Coordination and the theory of grammar

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The Current Crisis in Syntactic Theory

- Why are there so many theories of grammar?
- They are all very similar in their treatment of the "bounded" constructions (passive, raising, control, reflexivization et.).
- They are all of very high expressive power as far as the rest of the grammar goes (relativization, coordination etc.)

Why Would we Expect Natural Grammars to be Simple?

- In artificial languages like arithmetic, logic, and LISP, grammar is almost trivial.
- Syntax is mostly context-free (CF). The only important exception is variable binding, which motivated the introduction of the Indexed Language level(s) to the Chomsky hierarchy (see Gazdar 1988), a level only "mildly" more expressive than CF.
- Rules and constituents of syntax and semantics are essentially related one-to-one.
- What little ambiguity these languages permit is strictly local (usually resolved by the adjacent symbol.)

The Constituent Condition on Rules

- The fact that we would expect natural grammars to be the same is enshrined in what the linguists call the "Constituent Condition on Rules":
  - The inputs to, and outputs from, all rules of syntax should be constituents.
- Since constituents are merely the units to which the grammar assigns meaning, this amounts to saying that rules of grammar should have a compositional semantics.

What is a Constituent?

- Interestingly, traditional linguistic tests are equivocal on this basic question. Chomsky (1955/1975) offers the following "criteria:"

(1) a. The rule for conjunction
b. Intrusion of parenthetical expressions
c. Ability to enter into transformations
d. Certain intonational features

- The implication is that the rules that capture these phenomena should all conform to the constituent condition.
- There has been some success with the bounded constructions and the "*wh*-movement" family of unbounded constructions under heading (c).
- It has proved harder to make good on the implicit claim with respect to the remaining three phenomena.

Fragments: "The rule for conjunction"

- Among the coordinate constructions, "right node raising" looks very like *wh*-movement. It is unbounded:

(2) a. a book which *I expect I will find*, and *I think that you must have read without really understanding*
b. *I expect I will find*, but *I think that you must have read without really understanding*, that novel about the secret life of legumes.

- It is subject to similar, though not identical, "island conditions:"

(3) a. *How many mathematicians do you think in ten derive a lemma?
b. *Three mathematicians in ten derive a lemma and in a hundred prove completeness.

- However, the residues of "deletion under coordination" are much more diverse than those of *wh*-movement:

(4) a. I want to try to write, and *hope to see produced*, a musical about the life of Sir Stafford Cripps.
b. Give Deadeye Dick a sugar-stick, and *Mexican Pete, a bun*.
c. I want to try to write a novel, and *you, a screenplay*.

- All of these appear to violate the constituent condition on rules.

Fragments: "Intrusion of Parenthetical Expressions"

- Parentheticals seem to isolate similar non-constituent fragments:

(5) a. "*Are you now or have you ever been*," demanded Harriet, "a member of the Friends of the Ukraine Film Society?"
b. *You could give*, she chortled, a policeman a flower.

- They obey similar restrictions to coordinates:

(6) *"Three mathematicians," expostulated Mexican Pete, "in ten derive a lemma."

Fragments: “Certain Intonational Features”

- Intonational phrases (as defined by for example “continuation rises” here marked informally by right brackets) can correspond to non-constituents:

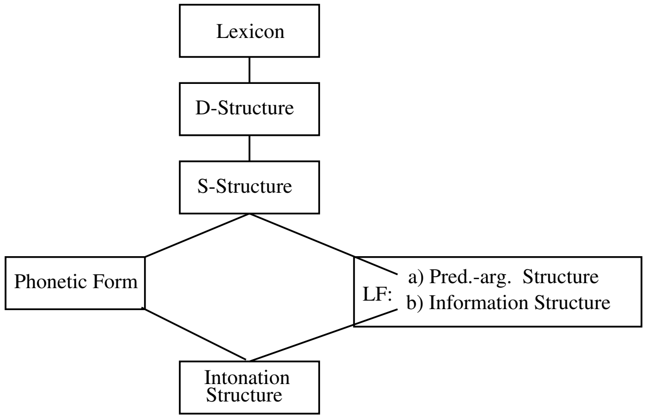
(7) a. (The absent minded PROFESSOR)(was avidly READING)(about the latest BIOGRAPHY)(of Marcel PROUST).
b. (Marcel PROVED) (COMPLETENESS).

- Phonological processes like the Rhythm Rule (which turns “Marcél” into “Márcel” in the above) are sensitive to intonational phrase boundaries.
- They obey similar restrictions to coordination and parentheticalization:

(8) *(Three MATHEMATICIANS)(in ten derive a LEMMA).

- Hence the “Sense Unit Condition” on Intonation Structure of Halliday (1967) and Selkirk (1984)

Architecture of GB/P&P Generative Grammar



(Adapted from Selkirk 1984)

A Serious Problem

- This theory has a number of worrying features.
- It has *two* levels of structure mediating between sound and meaning (i.e. two syntaxes)!
- PF also does a lot of strictly syntactic work In particular it is the domain of coordination and parentheticalization, which means that it is duplicating much of the work of Intonation Structure.
- To stipulate a Sense Unit Condition is a massive failure for any theory of grammar. (Imagine it being proposed for a Standard Theory TG syntax!) What is a theory of grammar if not a theory of sense units?
- It would be in keeping with other contemporary developments to reduce the number of modules in the theory.

The Categorial Turn

- A number of researchers have reacted to the above situation by abandoning traditional notions of constituency, allowing “flexible” syntactic structures that provide whatever is needed for the constituent condition on rules to hold.
- Many of these grammars give equal status to both traditional and nontraditional structures such as the following minimal example:

(9) a. Anna married Manny b. Anna married Manny

- This talk presents one of the alternatives, developed in work at Penn and Edinburgh with Ades, Szabolcsi, Jowsey, Hepple, Joshi, Hoffman, Prevost, Park, Komagata, Bierner, Baldridge, Hockenmaier, and others.

Combinatory Categorial Grammar

(10) $S \rightarrow NP \quad VP$

$VP \rightarrow TV \quad NP$

$TV \rightarrow \{proved,\ finds,\ \ldots\}$

(11) proved $:= (S\backslash NP)/NP$

(12) *The functional application rules*

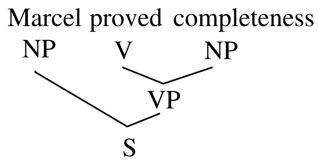
a. $X/Y \quad Y \Rightarrow X$ $\quad (>)$

b. $Y \quad X\backslash Y \Rightarrow X$ $\quad (<)$

A Derivation

(13) a.

$$\begin{array}{ccc}
\text{Marcel} & \text{proved} & \text{completeness} \\
\hline
NP & (S\backslash NP)/NP & NP \\
 & \multicolumn{2}{c}{\overline{\quad\quad S\backslash NP \quad\quad}^{>}} \\
\multicolumn{3}{c}{\overline{\quad\quad\quad S \quad\quad\quad}^{<}}
\end{array}$$

b. 

Semantics

(14) proved $:= (S\backslash NP_{3s})/NP : \lambda x.\lambda y.prove'xy$

(15) *Functional application*

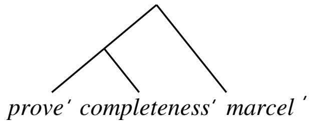
a. $X/Y : f \quad Y : a \Rightarrow X : fa$ $\quad (>)$

b. $Y : a \quad X\backslash Y : f \Rightarrow X : fa$ $\quad (<)$

(16)

$$\begin{array}{ccc}
\text{Marcel} & \text{proved} & \text{completeness} \\
\hline
NP_{3sf} : marcel' & (S\backslash NP_{3s})/NP : \lambda x.\lambda y.prove'xy & NP : completeness' \\
 & \multicolumn{2}{c}{\overline{\quad S\backslash NP_{3s} : \lambda y.prove'completeness'y \quad}^{>}} \\
\multicolumn{3}{c}{\overline{\quad\quad S : prove'completeness'marcel' \quad\quad}^{<}}
\end{array}$$

Notation: Left-Associativity Convention over Logical Forms

(17) a. $(prove'completeness')marcel'$ b. 

- A nonordered form of the traditional VP is reflected at the level of propositional logical form.
- Such logical forms therefore preserve traditional c-command.

Coordination

(18) *Simplified coordination rule* ($<\Phi>$)

$X \quad CONJ \quad X' \Rightarrow \quad X''$

(19)
$$\begin{array}{ccccc}
\text{Marcel} & \text{conjectured} & \text{and} & \text{proved} & \text{completeness}\\
\hline
NP & (S\backslash NP)/NP & CONJ & (S\backslash NP)/NP & NP \\
\cline{2-4}
 & \multicolumn{3}{c}{(S\backslash NP)/NP \;\; {<}\Phi{>}} & \\
\cline{2-5}
 & \multicolumn{4}{c}{S\backslash NP \;\; >}\\
\cline{1-5}
\multicolumn{5}{c}{S \;\; <}
\end{array}$$

Composition

(20) *Forward composition* ($>\mathbf{B}$)

$X/Y : f \quad Y/Z : g \quad \Rightarrow_{\mathbf{B}} \quad X/Z : \lambda x.f(gx)$

(21)
$$\begin{array}{cccccc}
\text{Marcel} & \text{conjectured} & \text{and} & \text{might} & \text{prove} & \text{completeness}\\
\hline
NP & (S\backslash NP)/NP & CONJ & (S\backslash NP)/VP & VP/NP & NP\\
: marcel' & : conjecture' & : and' & : might' & : prove' & : completeness'\\
\cline{4-5}
 & & & \multicolumn{2}{c}{(S\backslash NP)/NP \;\; >\mathbf{B}} & \\
 & & & \multicolumn{2}{c}{: \lambda x.\lambda y.might'(prove'x)y} & \\
\cline{2-5}
 & \multicolumn{4}{c}{(S\backslash NP)/NP \;\; {<}\Phi{>}} & \\
 & \multicolumn{4}{c}{: \lambda x.\lambda y.and'(might'(prove'x)y)(conjecture'xy)} & \\
\cline{2-6}
 & \multicolumn{5}{c}{S\backslash NP \;\; >}\\
 & \multicolumn{5}{c}{: \lambda y.and'(might'(prove'completeness')y)(conjecture'completeness'y)}\\
\cline{1-6}
\multicolumn{6}{c}{S : and'(might'(prove'completeness')marcel')(conjecture'completeness'marcel') \;\; <}
\end{array}$$

Type-Raising

(22) *Forward type-raising* ($>\mathbf{T}$)

$NP : a \quad \Rightarrow_{\mathbf{T}} \quad \mathrm{T}/(\mathrm{T}\backslash NP) : \lambda f.fa$

(23)
$$\begin{array}{cccccc}
\text{Marcel} & \text{proved} & \text{and} & \text{I} & \text{disproved} & \text{completeness}\\
\hline
NP & (S\backslash NP)/NP & CONJ & NP & (S\backslash NP)/NP & NP\\
\cline{1-1}\cline{4-4}
S/(S\backslash NP) \;\; >\mathbf{T} & & & S/(S\backslash NP) \;\; >\mathbf{T} & & \\
\cline{1-2}\cline{4-5}
\multicolumn{2}{c}{S/NP \;\; >\mathbf{B}} & & \multicolumn{2}{c}{S/NP \;\; >\mathbf{B}} & \\
\cline{1-5}
\multicolumn{5}{c}{S/NP \;\; {<}\Phi{>}} & \\
\cline{1-6}
\multicolumn{6}{c}{S \;\; >}
\end{array}$$

- Type raising is restricted to primitive argument categories, NP, PP etc., and over primitive functors like verbs, resembling the traditional notion of *case*.

Universal Grammar

- Only rules which obey the following principles are allowed:

(24) *The Principle of Adjacency:*
Combinatory rules may only apply to finitely many phonologically realized and string-adjacent entities.

(25) *The Principle of Consistency:*
All syntactic combinatory rules must be consistent with the directionality of the principal function.

(26) *The Principle of Inheritance:*
If the category that results from the application of a combinatory rule is a function category, then the slash defining directionality for a given argument in that category will be the same as the one(s) defining directionality for the corresponding argument(s) in the input function(s).

- The Principle of Adjacency is merely the definition of a combinator.
- The other two principles say that combinatory rules may not override, but must rather "project," the directionality specified in the lexicon:
- The Principle of Consistency excludes the following kind of rule:

(27) $X\backslash Y \quad Y \quad \not\Rightarrow \quad X$

- The Principle of Inheritance excludes rules like the following:

(28) $X/Y \quad Y/Z \quad \not\Rightarrow \quad X\backslash Z$

- These principles do allow rules such as the following:

(29) *Forward crossing composition* ($>\mathbf{B}_\times$)
$X/Y : f \quad Y\backslash Z : g \quad \Rightarrow_{\mathbf{B}_\times} \quad X\backslash Z : \lambda x.f(gx)$

- Individual languages are free to limit such rules to specific categories, or to exclude them entirely.

Many Linguistic Predictions

- We correctly predict the fact that right-node raising is unbounded, as in a, below, and also provide the basis for an analyis of the similarly unbounded character of leftward extraction, as in b (see Steedman (1996, 2000b) for details, including discussion of ECP effects and other extraction asymmetries):

(30) a. [I conjectured]$_{S/NP}$ and [you think Marcel proved]$_{S/NP}$ completeness.
b. The result [which]$_{(N\backslash N)/(S/NP)}$ [you think Marcel proved]$_{S/NP}$.

Linguistic Predictions (contd.)

- Since we have assumed Forward Type Raising and Composition, the following construction is predicted on arguments of symmetry.

(31)
$$\begin{array}{cccccc}
\text{give} & \text{a teacher} & \text{an apple} & \text{and} & \text{a policeman} & \text{a flower} \\
\hline
DTV & TV\backslash DTV \;{}^{<\mathbf{T}} & VP\backslash TV \;{}^{<\mathbf{T}} & CONJ & TV\backslash DTV \;{}^{<\mathbf{T}} & VP\backslash TV \;{}^{<\mathbf{T}}
\end{array}$$
$$\underline{TV\backslash DTV \quad VP\backslash TV}_{<\mathbf{B}} \Rightarrow VP\backslash DTV \qquad \underline{TV\backslash DTV \quad VP\backslash TV}_{<\mathbf{B}} \Rightarrow VP\backslash DTV$$
$$\underline{VP\backslash DTV \quad CONJ \quad VP\backslash DTV}_{<\Phi>} \Rightarrow VP\backslash DTV$$
$$\underline{DTV \quad VP\backslash DTV}_{<} \Rightarrow VP$$

- $DTV = (VP/NP)/NP \qquad TV = VP/NP$

(32) *Three mathematicians [[in ten]$_{PP}$ [derive a lemma,]$_{S\backslash NP}$] and [in a hundred prove completeness.]

CCG is "Mildly Context Sensitive"

- The availability of *crossed* composition under the Principles of Consistency and Inheritance allows crossed dependencies:

(33)
$$\begin{array}{cccccc}
\text{dat} & \text{ik} & \text{Cecilia} & \text{de nijlpaarden} & \text{zag} & \text{voeren} \\
& NP_1 & NP_2 & NP_3 & ((S_{+SUB}\backslash NP_1)\backslash NP_2)/VP_{-SUB} & VP\backslash NP_3
\end{array}$$
$$\underline{((S_{+SUB}\backslash NP_1)\backslash NP_2)/VP_{-SUB} \quad VP\backslash NP_3}_{>\mathbf{B}_\times} \Rightarrow ((S_{+SUB}\backslash NP_1)\backslash NP_2)\backslash NP_3$$
$$\underline{NP_3 \quad ((S_{+SUB}\backslash NP_1)\backslash NP_2)\backslash NP_3}_{<} \Rightarrow (S_{+SUB}\backslash NP_1)\backslash NP_2$$
$$\underline{NP_2 \quad (S_{+SUB}\backslash NP_1)\backslash NP_2}_{<} \Rightarrow S_{+SUB}\backslash NP_1$$
$$\underline{NP_1 \quad S_{+SUB}\backslash NP_1}_{<} \Rightarrow S_{+SUB}$$

- CCG is provably weakly equivalent to Tree-adjoining Grammar (TAG), Head Grammar (HG), and Linear Indexed Grammar, a fact that gives rise to a polynomial time worst-case complexity result (Vijay-Shanker and Weir 1994).

Gapping and the Order of Constituents

- Ross (1970): direction of gapping (leftward or rightward) depends on basic constituent order:

(34) a. SOV: *SOV and SO, SO and SOV

b. VSO: VSO and SO, *SO and VSO

c. SVO: SVO and SO, *SO and SVO

- Mixed exceptions such as Zapotec and Dutch have mixed word order.

Gapping and SOV Word Order

- By symmetry with English (31), Japanese subject and object must allow forward type-raising over the SOV verb (a) to allow the cluster in (b):

(35) tazuneta$_{SOV}$:= $(S\backslash NP_{nom})\backslash NP_{acc} : \lambda x.\lambda y.visit'xy$

(36) a. Ken-ga Naomi-o tazuneta.

Ken-NOM Naomi-ACC visit-PAST.CONCL

'Ken visited Naomi.'

b.

$$\begin{array}{ccc}
\text{Ken-ga} & \text{Naomi-o} & \text{tazuneta} \\
\overline{S/(S\backslash NP_{nom})}^{>\mathbf{T}} & \overline{(S\backslash NP_{nom})/((S\backslash NP_{nom})\backslash NP_{acc})}^{>\mathbf{T}} & \overline{(S\backslash NP_{nom})\backslash NP_{acc}} \\
\multicolumn{2}{c}{\overline{S/((S\backslash NP_{nom})\backslash NP_{acc})}^{>\mathbf{B}}} & \\
\multicolumn{3}{c}{\overline{S}^{>}}
\end{array}$$

Gapping and SOV Word Order (contd)

- The resulting nonstandard constituent *Ken-ga Naomi-o* can therefore conjoin:

(37) [Ken-ga Naomi-o], [Erika-ga Sara-o] tazuneta.

$S/((S\backslash NP_{nom})\backslash NP_{acc})$ $S/((S\backslash NP_{nom})\backslash NP_{acc})$ $(S\backslash NP_{nom})\backslash NP_{acc}$

Ken-NOM Naomi-ACC Erika-NOM Sara-ACC visit-PAST.CONCL

'Ken visited Naomi, and Erika, Sara.'

Gapping and SOV Word Order (contd)

- Ditransitives similarly allow larger argument clusters:

(38) a. Kyooju-ga komonjo-o gakusee-ni kasita.

Professor-NOM manuscrip-ACC student-DAT lent-PAST.CONCL

'The professor lent the manuscript to the student.'

b.

$$\begin{array}{cccc}
\text{Kyooju-ga} & \text{komonjo-o} & \text{gakusee-ni} & \text{kasita.} \\
\overline{S/VP}^{>\mathbf{T}} & \overline{VP/TV}^{>\mathbf{T}} & \overline{TV/DTV}^{>\mathbf{T}} & \overline{DTV} \\
\multicolumn{2}{c}{\overline{S/TV}^{>\mathbf{B}}} & & \\
\multicolumn{3}{c}{\overline{S/DTV)}^{>\mathbf{B}}} & \\
\multicolumn{4}{c}{\overline{S}^{>}}
\end{array}$$

Gapping and SOV Word Order (contd)

- In this case there is another derivation for the argument cluster:

(39) Kyooju-ga komonjo-o gakusee-ni kasita.

$$\begin{array}{cccc}
\text{Kyooju-ga} & \text{komonjo-o} & \text{gakusee-ni} & \text{kasita.}\\
\overline{S/VP}^{\,>\mathbf{T}} & \overline{VP/TV}^{\,>\mathbf{T}} & \overline{TV/DTV}^{\,>\mathbf{T}} & \overline{DTV}\\
 & \overline{\quad VP/DTV \quad}^{\,>\mathbf{B}} & & \\
 & \overline{\quad S/DTV \quad}^{\,>\mathbf{B}} & & \\
 & & \overline{\quad S \quad}^{\,>} &
\end{array}$$

- Again, all non-standard argument cluster constituents formed in both derivations can coordinate.

Ross's generalization Captured

- Principles of Adjacency, Consistency, and Inheritance, together with the order-preserving constraint on type-raising that is the sine qua non of an order-dependent language, permit any raised categories or rules of composition that would produce a *leftward*-looking function. "Forward Gapping" is therefore disallowed given the SOV lexicon:

(40) *Ken-ga Naomi-o tazunete, Erika-ga Sara-o
Ken-NOM Naomi-ACC visit-PAST.ADV Erika-NOM Sara-ACC
'Ken visited Naomi, and Erika, Sara.'

Apparent Exceptions

- Dutch *does* allow coordinations on the above pattern in subordinate-clause conjunctions:

(41) ...dat Maaike aardappels eet en Piet bonen
...that Maaike potatoes eats and Piet beans
'...that Maaike eats potatoes and Piet beans.'

- This fact is related to the fact that it has VSO/SVO word order as well as SOV.
- Ross' generalization should be phrased in terms of surface order, i.e lexical type, not underlying order.

OSV order in Japanese

- Japanese also allows OSV word order, as in (42):

(42) Naomi-o Ken-ga tazuneta.
Naomi-ACC Ken-NOM visit-PAST.CONCL
'Ken visited Naomi.'

- OS order can also give rise to constituent cluster coordination parallel to (37), as in (43):

(43) [Naomi-o Ken-ga,] [Sara-o Erika-ga] tazuneta
$S/((S\backslash NP_{acc})\backslash NP_{nom})$ $S/((S\backslash NP_{acc})\backslash NP_{nom})$ $(S\backslash NP_{acc})\backslash NP_{nom}$
Naomi-ACC Ken-NOM, Sara-ACC Erika-NOM visit-PAST.CONCL
'Ken visited Naomi and Erika, Sara.'

- The natural solution is to regard so-called scrambling constituent orders in Japanese as lexically specified, either via multiple verb categories or via explicitly unordered leftward verb categories, in keeping with the observation that scrambling (as distinct from true extraction) is clause-bounded.
- See Miyagawa 1997 on base-generation of scrambling in Japanese See Komagata 1999, Hoffman 1995a,b, and Baldridge 1998 for discussion of extended formalisms for unordered categories.
- The mixed SOV/VSO pattern of gapping in Dutch and German can also be accounted for on the basis of multiple lexical entries for verbs.

Gapping and VSO Word Order

(44) chonaic$_{VSO}$:= $(S/NP)/NP : \lambda x.\lambda y.see'yx$

(45) a. Chonaic Eoghan Siobhán.
saw Eoghan Siobhán
'Eoghan saw Siobhán.'

b.
$$
\begin{array}{ccc}
\text{Chonaic} & \text{Eoghan} & \text{Siobhán} \\
\overline{(S/NP)/NP} & \overline{(S/NP)\backslash((S/NP)/NP)}^{<\mathbf{T}} & \overline{S\backslash(S/NP)}^{<\mathbf{T}} \\
 & \multicolumn{2}{c}{\overline{S\backslash((S/NP)/NP)}^{<\mathbf{B}}} \\
\multicolumn{3}{c}{\overline{S}^{<}}
\end{array}
$$

(46) Chonaic [Eoghan Siobhán] agus [Eoghnaí Ciarán].
$(S/NP)/NP$ $S\backslash((S/NP)/NP)$ $S\backslash((S/NP)/NP)$
saw Eoghan Siobhán and Eoghnaí Ciarán
'Eoghan saw Siobhán, and Eoghnaí, Ciarán.'

- Again the three principles exclude the "backward gapping" construction that Ross (1970) held to be generally disallowed in strictly verb-initial languages:

(47) *[Eoghan Siobhán] agus chonaic [Eoghnaí Ciarán].
$S\backslash((S/NP)/NP)$ $(S/NP)/NP$ $S\backslash((S/NP)/NP)$
Eoghan Siobhán and saw Eoghnaí Ciarán

Gapping and SVO Word Order

- The fact that gapping in English and other verb-medial languages is rightward, on the VSO pattern, needs further explanation. However, example (31) already suggests that the answer is not far away.

Intonation in English

- Consider the following minimal pair of dialogs:

(48) Q: I know who proved soundness. But who proved COMPLETENESS?
A: (MARCEL) (proved COMPLETENESS).
H* L L+H* LH%

(49) Q: I know which result Marcel PREDICTED. But which result did Marcel PROVE?
A: (Marcel PROVED) (COMPLETENESS).
L+H*LH% H* LL%

Surface Structure in CCG

(50)

$$\begin{array}{ccc}
\text{Marcel} & \text{proved} & \text{completeness} \\
\hline
NP : marcel' & (S\backslash NP)/NP : prove' & (S\backslash NP)\backslash((S\backslash NP)/NP) \\
\xrightarrow{\quad\quad\quad\quad\quad\quad}{>}\mathbf{T} & & : \lambda p.p\ completeness' \\
S/(S\backslash NP) : \lambda f.f\ marcel' & & \\
& \multicolumn{2}{c}{\underline{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}<} \\
& \multicolumn{2}{c}{S\backslash NP : \lambda y.prove'completeness'y} \\
\multicolumn{3}{c}{\underline{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}<} \\
\multicolumn{3}{c}{S : prove'completeness'marcel'}
\end{array}$$

(51)

$$\begin{array}{ccc}
\text{Marcel} & \text{proved} & \text{completeness} \\
\hline
NP : marcel' & (S\backslash NP)/NP : prove' & S\backslash(S/NP) : \lambda p.p\ completeness' \\
\xrightarrow{\quad\quad\quad\quad\quad\quad}{>}\mathbf{T} & & \\
S/(S\backslash NP) : \lambda f.f\ marcel' & & \\
\multicolumn{2}{c}{\underline{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}{>}\mathbf{B}} & \\
\multicolumn{2}{c}{S/NP : \lambda x.prove'x\ marcel'} & \\
\multicolumn{3}{c}{\underline{\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad}<} \\
\multicolumn{3}{c}{S : prove'completeness'marcel'}
\end{array}$$

Combinatory Prosody

- The above alternative derivations provide exactly what is needed to support the phonologists' notion of intonation structure.
- In particular, the derivations deliver lambda terms that correspond semantically to units of Information Structure.
- Thus we can bring notions like Topic/Theme and Comment/Rheme into compositional semantics and competence grammar.
- See Prevost and Steedman (1994), Steedman (2000a).

Parsing

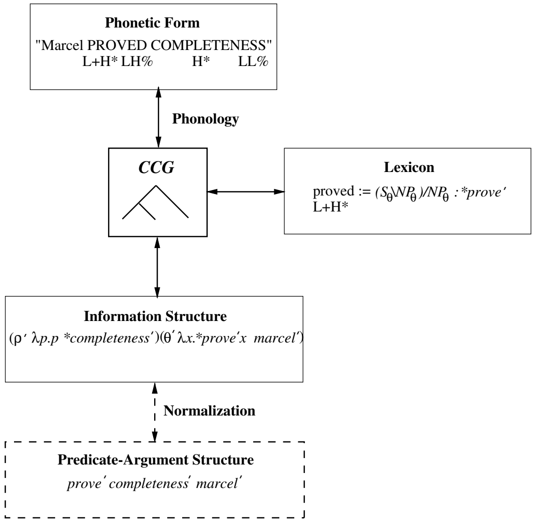
- Polynomial worst case parsing complexity is guaranteed by weak equivalence to TAG/HG/LIG (Vijay-Shanker and Weir 1994).
- In practice, observed complexity for CKY parsing with subsumption checking for table entry on categories *including normalized logical form* is better than cubic (Komagata 1999).
- Such parsers are readily statistically optimizable using techniques of the kind proposed by Collins (1998)—see Hockenmaier, Bierner and Baldridge (2000).
- Human processing appears to be even more constrained, to be linear or better, by being *incomplete* (Bever 1970):

(52) a. The doctor sent for the patient arrived.
b. The flowers sent for the patient arrived.

Consequences of Flexible Surface Structure

- Coordination, Parentheticalization, Intonation Structure, and "*Wh*-movement" constructions can all be handled by the same purely type-driven syntactic rules, strictly adhering to the Constituent Condition.
- Efficient processing including "weak" semantically interactive incremental parsing remains possible within the constraints of the Strict Competence Hypothesis.
- Everything that depends on relations of "c-command" (e.g. binding and control, quantifier scope) must be dealt with at the level of logical form (cf. Bach 1980; Lasnik and Saito 1984), with a consequent transfer of responsibility for the grammar of bounded constructions to the lexicon.
- The modules of Phonological Form, S-Structure, and Intonational Structure are unified into a single surface derivational module.

The Architecture of CCG



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