Scope in an incremental context

Lecture 1: scope basics

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Notes will appear after each lecture at: http://bit.ly/esslli19scope

Which maid has which mop?

The Walrus and the Carpenter
Were walking close at hand;
They wept like anything to see
Such quantities of sand:
"If this were only cleared away,"
They said, "it would be grand!"

"If seven maids with seven mops
Swept it for half a year.
Do you suppose," the Walrus said,
"That they could get it clear?"
"I doubt it," said the Carpenter,
And shed a bitter tear.

— Lewis Carroll, *The Walrus and the Carpenter*.

Is there any time for scope?

Surely the answer is: yes

Surely the answer is: yes, there is any time for scope.

(Because it's true, of course.)

But English-speakers reject the use of "any" that way.

Acceptable:

- Is there any time for scope?
- No, there isn't any time for scope. [direct negation works]
- No, there's no time for scope. [equivalent to above]
- I wouldn't say that there is any time for scope.
- When did Bob say that there is any time for scope?

But English-speakers reject the use of "any" that way.

Never:

- *Yes, there is any time for scope.
- *I can say that there is any time for scope.
- *Bob said that there is any time for scope tomorrow.

What is so special about “any”?

It’s a “negative-polarity item”.

- That means it must usually* exist in a “downward-entailing” environment.
- Upward-entailment: implies a larger set of events, preserves semantic “strength”.
  - John ran fast ⇒ John ran.
  - (But not the other way.)
- Downward-entailment: reverses semantic “strength”.
  - Nobody ran ⇒ Nobody ran fast.
  - (But not the other way.)

What is so special about "any"?

Downward entailment:

No, there isn't any time for scope.

$\Rightarrow$

No, there isn't any time for thinking about scope.

$\Rightarrow$

No, there isn't any time for thinking about quantifier scope.

But it doesn't imply that there isn't any time for thing about anything!

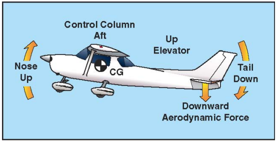


Figure 4-6. The elevator is the primary control for changing the pitch attitude of an airplane.

This is a question of meaning relations. . .

. . . but it has a relation to the structure of the sentence.

Is there	
I wouldn't say that there is	**any time for scope**
When did Bob say that there is	

It's like there is something that "validates" the any-phrase.

Let's postulate an operator ϕ_{DE} (for Downward Entailment).

Is there I wouldn't say that there is When did Bob say that there is	ϕ_{DE}(**any time for scope**)

This gives us a crude first definition of "scope".

ϕ_{DE}(**any time for scope**)

A scope consists of

- an operator that maps from structure ⇒ interpretation.
- a structure to which the operator is applied.

(What specifically that operator really is, we'll take a pass on.)

But that leaves us with an obvious couple of questions.

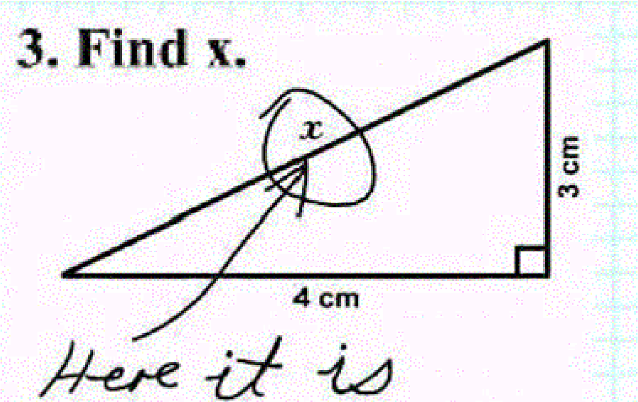
What the heck is a structure?

What the heck is an operator?

Actually, it leaves us with one more question.

What does it mean to apply and interpret? (Well, two more questions.)

WARNING WARNING: We now begin OVERSIMPLIFICATION. (I wish Latex had blink tags.)



How can we think about structure?

Structure mediates between "articulatory" and semantic form.

- And what is omitted or not articulated is as important as what is.
- One task of the linguist: find a way to infer what is *not* articulated that has an effect on structure and interpretation.
- But also: find a way to infer what is not interpreted that has an effect on structure and articulation. . .
- Typical example: syntactic trees.

Goals of the course

- To gain a high-level understanding of scope and incremental scope processing phenomena.
- To understand how scope phenomena affect different levels of linguistic representation.
- To get an overview of different approaches to investigating scope phenomena: theoretical, formal/logical, psycholinguistic, and computational.
- To give students further practice in debating, critiquing, and creating linguistic thoughts.

Ideally: a discussion group atmosphere.

Who is this course aimed at?

I want to avoid this seminar being too specialized.

- Scope can be dealt with a very technical way, want to minimize the requirement to know a lot of formalism.
- Unfortunately, formalism is unavoidable, I'm hoping this is all we'll need:
  - Basic first-order predicate calculus.
  - Lambda-calculus would be nice.
  - Some notion of syntactic formalism, ideally "traditional" (S$\rightarrow$NP VP, etc).
- I'll try to give a little refresher.

“Getting to know you” pause.

Some things to consider

We are only trying to skim the highest levels: breadth more than depth! Incremental scope processing is a “niche” area but even then, we can’t hope to cover everything this week

- I don’t expect you to understand deeply everything we discuss (only one week!).
- Theory changes over time and the “intro material” can become outdated, other than the basic axioms of logic.
- I want you to instead learn to “appreciate” the material at an abstract level and be able to pursue the “useful” threads.

USEFUL?!?!!

Well, sort of. . .

My opinion: scope is one of the next frontiers.

- In terms of cognitive science: the abstraction required is extremely hard to capture neurolinguistically.
- In terms of technology: interpreting and responding to complex queries/interactions in context.

Comp ling is getting more grammatically detailed.

The underlying principles are starting to matter. An example from my own experience.

- The "corner cases" of quantifier interpretation (a syntactic AND semantic issue) have long been central in theory.
- **Just** becoming relevant in spoken dialogue systems.
- But how to handle it without e.g. **movement**? Not always easy.
  - There are a lot of movement-o-phobes :) so there's a lot of formal work on this!

Some overlap with the other courses. (But we're less formally committed.)

Course plan

(Subject to change to avoid too much overlap, class reaction.)

- Monday: this lecture. basics of incremental scope.
- Tuesday: formal and theoretical considerations for incrementality.
- Wednesday: psycholinguistic/sentence processing aspects of scope ambiguity.
- Thursday: computational aspects
- Friday: speculations and recent developments

Part 1: scopal operators in natural language

How can we think about operators?

Operators are bridges between semantic forms and interpretations and between different interpretations.

- Usually expressed as some kind of higher-order logical function.
- Usually "bind" variables within the scope, limiting their interpretation.
- Usually applied to semantic expressions (but have a presence in some theories of syntax.
- Typical examples: $\exists$, $\forall$ ..., but many "exotic" kinds.

How can we think about interpretation?

So many different approaches:

- Model-theoretic: mapping elements of expression to “individuals” and truth values.
- Proof-theoretic: role of an expression in a system of infererences.
- Truth-conditional: like model-theoretic, but without mapping to individuals in a domain.
- Probabilistic.
- ...

(But we’re not going to focus on this can of worms. Let us just assume “model-theoretic” interpretation for now.)

How can we think about applying an operator?

Ah, now we're really getting into the "weeds"!

- Conventionally: applying a "higher-order function" to a semantic expression.
  - To convert it into another expression with a different type.
- But we are not conventional:
  - Psycholinguistic consequences: does operator application affect the human processor/learner?
  - Technological: how do operators and scope interactions affect machine understanding of NLs?

But that's a lot of things to mix together!

It affects/is affected by linguistic representation at all levels:

- Syntactic: not every operator is allowed everywhere, like "any", even if they "make sense."
- Semantic: not every operator "makes sense" everywhere – or they're ambiguous.
- Pragmatic: world-knowledge affects how you choose to interpret – "Every child climbed a tree".

Even things like prosody are important: "every child climbed **A** tree."

So having said all that, let's talk a little bit about formalism.

Say hello to some variables.

$$x, y, z$$

(Hi, variables!)

And a unary predicate

$$\text{child}(x)$$

This just says: "x is a child".

And a binary predicate

$$\text{climb}(x, y)$$

This just says: "x climbs y".

Conjunction. . .

$$\text{child}(x) \wedge \text{tree}(y)$$

This just says: "x is a child and y is a tree".

. . . and disjunction . . .

$$\text{child}(x) \vee \text{tree}(x)$$

This just says: "x is a child or x is a tree".

. . . and implication.

$$(\text{child}(x) \land \text{tree}(y)) \rightarrow \text{climb}(x, y)$$

This just says: "if x is a child and y is a tree, x climbs y".

But we usually want variables to be “bound”. (Why?)

Existential quantification. . .

$$\exists x \ \mathrm{child}(x)$$

This just says: “there exists an entity x such that x is a child”.
(Quantification scope established!)

. . . and universal quantification.

$$\forall y \; \text{tree}(y)$$

This just says: "for all entities y, y is a tree".
(And we can have many more exotic quantifiers/operators.)

Et voilà!

"Every child climbs a tree":

$$\forall x \text{ child}(x) \rightarrow \exists y \text{ tree}(y) \land \text{climb}(x, y)$$

This just says: "for all x, if x is a child, then there is a y such that y is a tree, and x climbs y".

Whew!

Except: the magical language gremlins are not always so nice.

"Every child climbs a tree":

$$\exists y \text{ tree}(y) \wedge \forall x \text{ child}(x) \rightarrow \text{climb}(x, y)$$

This just says: "there is a y such that for all x, x is a child, and x climbs y".

And how the gremlins do this is our question for this course.

But since we made it this far...

...one more puzzle:

Two politicians spied on someone from every city.

How many interpretations does this have? Can we count them in terms of quantifier (etc.) scope orders?

Part 2: scope at the syntax/semantics interface

Developing an incremental semantics

Augmentation of incrementality-friendly syntactic formalisms by adding semantic component.

- Problem: how to deal with "late update" of semantic structure.
- "An athlete practices...": $\exists x \text{Athlete}(x) \wedge \text{Practice}(x)$
- "An athlete practices on Tuesday": where does the "Tuesday" go?
  - Adjunct items and optional role fillers hard to integrate *post hoc*.

One solution: "neo-Davidsonian event semantics"

Introduce an existentially-quantified event variable. All elements are descriptions of that event.

- "An athlete practices...": $\exists x \exists e \text{Athlete}(x) \wedge \text{Practice}(e) \wedge \text{Agent}(e, x)$
- "An athlete practices on Tuesday": $\exists x \exists e \text{Athlete}(x) \wedge \text{Practice}(e) \wedge \text{Agent}(e, x) \wedge \text{Time}(e, \text{Tuesday})$

Much easier now!

But we still have a problem.

How to represent ambiguous scope? Putting the operators (usu. quantifiers) in fixes the scope order.

- "Every athlete practices...":
  $\forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e, x)$
- "Every athlete practices on some day.":
  $\forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e, x) \wedge \exists y \text{Day}(y) \wedge \text{Time}(e, y)$

But we still have a problem.

- "Every athlete practices on some day."
  - $\forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e,x) \wedge \exists y \text{Day}(y) \wedge \text{Time}(e,y)$
  - $\exists y\ \forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e,x) \wedge \text{Day}(y) \wedge \text{Time}(e,y)$

How do we get to the second reading, when we've already committed to the first scope order?

Obvious answer: the “Scope Fairy” did it.

The Scope Fairy

Scope is a rather odd part of language.

Two politicians spied on someone from every city.

- Multiple readings of this.
- But not all possible readings are acceptable to all people.
- Nothing has to "overtly" distinguish any reading in the string.

But the Scope Fairy is not alone.

Someone from every American city participated.

- The scope fairy allows two readings...
- ...but the "Pragmatics Fairy" tells us one person can't be from every American city.

$\Rightarrow$ forced inverse reading.

But the Scope Fairy is not alone.

Someone who came from every American city participated.

- The Scope Fairy only allows the **direct** reading. . .
- . . . but the Pragmatics Fairy tells us one person can't be from every American city.

$\Rightarrow$ pragmatic infelicity.

The Pragmatics Fairy

So getting back to our example.

- "Every athlete practices on some day."
  - $\forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e, x) \wedge \exists y \text{Day}(y) \wedge \text{Time}(e, y)$
  - $\exists y\ \forall x \text{Athlete}(x) \rightarrow \exists e \text{Practice}(e) \wedge \text{Agent}(e, x) \wedge \text{Day}(y) \wedge \text{Time}(e, y)$

Does the Scope Fairy "get us" from one interpretation to the other?

Not necessarily.

Two approaches: underspecification vs. "reanalysis".

- Underspecification: scope-bearing operators "live" *outside syntax*, their relations only constrained when necessary.
  - The Scope Fairy as constraint manager.

Someone (x) who visited every city (y) participated in every game (z).

Specified scope: $\exists x > \forall y$. Leave relation between x and z unspecified.

So we don't need to "get" between interpretations.

The alternative: there is a default interpretation, and it takes *effort* to get from one to the other. Two major "reanalysis" approaches:

- Alternate derivations of the logical form.
- Observe that the constraints on interpretation are "covert" equivalents of "overt" constraints.
  - aka Quantifier Raising (QR) [May, 1985].
  - Quantifiers are "covertly" interpreted the way *wh*-items are distributed "overtly".

Part 3: “traditional” approaches to scope

And now, a quickie intro to typed λ-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: β-reduction

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

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

Now do β-reduction...

The most important operation: β-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 – an overview from Ruys and Winter (2011)

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.)

Syntax

S	→	NP	VP	N'	→	N		S'	→	Rel	VP
VP	→	V_{tr}	NP	N'	→	N_{tr}	NP				
VP	→	V		N'	→	N'	S'				
NP	→	D	N'	N'	→	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(λx.(EVERY(MIDWEST_CITY))(λy.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.
  - "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. $\forall x[\text{MAN}(x) \rightarrow \exists y[\text{WOMAN}(y) \wedge \text{ADMIRE}(y)(x)]]$

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

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

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

- 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.)

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. . .

(We will mainly deal with quantification in most of this course.)

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

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

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.

Tomorrow: incrementality and semantics

Notes: http://bit.ly/esslli19scope