Canonical Constituents and Non-canonical Coordination

Simple Categorial Grammar Account

http://okmij.org/ftp/gengo/NL.pdf

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A variation of the standard non-associative Lambek calculus with the slightly non-standard yet very traditional semantic interpretation turns out to straightforwardly and uniformly express the instances of non-canonical coordination while maintaining phrase structure constituents. Non-canonical coordination looks just as canonical on our analyses. Gapping, typically problematic in Categorial Grammar–based approaches, is analyzed just like the ordinary object coordination. Furthermore, the calculus uniformly treats quantification in any position, quantification ambiguity and islands. It lets us give what seems to be the simplest account for both narrow- and wide-scope quantification into coordinated phrases and of narrow- and wide-scope modal auxiliaries in gapping.

The calculus lets us express standard covert movements and anaphoric-like references (analogues of overt movements) in types – as well as describe how the context can block these movements.

Coordination: Canonical

1. John left but Mary stayed.
2. John and Mary left.
3. John tripped and fell.
4. John gave a book and a record to Mary.

This talk is about coordination, and here are the simplest examples of it.

Coordination: Canonical

1. [*John left* but *Mary stayed*].
2. [*John* and *Mary*] left.
3. John [*tripped* and *fell*].
4. John gave [*a book* and *a record*] to Mary.

Coordination happens at different categories: In (1), S, in (2) NP (subject), in (3) VP, in (4) QNP (in the object position).

The canonical coordination is straightforward to analyze in most theories. We assume the polymorphic AND entry, whose semantics is some sort of a union.

Coordination: Non-Canonical

1. John liked but Mary hated Bill.

But as everywhere in linguistics, things become very complex very fast.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.

The example looks quite like the one we've seen before. But the coordinated phrases are not what are generally considered constituents. Some analyses, CCG in particular, are OK with this. They would argue that "John liked" is a sort of a constituent. Some people, including me, are uneasy about such arguments.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.
2. John gave a book to Mary and a record to Sue.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.
2. John gave [*a book to Mary* and *a record to Sue*].

Here what seems to be coordinated are just two unconnected, unrelated phrases. It is becoming harder to argue that “a book to Mary” is a constituent of sorts. It is hard to give this phrase any category (type). But things can get worse.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.
2. John gave [*a book to Mary* and *a record to Sue*].
3. I gave Leslie a book and she a CD.

This is the example of gapping.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.
2. John gave [*a book to Mary* and *a record to Sue*].
3. *I gave Leslie a book and she a CD.*

Although it looks like a coordination, it is hard to see what is coordinated with what. What are the two phrases that are coordinated? It seems like “gave” is missing.

Coordination: Non-Canonical

1. [*John liked* but *Mary hated*] Bill.
2. John gave [*a book to Mary* and *a record to Sue*].
3. *I gave Leslie a book and she a CD*.
4. Terry can go with me and Pat with you.

It is not just a simple verb can go missing. It can be a complex phrase including a verb with arguments and complements, or, as in this example, a verb and an auxiliary verb.

Coordination: Scoping

John gave a present to Robin on Thursday and to Leslie on Friday.

- $\exists p$: Gift. gaveToRTh p john $\wedge$ gaveToLFr p john
- $(\exists p$: Gift. gaveToRTh p john$) \wedge (\exists p$: Gift. gaveToLFr p john$)$

There are further challenges, the issues of scope. Kubota and Levine draw attention to the often neglected challenge of the seemingly anomalous scope.

Coordination: Scoping

John gave a present to Robin on Thursday and to Leslie on Friday.

- $\exists p$: Gift. gaveToRTh p john $\wedge$ gaveToLFr p john
- $(\exists p$: Gift. gaveToRTh p john$) \wedge (\exists p$: Gift. gaveToLFr p john$)$

Mrs. J can't live in Boston and Mr. J in LA.

- $\neg\Diamond($live Ms B $\wedge$ live Mr LA$)$
- $(\neg\Diamond$ live Ms B$) \wedge (\neg\Diamond$ live Mr LA$)$

This is the well-known example by Dick Oehrle. It is ambiguous. It may mean that it is bad when Mr. and Mrs. J live separately, one in LA and the other in Boston. Or it may mean that it is bad when at least one lives in Boston, or LA. Dick Oehrle lives in CA, so he knows what he is talking about.

Coordination: Scoping

John gave a present to Robin on Thursday and to Leslie on Friday.

- $\exists p$: Gift. gaveToRTh p john $\wedge$ gaveToLFr p john
- ($\exists p$: Gift. gaveToRTh p john) $\wedge$ ($\exists p$: Gift. gaveToLFr p john)

Mrs. J can't live in Boston and Mr. J in LA.

- $\neg\Diamond$(live Ms B $\wedge$ live Mr LA)
- ($\neg\Diamond$ live Ms B) $\wedge$ ($\neg\Diamond$ live Mr LA)

Pete wasn't called by Vanessa but rather John by Jesse.

($\neg$ calledBy P V) $\wedge$ (calledBy Jh Je)

Negation somehow scopes over the first “coordinated structure” but not over the second.

Contributions

Uniform approach to the analysis all of the above cases of coordination

Quantification: in any position, ambiguity and *islands* (inverse linking?)

Traditional

- Traditional **NL** somewhat non-standard but still deeply conservative, compositional semantic interpretation
- No monads, continuations, dependent types,...
- Standard (not higher-order) phonology
- Simulate movements but no lexical item ever moves

Stress islands: predict negative examples. As you can see, a lot of effort went into preventing overgeneration. Traditional **NL** with the somewhat non-standard but still deeply conservative semantic interpretation

The **NL** calculus

$$\frac{\Gamma \vdash t_1 : B/A \quad \Delta \vdash t_2 : A}{(\Gamma, \Delta) \vdash t_1 t_2 : B}\,/E \qquad \frac{\Gamma \vdash t_1 : A \quad \Delta \vdash t_2 : A\backslash B}{(\Gamma, \Delta) \vdash t_1 t_2 : B}\,\backslash E$$

$$\frac{(\Gamma, A) \vdash t : B}{\Gamma \vdash \leftthreetimes t : B/A}\,/I \qquad \frac{(A, \Gamma) \vdash t : B}{\Gamma \vdash \rightthreetimes t : A\backslash B}\,\backslash I$$

$$\frac{}{A \vdash x : A}\,Var$$

Antecedent tree: Non-associative
No structural rules!

The non-associative Lambek calculus **NL**. The rules are standard and should be familiar to everyone: left and right slashes, and their elimination and introduction rules. The sequents are labeled with terms. I will not distinguish left and right applications, types should disambiguate.

The antecedent structure, Γ, is a tree, and non-associative. There are no structural rules.

Derived rules

$$\frac{\Gamma \vdash t_1 : A \quad (A, \Delta) \vdash t_2 : B}{(\Gamma, \Delta) \vdash t_1 \cdot t_2 : B} \; HypL \qquad \frac{(\Delta, A) \vdash t_2 : B \quad \Gamma \vdash t_1 : A}{(\Delta, \Gamma) \vdash t_1 \cdot t_2 : B} \; Hy$$

$$\frac{\Delta \backslash A \vdash t_1 : \Gamma \backslash A \quad \mathcal{C}[\Delta] \vdash t_2 : A}{\mathcal{C}[\Gamma] \vdash t_1 \uparrow t_2 : A} \; Hyp$$

Convenient derived rules (In the rule Hyp, Γ must be a full structure type.)

It often happens that the introduction (abstracting out the hypothesis) is immediately followed by the elimination rule. To capture this pattern, and to save space in derivations, we introduce the convenient cut-like rules: HypL and HypR.

We explain Hyp on the example below.

The Hyp rule and structural constants

$$\frac{\Delta\backslash A \vdash t_1 : \Gamma\backslash A \quad \mathcal{C}[\Delta] \vdash t_2 : A}{\mathcal{C}[\Gamma] \vdash t_1 \uparrow t_2 : A}\; Hyp$$

$$\begin{array}{rl} \bullet & \vdash \text{John} : NP \\ \bullet & \vdash \text{liked} : (NP\backslash S)/NP \\ \mathcal{U} & \vdash \text{everyone} : NP \\ (\bullet,(\bullet,\Gamma))\backslash A & \vdash oL : (\bullet,\Gamma)\backslash A \end{array}$$

$$\cfrac{\cfrac{(\bullet,\mathcal{U}) \vdash \text{liked everyone}}{(\bullet,(\bullet,\mathcal{U})) \vdash \text{John liked everyone}}\;\backslash E}{(\bullet,\mathcal{U}) \vdash oL \uparrow \text{John liked everyone}}\; Hyp$$

Structural rules are lexicalized

The derivation can be reconstructed from its conclusion

The meaning of the Hyp rule: a part of the structure Δ, perhaps buried inside the structure, can be replaced with Γ – *provided* the theory has a constant of the appropriate type, which licenses the replacement, so to speak. Here is the example.

The derivation can be reconstructed from its conclusion. Therefore, we will only show conclusions. It saves a lot of space. Recall, we do not distinguish left and right applications, types should disambiguate.

Simple coordination: John tripped and fell (1)

$$And \vdash \text{and} : (S\backslash S)/S$$
$$\bullet \vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S)$$
$$(\Gamma, (And, \Gamma))\backslash A \vdash and_C : \Gamma\backslash A$$

$$\dfrac{\dfrac{\dfrac{NP \vdash x : NP \quad NP \vdash y : NP}{((NP, \bullet), (And, (NP, \bullet))) \vdash (x \text{ tripped}) \text{ and } (y \text{ fell}) : S} \; Hyp}{(NP, \bullet) \vdash and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S} \; HypL}{(\bullet, \bullet) \vdash \text{John} \cdot and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}$$

And is a context type.

Let move to coordination, first to very simple examples. We show two analyses – two approaches. One of them is simpler to explain but it does not always work. The second is more general, and more difficult. To be sure, the analysis is contrived and is shown only for the sake of example. It's better to explain detail on the simplest, familiar examples.

We first assume to NPs.

Simple coordination: John tripped and fell (1)

$$\begin{aligned} And &\vdash \text{and} : (S\backslash S)/S \\ \bullet &\vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S) \\ (\Gamma, (And, \Gamma))\backslash A &\vdash and_C : \Gamma\backslash A \end{aligned}$$

$$\dfrac{\dfrac{\dfrac{NP \vdash x : NP \quad NP \vdash y : NP}{((NP, \bullet), (And, (NP, \bullet))) \vdash (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}}{(NP, \bullet) \vdash and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, Hyp}{(\bullet, \bullet) \vdash \text{John} \cdot and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, HypL$$

And is a context type.

Then we coordinate them. Here And is a type – a context marker.

Simple coordination: John tripped and fell (1)

$$And \vdash \text{and} : (S\backslash S)/S$$
$$\bullet \vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S)$$
$$(\Gamma, (And, \Gamma))\backslash A \vdash and_C : \Gamma\backslash A$$

$$\dfrac{\dfrac{\dfrac{NP \vdash x : NP \quad NP \vdash y : NP}{((NP, \bullet), (And, (NP, \bullet))) \vdash (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}}{(NP, \bullet) \vdash and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, Hyp}{(\bullet, \bullet) \vdash \text{John} \cdot and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, HypL$$

And is a context type.

Two identical branches of the antecedent structure – two identical assumptions – can be collapsed. But only if there is *And* in-between.

Simple coordination: John tripped and fell (1)

$$And \vdash \text{and} : (S\backslash S)/S$$
$$\bullet \vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S)$$
$$(\Gamma, (And, \Gamma))\backslash A \vdash and_C : \Gamma\backslash A$$

$$\dfrac{\dfrac{\dfrac{NP \vdash x : NP \quad NP \vdash y : NP}{((NP, \bullet), (And, (NP, \bullet))) \vdash (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}}{(NP, \bullet) \vdash and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, Hyp}{(\bullet, \bullet) \vdash \text{John} \cdot and_C \uparrow (x \text{ tripped}) \text{ and } (y \text{ fell}) : S}\, HypL$$

And is a context type.

Finally, NP can be cut with John. Stress the final HypL rule.

Simple coordination: John tripped and fell (2)

- Intuition: John tripped. He fell.
- Not really a pronoun: resolved syntactically rather than pragmatically

$$\begin{aligned} \mathit{And} &\vdash \text{and} : (S\backslash S)/S \\ \bullet &\vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S) \\ \overline{A} &\vdash \mathit{ref} : A/A \\ (((\overline{A}, \bullet), \Gamma), (\mathit{And}, (A, \Delta)))\backslash S &\vdash \mathit{and}_L : ((\bullet, \Gamma), (\mathit{And}, (\bullet, \Delta)))\backslash S \end{aligned}$$

$$\cfrac{\cfrac{((\overline{NP}, \bullet), \bullet) \vdash (\mathit{ref}\,\text{John})\ \text{tripped} : S}{(((\overline{NP}, \bullet), \bullet), (\mathit{And}, (NP, \bullet))) \vdash (\mathit{ref}\,\text{John})\ \text{tripped and } (x \text{ fell}) : S}}{\bullet \vdash \mathit{and}_C \uparrow \mathit{and}_L \uparrow (\mathit{ref}\,\text{John})\ \text{tripped and } (x \text{ fell}) : S}$$

and_L generalizes and_C and HypL

This is even more overkill of an analysis. But please bear with me, for the sake of example. The intuition for the analysis comes from the Montagovian-like paraphrase.

Simple coordination: John tripped and fell (2)

- Intuition: John tripped. He fell.
- Not really a pronoun: resolved syntactically rather than pragmatically

$$
\begin{aligned}
And &\vdash \text{and} : (S\backslash S)/S \\
\bullet &\vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S) \\
\overline{A} &\vdash \mathit{ref} : A/A \\
(((\overline{A}, \bullet), \Gamma), (And, (A, \Delta)))\backslash S &\vdash \mathit{and}_L : ((\bullet, \Gamma), (And, (\bullet, \Delta)))\backslash S
\end{aligned}
$$

$$
\dfrac{\dfrac{((\overline{NP}, \bullet), \bullet) \vdash (\mathit{ref}\,\text{John})\ \text{tripped} : S}{(((\overline{NP}, \bullet), \bullet), (And, (NP, \bullet))) \vdash (\mathit{ref}\,\text{John})\ \text{tripped and } (x \text{ fell}) : S}}{\bullet \vdash \mathit{and}_C \uparrow \mathit{and}_L \uparrow (\mathit{ref}\,\text{John})\ \text{tripped and } (x \text{ fell}) : S}
$$

and_L generalizes and_C and HypL

What new here is the *ref* constant, whose antecedent is an type marked by the overbar. It is just a regular type, as far as the calculus is concerned. The intuition is different: *ref* John does not *require* an NP, it *provides* NP.

The constant and_L matches up the required NP and provided NP. Its seemingly contrived type is meant as a simple generalization of HypL: "push HypL through and_C. This analysis is designed just as a generalization of the previous one: the branches of coordinated structure are similar, but not necessarily identical structure.

Simple coordination: John tripped and fell (2)

- Intuition: John tripped. He fell.
- Not really a pronoun: resolved syntactically rather than pragmatically

$$\begin{aligned} And &\vdash \text{and} : (S\backslash S)/S \\ \bullet &\vdash \text{tripped} : VP \quad (VP \text{ is } NP\backslash S) \\ \overline{A} &\vdash \mathit{ref} : A/A \\ (((\overline{A}, \bullet), \Gamma), (And, (A, \Delta)))\backslash S &\vdash \mathit{and}_L : ((\bullet, \Gamma), (And, (\bullet, \Delta)))\backslash S \end{aligned}$$

$$\cfrac{\cfrac{((\overline{NP}, \bullet), \bullet) \vdash (\mathit{ref}\,\text{John})\ \text{tripped} : S}{(((\overline{NP}, \bullet), \bullet), (And, (NP, \bullet))) \vdash (\mathit{ref}\,\text{John})\ \text{tripped and } (x\ \text{fell}) : S}}{\bullet \vdash \mathit{and}_C \uparrow \mathit{and}_L \uparrow (\mathit{ref}\,\text{John})\ \text{tripped and } (x\ \text{fell}) : S}$$

and_L generalizes and_C and HypL

Object coordination: John saw Bill and Mary (1)

$$\dfrac{\dfrac{\bullet \vdash x : NP \quad \bullet \vdash y : NP \quad \bullet \vdash v : TV}{(NP, (TV, \bullet)) \vdash and_C \uparrow (x\ (y\ \text{Bill}))\ \text{and}\ (u\ (v\ \text{Mary}))}}{\times}$$

Object coordination: John saw Bill and Mary (2)

$$((\bullet, ((\overline{TV}, \bullet), \bullet)), (And, (\bullet, (TV, \bullet)))) \vdash$$
$$and_L \uparrow (\mathit{ref}\ \text{John})\ ((\mathit{ref}\ \text{see})\ \text{Bill})\ \text{and}\ (x\ (v\ \text{Mary})) : S$$

. . . and then use and_D
match up provided and required, *away from the edges*

$$((\Gamma_1, ((\overline{TV}, \bullet), \Gamma_2)), (And, (\Delta_1, (TV, \Delta_2))))\backslash S \vdash$$
$$and_D : ((\Gamma_1, (VB, \Gamma_2)), (And, (\Delta_1, (VB, \Delta_2))))\backslash S$$

Must be TV or a similar relation-like type (not NP)

Show the type of and_D which has a rather simple intuition.

Semantic interpretation

NL sequent $\Gamma \vdash A$ to Ty2 formula of the type $\lceil \Gamma \backslash A \rceil$

$$
\begin{array}{rcc}
NP & \mapsto & e \\
S & \mapsto & t \\
A \backslash B & \mapsto & \lceil A \rceil \to (\lceil B \rceil, t) \\
B / A & \mapsto & \lceil A \rceil \to (\lceil B \rceil, t) \\
\bullet & \mapsto & () \\
(A, B) & \mapsto & (\lceil A \rceil, \lceil B \rceil) \\
\overline{A} & \mapsto & \lceil A \rceil \\
And & \mapsto & () \\
 & \text{the same for all other context markers} & \\
\mathcal{U} & \mapsto & e \\
\mathcal{E} & \mapsto & e
\end{array}
$$

Mapping **NL** types to semantic types. What somewhat unusual is the interpretation of functions. Let us see that on simple examples.

Semantic interpretation: John tripped and fell.

$NP \vdash NP$	$e \to (e, t)$
$NP \vdash x : NP$	$\lambda x.(x, \top)$
$(\overline{NP}, \bullet) \vdash NP$	$(e, ()) \to (e, t)$
$(\overline{NP}, \bullet) \vdash \textit{ref}\,\text{John} : NP$	$\lambda(x, ()).\ (\mathsf{john}, x = \mathsf{john})$
$((\overline{NP}, \bullet), \bullet) \vdash$ $(\textit{ref}\,\text{John})\ \text{tripped} : S$	$\lambda((x, ()), ()).$ $(\mathsf{trip\ john}, x = \mathsf{john})$
$\bullet \vdash S$	$() \to (t, t)$

Overall:

$$\exists x.(\mathsf{tripped\ john} \wedge \mathsf{fell}\ x) \wedge x = \mathsf{john}$$

To explain how the constant and_L matches up the provided and the required types, it is easier just to look at the final result. Classical existential, guessing.

Non-canonical coordination

RNR: "John liked and Mary hated Bill."

$$(and_C \uparrow \text{John (liked } x\text{) and (Mary (hated } y\text{)))} \cdot \text{Bill}$$

"*John liked Bill and Mary hated ϕ"

$$\times$$

Non-canonical coordination

RNR: "John liked and Mary hated Bill."

$$(and_C \uparrow \text{John (liked } x\text{) and (Mary (hated } y\text{)))} \cdot \text{Bill}$$

"*John liked Bill and Mary hated ϕ"

$$\times$$

Gapping: "Mary liked Chicago and Bill Detroit."

$$and_D \uparrow \text{Mary ((}ref\text{ liked) Chicago) and (Bill (}v\text{ Detroit))}$$

cf.

$$and_D \uparrow and_L \uparrow (ref \text{ John) ((}ref\text{ see) Bill) and (}x\text{ (}v\text{ Mary))} : S$$

Gapping and object coordination: the same analysis

Quantification

$$\dfrac{\dfrac{\dfrac{\mathcal{U} \vdash \text{everyone} : NP}{(\bullet, (\bullet, \mathcal{U})) \vdash \text{John liked everyone}}}{(\mathcal{U}, (\bullet, \bullet)) \vdash float_U \uparrow \text{John liked everyone}} \qquad \bullet \vdash \mathit{forall} : (S/(\mathcal{U}\backslash S))}{\bullet \vdash \mathit{forall}\ (float_U \uparrow (\text{John (liked everyone)})) : S}$$

Quantification

$$\dfrac{\dfrac{\dfrac{\mathcal{U} \vdash \text{everyone} : NP}{(\bullet,(\bullet,\mathcal{U})) \vdash \text{John liked everyone}}}{(\mathcal{U},(\bullet,\bullet)) \vdash \mathit{float}_U \uparrow \text{John liked everyone}} \qquad \bullet \vdash \mathit{forall} : (S/(\mathcal{U}\backslash S))}{\bullet \vdash \mathit{forall}\ (\mathit{float}_U \uparrow (\text{John (liked everyone)})) : S}$$

Semantics

$\mathcal{U} \vdash \text{everyone} : NP$	$\lambda x.\ (x, \top)$
$\bullet \vdash \mathit{forall} : (S/(\mathcal{U}\backslash S))$	$\lambda().(\lambda k.(\forall x.$
	$\text{let } (b_v, b_s) = k\ x \text{ in } b_s \Rightarrow b_v, \top), \top)$

Semantics: here are the semantic interpretation of "everyone" and the *forall* constant. The whole sentence then have the meaning you'd expect.

Quantifier ambiguity

"Someone likes everyone."

$$(\mathcal{E}, (\bullet, \mathcal{U})) \vdash \text{someone (like everyone)} : S$$

Choice of reading: the order of discharging $\mathcal{U}$ and $\mathcal{E}$

Easy generalizations:

- Scope islands
- Non-trivial restrictors
- Coordination and quantification

Conclusions: **NL** is powerful

Powerful

- Uniform analyses of coordination and gapping
- Quantification: any position, ambiguity and islands
- Calculus of general discontinuity?

Traditional

- Standard phonology, directly compositional semantics
- *No* unbound traces, *no* free variables, *no* real movements
- No monads, no continuations, no mutations, ...

Somewhat Classical

- Assumptions and Provisions
- Structural rules, lexicalized and computational
- Filling-in the hole: guessing
- 'Side-conditions'

In conclusion, I'd like to list several keywords, to be associated with **NL**.