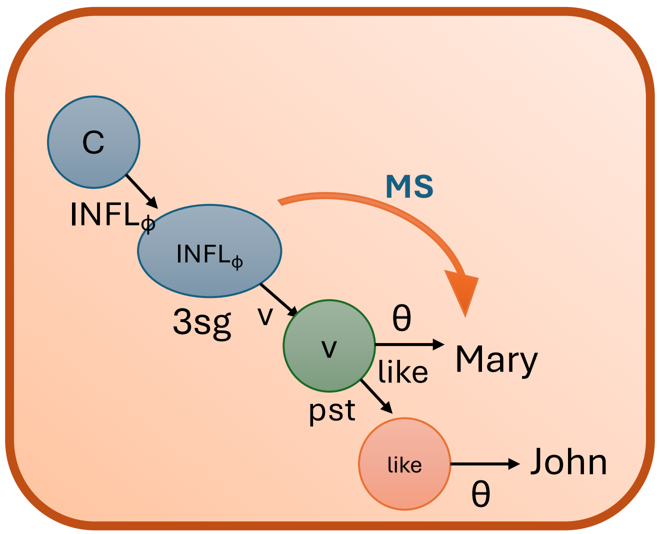
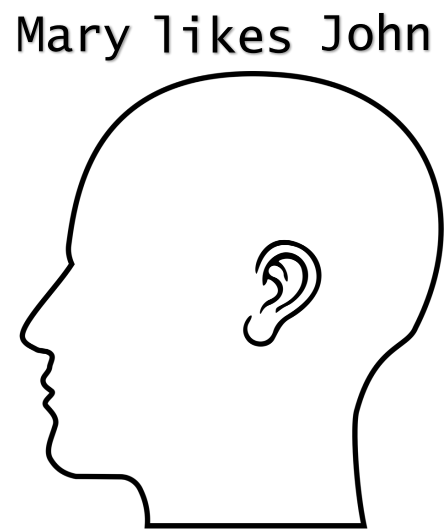
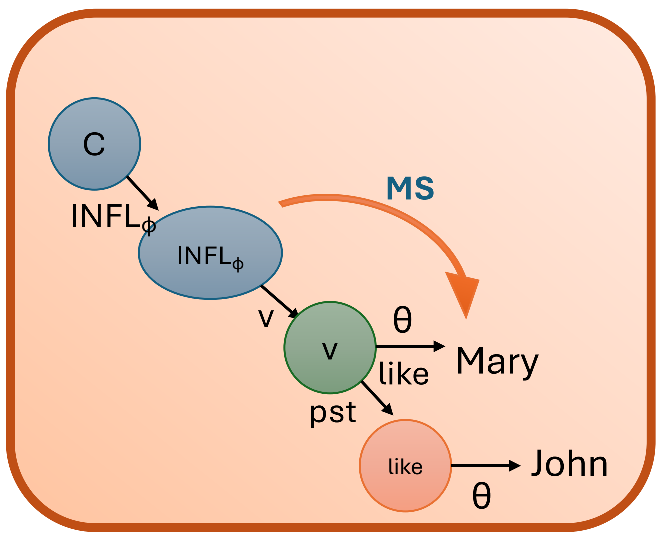


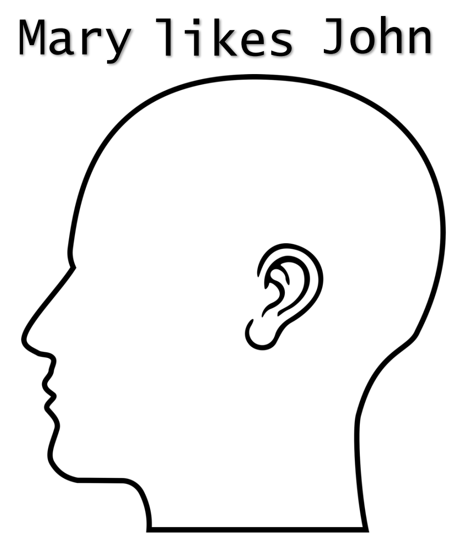


Parser Model: *view* #1

- Workspace (**WS**):
  - **SBO** space
  - atoms inserted from **LEX**
  - **Merge** fires! builds molecules



EXT: Mary 3sg pst like John



Parser Model: *view* #1

- Workspace (**WS**):
  - **SBO** space
  - atoms inserted from **LEX**
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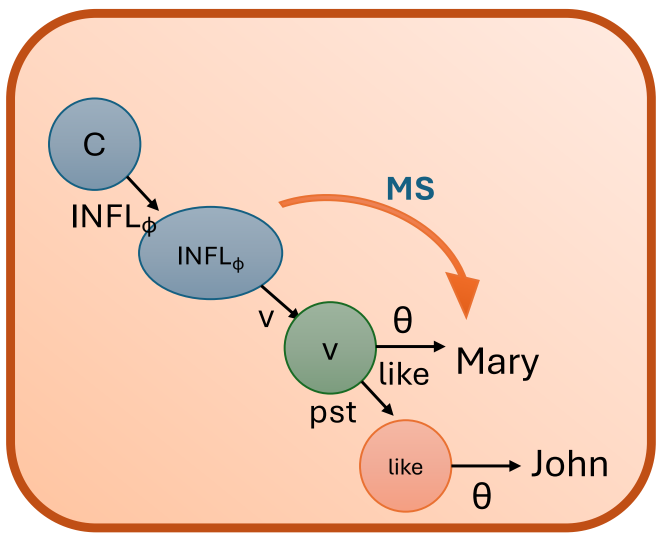
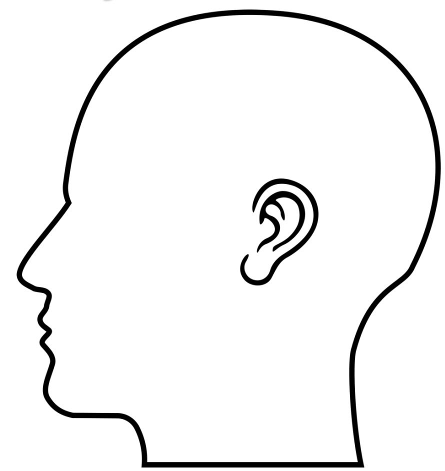


EXT: Mary $\boxed{\text{3sg pst like}}$ John

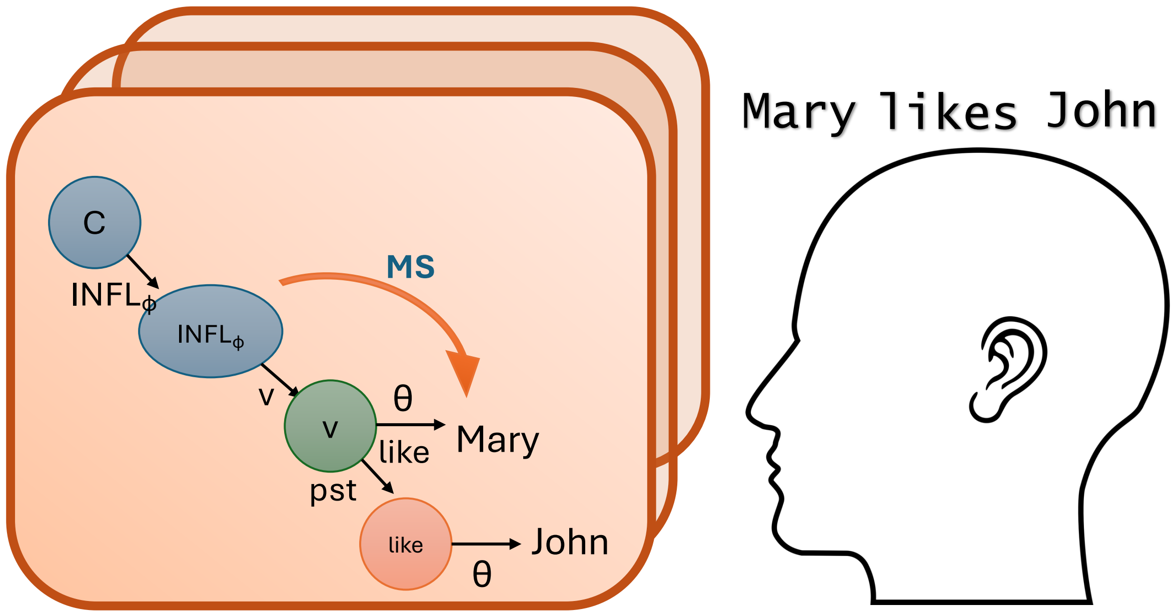
Amalgamation: *likes*

Mary likes John



Parser Model: *view* #1

- Workspace (**WS**):
  - **SBO** space
  - atoms inserted from **LEX**
  - **Merge** fires! builds molecules
- **LEX** ambiguity = multiple **WS**s (*no sharing*)
  - *who*: *wh*-noun vs. relative pronoun
  - *man*: noun vs. verb



EXT: Mary $\boxed{\text{3sg pst like}}$ John

Amalgamation: *likes*

Parser Architecture: *view* #2

- Process view:

Words
(*a sequence*)

LEX
lookup
+
linear
processing

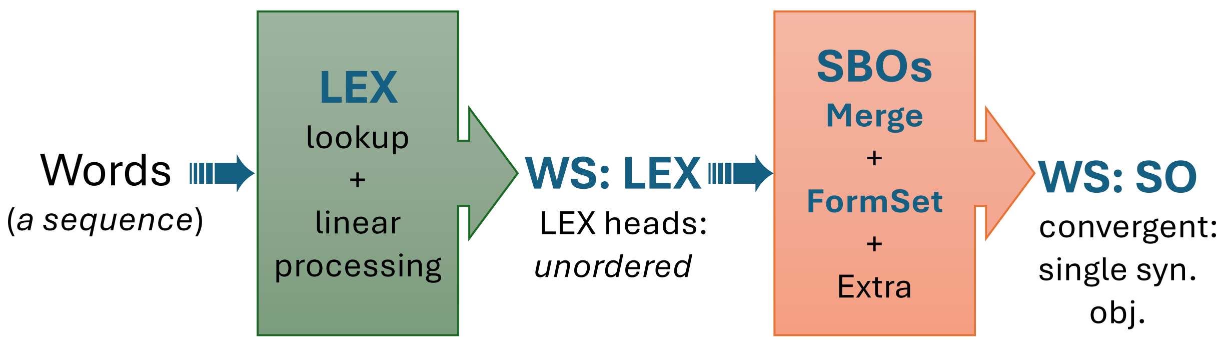
WS: LEX
LEX heads:
unordered

colorless
green ideas
sleep
furiously

furiously$_{v}$
sleep$_{\emptyset}$
v$_{sleep:\theta:pres}$
INFL$_{v}$ ideas
green$_{\theta}$
colorless$_{\theta}$

Parser Architecture: *view* #2

- Process view:



colorless
green ideas
sleep
furiously

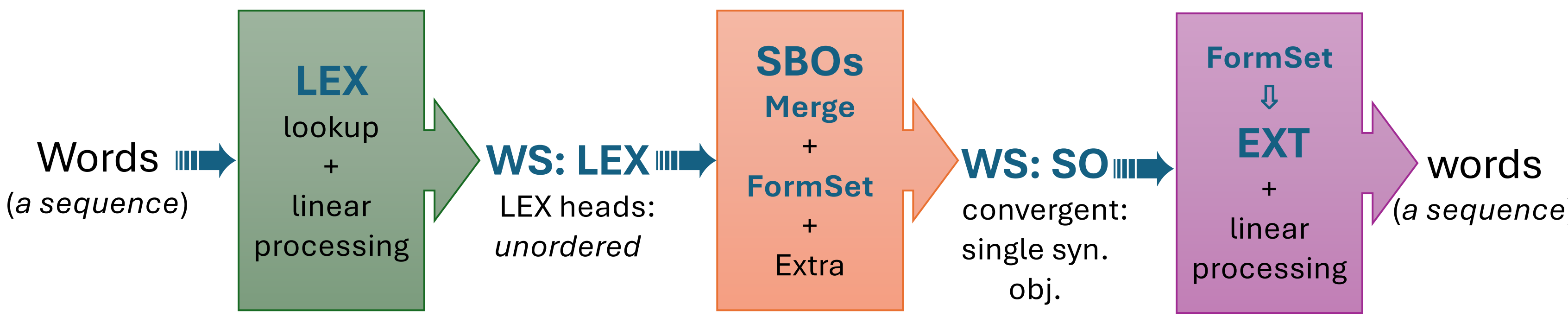
furiously$_v$
sleep$_ø$
v$_{sleep:\theta:pres}$
INFL$_v$ ideas
green$_\theta$
colorless$_\theta$

{C, {INFL$_v$, {furiously$_v$, {{ideas, **{**{green$_\theta$, ideas},
{colorless$_\theta$, ideas}**}**}, {v$_{sleep:\theta:pres}$, sleep$_ø$}}}}}

an old example: **{…}**
FormSet analysis

Parser Architecture: *view* #2

- Process view:



colorless
green ideas
sleep
furiously

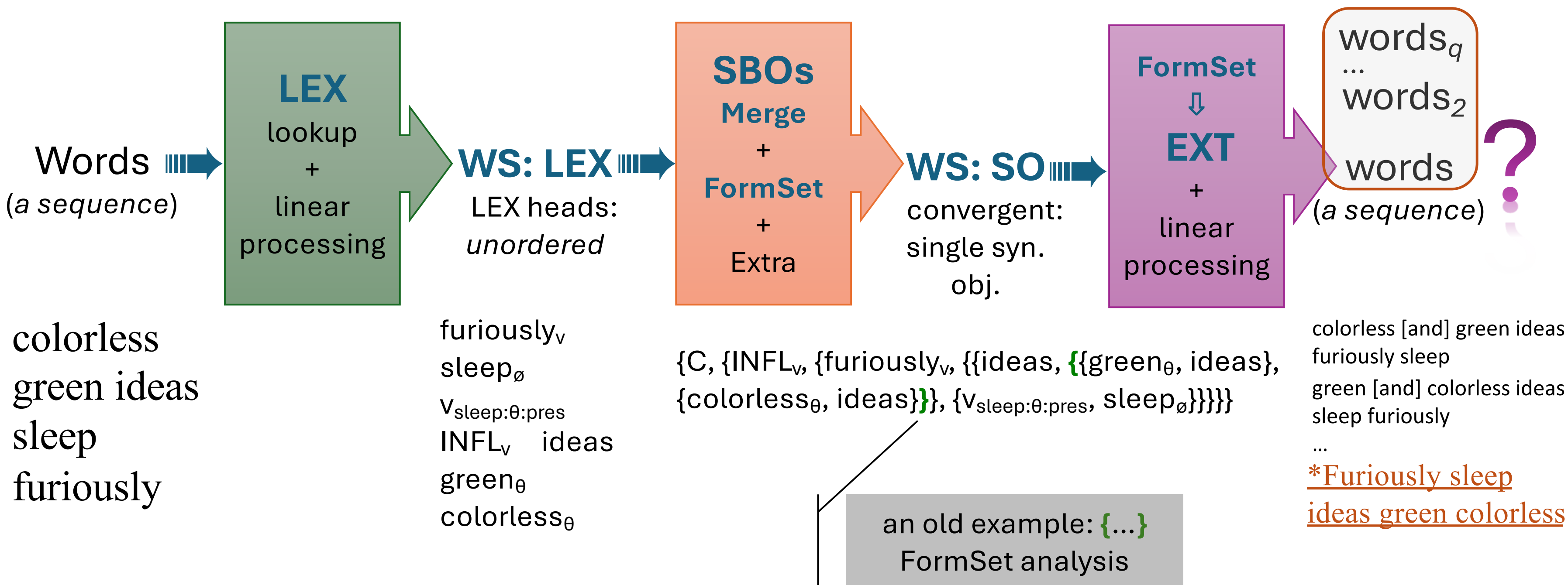
furiously$_{v}$
sleep$_{ø}$
$v_{sleep:θ:pres}$
INFL$_{v}$ ideas
green$_{θ}$
colorless$_{θ}$

{C, {INFL$_{v}$, {furiously$_{v}$, {{ideas, {{green$_{θ}$, ideas}, {colorless$_{θ}$, ideas}}}, {$v_{sleep:θ:pres}$, sleep$_{ø}$}}}}}

an old example: {…}
FormSet analysis

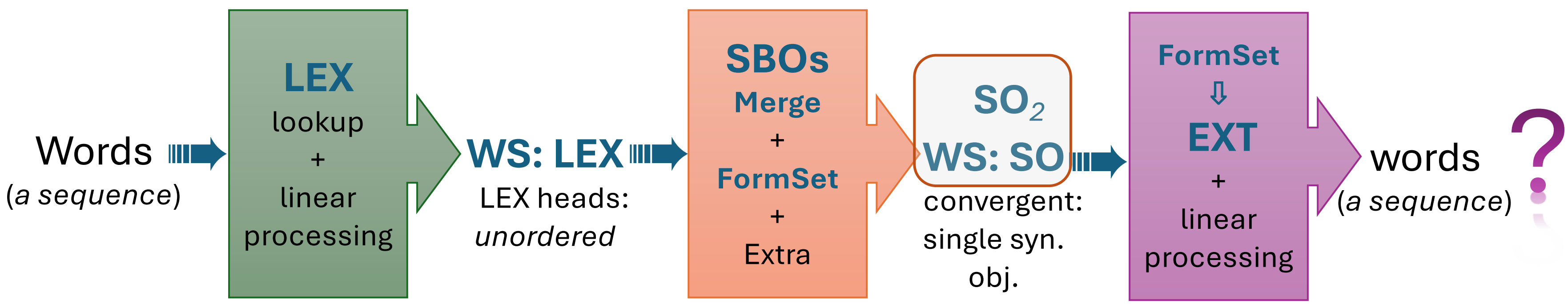
Parser Architecture: *view* #2

- Process view:



Parser Architecture: *view* #2

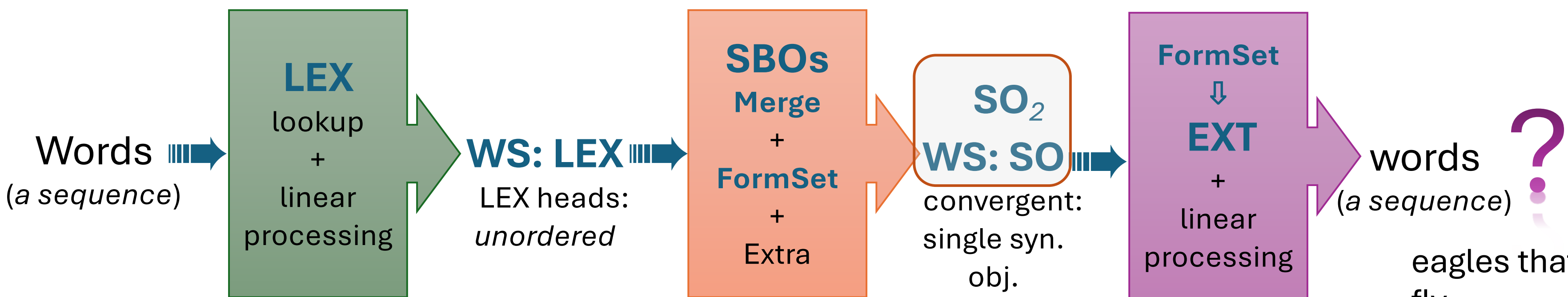
- Process view:



eagles that fly
instinctively
swim

Parser Architecture: *view* #2

- Process view:



eagles that fly
instinctively
swim

swim$_{ø}$
v$_{swim:θ:pres}$ INFL$_{v}$
instinctively$_{v}$
fly$_{ø}$ v$_{fly:θ:pres}$
INFL$_{v}$ C$_{rel:that}$
eagles

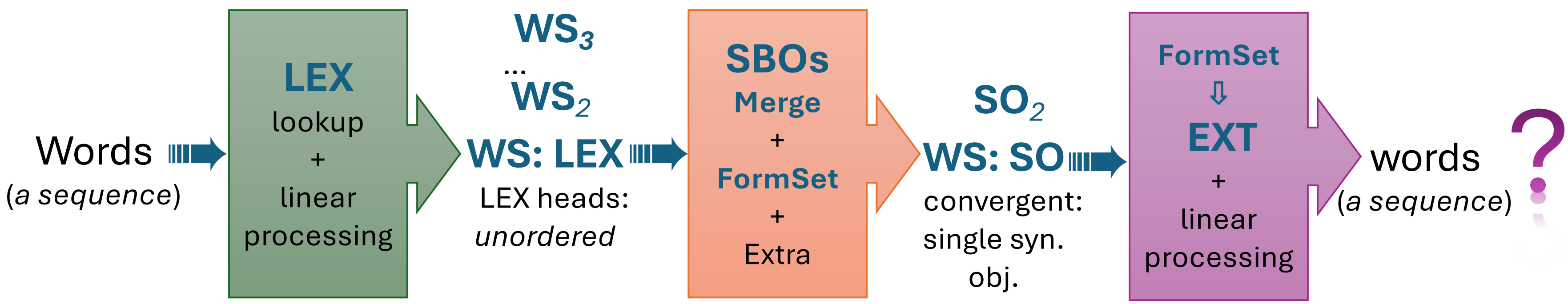
{C, {INFL$_{v}$, {{eagles, {C$_{rel:that}$, {INFL$_{v}$, {***instinctively***$_{v}$, {eagles, {v$_{fly:θ:pres}$, fly$_{ø}$}}}}}}, {v$_{swim:θ:pres}$, swim$_{ø}$}}}}

{C, {INFL$_{v}$, {***instinctively***$_{v}$, {{eagles, {C$_{rel:that}$, {INFL$_{v}$, {eagles, {v$_{fly:θ:pres}$, fly$_{ø}$}}}}}, {v$_{swim:θ:pres}$, swim$_{ø}$}}}}}

eagles that
fly
instinctively
swim

Parser Architecture: *view* #2

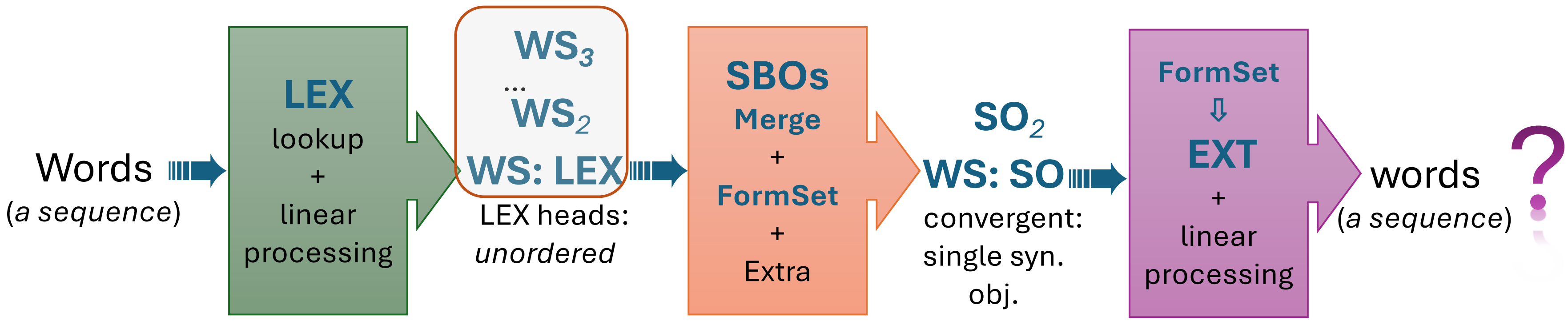
- Process view:



they are
flying
planes

Parser Architecture: *view* #2

- Process view:



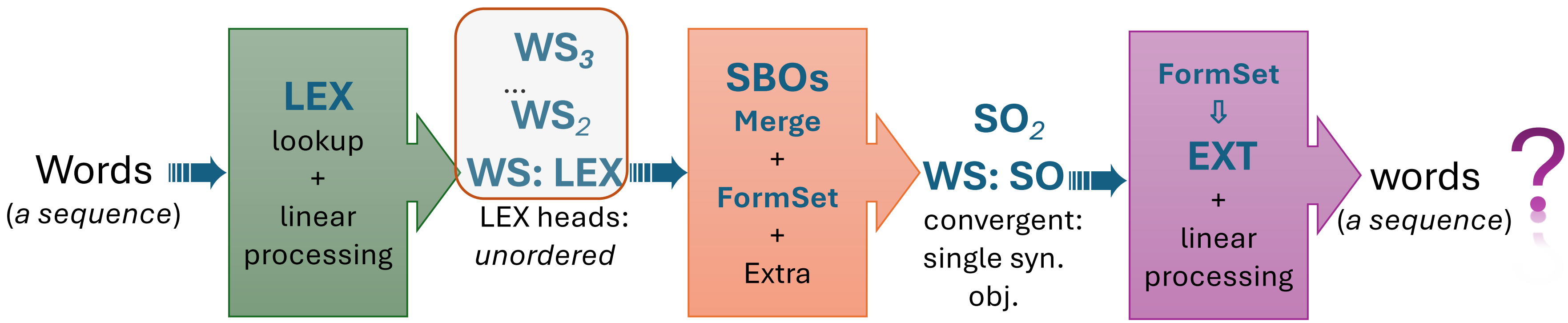
they are flying planes

planes fly$_{\theta:presp}$ v$_{fly:\theta}$ v$_{v:prog:pres}$ INFL$_{v:pl}$ they

planes flying$_{\theta}$ be$_{\theta}$ v$_{be:\theta:pres}$ INFL$_{v:pl}$ they

Parser Architecture: *view* #2

- Process view:



they are flying planes

planes $\text{fly}_{\theta:\text{presp}}$ $v_{\text{fly}:\theta}$ $v_{\text{v:prog:pres}}$ $\text{INFL}_{\text{v:pl}}$ they

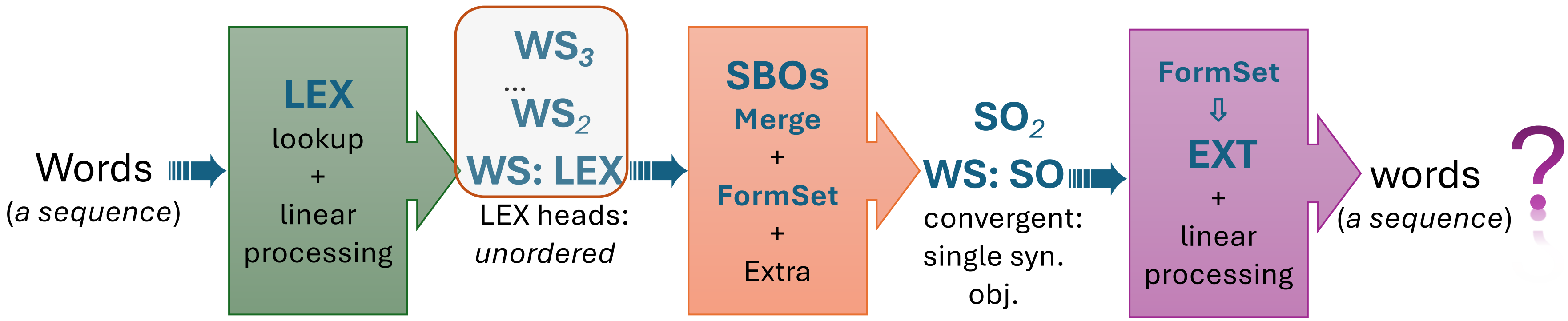
planes flying_{θ} be_{θ} $v_{\text{be}:\theta:\text{pres}}$ $\text{INFL}_{\text{v:pl}}$ they

{C, {$\text{INFL}_{\text{v:pl}}$, {$v_{\text{v:prog:pres}}$, {they, {$v_{\text{fly}:\theta}$, {$\text{fly}_{\theta:\text{presp}}$, planes}}}}}}

{C, {$\text{INFL}_{\text{v:pl}}$, {they, {$v_{\text{be}:\theta:\text{pres}}$, {$\text{be}_{\theta}$, {planes, {$\text{flying}_{\theta}$, planes}}}}}}}

Parser Architecture: *view* #2

- Process view:



they are flying planes

planes $\text{fly}_{\theta:\text{presp}}$ $v_{\text{fly}:\theta}$ $v_{\text{v:prog:pres}}$ $\text{INFL}_{\text{v:pl}}$ they

planes flying_{θ} be_{θ} $v_{\text{be}:\theta:\text{pres}}$ $\text{INFL}_{\text{v:pl}}$ they

$\{C, \{\text{INFL}_{\text{v:pl}}, \{v_{\text{v:prog:pres}}, \{\text{they}, \{v_{\text{fly}:\theta}, \{\text{fly}_{\theta:\text{presp}}, \text{planes}\}\}\}\}\}$

$\{C, \{\text{INFL}_{\text{v:pl}}, \{\text{they}, \{v_{\text{be}:\theta:\text{pres}}, \{\text{be}_{\theta}, \{\text{planes}, \{\text{flying}_{\theta}, \text{planes}\}\}\}\}\}\}$

$\Uparrow$

planes $\text{fly}_{ø:\text{presp}}$ $v_{\text{fly}:\theta}$ $v_{\text{v:prog:pres}}$ $\text{INFL}_{\text{v:pl}}$ they

Parser Architecture: *view* #2

Chomsky (1955/1975), *LSLT*

The grammar must generate a set of grammatical sentences on the basis of a limited corpus: Is it correct to identify "grammaticalness" with "significance"? I think that it is not. If we take "meaningfulness" or "significance" seriously, I think we must admit that

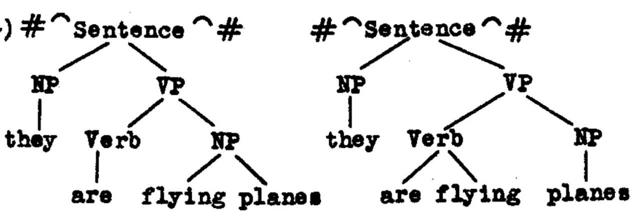
2 *colorless green ideas sleep furiously*

is thoroughly meaningless and nonsignificant, but it seems to me that as a speaker of English, I would regard this as a "grammatical" sentence,

Chomsky (1956), *3 models*

equivalent derivations of the sentence "they are flying planes", reducing to the diagrams:

(24)



Hence this sentence will have two phrase structures assigned to it; it can be analyzed as

Chomsky (2013), *POP*

One early puzzle, still alive, has to do with a simple but curious fact, never recognized to be
it is. Consider the sentences (6):

(6) (a) can eagles that fly swim?
(b) instinctively, eagles that fly swim

In (b), the adverb is associated with *swim*, not *fly*. Similarly, in (a), the question is about abilit
cases, that is clear from the interpretation, and is also shown by morphology, e.g., (7) but n

(7) are eagles that fly swimming?

(8) *are eagles that swimming fly"

Sentence (8) does not ask whether it is the case that eagles that are swimming fly. As i
interpretations of (6a,b), that is a fine thought, but it cannot be expressed by (8). Something ab

SMT: *Strong Minimalist Thesis*

Outline:

- **Introduction**: atoms and molecules of syntax
- **SMT Parser**: system architecture
- **SMT Theory and Computation Model**: some highlights
- **SMT**: motivating optimal simplicity

SMT Theory Highlights

Three examples:

- **M-gap:** subject control example
- **FormSet**: unbounded, unstructured coordination example
- **Raising to Object**: *expect* vs. *persuade*

Markovian Gap (**M-gap**)

Chomsky (2021), GK pg.21

Copies can be assigned a θ-role only once, but inscriptions with distinct θ-roles can be copies. That possibility is exemplified. Take the sentence form (7):

(7) John tried [X to win]

Suppose X is *John*. In this case, X can delete, unlike *John saw John*. The difference is that there is no Θ-Theory violation. There are two θ-assigners, *try* and *win*.

Application of IM to form (7) would violate Duality of Semantics, but there is no barrier to FC. Hence the <*John*, *John*> pair is an M-gap.

To spell it out more fully, for expository convenience, suppose there is an operation *Interpretation* (INT), which surveys the current stage of derivation — that is, the Workspace — and decides what can be done next. Viewing the Workspace, INT can detect the kind of structure created by IM — call it an "IM-configuration" — but lacking access to history, it doesn't know how it was constructed. INT does however know that identical inscriptions <P, Q> in an IM-configuration can be assigned the Copy relation by FC, which differs from IM only in that it is unaware of LSCs. What INT does not know is whether <P, Q> was formed by IM or is an M-gap.

The two occurrences of *John* in (7) are assigned θ-roles independently, so the IM-configuration could not have been formed by IM, which is bound by Duality of Semantics. Therefore the IM-configuration must be an M-gap. In this case M-gaps yield obligatory control — a module enabled by SMT and LSCs (specifically Duality of Semantics).[32]

SMT therefore captures Norbert Hornstein's important insight about similarity of raising and control; similarity, but not identity, because there are two kinds of IM-configurations, one derived from Merge and the other from FC: trace and PRO in traditional terms; I'll keep the terms for expository convenience. INT cannot distinguish them, but other operations can, and do. They differ in many ways.

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Chomsky (2021), **GK** pg.21

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Markovian Gap (**M-gap**)

Words: John tried to win

▼ **Initial WS 1:** $\boxed{\text{win}_{\emptyset} \quad \text{v}_{\text{win:}\theta\text{:nonf:to}} \quad \text{try}_{\text{V}} \quad \text{v}_{\text{try:}\theta\text{:pst}} \quad \text{INFL}_{\text{V}} \quad \text{John}}$

▼ **WS 1:** $\{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V} John

WS 2: $\{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 3: $\{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}$ $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 4: $\{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}$ INFL_{V}

WS 5: $\{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}$ INFL_{V}

WS 6: $\{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}$

Final WS: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

INT/EXT: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

EXT: John 3sg pst try to win

Spellout: John tried to win

Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

θ-configuration

Words: John tried to win

▼ **Initial WS 1:** $\mathrm{win}_{\emptyset}$ $v_{\mathrm{win:\theta:nonf:to}}$ try_{v} $v_{\mathrm{try:\theta:pst}}$ INFL_{v} John

▼ **WS 1:** $\{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}$ try_{v} $v_{\mathrm{try:\theta:pst}}$ INFL_{v} John

WS 2: $\boxed{\{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}}$ $\boxed{\mathrm{try}_{v}\ \ v_{\mathrm{try:\theta:pst}}\ \ \mathrm{INFL}_{v}}$

WS 3: $\{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}$ $v_{\mathrm{try:\theta:pst}}$ INFL_{v}

WS 4: $\{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}$ INFL_{v}

WS 5: $\{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}$ INFL_{v}

WS 6: $\{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}$

Final WS: $\{C, \{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}$

INT/EXT: $\{C, \{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}$

EXT: John 3sg pst try to win

Spellout: John tried to win

Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

Words: John tried to win
▼ **Initial WS 1:** $\mathrm{win}_{\emptyset}$ $v_{\mathrm{win:\theta:nonf:to}}$ try_{v} $v_{\mathrm{try:\theta:pst}}$ INFL_{v} John
▼ **WS 1:** $\{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}$ try_{v} $v_{\mathrm{try:\theta:pst}}$ INFL_{v} John
WS 2: $\{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}$ try_{v} $v_{\mathrm{try:\theta:pst}}$ INFL_{v}
WS 3: $\boxed{\{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}}$ $\boxed{v_{\mathrm{try:\theta:pst}} \quad \mathrm{INFL}_{v}}$
WS 4: $\{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}$ INFL_{v}
WS 5: $\{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}$ INFL_{v}
WS 6: $\{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}$
Final WS: $\{C, \{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}$
INT/EXT: $\{C, \{\mathrm{INFL}_{v}, \{\mathrm{John}, \{v_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{v}, \{\mathrm{John}, \{v_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}$
EXT: John 3sg pst try to win
Spellout: John tried to win
Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

Words: John tried to win

▼ **Initial WS 1:** $\text{win}_{\emptyset}$ $\text{v}_{\text{win:}\theta\text{:nonf:to}}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V} John

▼ **WS 1:** $\{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V} John

WS 2: $\{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 3: $\{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}$ $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 4: $\boxed{\{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}}$ INFL_{V}

WS 5: $\{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}$ INFL_{V}

WS 6: $\{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}$

Final WS: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

INT/EXT: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

EXT: John 3sg pst try to win

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Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

Words: John tried to win

▼ **Initial WS 1:** $\text{win}_{\emptyset}$ $\text{v}_{\text{win:}\theta\text{:nonf:to}}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V} John

▼ **WS 1:** $\{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V} John

WS 2: $\{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}$ try_{V} $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 3: $\{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}$ $\text{v}_{\text{try:}\theta\text{:pst}}$ INFL_{V}

WS 4: $\boxed{\{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}}$ INFL_{V}

WS 5: $\boxed{\{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}}$ INFL_{V}

θ-theory: SMT parser operation

WS 6: $\{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}$

Final WS: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

INT/EXT: $\{\text{C}, \{\text{INFL}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{try:}\theta\text{:pst}}, \{\text{try}_{\text{V}}, \{\text{John}, \{\text{v}_{\text{win:}\theta\text{:nonf:to}}, \text{win}_{\emptyset}\}\}\}\}\}\}\}$

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Spellout: John tried to win

Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

- This means **perception** provides an *incomplete* **WS**
- To satisfy θ-theory, we need this SMT parser operation

Words: John tried to win

▼ **Initial WS 1:** $\mathrm{win}_{\emptyset}$ $\mathrm{v}_{\mathrm{win:\theta:nonf:to}}$ $\mathrm{try}_{\mathrm{V}}$ $\mathrm{v}_{\mathrm{try:\theta:pst}}$ $\mathrm{INFL}_{\mathrm{V}}$ John

▼ **WS 1:** $\{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}$ $\mathrm{try}_{\mathrm{V}}$ $\mathrm{v}_{\mathrm{try:\theta:pst}}$ $\mathrm{INFL}_{\mathrm{V}}$ John

WS 2: $\{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}$ $\mathrm{try}_{\mathrm{V}}$ $\mathrm{v}_{\mathrm{try:\theta:pst}}$ $\mathrm{INFL}_{\mathrm{V}}$

WS 3: $\{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}$ $\mathrm{v}_{\mathrm{try:\theta:pst}}$ $\mathrm{INFL}_{\mathrm{V}}$

WS 4: $\{\mathrm{v}_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}$ $\mathrm{INFL}_{\mathrm{V}}$

θ-theory: SMT parser operation

WS 5: $\{\mathrm{John}, \{\mathrm{v}_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}$ $\mathrm{INFL}_{\mathrm{V}}$

WS 6: $\{\mathrm{INFL}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}$

Final WS: $\{\mathrm{C}, \{\mathrm{INFL}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}$

INT/EXT: $\boxed{\{\mathrm{C}, \{\mathrm{INFL}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{try:\theta:pst}}, \{\mathrm{try}_{\mathrm{V}}, \{\mathrm{John}, \{\mathrm{v}_{\mathrm{win:\theta:nonf:to}}, \mathrm{win}_{\emptyset}\}\}\}\}\}\}\}}$

post-Merge operation
FormCopy

EXT: John 3sg pst try to win

Spellout: John tried to win

Parse found: John 3sg pst try to win

Markovian Gap (**M-gap**)

- This means **perception** provides an *incomplete* **WS**
- To satisfy θ-theory, we need this SMT parser operation

Words: John tried to win

Chomsky (2021) **GK**, fn.12

[12] The most serious cases involve deletion of copies in accord with computational efficiency, leading to some of the hardest parsing problems. But there are many others.

WS 2: {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}} try_V $v_{try:\theta:pst}$ $INFL_V$

WS 3: {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}} $v_{try:\theta:pst}$ $INFL_V$

WS 4: {$v_{try:\theta:pst}$, {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}}} $INFL_V$

WS 5: {John, {$v_{try:\theta:pst}$, {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}}}} $INFL_V$

WS 6: {$INFL_V$, {John, {$v_{try:\theta:pst}$, {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}}}}}

Final WS: {C, {$INFL_V$, {John, {$v_{try:\theta:pst}$, {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}}}}}}

θ-theory: SMT parser operation

INT/EXT: {C, {$INFL_V$, {John, {$v_{try:\theta:pst}$, {try_V, {John, {$v_{win:\theta:nonf:to}$, $win_{ø}$}}}}}}}

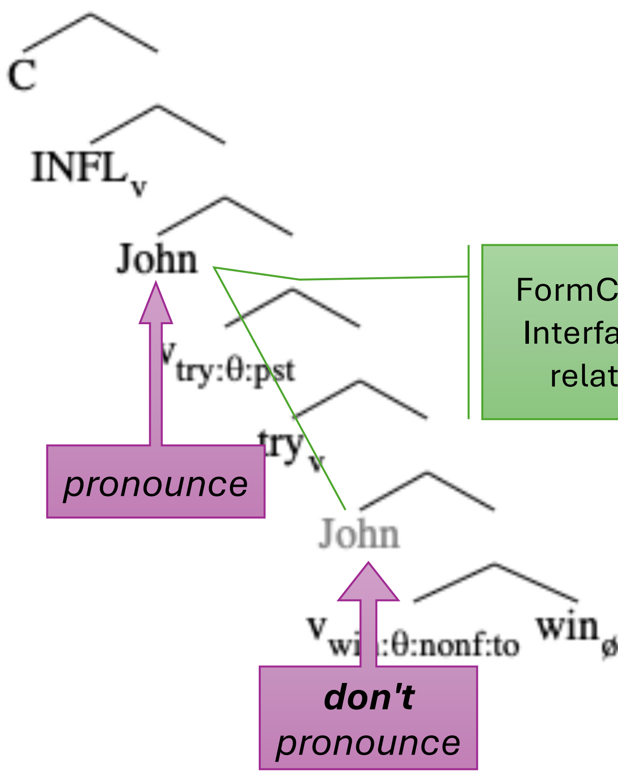
EXT: John 3sg pst try to win

Spellout: John tried to win

Parse found: John 3sg pst try to win

post-Merge operation **FormCopy**

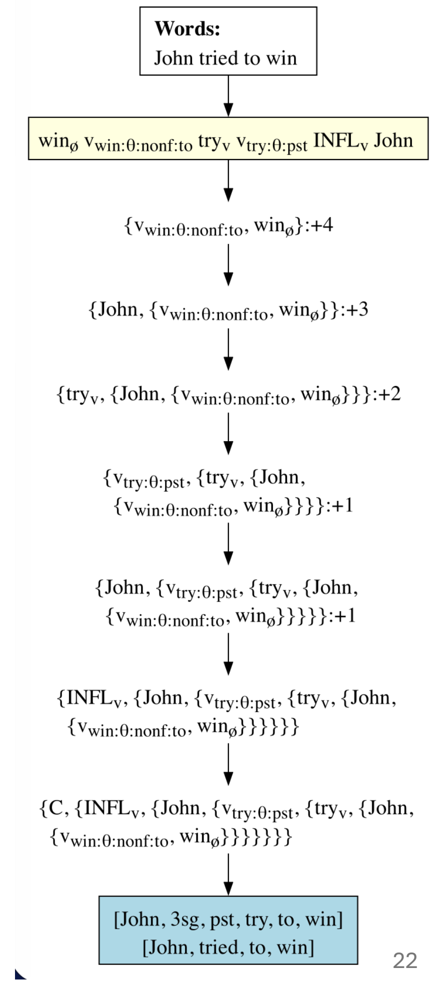
Markovian Gap (**M-gap**)



FormCopy computed @ Interface: **c-command** relation (John, John)

Computation:

Merge *taken a step at a time*



Unbounded, Unstructured Coordination (**UUS**)

Chomsky (2021) **GK**, p33

With this much background, consider one of the more complex sequences, pairing unaccusative and transitive, keeping to essentials:

(39) John arrived and met Bill.

The first step is to form the two independent objects $\{_1\ v, \{\textit{arrive, John}_1\}\}$ and $\{_2\ \textit{John}_2, \{v^*, \{\textit{meet, Bill}\}\}\}$ of (40a) (*John arrived* and *John met Bill*) in the normal way, satisfying Θ-Theory. The next step is to construct the *set* (40b):

(40) a. $\{_1\ v, \{\text{arrive, John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet, Bill}\}\}\}$
b. $\{\{_1\ v, \{\text{arrive, John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet, Bill}\}\}\}\}$

I am adopting here the Borer–Marantz root-categorizer analysis, so that *arrive* and *meet* are roots interpreted as verbal with the categorizer *v*. The *v/v** and phasal distinction is determined by the lexical content of the root, with no need to postulate different categorizers. I will distinguish them only for expository convenience.

Application of Merge, introducing & and INFL, yields (41):

(41) $\text{INFL}, \{\&, \{\{_1\ v, \{\text{arrive, John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet, Bill}\}\}\}\}\}$

Since we so far have only sets, extraction is possible, so either of the occurrences of *John* can be raised to SPEC–INFL, yielding (42), which is converted to (43) by merging C and then applying FSQ:[51]

(42) $\text{John}_3, \{\text{INFL}, \{\&, \{\{_1\ v, \{\text{arrive, John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet, Bill}\}\}\}\}\}\}$
(43) $\text{C}, \{\text{John}_3, \{\text{INFL}, \langle \&, \{_1\ v, \{\text{arrive, John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet, Bill}\}\}\} \rangle\}\}$

Either *John*$_1$ or *John*$_2$ can raise by IM to the position of *John*$_3$. The one that does not raise is determined by FC to be a copy of *John*$_3$. INT cannot determine which one raised. But it doesn't matter. The choice doesn't affect later operations: there is no indeterminacy. There is also no ambiguity: the interfaces are not affected. Whichever choice is taken, what reaches CI and SM is the same.

Unbounded, Unstructured Coordination (**UUS**)

Chomsky (2021) **GK**, p33

With this much background, consider one of the more complex sequences, pairing unaccusative and transitive, keeping to essentials:

(39) John arrived and met Bill.

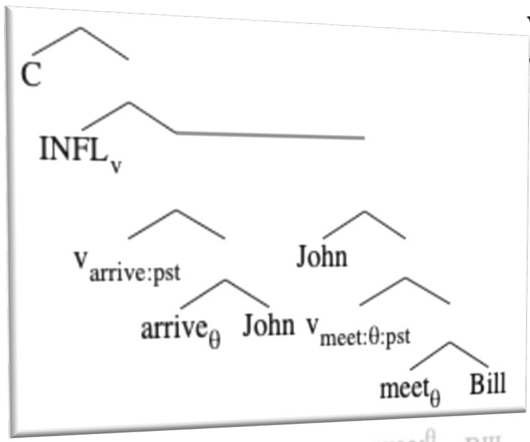
The first step is to form the two independent objects $\{_1\ v, \{arrive, John_1\}\}$ and $\{_2\ John_2, \{v^*, \{meet, Bill\}\}\}$ of (40a) (*John arrived* and *John met Bill*) in the normal way, satisfying Θ-Theory. The next step is to construct the *set* (40b):

(40) a. $\{_1\ v, \{\text{arrive}, \text{John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet}, \text{Bill}\}\}\}$
b. $\{\{_1\ v, \{\text{arrive}, \text{John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet}, \text{Bill}\}\}\}\}$

(43) $\text{C}, \{\text{John}_3, \{\text{INFL}, <\&, \{_1\ v, \{\text{arrive}, \text{John}_1\}\}, \{_2\ \text{John}_2, \{v^*, \{\text{meet}, \text{Bill}\}\}\}>\}\}$

Either *John*$_1$ or *John*$_2$ can raise by IM to the position of *John*$_3$. The one that does not raise is determined by FC to be a copy of *John*$_3$. INT cannot determine which one raised. But it doesn't matter. The choice doesn't affect later operations: there is no indeterminacy. There is also no ambiguity: the interfaces are not affected. Whichever choice is taken, what reaches CI and SM is the same.

Unbounded, Unstructured Coordination (**UUS**)



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill meet_θ $\text{v}_{\text{meet:}\theta\text{:pst}}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John

▼ **WS 1:** $\{\text{meet}_\theta, \text{Bill}\}$ $\text{v}_{\text{meet:}\theta\text{:pst}}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John

WS 2: $\{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John [gray]

WS 3: $\{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v

WS 4: $\{\text{arrive}_\theta, \text{John}\}$ $\{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}$ INFL_v $\text{v}_{\text{arrive:pst}}$ INFL_v

WS 5: $\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_\theta, \text{John}\}\}$ $\{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}$ INFL_v INFL_v

WS 6: $\{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_\theta, \text{John}\}\}, \{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}\}$ INFL_v INFL_v

WS 7: $\{\text{INFL}_\text{v}, \{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_\theta, \text{John}\}\}, \{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}\}\}$

Final WS: $\{\text{C}, \{\text{INFL}_\text{v}, \{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_\theta, \text{John}\}\}, \{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}\}\}\}$

INT/EXT: $\{\text{C}, \{\text{INFL}_\text{v}, \{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_\theta, \text{John}\}\}, \{\text{John}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_\theta, \text{Bill}\}\}\}\}\}\}$

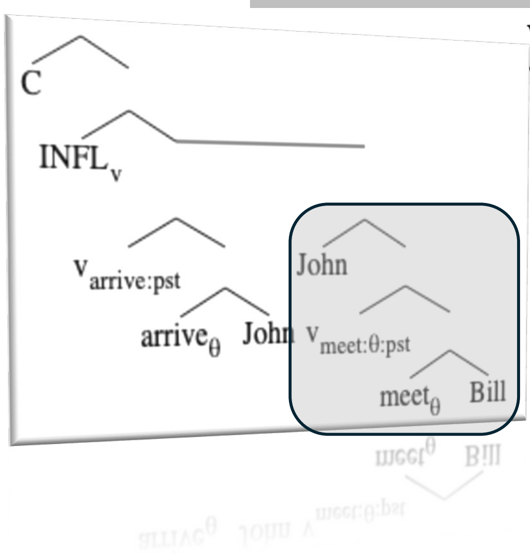
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-configuration



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill $meet_\theta$ $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

▼ **WS 1:** {$meet_\theta$, Bill} $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

WS 2: {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John [gray]

WS 3: {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$

WS 4: {$arrive_\theta$, John} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $v_{arrive:pst}$ $INFL_v$

WS 5: {$v_{arrive:pst}$, {$arrive_\theta$, John}} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $INFL_v$

WS 6: {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}} $INFL_v$ $INFL_v$

WS 7: {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}

Final WS: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

INT/EXT: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

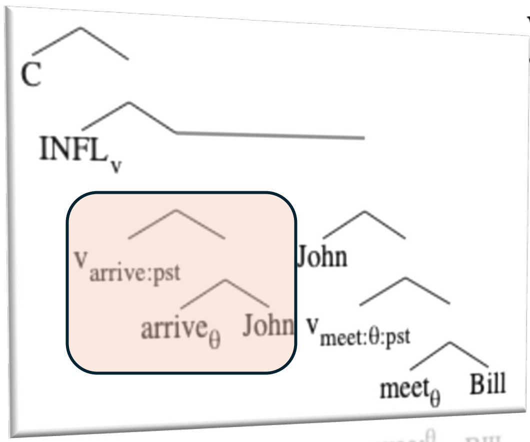
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-theory: SMT parser operation



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill meet$_\theta$ $v_{meet:\theta:pst}$ INFL$_v$ arrive$_\theta$ $v_{arrive:pst}$ INFL$_v$ John

▼ **WS 1:** {meet$_\theta$, Bill} $v_{meet:\theta:pst}$ INFL$_v$ arrive$_\theta$ $v_{arrive:pst}$ INFL$_v$ John

WS 2: {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}} INFL$_v$ arrive$_\theta$ $v_{arrive:pst}$ INFL$_v$ John [gray]

WS 3: {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}} INFL$_v$ arrive$_\theta$ $v_{arrive:pst}$ INFL$_v$

WS 4: {arrive$_\theta$, John} {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}} INFL$_v$ $v_{arrive:pst}$ INFL$_v$

WS 5: {$v_{arrive:pst}$, {arrive$_\theta$, John}} {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}} INFL$_v$ INFL$_v$

WS 6: {{$v_{arrive:pst}$, {arrive$_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}}} INFL$_v$ INFL$_v$

WS 7: {INFL$_v$, {{$v_{arrive:pst}$, {arrive$_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}}}}

Final WS: {C, {INFL$_v$, {{$v_{arrive:pst}$, {arrive$_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}}}}}

INT/EXT: {C, {INFL$_v$, {{$v_{arrive:pst}$, {arrive$_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {meet$_\theta$, Bill}}}}}}

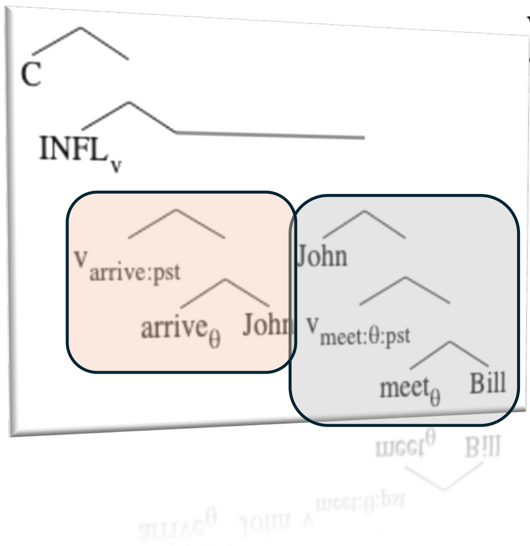
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-theory: SMT parser operation



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill $meet_\theta$ $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

▼ **WS 1:** {$meet_\theta$, Bill} $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

WS 2: {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John [gray]

WS 3: {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$

WS 4: {$arrive_\theta$, John} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $v_{arrive:pst}$ $INFL_v$

WS 5: {$v_{arrive:pst}$, {$arrive_\theta$, John}} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $INFL_v$

WS 6: {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}} $INFL_v$ $INFL_v$

WS 7: {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}

Final WS: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

INT/EXT: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

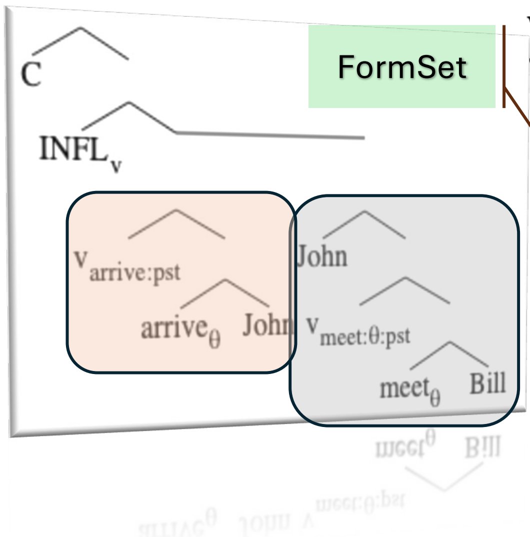
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-theory: SMT parser operation



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill $meet_\theta$ $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

▼ **WS 1:** {$meet_\theta$, Bill} $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

WS 2: {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John [gray]

WS 3: {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$

WS 4: {$arrive_\theta$, John} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $v_{arrive:pst}$ $INFL_v$

WS 5: {$v_{arrive:pst}$, {$arrive_\theta$, John}} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $INFL_v$

WS 6: {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}} $INFL_v$ $INFL_v$

WS 7: {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}

Final WS: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

INT/EXT: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

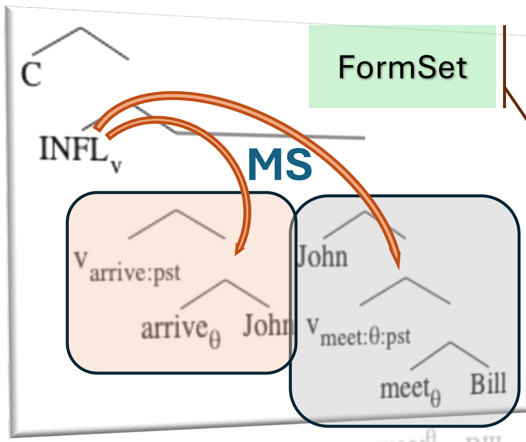
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-theory: SMT parser operation



Words: John arrived and met Bill

▼ **Initial WS 1:** Bill $meet_\theta$ $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

▼ **WS 1:** {$meet_\theta$, Bill} $v_{meet:\theta:pst}$ $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John

WS 2: {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$ John [gray]

WS 3: {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $arrive_\theta$ $v_{arrive:pst}$ $INFL_v$

WS 4: {$arrive_\theta$, John} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $v_{arrive:pst}$ $INFL_v$

WS 5: {$v_{arrive:pst}$, {$arrive_\theta$, John}} {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}} $INFL_v$ $INFL_v$

WS 6: {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}} $INFL_v$ $INFL_v$

WS 7: {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}

Final WS: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

INT/EXT: {C, {$INFL_v$, {{$v_{arrive:pst}$, {$arrive_\theta$, John}}, {John, {$v_{meet:\theta:pst}$, {$meet_\theta$, Bill}}}}}}

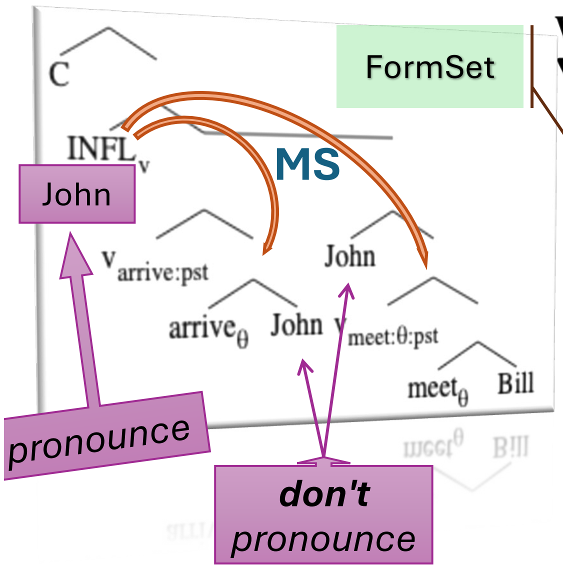
EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

θ-theory: SMT parser operation



- **Initial WS**: *an incomplete reconstruction*

Words: John arrived and met Bill

▼ **Initial WS 1:** Bill meet_θ $\text{v}_{\text{meet:}\theta\text{:pst}}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John

▼ **WS 1:** {meet_θ, Bill} $\text{v}_{\text{meet:}\theta\text{:pst}}$ INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John

WS 2: {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}} INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v John [gray]

WS 3: {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}} INFL_v arrive_θ $\text{v}_{\text{arrive:pst}}$ INFL_v

WS 4: {arrive_θ, John} {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}} INFL_v $\text{v}_{\text{arrive:pst}}$ INFL_v

WS 5: {$\text{v}_{\text{arrive:pst}}$, {$\text{arrive}_\theta$, John}} {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}} INFL_v INFL_v

WS 6: {{$\text{v}_{\text{arrive:pst}}$, {$\text{arrive}_\theta$, John}}, {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}}} INFL_v INFL_v

WS 7: {INFL_v, {{$\text{v}_{\text{arrive:pst}}$, {$\text{arrive}_\theta$, John}}, {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}}}}

Final WS: {C, {INFL_v, {{$\text{v}_{\text{arrive:pst}}$, {$\text{arrive}_\theta$, John}}, {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}}}}}

INT/EXT: {C, {INFL_v, {{$\text{v}_{\text{arrive:pst}}$, {$\text{arrive}_\theta$, John}}, {John, {$\text{v}_{\text{meet:}\theta\text{:pst}}$, {$\text{meet}_\theta$, Bill}}}}}}

EXT: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: John {[arrived],[and],[met,Bill]}

Parse found: John {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

- Incomplete reconstruction of the **WS**:
  - has desirable **3rd Factor** consequences
  - Example: **[**$_{NP}$ *The mechanic who fixed the car* **]** *arrived and met Bill*

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  - θ-theory: *build the complex NP twice and* ***EM*** *twice*
  - θ-theory **SMT parser operation** *only builds it once*!

θ-configuration

Words: the mechanic who fixed the car arrived and met Bill

Initial WS 1: Bill meet$_{\theta}$ v$_{meet:\theta:pst}$ INFL$_{v}$ arrive$_{\theta}$ v$_{arrive:pst}$ INFL$_{v}$ car$_{the}$ fix$_{\theta}$ v$_{fix:\theta:pst}$ INFL$_{v}$ C$_{rel:who}$ mechanic$_{the}$

…

WS 7: {{mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}, {v$_{meet:\theta:pst}$, {meet$_{\theta}$, Bill}}} INFL$_{v}$ arrive$_{\theta}$ v$_{arrive:pst}$ INFL$_{v}$

WS 8: {arrive$_{\theta}$, {mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}} {{mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}, {v$_{meet:\theta:pst}$, {meet$_{\theta}$, Bill}}} INFL$_{v}$ v$_{arrive:pst}$ INFL$_{v}$

…

Final WS: {C, {INFL$_{v}$, {{v$_{arrive:pst}$, {arrive$_{\theta}$, {mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}}}, {{mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}, {v$_{meet:\theta:pst}$, {meet$_{\theta}$, Bill}}}}}}

INT/EXT: {C, {INFL$_{v}$, {{v$_{arrive:pst}$, {arrive$_{\theta}$, {mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the:}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}}}, {{mechanic$_{the}$, {C$_{rel:who}$, {INFL$_{v}$, {mechanic$_{the:}$, {v$_{fix:\theta:pst}$, {fix$_{\theta}$, car$_{the}$}}}}}}, {v$_{meet:\theta:pst}$, {meet$_{\theta}$, Bill}}}}}}

EXT: the mechanic who 3sg pst fix the car {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: the mechanic who fixed the car {[arrived],[and],[met,Bill]}

Parse found: the mechanic who 3sg pst fix the car {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Unbounded, Unstructured Coordination (**UUS**)

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Words: the mechanic who fixed the car arrived and met Bill

Initial WS 1: Bill meet_{θ} $\text{v}_{\text{meet:}\theta\text{:pst}}$ INFL_{v} arrive_{θ} $\text{v}_{\text{arrive:pst}}$ INFL_{v} car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} $\text{C}_{\text{rel:who}}$ $\text{mechanic}_{\text{the}}$

…

WS 7: $\{\{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}\}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_{\theta}, \text{Bill}\}\}\}$ INFL_{v} arrive_{θ} $\text{v}_{\text{arrive:pst}}$ INFL_{v}

WS 8: $\{\text{arrive}_{\theta}, \boxed{\{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}}\}$ $\{\boxed{\{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}}\ \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_{\theta}, \text{Bill}\}\}\}$ INFL_{v} $\text{v}_{\text{arrive:pst}}$ INFL_{v}

…

θ-theory: SMT parser operation

Final WS: $\{\text{C}, \{\text{INFL}_{\text{v}}, \{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_{\theta}, \{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}$ … $\text{:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}\}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_{\theta}, \text{Bill}\}\}\}\}\}\}$

INT/EXT: $\{\text{C}, \{\text{INFL}_{\text{v}}, \{\{\text{v}_{\text{arrive:pst}}, \{\text{arrive}_{\theta}, \{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the:}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}\}\}, \{\{\text{mechanic}_{\text{the}}, \{\text{C}_{\text{rel:who}}, \{\text{INFL}_{\text{v}}, \{\text{mechanic}_{\text{the:}}, \{\text{v}_{\text{fix:}\theta\text{:pst}}, \{\text{fix}_{\theta}, \text{car}_{\text{the}}\}\}\}\}\}\}, \{\text{v}_{\text{meet:}\theta\text{:pst}}, \{\text{meet}_{\theta}, \text{Bill}\}\}\}\}\}\}$

EXT: the mechanic who 3sg pst fix the car {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

Spellout: the mechanic who fixed the car {[arrived],[and],[met,Bill]}

Parse found: the mechanic who 3sg pst fix the car {[3sg,pst,arrive],[and],[3sg,pst,meet,Bill]}

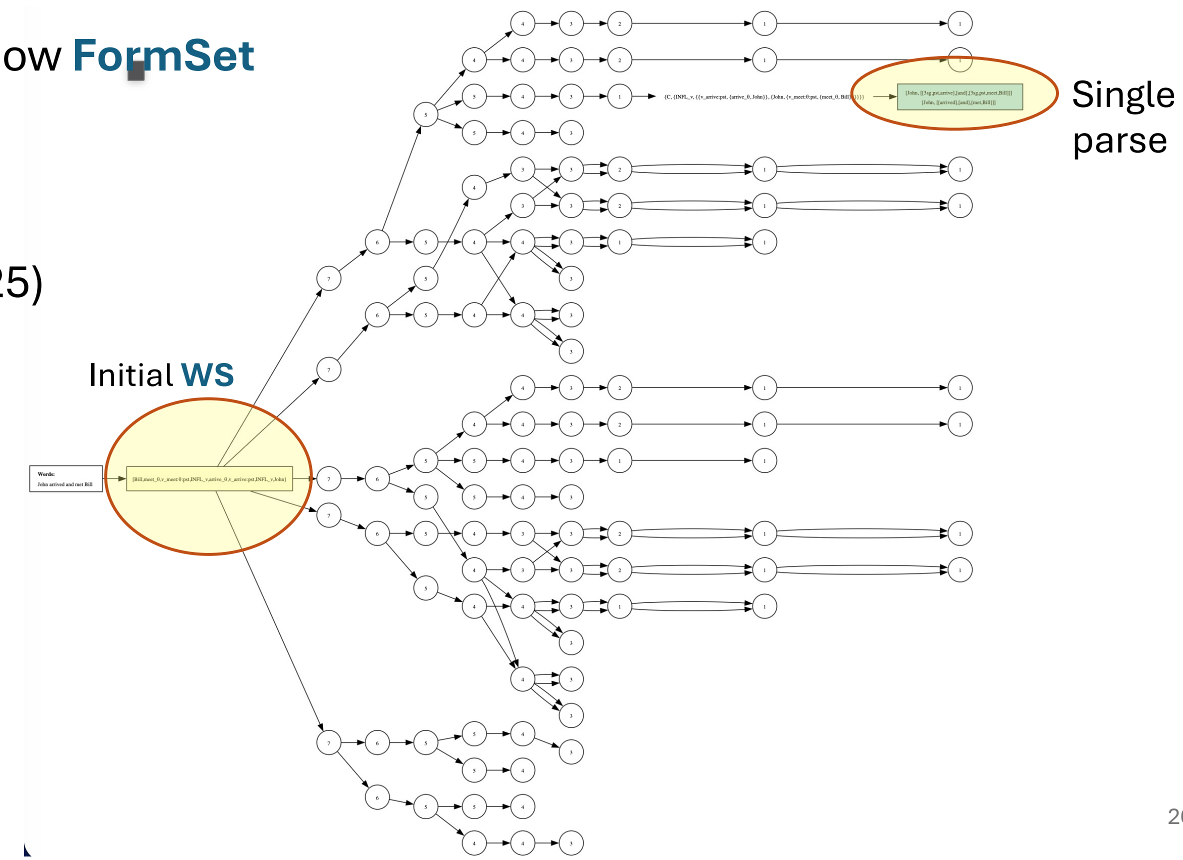
Unbounded, Unstructured Coordination (**UUS**)

For more detail on how **FormSet** works, see:

- Chomsky (2021)
- Chomsky (2024)
- Fong & Oishi (2025)

Computation space:
represented here as a graph

- *vertex = **WS** state*
- *edge = **Merge** step*



Raising to Object: *expect* vs. *persuade*

Chomsky (2021), **GK**, p24

So far we have been considering raising to subject. Let's turn to raising to object, which should work much the same way:

(15) a. John expected Bill to leave
b. John persuaded Bill to leave

These should be analogous to the subject-raising/control cases already discussed.

In (15a), *Bill* raises by IM to SPEC–*expect*. In (15b), *Bill* is merged by EM with the complex verbal structure {*persuade*, {*Bill to leave*}} as its direct object. Within our highly restricted framework, the structures should therefore be as in [H] skipping details, where V is either *expect* or *persuade*:

[H] John INFL {$_2$ Bill$_1$, {$_1$ V, {Bill$_2$ to leave}}}

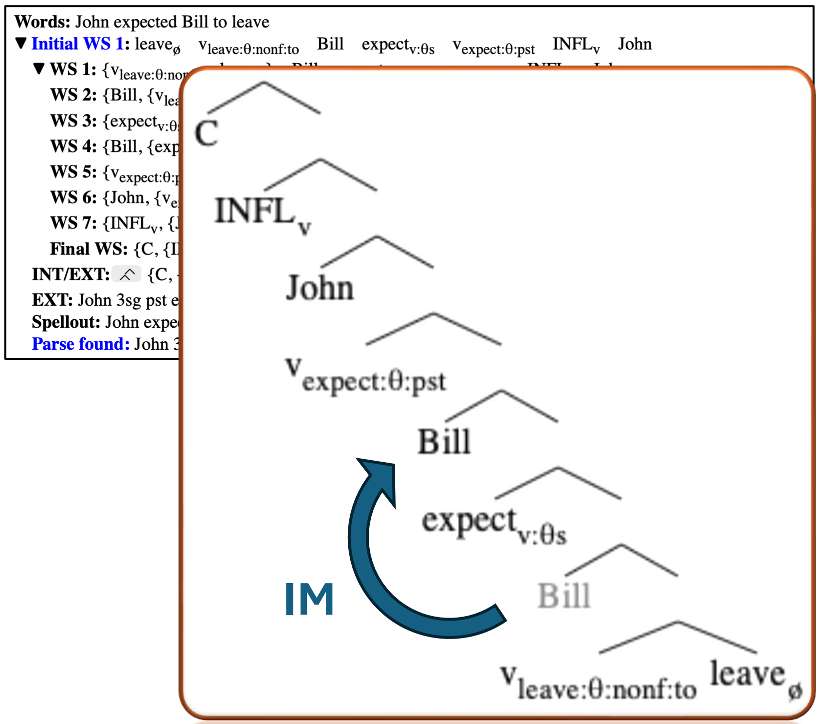
In both cases, FC determines that the two occurrences of *Bill* are copies. If V = *expect*, the paired Copies were generated by IM; if V = *persuade*, *Bill*$_1$ was generated by EM, with its own θ-role; it is an M-gap, a PRO structure. In both cases MS determines deletion of *Bill*$_2$. Thus object control falls into place along with subject control, crucially relying on the distinction between the reincarnation of trace and PRO, now within SMT.

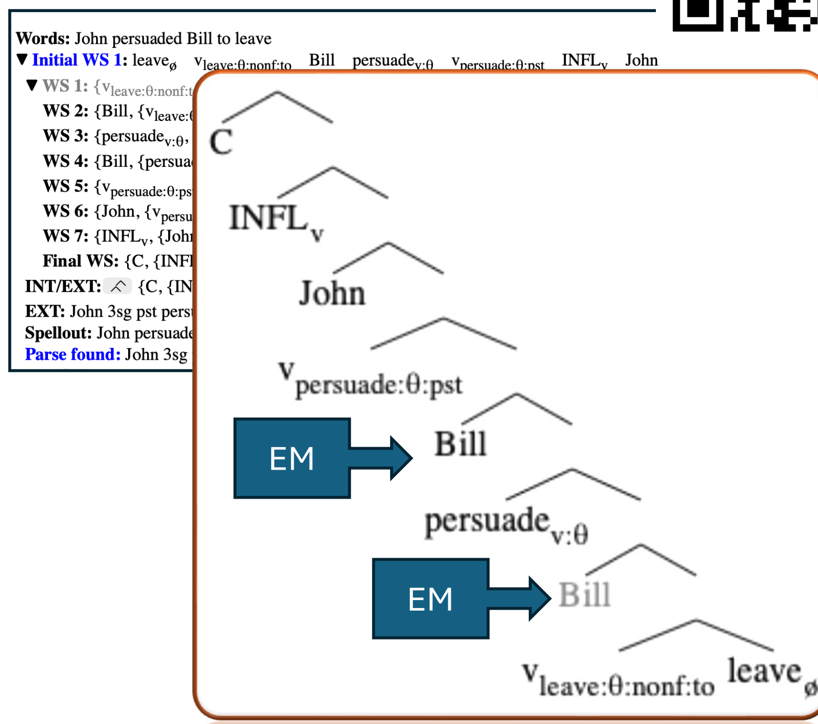
Raising to Object: *expect* vs. *persuade*

Words: John expected Bill to leave
▼ **Initial WS 1:** $\text{leave}_{\emptyset}$ $v_{\text{leave:}\theta\text{:nonf:to}}$ Bill $\text{expect}_{v:\theta s}$ $v_{\text{expect:}\theta\text{:pst}}$ INFL_v John
▼ **WS 1:** {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$} Bill $\text{expect}_{v:\theta s}$ $v_{\text{expect:}\theta\text{:pst}}$ INFL_v John
WS 2: {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}} $\text{expect}_{v:\theta s}$ $v_{\text{expect:}\theta\text{:pst}}$ INFL_v John
WS 3: {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}} $v_{\text{expect:}\theta\text{:pst}}$ INFL_v John
WS 4: {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}} $v_{\text{expect:}\theta\text{:pst}}$ INFL_v John
WS 5: {$v_{\text{expect:}\theta\text{:pst}}$, {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}} INFL_v John
WS 6: {John, {$v_{\text{expect:}\theta\text{:pst}}$, {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}} INFL_v
WS 7: {INFL_v, {John, {$v_{\text{expect:}\theta\text{:pst}}$, {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}
Final WS: {C, {INFL_v, {John, {$v_{\text{expect:}\theta\text{:pst}}$, {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}}
INT/EXT: {C, {INFL_v, {John, {$v_{\text{expect:}\theta\text{:pst}}$, {Bill, {$\text{expect}_{v:\theta s}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}}
EXT: John 3sg pst expect Bill to leave
Spellout: John expected Bill to leave
Parse found: John 3sg pst expect Bill to leave

Words: John persuaded Bill to leave
▼ **Initial WS 1:** $\text{leave}_{\emptyset}$ $v_{\text{leave:}\theta\text{:nonf:to}}$ Bill $\text{persuade}_{v:\theta}$ $v_{\text{persuade:}\theta\text{:pst}}$ INFL_v John
▼ **WS 1:** {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$} Bill $\text{persuade}_{v:\theta}$ $v_{\text{persuade:}\theta\text{:pst}}$ INFL_v John
WS 2: {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}} $\text{persuade}_{v:\theta}$ $v_{\text{persuade:}\theta\text{:pst}}$ INFL_v John [gray]
WS 3: {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}} $v_{\text{persuade:}\theta\text{:pst}}$ INFL_v John [gray]
WS 4: {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}} $v_{\text{persuade:}\theta\text{:pst}}$ INFL_v John
WS 5: {$v_{\text{persuade:}\theta\text{:pst}}$, {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}} INFL_v John
WS 6: {John, {$v_{\text{persuade:}\theta\text{:pst}}$, {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}} INFL_v
WS 7: {INFL_v, {John, {$v_{\text{persuade:}\theta\text{:pst}}$, {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}
Final WS: {C, {INFL_v, {John, {$v_{\text{persuade:}\theta\text{:pst}}$, {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}}
INT/EXT: {C, {INFL_v, {John, {$v_{\text{persuade:}\theta\text{:pst}}$, {Bill, {$\text{persuade}_{v:\theta}$, {Bill, {$v_{\text{leave:}\theta\text{:nonf:to}}$, $\text{leave}_{\emptyset}$}}}}}}}}
EXT: John 3sg pst persuade Bill to leave
Spellout: John persuaded Bill to leave
Parse found: John 3sg pst persuade Bill to leave

Raising to Object: *expect* vs. *persuade*



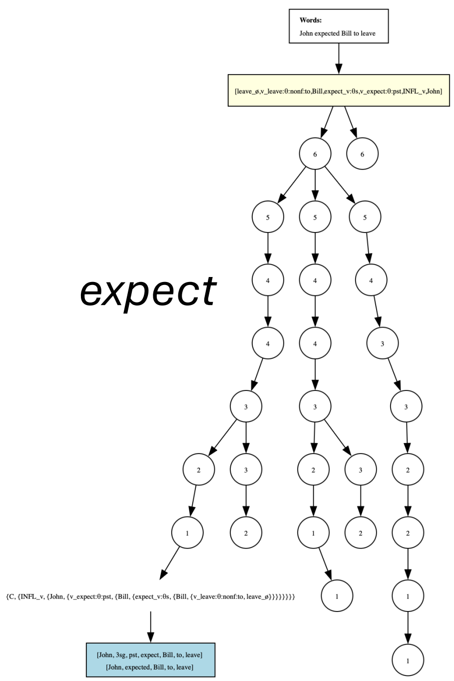


Steps (*to the parse*): computation graphs

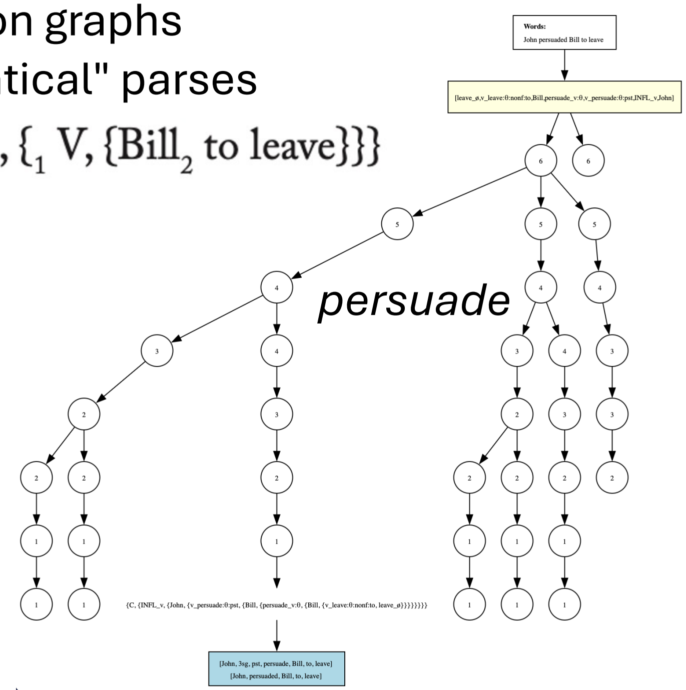
- ***different*** computation graphs
- but structurally "identical" parses

[H] John INFL $\{_2\ \text{Bill}_1, \{_1\ \text{V}, \{\text{Bill}_2 \text{ to leave}\}\}\}$

expect

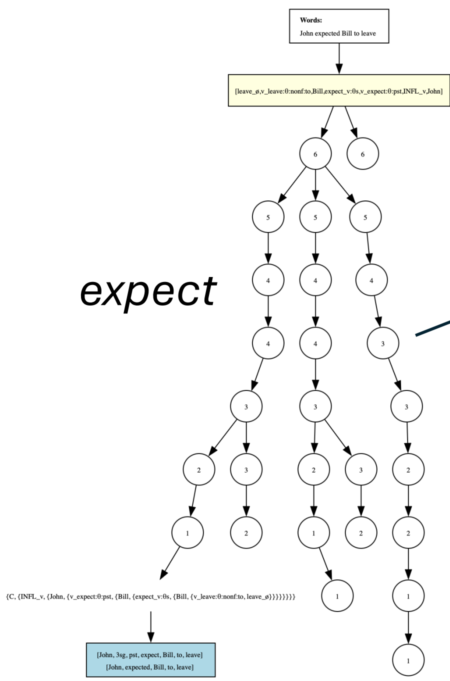


persuade



Steps (*to the parse*): computation graphs

expect



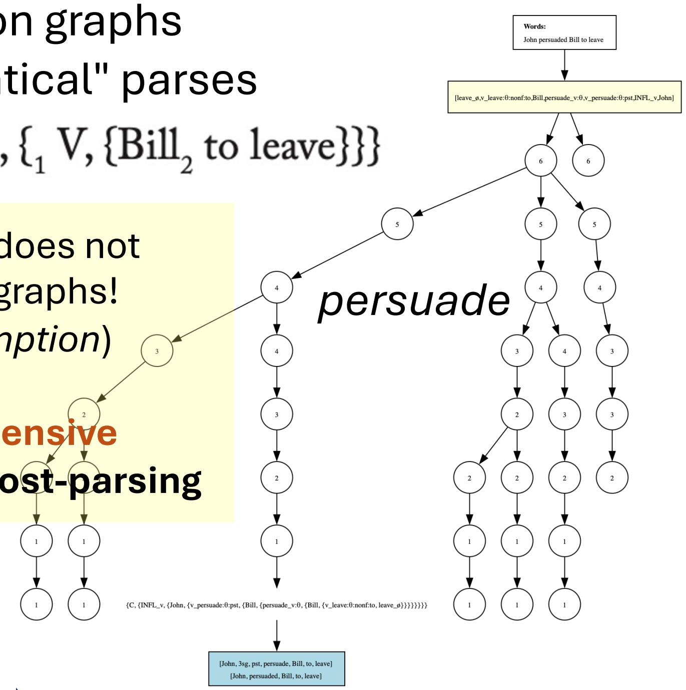
- ***different*** computation graphs
- but structurally "identical" parses

[H] John INFL $\{_2$ Bill$_1$, $\{_1$ V, $\{$Bill$_2$ to leave$\}\}\}$

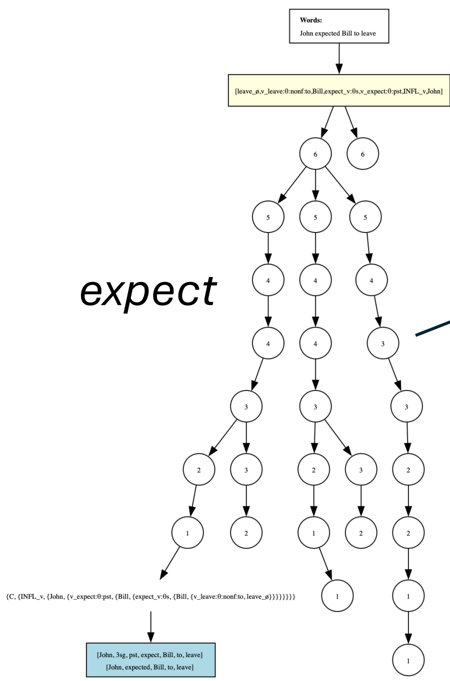
Note: **SMT parser** does not access/compute graphs! (*Markovian assumption*)

- graphs = **WS** history
- graph = **resource intensive**
- **graphs computed post-parsing**

persuade



Steps (*to the parse*): computation graphs



expect

- ***different*** computation graphs
- but structurally "identical" parses

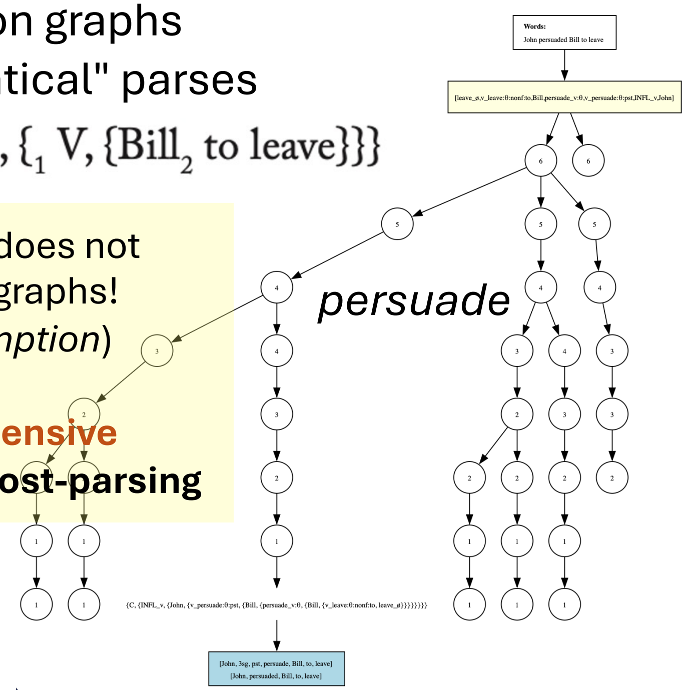
[H] John INFL $\{_2$ Bill$_1$, $\{_1$ V, {Bill$_2$ to leave}}}

Note: **SMT parser** does not access/compute graphs! (*Markovian assumption*)

- graphs = **WS** history
- graph = **resource intensive**
- **graphs computed post-parsing**

SMT: limited resources I-Language computation should be efficient

persuade



SMT: *Strong Minimalist Thesis*

Outline:

- **Introduction**: atoms and molecules of syntax
- **SMT Parser**: system architecture
- **Theory and Computation Model**: some highlights
- **SMT**: motivating optimal simplicity

SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints

Input: words

stemming:
unpack inflected verb/noun/adj

Linear Processing: [...]

affixation:
INFLϕ ⇋ CL, ϕ+TNS+R

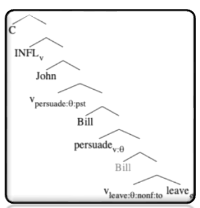
Linear Processing: [...]

Output: words

SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints

Input: words



Linear Processing: [...]

WS

Merge & **FormSet:** {...} **{...}**

Minimal Search (**MS**)

Hierarchical Processing

Interface

FormSet: (XP, XP)

Linear Processing: [...]

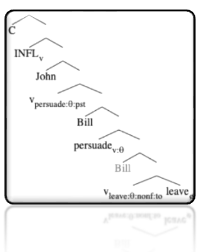
Output: words

SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints

Input: words

Linear Processing: […]



WS

Merge & **FormSet:** {…} {…}

Minimal Search (MS)

Universal

Hierarchical Processing

no parameters/ no statistics

Interface

FormSet: (XP, XP)

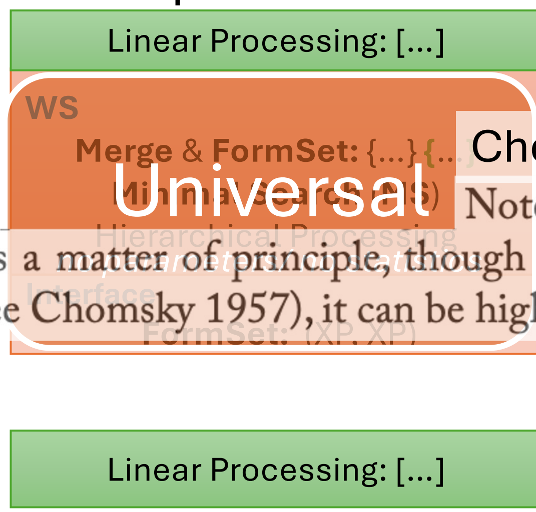
Linear Processing: […]

Output: words

SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints

Input: words



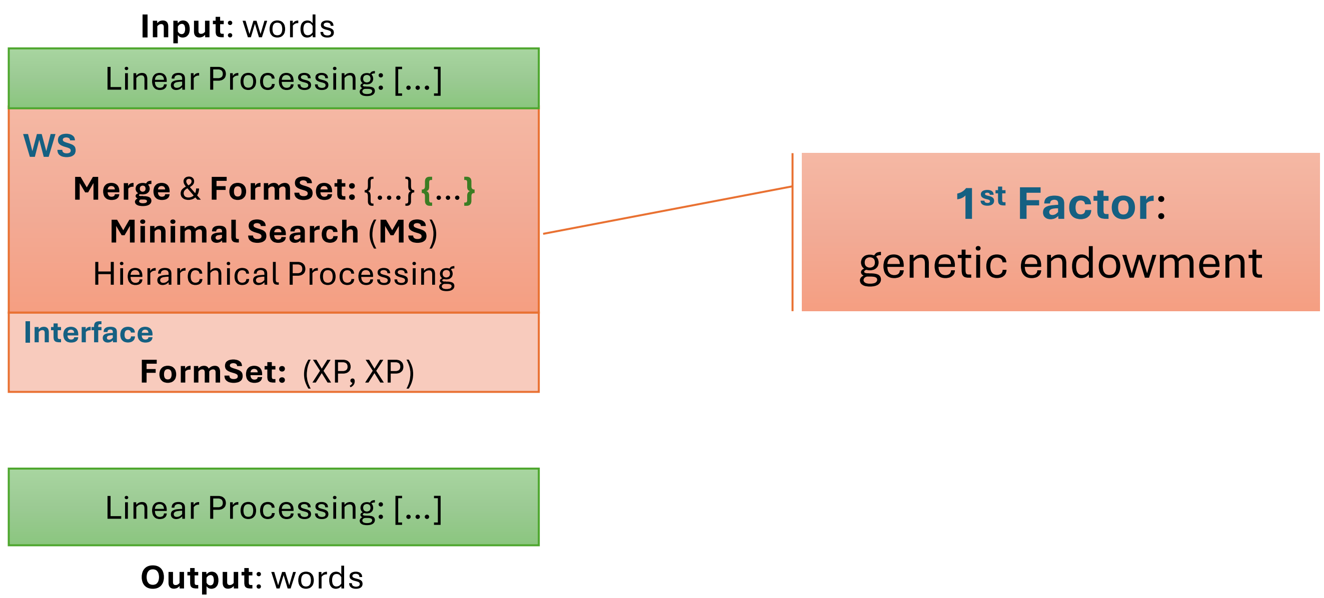
Output: words

Chomsky (2021) GK, fn.14

Note that statistical information is irrelevant to I-language as a matter of principle, though as has always been assumed in the generative enterprise (see Chomsky 1957), it can be highly relevant to processing and acquisition

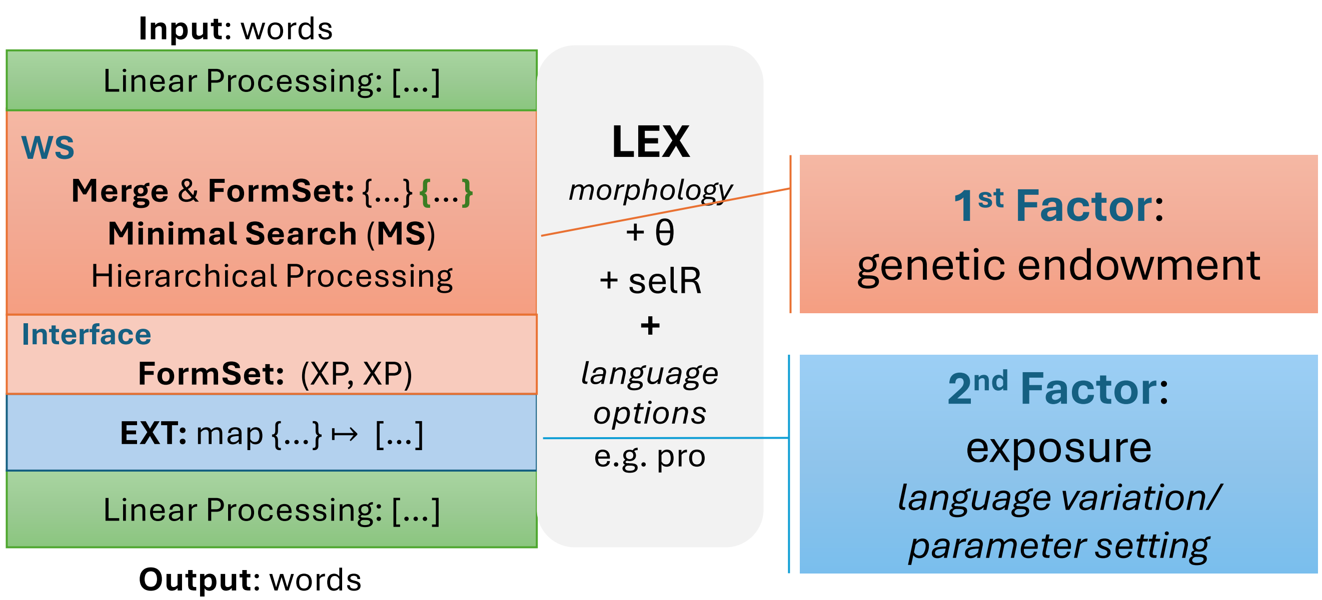
SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints



SMT: *Strong Minimalist Thesis*

- **SMT** Parser: respect fundamental constraints

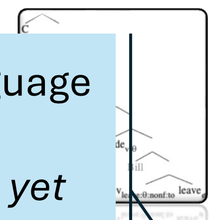


SMT: *Strong Minimalist Thesis*

Chomsky (2021) **GK**, fn.14

[14] Externalization should not be confused with processing. It is pure syntax,

stemming:
unpack inflected verb/noun/adj



Given surface language variation:
must be very rich yet highly structured for learnability

affixation:
INFLϕ ⇋ CL, ϕ+TNS+R

Input: words

Linear Processing: [...]

WS
Merge & **FormSet:** {...} **{...}**
Minimal Search (**MS**)
Hierarchical Processing

Interface
FormSet: (XP, XP)

EXT: map {...} ↦ [...]

Linear Processing: [...]

Output: words

LEX
morphology
+ θ
+ selR
+
language options
e.g. pro

WS Complexity

Chomsky (2021) **GK**, p9

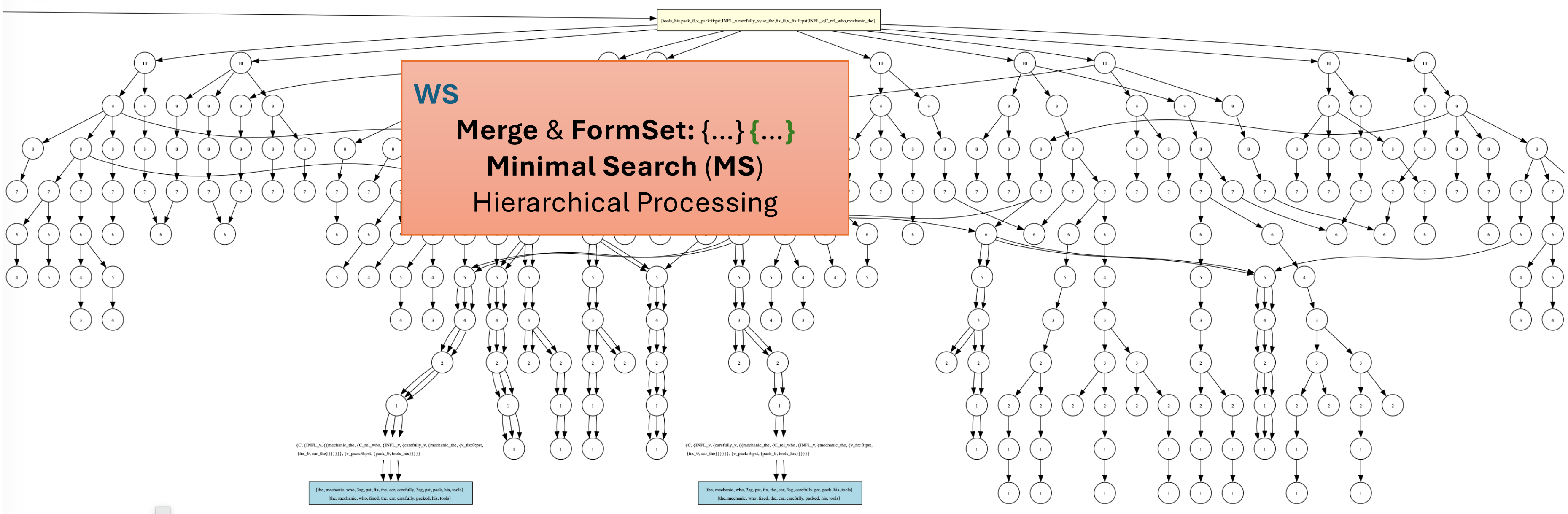
(3) a. the mechanic fixed the car carefully
b. the mechanic carefully packed his tools
c. the mechanic who fixed the car carefully packed his tools

Sentence (3c) is ambiguous. It can be understood as in (3a) or (3b).

WS Complexity

Words: the mechanic who fixed the car carefully packed his tools

- **Initial WS 1:** $\text{tools}_{\text{his}}$ pack_{θ} $\text{v}_{\text{pack:}\theta\text{:pst}}$ INFL_{v} $\text{carefully}_{\text{v}}$ car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} who $\text{mechanic}_{\text{the}}$
- **Initial WS 2:** $\text{tools}_{\text{his}}$ pack_{θ} $\text{v}_{\text{pack:}\theta\text{:pst}}$ INFL_{v} $\text{carefully}_{\text{v}}$ car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} $\text{C}_{\text{rel:who}}$ $\text{mechanic}_{\text{the}}$



WS Complexity

Words: the mechanic who fixed the car carefully packed his tools

- **Initial WS 1:** $\text{tools}_{\text{his}}$ pack_{θ} $\text{v}_{\text{pack:}\theta\text{:pst}}$ INFL_{v} $\text{carefully}_{\text{v}}$ car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} who $\text{mechanic}_{\text{the}}$
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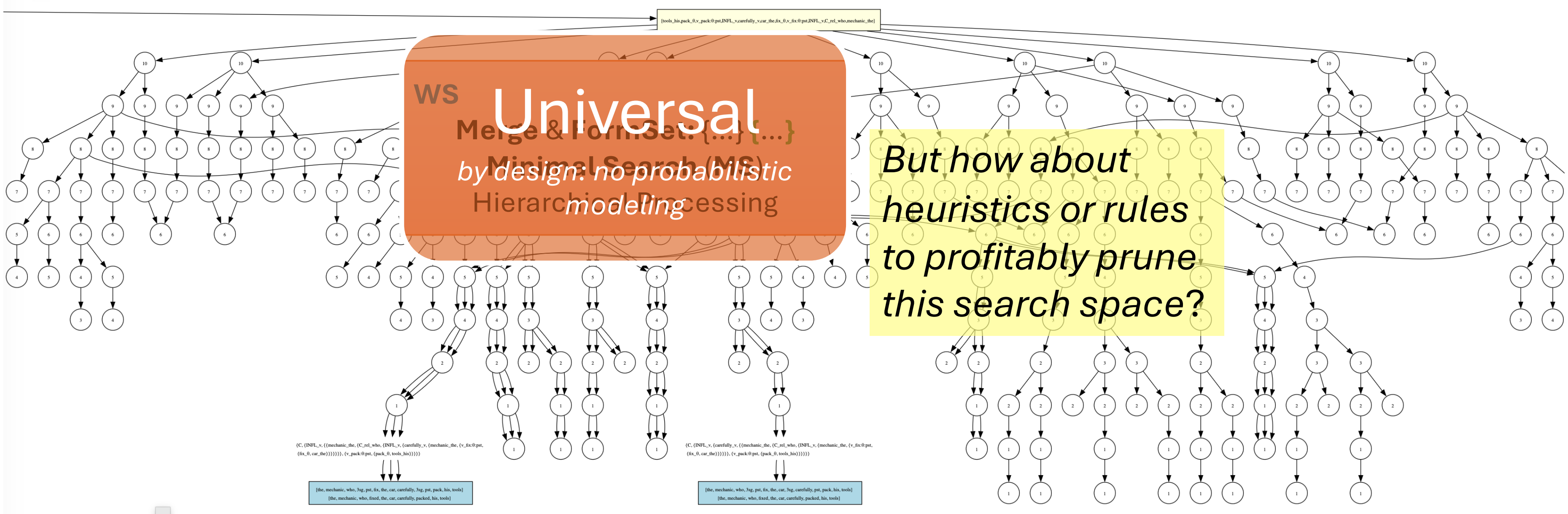


WS

Merge & FormSet: {...} {...}

Minimal Search (MS)

Hierarchical Processing

Universal

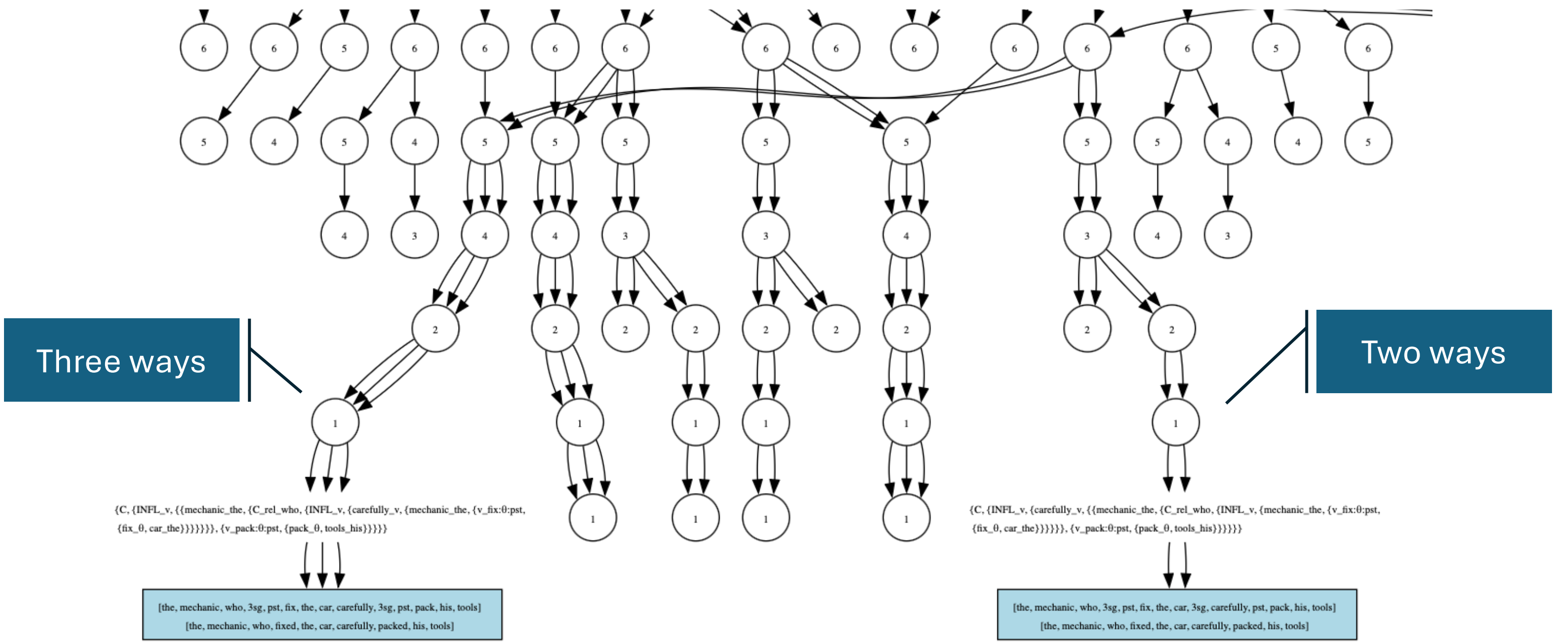
by design: no probabilistic modeling

But how about heuristics or rules to profitably prune this search space?

WS Complexity

†only reason: *debugging is easier*

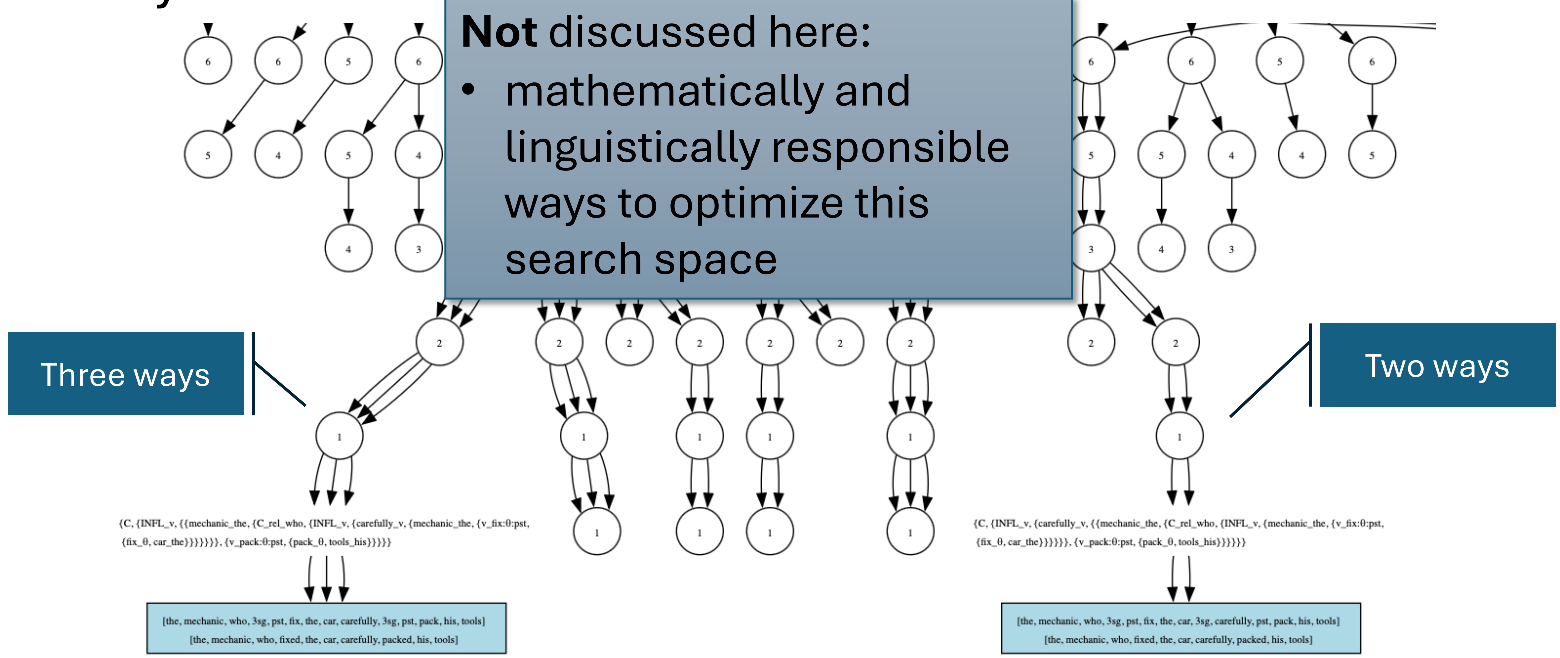
- **SMT Parser**: in serial mode† (not *parallel* mode), a (linearized) proof system:



WS Complexity

†only reason: *debugging is easier*

- **SMT Parser**: in serial mode† (not *parallel* mode), a (linearized) proof system:



Not discussed here:

- mathematically and linguistically responsible ways to optimize this search space

WS Complexity

Words: the mechanic who fixed the car carefully packed his tools

- ▶ **Initial WS 1:** $\text{tools}_{\text{his}}$ pack_{θ} $\text{v}_{\text{pack:}\theta\text{:pst}}$ INFL_{v} $\text{carefully}_{\text{v}}$ car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} who $\text{mechanic}_{\text{the}}$
- ▶ **Initial WS 2:** $\text{tools}_{\text{his}}$ pack_{θ} $\text{v}_{\text{pack:}\theta\text{:pst}}$ INFL_{v} $\text{carefully}_{\text{v}}$ car_{the} fix_{θ} $\text{v}_{\text{fix:}\theta\text{:pst}}$ INFL_{v} $\text{C}_{\text{rel:who}}$ $\text{mechanic}_{\text{the}}$

- two **WS**s, only one converges, **WS 2**'s computation graph shown earlier
  - **WS**s are silo-ed, assume they proceed in parallel (**Merge** from one cannot access the other)

WS Complexity

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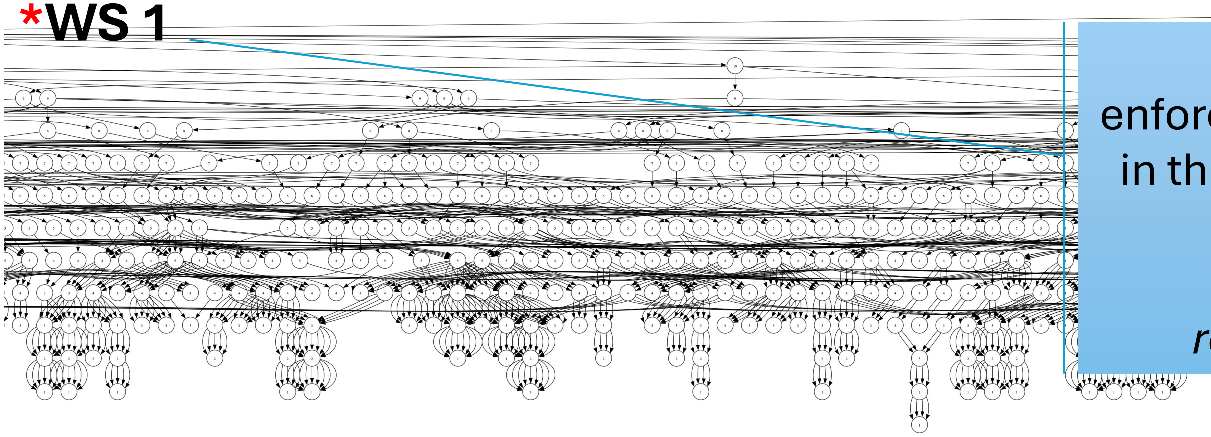
*WS 1

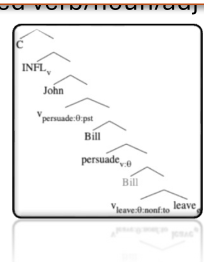


3rd Factor:
enforce efficient computation
in the combinatorial system
(of **SMT**):
"usable" language
resource restrictions

SMT: *Strong Minimalist Thesis*

- Robustness of **SBO** despite lack of exposure or level of suprisal

> It is easy to fall into error on these matters, as I did in *LSLT* (Chomsky 1955) in seeking to determine word boundaries in I-language in terms of transitional probabilities, part of the failure in those early days to distinguish sharply between explanation and procedural analysis of data.
>
> Chomsky (2021) **GK**, fn.14



WS
Merge & **FormSet:** {...} **{...}**
Minimal Search (**MS**)
Hierarchical Processing

Interface
FormSet: (XP, XP)

EXT: map {...} ↦ [...]

Linear Processing: [...]

Output: words

LEX
morphology
+ θ
+ selR
+
language options
e.g. pro

affixation:
INFLϕ ⇋ CL, ϕ+TNS+R

SMT = Ultimate Simplicity

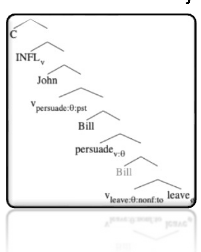
- Reason for (*forced*) simplicity of operations:
  - evolutionary time-scale (≈ 300kya is brief): **I-Language** coinciding with the appearance of anatomically-modern humans.

Returning to structure-dependence, the problem of learnability is overcome if the property is part of UG, as seems clearly to be the case. There is, then, no learning. The problem of evolvability is overcome if the property follows from the simplest combinatorial operation, one that must exist if language is to exist at all.[17] In fact, it does. The simplest combinatorial operation is binary set-formation, Merge in contemporary terminology — though the matter is more intricate as we see directly. Structure-dependence follows at once. Linear order is not an option for the child if computation is based on the simplest operation, the one yielded by evolution in its normal course.

SMT: *Strong Minimalist Thesis*

- **Merge** is fundamentally **bottom-up** *(Nature doesn't care!)*
- The **SMT Parser** eschews all parsing algorithms and mechanisms, e.g. CKY, LR, etc.

stemming:
unpack inflected verb/noun/adj



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Nature then took the usual course of seeking the simplest such operation (reconstruction), relying on natural law (in this case, principles of computational efficiency), and on a particular concept of simplicity. The result is a system satisfying the Basic Property of Language. Its deepest and most surprising property, structure-dependence, relies on elementary properties of computational efficiency: adopting the simplest computational operation and the No-Tampering Condition (NTC), which basically says "don't add bells and whistles but keep to pure elegance."

INFLφ ⇒ CL, φ+TNS+R

Output: words

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Simplest possible:

WS: ...,X, ...,Y, .. ⟼ WS': ...,{X, Y},...,.. (**EM**)

WS: ...,XP,.. ⟼ WS': ...,{Y, XP} ,.. (**IM**)

XP **MS** contains Y No **sideways**, no **parallel Merge**, etc.

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WS: ..,XP,.. $\longmapsto$ WS': ..,{Y, XP} ,.. (**IM**)

XP **MS** contains Y No **sideways**, no **parallel Merge**, etc.

Must adopt this!

*won't have simultaneously evolved two distinct **SBO**s, one for thought and one for parsing*

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SMT: *Strong Minimalist Thesis*

- **Merge** is fundamentally bottom-up
- Minimal Search (**MS** or **Σ**):
  find 1st matching element and stop (*no comparisons/**equidistance***)

3rd Factor:
ultimate simplicity also
= most efficient
limits ***"usable" language***

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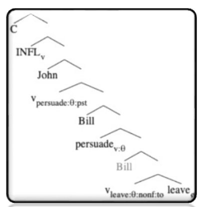
unpack inflected verb/noun/adj



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Another natural condition is limiting search. For an operation *O* to apply to items it must first locate them. It must incorporate an operation Σ that searches LEX and WS and selects items to which *O* will apply. It is fair to take Σ to be a third factor element, on the shelf and available for any operation.[27]

We assume here that minimization of search is Nature's guide in seeking simple solutions for computational systems, the reconstruction stage of evolution discussed above.

Output: words

SMT: *Strong Minimalist Thesis*

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That's the simplest imaginable condition of computational efficiency. If that makes expressions harder to process and even makes some thoughts impossible to express without circumlocution, too bad. Nature doesn't care.[14]

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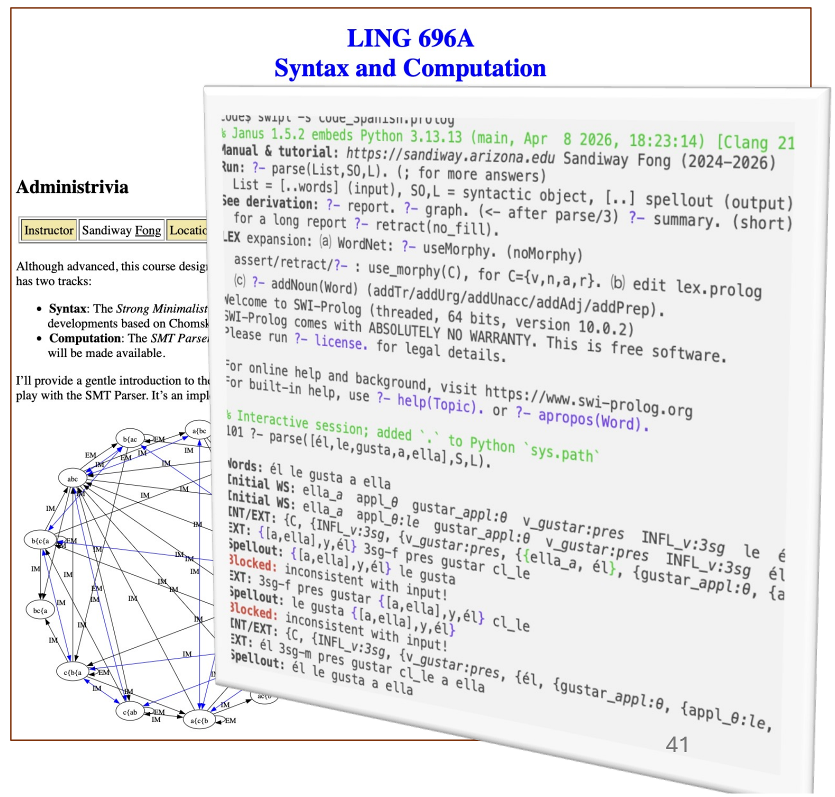
SOME ADVERTISING: theory & software

- Graduate seminar on *Syntax and Computation* (Fall semester 2026)
  - course materials will be freely available
  - a (*simplified*) SMT Parser will be freely available
  - (A few have it for testing/debugging)
  - *Currently, a bit uneven:*
    - *some simple parts are quite incomplete, others are quite sophisticated*
    - *many more examples to be put online*
    - *adding more theory*
    - *improving the computational model*
    - *work on a theory of EXT (language variation)*



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