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Syntactic Features for Regular Constraints and an Approximation of Directional Slashes in Abstract Categorial Grammars

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Plan

- What is ACG?
- How to obtain syntactic features expressing regular constraints
- Gapping

This talk will have a difference emphasis than my paper in the proceedings.

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Lambda Calculus and Formal Grammar

4th workshop

Sep. 18-19 2007, Nancy (France)

Program

Tuesday September 18th

10:00		Welcome and opening
10:20	Reinhard Muskens	English as a formal system (slides)
11:00		Break
11:30	Gilad Ben-Avi/Yoad Winter	A sound intensionalization procedure
12:10	Philippe de Groote	Yet another dynamic logic (slides)
12:50		Lunch
14:30	Sébastien Hinderer	Compositional approaches to discourse representation structures construction (slides)
15:10	Christina Unger	Feature-driven movement as delimited control (slides)
15:50		Break
16:20	Chris Barker	Reasonning about contexts in Lambek Grammars (slides)

Wednesday September 19th

09:40	Makoto Kanazawa	Almost Linear Abstract Categorial Grammars and Attribute Grammars (slides)
10:20	Michael Moortgat	Lexical and derivational semantics for Lambek-Grishin calculus
11:00		Break
11:30	Carl Pollard	The Logics of Overt and Covert Movement in aRelational Type-Theoretic Grammar (slides)
12:10	Glyn Morrill	Grammar and Incremental processing of Dutch word order (slides)
12:50		Lunch
14:45	Sylvain Salvati	On grammatical analyses of Lambek grammars (slides)
15:25	Ryo Yoshinaka	On two extensions of Abstract Categorial Grammars (slides)
16:05		Closing

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"Why is it called abstract **categorial** grammar?"

–Anna Chernilovskaya

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Abstract Categorial Grammar (de Groote 2001, Muskens 2001)

- not a new kind of categorial grammar
- represents basic building blocks of the grammar as well as grammatical operations on them with typed linear λ-terms
- a general formalism meant to be restricted in various ways to produce more constrained grammars
- generalizes
  - CFG (context-free grammar)
  - TAG (tree-adjoining grammar)
  - MCFG (multiple context-free grammar) (or LCFRS (linear context-free rewriting system))
  - but not Lambek categorial grammar
- is like categorial grammar in that semantic composition is a homomorphic image of syntactic derivation
- treats form and meaning symmetrically

This slide is from a talk I gave in 2005. The title of my talk was "Abstract Categorial Grammar and Linear Logic".
Mitsuhiro Okada introduced me saying I was going to talk about the latest exciting developments in categorial grammar.

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ACG is **not** a categorial grammar.

The connection of ACGs with context-free/tree-adjoining grammars and mainstream formal language theory is more important than the aspects of ACGs inherited from the categorial grammar tradition.
"Abstract context-free grammar" or "abstract tree-adjoining grammar" would have been at least as appropriate.

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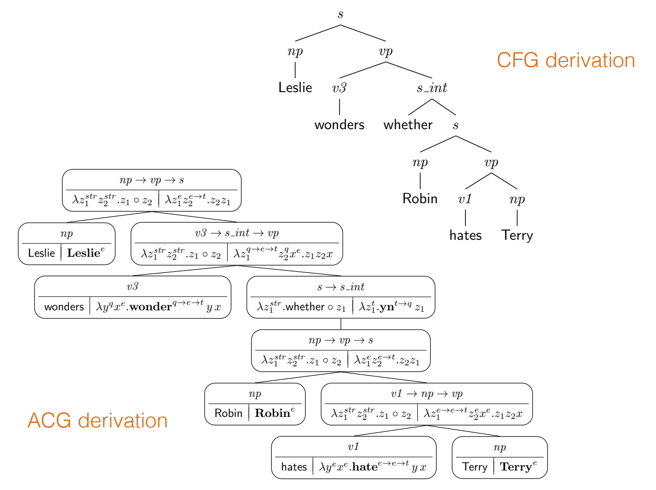

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Building Blocks

syntactic type

$$np \to vp \to s$$

$$\lambda z_1^{str} z_2^{str} . z_1 \circ z_2 \;\Big|\; \lambda z_1^{e} z_2^{e \to t} . z_2 z_1$$

form meaning

$s \mapsto str$	$v1 \mapsto str$	$s \mapsto t$	$v1 \mapsto e \to e \to t$
$np \mapsto str$	$v2 \mapsto str$	$np \mapsto e$	$v2 \mapsto t \to e \to t$
$vp \mapsto str$	$v3 \mapsto str$	$vp \mapsto e \to t$	$v3 \mapsto q \to e \to t$
$s\_bar \mapsto str$		$s\_bar \mapsto t$	
$s\_int \mapsto str$		$s\_int \mapsto q$	

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$$np \to vp \to s$$

$$\lambda z_1^{str} z_2^{str} . z_1 \circ z_2 \;\Big|\; \lambda z_1^{e} z_2^{e \to t} . z_2 z_1$$

An ACG need not be lexicalized.

One important respect in which ACG is not a categorial grammar.

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ACG is a generalization of TAG.

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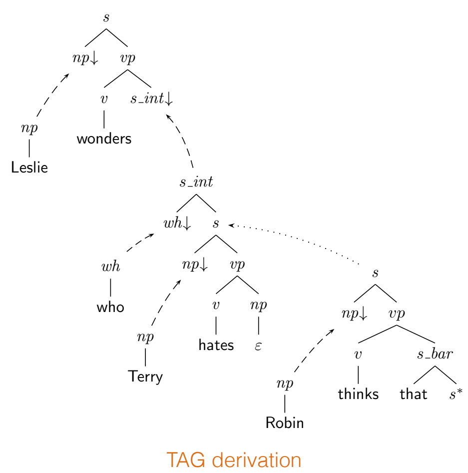

ACGs are a generalization of TAGs.
Elementary trees = trees (initial trees) / unary functions on trees (auxiliary trees).
ACGs have elementary λ-terms instead of elementary trees.

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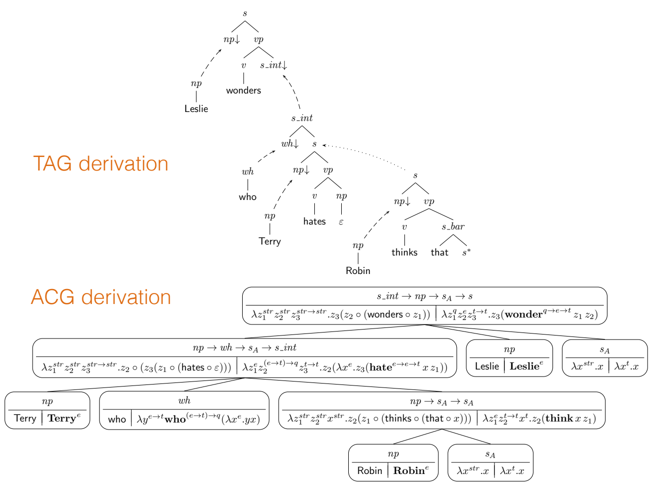

Sylvain Pogodalla has written many papers on the relation between TAGs and ACGs.

Building Blocks

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syntactic type

$$\dfrac{np \to wh \to s_A \to s\_int}{\lambda z_1^{str} z_2^{str} z_3^{str \to str}. z_2 \circ (z_3(z_1 \circ (\mathsf{hates} \circ \varepsilon))) \;\Big|\; \lambda z_1^{e} z_2^{(e \to t) \to q} z_3^{t \to t}. z_2(\lambda x^{e}. z_3(\mathbf{hate}^{e \to e \to t}\, x\, z_1))}$$

form	meaning
$s \mapsto str$	$s \mapsto t$
$np \mapsto str$	$np \mapsto e$
$s\_int \mapsto str$	$s\_int \mapsto q$
$wh \mapsto str$	$wh \mapsto (e \to t) \to q$
$s_A \mapsto str \to str$	$s_A \mapsto t \to t$

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$$s_A \mapsto str \to str$$

An atomic syntactic type can be mapped to a complex “prosodic” type.

Another important respect in which ACG is not a categorial grammar. The complexity of the substitution is an important parameter according to which ACGs form a hierarchy.

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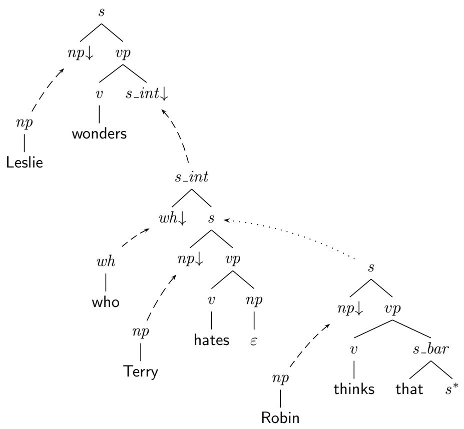
$$\dfrac{np \to s_A \to s_A}{\lambda z_1^{str} z_2^{str} x^{str}. z_2(z_1 \circ (\mathsf{thinks} \circ (\mathsf{that} \circ x))) \;\Big|\; \lambda z_1^{e} z_2^{t \to t} x^{t}. z_2(\mathbf{think}\, x\, z_1)}$$

$$\dfrac{np}{\mathsf{Robin} \;\Big|\; \mathbf{Robin}^{e}} \qquad \dfrac{s_A}{\lambda x^{str}. x \;\Big|\; \lambda x^{t}. x}$$

A constituent with a gap may have an atomic syntactic type.

An arbitrarily complex λ-term can be derived from an atomic-typed subterm of a derivation.



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This illustrates a TAG-analysis of wh-movement originally due to Anthony Kroch.
One could easily imagine a TAG-inspired analysis of Right Node Raising in an ACG.
Gapping may be handled by a simple context-free grammar of rank ≥ 2.

Abstract Syntactic Types

	CFG-style	TAG-style	"Lambek-style"
unsaturated standard constituents	atomic	functional	functional
modifiers	atomic	atomic	functional
continuous non-standard constituents	-	-	functional
discontinuous constituents	-	functional / atomic	functional
constituents with gaps	atomic (GPSG)	atomic	functional

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You can classify various styles of analyses possible in ACGs in terms of atomic/functional distinction.

The ACG formalism supports many styles of linguistic analysis.

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To take advantage of the full potential of ACGs, different styles of analyses should be explored.

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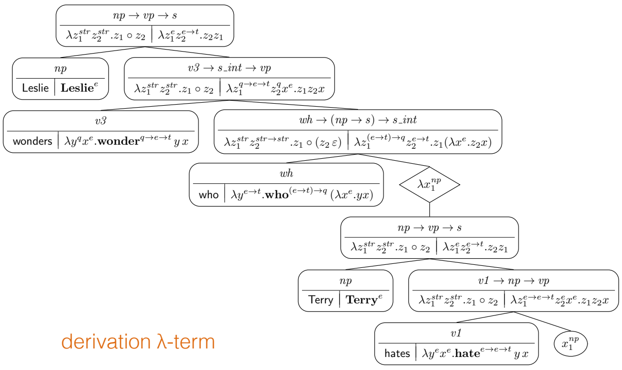
Second-Order vs. Higher-Order Abstract Syntax



derivation λ-term

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	derivations	"building block" λ-terms	language complexity	connections with computer science
second-order	trees	(almost) linear	LOGCFL	formal language theory, program schemes
		λI (= BCIW)	decidable	
higher-order	linear λ-terms	(almost) linear	?	BVASS
		λI (= BCIW)	?	

Higher-order ACGs are problematic.

Linearity is overrated.

Second-order ACGs have almost no resemblance with categorial grammars.
Problems that KLM pointed out have to do with higher-order ACGs.
Higher-order ACGs are problematic in other ways.

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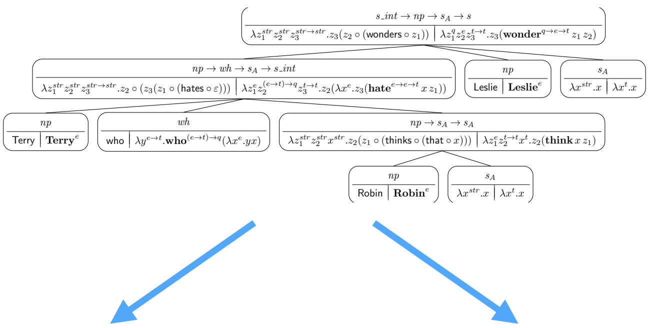
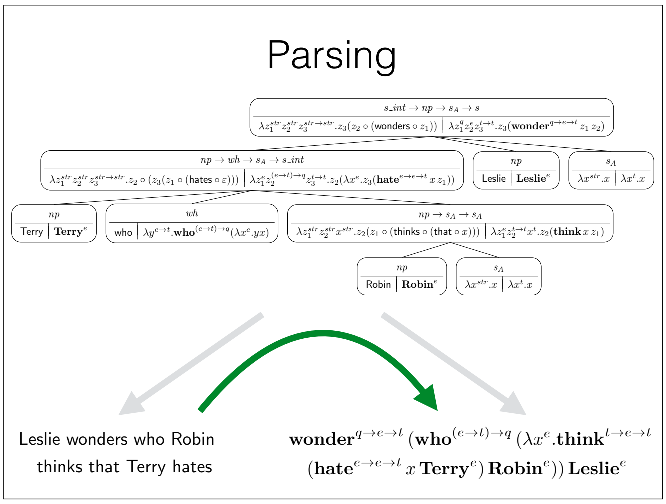
Symmetry



Leslie wonders who Robin thinks that Terry hates

$\mathbf{wonder}^{q \to e \to t}\,(\mathbf{who}^{(e \to t) \to q}\,(\lambda x^e.\mathbf{think}^{t \to e \to t}\,(\mathbf{hate}^{e \to e \to t}\,x\,\mathbf{Terry}^e)\,\mathbf{Robin}^e))\,\mathbf{Leslie}^e$



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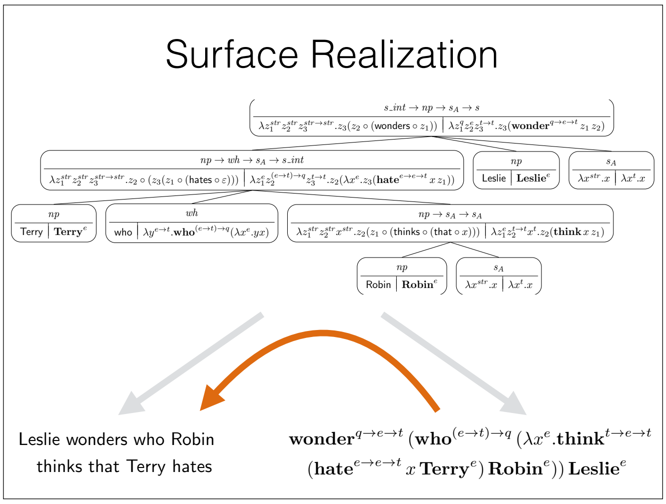
Two of the most important problems concerning grammars are parsing and surface realization (generation).



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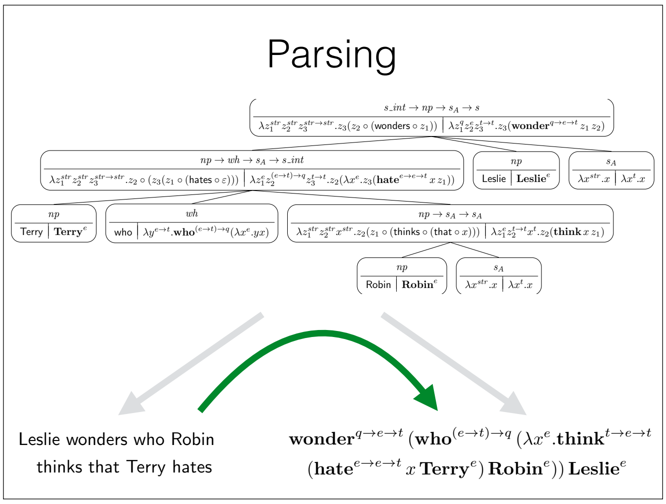

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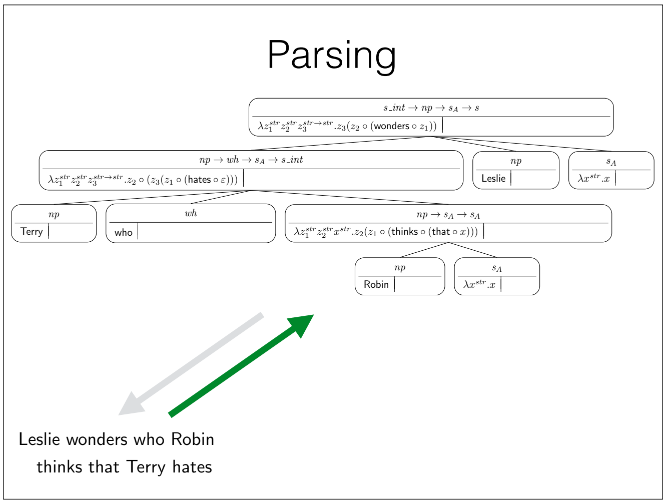
The problem boils down to finding the derivation from the input string.



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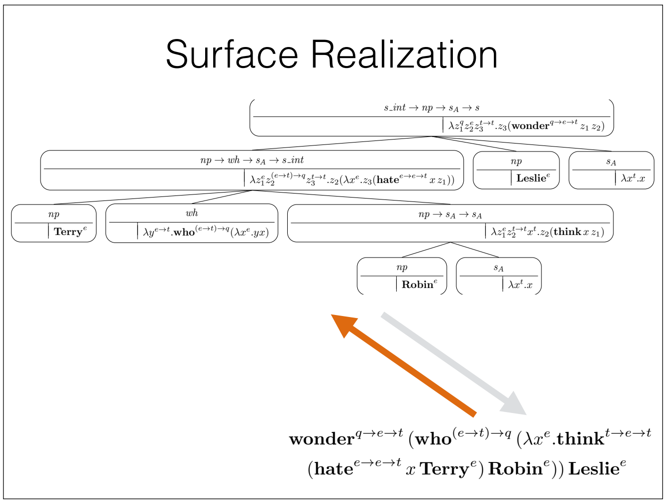
The semantic component of the grammar is irrelevant.



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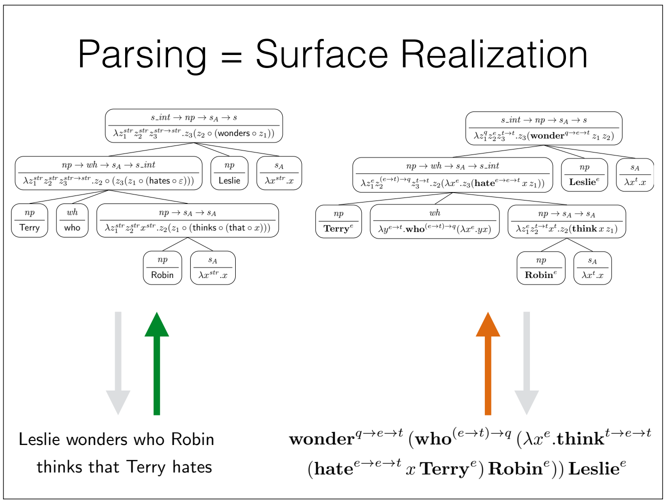
The “form” component of the grammar is irrelevant.



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In a fairly broad, interesting class of cases, the problems of parsing and surface realization have been solved.

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Tabular Parsing

$$?\!-\ s(0\text{–}8).$$

$$
\begin{aligned}
s(x_1) &:- s\_int(x_4), np(x_3), s_A(x_1, x_2), \circ(x_2, x_3, x_4), \circ(x_4, x_5, x_6), \mathsf{wonders}(x_5).\\
s\_int(x_1) &:- np(x_5), wh(x_2), s_A(x_3, x_4), \circ(x_1, x_2, x_3), \circ(x_4, x_5, x_6), \circ(x_6, x_7, x_8), \mathsf{hates}(x_7), \epsilon(x_8).\\
s_A(x_1, x_8) &:- np(x_3), s_A(x_1, x_2), \circ(x_2, x_3, x_4), \circ(x_4, x_5, x_6), \circ(x_6, x_7, x_8), \mathsf{thinks}(x_5), \mathsf{that}(x_7).\\
s_A(x_1, x_1) &:- .\\
np(x_1) &:- \mathsf{Terry}(x_1).\\
np(x_1) &:- \mathsf{Robin}(x_1).\\
np(x_1) &:- \mathsf{Leslie}(x_1).\\
wh(x_1) &:- \mathsf{who}(x_1).
\end{aligned}
$$

Leslie$(0\text{–}1)$. wonders$(1\text{–}2)$. who$(2\text{–}3)$. Robin$(3\text{–}4)$. thinks$(4\text{–}5)$. that$(5\text{–}6)$. Terry$(6\text{–}7)$. hates$(7\text{–}8)$.
$\circ(i\text{–}k, i\text{–}j, j\text{–}k)$.
$\epsilon(i\text{–}i)$.

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Tabular Realization

$$?\!-\ s(1).$$

$$
\begin{aligned}
s(x_1) &:- s\_int(x_3), np(x_4), s_A(x_1, x_2), \mathbf{wonder}(x_2, x_3, x_4).\\
s\_int(x_1) &:- np(x_5), wh(x_1, x_2, x_4), s_A(x_1, x_2), \mathbf{hate}(x_3, x_4, x_5).\\
s_A(x_1, x_3) &:- np(x_4), s_A(x_1, x_2), \mathbf{think}(x_2, x_3, x_4).\\
s_A(x_1, x_1) &:- .\\
np(x_1) &:- \mathbf{Terry}(x_1).\\
np(x_1) &:- \mathbf{Robin}(x_1).\\
np(x_1) &:- \mathbf{Leslie}(x_1).\\
wh(x_1, x_2, x_3) &:- \mathbf{who}(x_1, x_2, x_3).
\end{aligned}
$$

wonder$(1, 2, 8)$. **who**$(2, 3, 5)$. **think**$(3, 4, 5)$. **hate**$(4, 5, 6)$. **Terry**(6). **Robin**(7). **Leslie**(8).

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Symmetry between form and meaning is at the heart of ACG.

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KLM

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Right Node Raising

Lambek

$((s/np)\backslash(s/np))/(s/np)$: and : $\lambda z_1^{e\to t} z_2^{e\to t} x^e.\ \wedge^{t\to t\to t}\ (z_1\, x)(z_2\, x)$

ACG

$(np \to s) \to (np \to s) \to np \to s$

$\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.((z_2\, \varepsilon) \circ (\text{and} \circ (z_1\, \varepsilon))) \circ x \mid \lambda z_1^{e\to t} z_2^{e\to t} x^e.\ \wedge^{t\to t\to t}\ (z_1\, x)\, (z_2\, x)$

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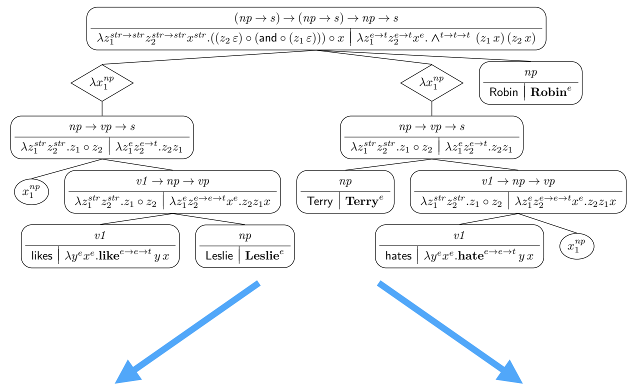

$((\text{Terry} \circ (\text{hates} \circ \varepsilon)) \circ (\text{and}$
$\circ\ (\varepsilon \circ (\text{likes} \circ \text{Leslie})))) \circ \text{Robin}$

$\wedge^{t\to t\to t}\ (\mathbf{like}^{e\to e\to t}\ \mathbf{Leslie}^e\ \mathbf{Robin}^e)$
$(\mathbf{hate}^{e\to e\to t}\ \mathbf{Robin}^e\ \mathbf{Terry}^e)$

"Terry hates Robin and Robin likes Leslie"

Right Node Raising.
An example of overgeneration.
The other entry considered by KLM gives "Terry hates and Robin likes Leslie".

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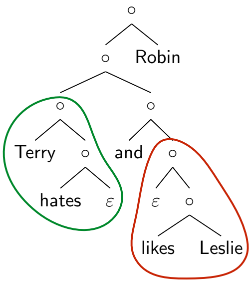

The gap in each conjunct of RNR must be on the right periphery.

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If you have a good specification, the grammar will write itself.

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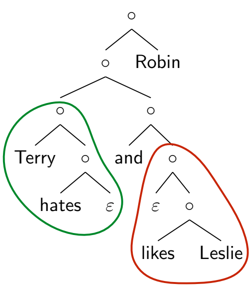

The gap in each conjunct of RNR must be on the right periphery.

Who did [Max entice _ to read _] and [Ted ask _ to summarize _] the latest paper by Chomsky?

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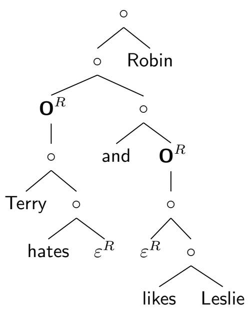
A conjunct of RNR may contain two gaps.



ε^R must be the rightmost leaf of a subtree whose root label is $\mathbf{O}^R$.

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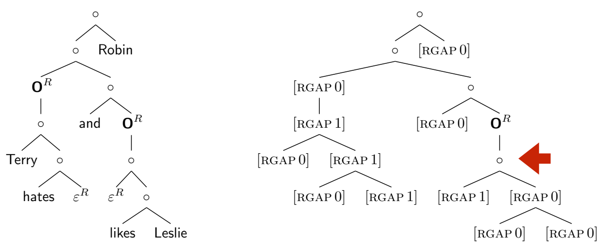
Good specification = regular set = finite tree automaton



$$
\begin{aligned}
\varepsilon^R &\to [\text{RGAP } 1], \\
a &\to [\text{RGAP } 0] \quad \text{for each terminal symbol } a, \\
[\text{RGAP } 0] \circ [\text{RGAP } 0] &\to [\text{RGAP } 0], \\
[\text{RGAP } 0] \circ [\text{RGAP } 1] &\to [\text{RGAP } 1], \\
\mathbf{O}^R\, [\text{RGAP } 1] &\to [\text{RGAP } 0].
\end{aligned}
$$

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Cf. model-theoretic syntax of Jim Rogers.

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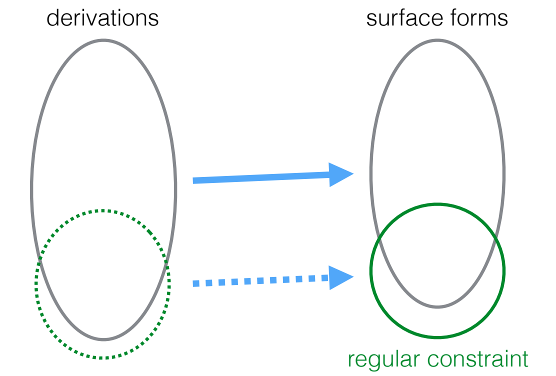

A generalization of the classic result that the class of context-free languages are closed under intersection with regular sets. Building block λ-terms must be almost linear.

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$$\frac{(np \to s) \to (np \to s) \to np \to s}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.((z_2\,\varepsilon)\circ(\mathsf{and}\circ(z_1\,\varepsilon)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

add markers

$$\frac{(np \to s) \to (np \to s) \to np \to s}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.(\mathbf{O}^R(z_2\,\varepsilon^R)\circ(\mathsf{and}\circ\mathbf{O}^R(z_1\,\varepsilon^R)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

intersect with regular set

$$\frac{(np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to (np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to np[\mathrm{RGAP}\,r] \to s[\mathrm{RGAP}\,r]}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.(\mathbf{O}^R(z_2\,\varepsilon^R)\circ(\mathsf{and}\circ\mathbf{O}^R(z_1\,\varepsilon^R)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

remove markers

$$\frac{(np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to (np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to np[\mathrm{RGAP}\,r] \to s[\mathrm{RGAP}\,r]}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.((z_2\,\varepsilon)\circ(\mathsf{and}\circ(z_1\,\varepsilon)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

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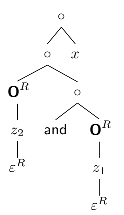
$$\frac{(np \to s) \to (np \to s) \to np \to s}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.(\mathbf{O}^R(z_2\,\varepsilon^R)\circ(\mathsf{and}\circ\mathbf{O}^R(z_1\,\varepsilon^R)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

intersect with regular set

$$\frac{(np[\mathrm{RGAP}\,r_1] \to s[\mathrm{RGAP}\,r_2]) \to (np[\mathrm{RGAP}\,r_3] \to s[\mathrm{RGAP}\,r_4]) \to np[\mathrm{RGAP}\,r_5] \to s[\mathrm{RGAP}\,r_6]}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.(\mathbf{O}^R(z_2\,\varepsilon^R)\circ(\mathsf{and}\circ\mathbf{O}^R(z_1\,\varepsilon^R)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$



$$\begin{aligned} z_1\,[\mathrm{RGAP}\,r_1] &\to [\mathrm{RGAP}\,r_2],\\ z_2\,[\mathrm{RGAP}\,r_3] &\to [\mathrm{RGAP}\,r_4],\\ x &\to [\mathrm{RGAP}\,r_5],\\[1ex] \varepsilon^R &\to [\mathrm{RGAP}\,1],\\ a &\to [\mathrm{RGAP}\,0] \quad \text{for each terminal symbol } a,\\ [\mathrm{RGAP}\,0]\circ[\mathrm{RGAP}\,0] &\to [\mathrm{RGAP}\,0],\\ [\mathrm{RGAP}\,0]\circ[\mathrm{RGAP}\,1] &\to [\mathrm{RGAP}\,1],\\ \mathbf{O}^R\,[\mathrm{RGAP}\,1] &\to [\mathrm{RGAP}\,0]. \end{aligned}$$

$$\frac{(np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to (np[\mathrm{RGAP}\,1] \to s[\mathrm{RGAP}\,1]) \to np[\mathrm{RGAP}\,r] \to s[\mathrm{RGAP}\,r]}{\lambda z_1^{str\to str} z_2^{str\to str} x^{str}.(\mathbf{O}^R(z_2\,\varepsilon^R)\circ(\mathsf{and}\circ\mathbf{O}^R(z_1\,\varepsilon^R)))\circ x \;\Big|\; \lambda z_1^{e\to t} z_2^{e\to t} x^{e}.\,\wedge^{t\to t\to t}\,(z_1\,x)(z_2\,x)}$$

Gapping

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Hybrid

$$\frac{(((np\backslash s)/np) \to s) \to (((np\backslash s)/np) \to s) \to ((np\backslash s)/np) \to s}{\lambda z_1^{str\to str} z_2^{str\to str} z_3^{str}.(z_2 z_3) \circ (\textsf{and} \circ (z_1\,\varepsilon)) \;\Big|\; \lambda z_1^{(e^2\to t)\to t} z_2^{(e^2\to t)\to t} z_3^{e^2\to t}. \wedge^{t\to t\to t} (z_1(\lambda y^e x^e.z_3 y x))\,(z_2(\lambda y^e x^e.z_3 y x))}$$

ACG

$$\frac{((np \to np \to s) \to s) \to ((np \to np \to s) \to s) \to (np \to np \to s) \to s}{\lambda z_1^{(str^2\to str)\to str} z_2^{(str^2\to str)\to str} z_3^{str^2\to str}.(z_2(\lambda y^{str} x^{str}.x \circ ((z_3\,\varepsilon\,\varepsilon) \circ y))) \circ (\textsf{and} \circ (z_1(\lambda y^{str} x^{str}.x \circ (\varepsilon \circ y)))) \;\Big|\; \dots}$$

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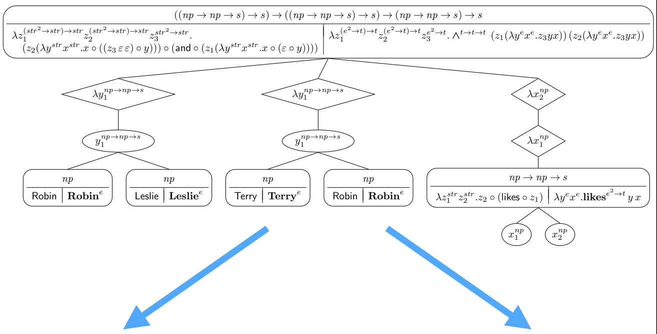

$(\textsf{Robin} \circ ((\varepsilon \circ (\textsf{likes} \circ \varepsilon)) \circ \textsf{Terry})) \circ (\textsf{and} \circ (\textsf{Leslie} \circ (\varepsilon \circ \textsf{Robin})))$

$\wedge^{t\to t\to t} (\mathbf{like}^{e\to e\to t}\, \mathbf{Leslie}^e\, \mathbf{Robin}^e)\, (\mathbf{like}^{e\to e\to t}\, \mathbf{Robin}^e\, \mathbf{Terry}^e)$

"Terry likes Robin and Robin likes Leslie"

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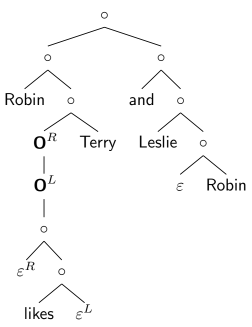

$$\frac{((np[0,r_1] \to np[l_1,0] \to s[l_1,r_1]) \to s[0,r]) \to ((np[0,r_2] \to np[l_2,0] \to s[l_2,r_2]) \to s[l,0]) \to (np[0,1] \to np[1,0] \to s[1,1]) \to s[l,r]}{\lambda z_1^{(str\to str\to str)\to str} z_2^{(str\to str\to str)\to str} z_3^{str\to str\to str}.(z_2(\lambda y^{str} x^{str}.x \circ (\mathbf{O}^R\,(\mathbf{O}^L\,(z_3\,\varepsilon^R\,\varepsilon^L)) \circ y))) \circ (\textsf{and} \circ (z_1(\lambda y^{str} x^{str}.x \circ (\varepsilon \circ y)))) \;\Big|\; \dots}$$

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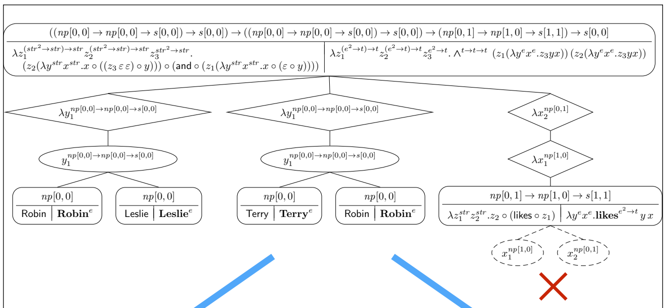

(Robin ∘ ((ε ∘ (likes ∘ ε)) ∘ Terry)) ∘ (and ∘ (Leslie ∘ (ε ∘ Robin)))

$\wedge^{t \to t \to t}$ $(\mathbf{like}^{e \to e \to t}\ \mathbf{Leslie}^{e}\ \mathbf{Robin}^{e})$ $(\mathbf{like}^{e \to e \to t}\ \mathbf{Robin}^{e}\ \mathbf{Terry}^{e})$

"Terry likes Robin and Robin likes Leslie"

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The right- or left-peripherality of a gap can be enforced by a syntactic feature.

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Reverse Word Order

Tom cooked the beans, and Bill, the potatoes.

Tom cooked the beans, and the potatoes, Bill.

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A. Gee, the beans and the potatoes are good! Did Tom cook them again?

B1. No. Today, Tom cooked the beans, and Bill, the potatoes.

B2. No. Today, Tom cooked the beans, and the potatoes, Bill.

The first remnant can be a Focus.

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Topicalization + Gapping

Tom cooked the beans, and Bill, the potatoes.

Tom cooked the beans, and the potatoes, Bill.

The beans, Tom cooked, and the potatoes, Bill.

Tom cooked the beans, and the potatoes, Bill.

The last two based on Hankamer's (1979) examples.

51

Discontinuous Gapping

While the canonical cases of gapping have medial gaps, the gap can also be discontinuous, e.g.

Should I call you, or $_{\text{should}}$ you $_{\text{call}}$ me?
Will Jimmy greet Jill first, or $_{\text{will}}$ Jill $_{\text{greet}}$ Jimmy $_{\text{first}}$?
He believes her to know the answer, and she $_{\text{believes}}$ him $_{\text{to know the answer}}$.
I expect you to help, and you $_{\text{expect}}$ me $_{\text{to help}}$.

-Wikepedia, Gapping

Discontinuous Gapping

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(16) Max seemed to be trying to force Ted to leave the room, and Walt [~~seemed to be trying to force~~] Ira [~~to leave the room~~] (Jackendoff, 1971, p. 25)

(17) Arizona elected Goldwater Senator, and Pennsylvania [~~elected~~] Schweiker [~~Senator~~] (Jackendoff, 1971, p. 24)

(18) Jack begged Elsie to get married, and Wilfred [~~begged~~] Phoebe [~~to get married~~] (Jackendoff, 1971, p. 24)

(19) Max wanted Ted to persuade Alex to get lost and [~~Max wanted~~] Walt [~~to persuade~~] Ira [~~to get lost~~] (Hankamer, 1973, pp. 26–27)

(20) John took Harry to the movies, and Bill [~~took~~] Mike [~~to the movies~~] (Sag, 1976, p. 218)

(21) John persuaded Dr. Thomas to examine Mary, and Bill [~~persuaded~~] Dr. Jones [~~to examine Mary~~] (Sag, 1976, p. 225)

(22) Joe covered the floor with red paint, and Alice [~~covered~~] the walls [~~with red paint~~] (Neijt, 1980, p. 79)

(23) Joe painted his boat red, and Alice [~~painted~~] her car [~~red~~] (Neijt, 1980, p. 79)

(24) Some people want all doors to open to the left and others [~~want~~] all windows [~~to open to the left~~] (Neijt, 1980, p. 160)

Discontinuous Gapping

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$$(((np\backslash s)/np) \to s) \to (((np\backslash s)/np) \to s) \to ((np\backslash s)/np) \to s$$

(25) Max ordered Ted to persuade Alex to get lost and [~~Max ordered~~] Walt [~~to persuade~~] Ira [~~to get lost~~]

(26) I asked Peter to take Susan home, and [~~I asked~~] John [~~to take~~] Wendy [~~home~~]

(27) Rarely does John call Mary at home, and [~~rarely does~~] Mary [~~call~~] John [~~at home~~]

The type of the gap = *np* → *np* → *s*

$$((np \to np \to s) \to s) \to ((np \to np \to s) \to s) \to ((np \to np \to s) \to s$$

$$\lambda z_1^{str\to str} z_2^{str\to str} z_3^{str}.(z_2 z_3) \circ (\textsf{and} \circ (z_1\ \varepsilon)) \quad \Big| \quad \lambda z_1^{(e^2\to t)\to t} z_2^{(e^2\to t)\to t} z_3^{e^2\to t}. \wedge^{t\to t\to t} (z_1(\lambda y^e x^e.z_3 yx))\,(z_2(\lambda y^e x^e.z_3 yx))$$

"I asked Peter to take Susan home and I asked Wendy to take John home."

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$$((np \to np \to s) \to s) \to ((np \to np \to s) \to s) \to ((np \to np \to s) \to s$$

$$\lambda z_1^{str\to str} z_2^{str\to str} z_3^{str}.(z_2 z_3) \circ (\textsf{and} \circ (z_1\ \varepsilon)) \quad \Big| \quad \lambda z_1^{(e^2\to t)\to t} z_2^{(e^2\to t)\to t} z_3^{e^2\to t}. \wedge^{t\to t\to t} (z_1(\lambda y^e x^e.z_3 yx))\,(z_2(\lambda y^e x^e.z_3 yx))$$

In the first conjunct of Gapping, the correspondent of the first remnant must precede the correspondent of the second remnant.

$$((np \to np \to s) \to s) \to ((np \to np \to s) \to s) \to ((np \to np \to s) \to s$$

$$\lambda z_1^{(str\to str\to str)\to str} z_2^{(str\to str\to str)\to str} z_3^{str\to str\to str}. (z_2(\lambda y^{str} x^{str}.\,\mathbf{O}^{<}\,(z_3(\mathbf{C}_2\,y)(\mathbf{C}_1\,x)))) \circ (\textsf{and} \circ (z_1(\lambda y^{str} x^{str}.x \circ (\varepsilon \circ y)))) \quad \Big| \quad \ldots$$

If, as has often been argued (Kuno, 1976; Neijt, 1980; Coppock, 2001; Johnson, 2014), the relative positions of the correspondents/remnants obey some (but perhaps not all) of the island constraints governing wh-extraction, those constraints can also be captured by the syntactic feature, as long as they are regular.

Conclusion

- ACG supports non-categorial-style analyses.
- In a Lambek-style analysis, any regular constraint on positions of gaps can be captured by syntactic features.