# $< e, t >$ go home

## Seminar week 2: Is there any time for scope? Winter 2014/2015

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# This is actually about punctuation, not scope, but anyway.

*ibis redibis numquam per bella peribis*

— oracle of Dodona.

**First order of business, getting a handle on the presentation schedule.**

# And now, a quickie intro to typed $\lambda$-calculus. (The version linguists often use.)

# Let's introduce some types.

Meet $e$ and $t$.

- $e$ - entity/individual
- $t$ - truth value

Then we can have function types. For example:

- $< e, t >$ – maps entities into truth values (e.g. nominals, intransitive verbs).
- $< e, < e, t >>$ – maps an entity into a function that takes an entity and returns a truth values
  - e.g a two-place predicate like a transitive verb.
- $<< e, t >, << e, t >, t >>$ – function that takes two entity-to-truth functions and returns a truth value. (e.g quantifier)

# And the lambda calculus itself.

This could take most of a course. But we only need the basics:

- $\lambda x.Y$ - given an expression $Y$, all mentions of $x$ are bound for substitution within $Y$.
- For example: $\lambda x.\text{man}(x)$ – this is an $< e, t >$ function that maps an individual to a truth value (true if that individual is a man).
- Another example: $\lambda y.\lambda x.\text{person}(x) \wedge \text{inhabit}(y)(x)$ is $< e, < e, t >>$.

# The most important operation: $\beta$-reduction

This is the operation by which an expression “eats” another.

$$(\lambda A.\lambda x.A(x)) \text{ man}$$

Now do $\beta$-reduction...

# The most important operation: $\beta$-reduction

...and we get

$$\lambda x.\text{man}(x)$$

And we can do this for expressions of arbitrary complexity.

# And with that, we're off!

# Ruys and Winter give us a lexicon.

**Lexicon**

| **Cat** | **Word** | **Translation** | **Type** |
|---|---|---|---|
| **N** | one, man, woman, city | $\Rightarrow$ PERSON, MAN, WOMAN, CITY | <e,t> |
| $\mathbf{N_{tr}}$ | inhabitant of | $\Rightarrow \lambda y \lambda x[\text{PERSON}(x) \wedge \text{INHABIT}(y)(x)]$ | <e,<e,t>> |
| **D** | every | $\Rightarrow \lambda A \lambda B.\forall x[A(x) \rightarrow B(x)]$ | <<e,t>,<<e,t>,t>> |
| | no | $\Rightarrow \lambda A \lambda B.\neg\exists x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | some,a | $\Rightarrow \lambda A \lambda B.\exists x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | $\varnothing$ | $\Rightarrow \lambda A \lambda B.\exists 2x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | three | $\Rightarrow \lambda A \lambda B.\exists 3x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | five | $\Rightarrow \lambda A \lambda B.\exists 5x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | exactly three | $\Rightarrow \lambda A \lambda B.\exists !3x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| | exactly five | $\Rightarrow \lambda A \lambda B.\exists !5x[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,t>> |
| **A** | midwestern | $\Rightarrow \lambda A \lambda x[\text{MIDWESTERN}(x) \wedge A(x)]$ | <<e,t>,<e,t>> |
| **NP** | John, Mary | $\Rightarrow \lambda A.A(\text{JOHN}_e), \lambda A.A(\text{MARY}_e)$ | <<e,t>,t> |
| **V** | participated | $\Rightarrow$ PARTICIPATED | <e,t> |
| $\mathbf{V_{tr}}$ | inhabit | $\Rightarrow$ INHABIT | <e,<e,t>> |
| | admire | $\Rightarrow$ ADMIRE | <e,<e,t>> |
| | meet | $\Rightarrow$ MEET | <e,<e,t>> |
| **Rel** | who | $\Rightarrow \lambda A \lambda B \lambda x.[A(x) \wedge B(x)]$ | <<e,t>,<<e,t>,<e,t>>> |

# They also give us a grammar.

But I'm going to gloss over the syntax they give since it's relatively straight-forward for CoLi people.

**Syntax**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S | $\to$ | NP | VP | N' | $\to$ | N | | S' | $\to$ | Rel | VP |
| VP | $\to$ | $V_{tr}$ | NP | N' | $\to$ | $N_{tr}$ | NP | | | | |
| VP | $\to$ | V | | N' | $\to$ | N' | S' | | | | |
| NP | $\to$ | D | N' | N' | $\to$ | A | N' | | | | |

# A first example.

Work out the intermediate steps ourselves:

Some woman admires every man.

# A first example: their solution.

(1) some woman admires every man

a. $[_{NP}$ some woman$]$ $[_{VP}$ admires $[_{NP}$ every man$]]$

b. $\text{SOME}(\text{WOMAN})(\lambda x.(\text{EVERY}(\text{MAN}))(\lambda y.\text{ADMIRE}(y)(x))$

c. $\equiv \exists x[\text{WOMAN}(x) \wedge \forall y[\ \text{MAN}(y) \rightarrow \text{ADMIRE}(y)(x)\ ]]$

# A second example.

Work out the intermediate steps ourselves:

Some inhabitant of every Midwestern city participated.

# A second example: their solution.

(2) some inhabitant of every midwestern city participated

a. $[_{NP}$ some inhabitant of $[_{NP}$ every midwestern city$]]$ participated

b. SOME($\lambda$x.(EVERY(MIDWEST_CITY))($\lambda$y.INHABITANT_OF(y)(x)))(PARTICIPATED)

c. $\equiv \exists x[[\text{PERSON}(x) \wedge \forall y[[\text{MIDWESTERN}(y) \wedge \text{CITY}(y)] \rightarrow \text{INHABIT}(y)(x)]] \wedge \text{PARTICIPATED}(x)]]$

# Let's try some of our own.

- Every midwestern city participated.
- No inhabitant of five cities met a woman.
- A man met a woman who admired exactly three cities.

# Now we can identify our first problem.

Scope ambiguity in English.

- "Some woman admires every man."
  - $\exists x$ woman$(x) \wedge (\forall y$ man$(y) \rightarrow$ admire$(x, y))$ *(linear scope)*
  - $\forall x$ man$(x) \rightarrow (\exists y$ woman$(y) \rightarrow$ admire$(y, x))$ *(inverse scope)*
  - (I prefer a slightly different notation.)

We don't (so far) have the logical rules for this transformation.

# Same thing holds for the second example.

The linear-scope interpretation is typically deprecated.

- "Some inhabitant of every Midwestern city participated."
  - $\exists x$ person$(x) \wedge \forall y(($ midwestern$(y) \wedge$ city$(y)) \rightarrow$ inhabit$(x, y)) \wedge$ participated$(x)$
  - ie, there's a single person who inhabits all midestern cities who participated.
  - Inverse scope (correct): $\forall y(($ midwestern$(y) \wedge$ city$(y)) \rightarrow$ inhabit$(x, y)) \wedge \exists x$ person$(x) \wedge$ participated$(x)$
  - ie, for all midwestern cities there is a person who participated.

# (A note on languages other than English.)

Different languages behave differently regarding scope ambiguities.

- Many English examples don't work in German.
  - One hypothesis: German object shift/verb-second grammar permits quantifiers to move *overtly*, making *covert* reinterpretation redundant.
- Many English examples don't work in Mandarin Chinese.
  - One hypothesis: Chinese is a *wh-in-situ* language, question words don't move – scope ambiguity is computed over question words, not quantifiers.

Just keep this in mind.

# How do we decide on scope evidence?

Intuitive judgements on complex syntax and semantic interactions.

- Ruys and Winter don't believe that we can simply "directly" ask a native speaker for judgements.
  - Too subtle a task, bound to suffer inconsistences. (really? – discuss)
  - "err on the side of caution"
- Instead: rely on speakers judgement of implications of utterances ie, "truth and inference".

# What factors need to be taken into account?

Ruys and Winter suggest two major ones (other than the multilingual one I just mentioned):

- Pragmatic considerations.
  - "Physical"/real-word plausibility affects what readings *seem* available.
- Logical dependence between readings.
  - One reading may entail another – what is the relationship of the "entailed" reading to the original sentence?
  - If readings are dependent, which is a "true" intuition based on the syntax?

# Let's first consider the pragmatics.

Ruys and Winter give us this example of attachment ambiguity (not scope).

- "John saw the man with the telescope."
  - The man could have the telescope, or John could be using it.
- "John saw the man with the dog."
  - Only the man can have the dog; John can't be using it to see.

Syntactically identical, but pragmatic considerations limit the attachments in the latter.

# An example with scope.

(7) $[_{NP}$ someone $[_{S'}$ who inhabits every midwestern city]] participated

a. $\exists x[[\text{PERSON}(x) \wedge \forall y[[\text{CITY}(y) \wedge \text{MIDWESTERN}(y)] \rightarrow \text{INHABIT}(y)(x)]] \wedge \text{PARTICIPATED}(x)]]$

b. $\forall y[[\text{CITY}(y) \wedge \text{MIDWESTERN}(y)] \rightarrow \exists x[\text{PERSON}(x) \wedge \text{INHABIT}(y)(x) \wedge \text{PARTICIPATED}(x)]]$

Contrast this to "some inhabitant of every Midwestern city participated."

- Only the infelicitous reading (7a) is syntactically allowed – we are forced to accept that there is someone who is a resident of every city.
- Evidence: we perceive the sentence itself as rather strange: we just can't get (7b).

# But what if readings are interdependent?

(8) [$_S$ [$_{NP}$ every man] [$_{VP}$ admires [$_{NP}$ some woman ]]]

a. $\forall x[\ \mathrm{MAN}(x) \rightarrow \exists y[\mathrm{WOMAN}(y) \wedge \mathrm{ADMIRE}(y)(x)\ ]]$

b. $\exists y[\mathrm{WOMAN}(y) \wedge \forall x[\mathrm{MAN}(x) \rightarrow \mathrm{ADMIRE}(y)(x)\ ]]$

Both (a) and (b) are acceptable readings of (8), but whenever (b) is true, so must (a).

- How do we know that an informant who gets both readings is going directly from (8) to (8b) without passing through (8a)?
- Here is one reason why Ruys and Winter don't rely on direct reports from speakers.

# So how to separate “proper” readings from derived?

Ruys and Winter propose three methods:

1. Construct examples in which linear (aka direct) reading and inverse reading are logically independent.
2. Use negation context.
3. Use “test” sentences to check the implications.

# What does a logically independent reading look like?

"Exactly three men admire some woman."

a. $\exists!3x[\text{MAN}(x) \wedge \exists y[\text{ WOMAN}(y) \wedge \text{ADMIRE}(y)(x)]]$

b. $\exists y[\text{ WOMAN}(y) \wedge \exists!3x[\text{MAN}(x) \wedge \text{ADMIRE}(y)(x)]]$

Apparently, there are situations in which (b) can be true but (a) is not.

- Ruys and Winter don't describe these. Can we find them?
- The structure of this is analogous to the "every" case, so we can try to argue that arguments for inverse scope "port" over well.

# How do we use negation context?

(10) it is not the case that every man admires some woman

a. $\neg\forall x[\ \mathrm{MAN}(x) \rightarrow \exists y[\mathrm{WOMAN}(y) \wedge \mathrm{ADMIRE}(y)(x)\ ]]$

b. $\neg\exists y[\mathrm{WOMAN}(y) \wedge \forall x[\mathrm{MAN}(x) \rightarrow \mathrm{ADMIRE}(y)(x)\ ]]$

- We still get two readings, but with a negation wrapped around them.
- But (10b) is now not stronger than (10a) – so we have evidence for logically independent scope inversion.

Alas:

- These results are not experimentally stable.
- Negation is "scope-bearing" and potentially interferes with the number of readings.

# Finally: using grammatical tests to prove independence.

1. "Every man admires some woman. She is really smart."
   - "She" forces inverse scope interpretation of "some woman".
2. ?¿'Every man admires some woman he knows. She is very smart."
   - Infelicitous, because "he" is blocking the inversion.
   - (ie, there must be an inverse reading to be blocked...)

**At this point, Ruys and Winter move on to more exotic scope interactions.**

# Take negation, for instance.

"John doesn't speak exactly three languages."

- Are there three languages that John doesn't speak, or does he speak some number other than three?

"All that glitters is not gold."

- Among the things that glitter are none of them gold, or are there glittering things that are not gold?
- (English idiom. The latter is the intended answer.)

Let's write these readings down formally.

# Or *de re* vs. *de dicto* readings.

Ruys and Winter's examples:

1. John is looking for *a book*. (Is he looking for one specific book? – *de re*)
2. An American runner is likely to win the race. (Just any American runner? – *de dicto*)

Scope relation between indefinite and predicate. Can we write these down formally?

# There's an interaction with *wh*-questions.

"Which woman does every man love?" Interpretations:

- There is a particular woman, and all men love that woman.
- For every man, there is a woman that he loves. (The "pair-list" reading.)

# Adverbs interact with everything.

| | | |
|---|---|---|
| (20) | a | John has never met a friend of mine |
| | b | someone always wins |
| (21) | a | John probably saw an article in this morning's *Times* |
| | b | someone probably spiked the punch |

e.g. in (21a), it is either that John probably saw some article (that happened to be in the New York Times) or that John definitely saw an article, but it was probably in the New York Times...

# And coordination is, as always, frightful.

- (Exactly) four teachers and authors smiled.
- John is looking for a maid or a cook. (exclusive vs non-exclusive "or")

(Should this really be in the semantics? I myself am not sure, but they cite arguments in favour – possible topic.)

**It looks like everything is ambiguous all the time!**

# Does anything prevent ambiguity other than world knowledge?

We've seen one already:

- "Every man admires some woman he knows."
- Prevented by the semantic restriction coming from "he knows" – coreference.
- But it turns out that there are other restrictions...

# . . . and they can be suspiciously syntax-like.

Remember:

- Some inhabitant of every city participated.
- ?Someone who inhabits every city participated.

The first one only makes sense because "every city" can take inverse scope.
So why can't the second? It's practically the same!

# Good old-fashioned movement to the rescue.

(26) a    which city$_i$ did you meet inhabitants of $t_i$ ?

b   * which city$_i$ did you meet people who inhabit $t_i$ ?

c    did you meet inhabitants of this city ?

d    did you meet people who inhabit this city ?

The old "Chomskyan" story: you can't *wh*-move a phrase from a relative clause.

- Called the "Complex NP Constraint" – other constraints can be shown.
- Held to be a "overt" counterpart to "covert" restrictions on quantifier interpretation.
- (Ruys and Winter remain agnostic at this point.)

# But it doesn't always work.

(29) every inhabitant of a/some midwestern city participated

(30) everyone who inhabits a/some midwestern city participated

(31) a $\exists x[\text{CITY}(x) \wedge \text{MIDWESTERN}(x) \wedge \forall y[[\text{PERSON}(y) \wedge \text{INHABIT}(x)(y)] \rightarrow \text{PARTICIPATED}(y)]]$

b $\forall y[[\text{PERSON}(y) \wedge \exists x[\text{CITY}(x) \wedge \text{MIDWESTERN}(x) \wedge \text{INHABIT}(x)(y)]] \rightarrow \text{PARTICIPATED}(y)]$

- Why should we be able to get a inverse scope reading of "some city" in (30)?
- Appears that simple indefinites can violate the movement constraint. Hmm.
- "John met everyone who admires three Midwestern cities."

# There are other anomalous scope mysteries.

Bare plurals don't get inverse scope.

(34) no man met women

a $\neg\exists x[\ \text{MAN}(x) \wedge \exists 2y[\text{WOMAN}(y) \wedge \text{MEET}(y)(x)\ ]]$

b $\exists 2y[\text{WOMAN}(y) \wedge \neg\exists x[\ \text{MAN}(x) \wedge \text{MEET}(y)(x)\ ]]$

You don't get reading (b), that there are multiple women who were met by no men.
Similar for "John met every inhabitant of Midwestern cities."

# There are other anomalous scope mysteries.

Some sources claim you can't get inverse scope for (38):

(37) some woman admires every man

(38) some woman inhabits exactly three cities

a $\exists x[\text{WOMAN}(x) \wedge \exists 3!y[\text{CITY}(y) \wedge \text{INHABIT}(y)(x)\ ]]$

b $\exists 3!y[\text{CITY}(y) \wedge \exists x[\text{WOMAN}(x) \wedge \text{INHABIT}(y)(x)\ ]]$

(ie, you can't say that there are three cities that are inhabited each by a different woman. I get this reading too.)

# But this judgement I DON'T get.

Apparently, “less than” can't take inverse scope:

(39) every man admires less than three women

a there are less than three women that every man admires

But I can get the (39a) reading. . .

# Just a few more.

"John met every man who admires exactly three Midwestern cities."

- Can't choose three Midwestern cities and prove this by John meeting every man who admires those cities.
- If there's even one man who John met who does not admire exactly three (of any) Midwestern city, it fails.

"Some man admires few women."

- Not the case that there are few women who are each admired by some different man.

# Bare numerals are a bit odd.

(43) some man admires three women

a $\exists x[\ \text{MAN}(x) \wedge \exists 3y[\text{WOMAN}(y) \wedge \text{ADMIRE}(y)(x)\ ]]$

b $\exists 3y[\text{WOMAN}(y) \wedge \exists x[\ \text{MAN}(x) \wedge \text{ADMIRE}(y)(x)\ ]]$

It can't be the case that there are three woman admired by some different man each

This is a little odd because inverse scope works for "John met every man who admires three Midwestern cities."

**But you get the point: we need a theory that accounts for these facts.**

# So what kinds of theories do we get?

Some of the more standard ones:

- Quantifier raising – based on standard issue "generative"/Chomskyan syntax.
  - Very well elaborated, but controversial.
  - These syntax/semantics interactions are central concern of generativism.
- Quantifying-in – based on Montague grammar.
  - Based on "translation rules" from syntactic fragments to semantics.
  - Rule allows quantifier translation ambiguity.

# So what kinds of theories do we get?

Some of the more standard ones:

- Cooper storage
  - Use an “external” storage for variable binding.
  - Allows simultaneous representation.
- Type flexibility
  - Use logic-external operators to shift the semantic “type” of an expression.
- Categorial approaches.
  - Use “hypothetical reasoning” to convert function types during derivation.

**Next class, I'll go through (some of) these approaches, as well as possibly an extra (short) reading.**

# In conclusion, $< e, t >$ go home.