Scales, quantity & degree

Lecture 1: Quantifiers

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Scales, quantity and degree

$S = \langle X, > \rangle$ or $S = \langle X, \models \rangle$

1. Quantifiers
2. Modified numerals
3. Intensifiers

What is a quantifier?

Every Some Several A few	Natural language determiners
Every student Some rabbits Several parts that move	Determiner phrases
$\forall \quad \exists$	Predicate logical syncategorema
$\lambda X.\lambda Y.\lvert X \cap Y\rvert > 3$	Generalised quantifiers

What is a quantifier?

- articles: a, the, . . .
- determiners: every, most, . . .
- number words: one, two, three, . . .
- comparatives: fewer than five hundred, more than just a few, . . .
- superlatives: at most five, at least twelve, . . .
- PPs: between sixty and seventy, up to two hundred, . . .
- adjectives: (very) many, (too) few, . . .
- modifications: almost every, exactly five, . . .
- coordinations: most but not all, two or three, . . .

_____ monkey(s) is/are asleep in the zoo

‘I see nobody on the road,’ said Alice.

‘I only wish *I* had such eyes,’ the King remarked in a fretful tone.
‘To be able to see Nobody! And at that distance, too!

Lewis Carrol, Throught the looking glass, and what Alice found there

According to the story, there was a man with a headache, who saw the advertisement:

`nothing acts faster than Aspirin`™

— so at once he went and took nothing.

(*after* Wilfrid Hodges, *Logic*, 1977)

According to the story, there was a man with a headache, who saw the advertisement:

`nothing acts faster than Aspirin™`

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(*after* Wilfrid Hodges, *Logic*, 1977)

— so at once he went and took Aspirin

Plan

- Quantifiers are obviously not referring terms

  quantifiers $\sim$ quantities
- Option 1: quantifiers stand proxy for quantities
- Option 2: quantifiers express relations between quantities
  generalised quantifier theory

- In favour of a much richer theory of quantifier meaning

The psychology of words versus numbers

Bryant & Norman 1980; Beyth & Marom 1982; Wallsten et.al. 1986; Erev & Cohen 1990; Renooij & Witteman 1999

- main application
  - expert knowledge communication
  - communication guidelines (e.g. medical professions)
- does/should an expert use words or numbers?
- how do words/phrases correspond with explicit cardinality or frequency
- this type of research presupposes that natural language quantifiers express quantities

The psychology of words versus numbers

Bryant & Norman 1980; Beyth & Marom 1982; Wallsten et.al. 1986; Erev & Cohen 1990; Renooij & Witteman 1999

- Hearers prefer numbers
- Speakers prefer words

The psychology of words versus numbers

Bryant & Norman 1980; Beyth & Marom 1982; Wallsten et.al. 1986; Erev & Cohen 1990; Renooij & Witteman 1999

many,*quite a few*, *few*, *a few*, *very few*, *a lot*, *not many*,*several*

The psychology of words versus numbers

Bryant & Norman 1980; Beyth & Marom 1982; Wallsten et.al. 1986; Erev & Cohen 1990; Renooij & Witteman 1999

- Huge between-subject variation
- Considerable overlap between words

Against quantifiers as words for amounts

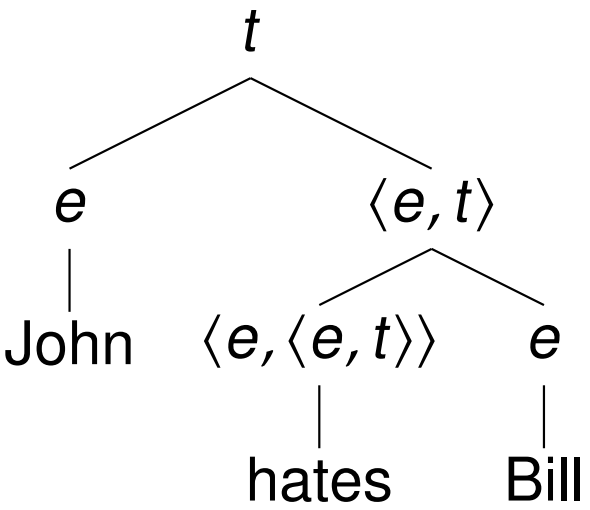
Linda Moxey, Anthony Sanford (Glasgow)

- Too many quantifiers (in a single free production experiment Moxey (1986) observed 182 different quantity expressions)
- Moxey & Sanford 1993
  - each subject can assign just one number to one quantifier on one occasion only (450 subjects)
  - no context effects, no comparison among quantifiers
  - results: impossible to distinguish between *a few, only a few, not many, few* and *very few*
- Support comes from studies on intensifiers such as *very* (Wright et.al. 1995)

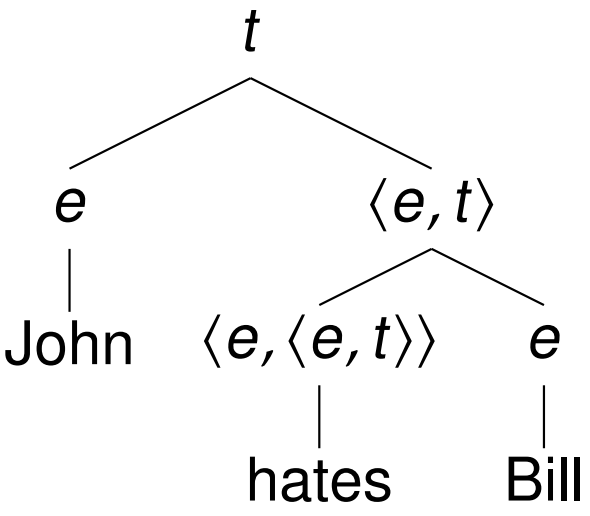
Words and numbers

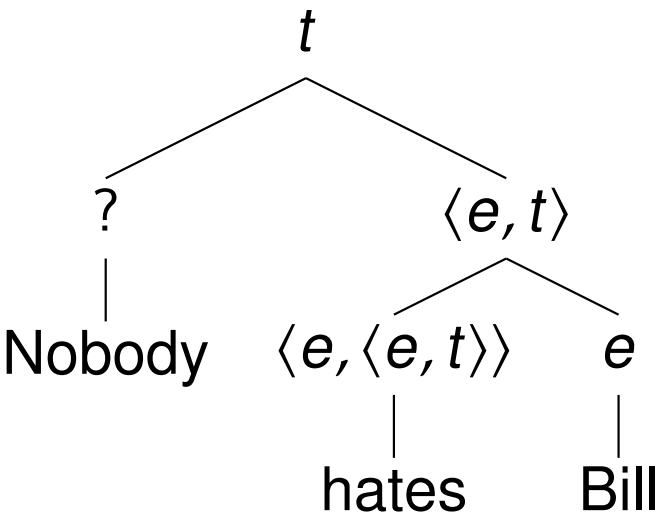
- Quantifiers do not go proxy for numbers
- In linguistic semantics the relation between quantifiers and quantities is a bit more complex, though

A dilemma for compositionality



A dilemma for compositionality





Quantifiers

Aristotelian syllogisms

All mortals die.
Some men are mortal.

Some men die.

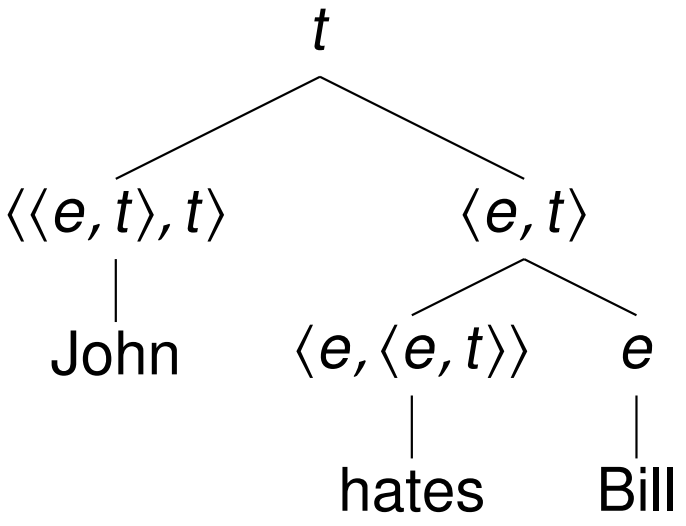
Medieval studies on quantification

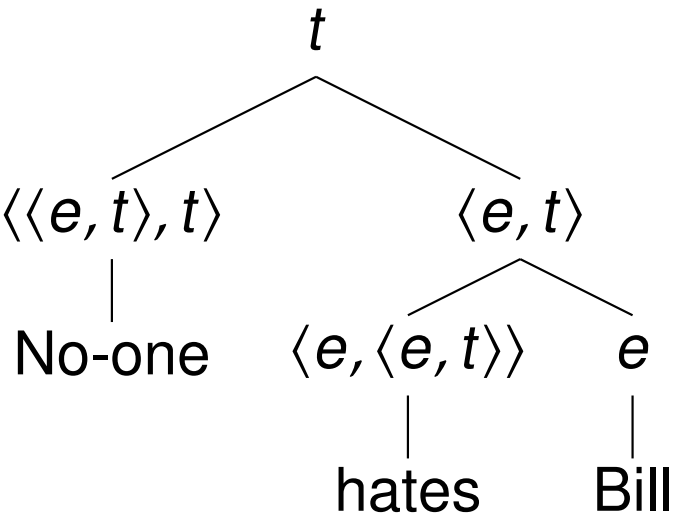
$\underbrace{\text{All men}}_{\textit{subject}}\ \underbrace{\text{are mortal}}_{\textit{predicate}}$

Question: What does the subject express?

The modern solution

Montague, Barwise & Cooper, Keenan & Stavi





Quantifiers as sets of sets

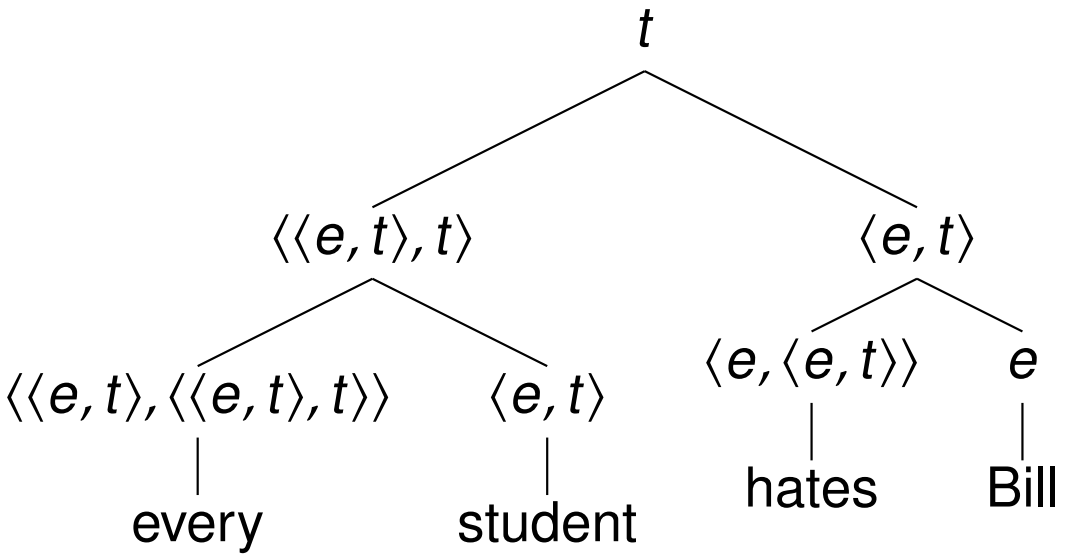
Let P be the set of people in the domain.

$$[\![\text{everyone}]\!] = \lambda X.P \subseteq X$$

$$[\![\text{someone}]\!] = \lambda X.P \cap X \neq \emptyset$$

$$[\![\text{noone}]\!] = \lambda X.P \cap X = \emptyset$$

Determiners as relations between sets



$$[\![\text{every}]\!] = \lambda X.\lambda Y.X \subseteq Y$$

$$[\![\text{some}]\!] = \lambda X.\lambda Y.X \cap Y \neq \emptyset$$

$$[\![\text{no}]\!] = \lambda X.\lambda Y.X \cap Y = \emptyset$$

Generalised Quantifier Theory

Barwise & Cooper, Keenan, van Benthem, Westerstahl

- a collection of linguistic and mathematical insights
- properties of linguistic and mathematical quantifiers
- linguistic universals concerning such properties
- main focus is on *generalisations*

- to a much lesser extent: processing aspects of quantifiers
- to a much lesser extent: linguistic properties of particular quantifiers

Example: the definiteness effect

Milsark 1977, Barwise & Cooper 1981, Keenan 1987

(1) Weak quantifiers

a. There are at least three gnomes in the garden.
b. There are some biscuits left in the fridge.
c. There are no aliens on mars.
d. There are fifty-two typos in the manuscript.

(2) Strong quantifiers

a. *There is every student in the classroom.
b. *There are most biscuits on this plate.
c. *There are less than half the gnomes in the garden.
d. *There are not all aliens on mars.

The weak/strong distinction can be made formally explicit in terms of formal properties of quantifiers

Strong versus weak

Symmetry: $Q(X)(Y) \leftrightarrow Q(Y)(X)$

Strong quantifiers are not symmetrical:

If every student is a spy, then every spy is a student
If most students are spies, then most spies are students

Weak quantifiers are symmetrical:

If some students are spies, then some spies are students
If no students are spies, then no spies are students

Existential-there sentences only admit symmetrical quantifiers

Generalised Quantifier Theory

_____ is/are asleep in the zoo

Assumption of homogeneity within the class of GQs

Isomorphism invariance

For any U and U',

if $\pi : U \to U'$ is a bijection, then

$$Q_U(X, Y) \to Q_{U'}(\pi(X))(\pi(Y))$$

Isomorphism invariance

$\rightarrow_\pi$

U	U'
a	b
b	c
c	e
d	a

$$X = \{a, c, d\}$$
$$Y = \{a\}$$
$$Q = \lambda A.\lambda B.|A \cap B| < 10$$

$$Q(X)(Y) \leftrightarrow$$
$$|\{a, c, d\} \cap \{a\}| < 10 \leftrightarrow$$
$$|\{a\}| < 10$$

$\Downarrow_{pi}$

$$Q(\pi(X))(\pi(Y)) \leftrightarrow$$
$$|\{b, e, a\} \cap \{b\}| < 10 \leftrightarrow$$
$$|\{b\}| < 10$$

Logicality

- Logicality is the notion that purely logical operators are not about particular entities but are *topic neutral*
- van Benthem: *Quantifiers* are expressions that satisfy *isomorphism invariance*
- Most of the mathematical work on GQs concerns such logical quantifiers

- $[\![\textit{John}]\!] = \lambda A.A(j)$
- $[\![\textit{Every } \ldots \textit{ but John}]\!] = \lambda A.\lambda B.(B \cup \{j\}) \subseteq A$

- With some extra assumptions: logical quantifiers are those that rely solely on cardinality

Logicality: the tree of numbers

For a pair A and B, let $pos(A,B)$ be $|A \cap B|$ and $neg(A,B)$ be $|A \setminus B|$

$[\![\text{every}]\!](A)(B) \leftrightarrow neg(A,B) = 0$

$[\![\text{no}]\!](A)(B) \leftrightarrow pos(A,B) = 0$

$[\![\text{most}]\!](A)(B) \leftarrow pos(A,B) > neg(A,B)$

$[\![\text{more than 2}]\!](A)(B) \leftrightarrow pos(A,B) > 2$

$\langle neg(A,B), pos(A,B) \rangle$

Generalised Quantifier Theory

- Logicality represents extreme view within GQT
- There exists a subclass of logical quantifiers
- These only express a relation between their arguments and a

- Limited applicability to natural language
- There is more to quantifiers than cardinality
- Even the purported logical ones

Many is non-extensional

- Logicality assumes that at the heart of quantifier semantics is cardinality comparison
- The arguments of a quantifier are taken for granted
- $[\![\text{many}]\!] = \lambda A.\lambda B.|A \cap B| > m$
  - Many lawyer attended the meeting this year.
  - Many women attended the meeting this year.

Many is non-extensional

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  - Many lawyer attended the meeting this year.
  - Many women attended the meeting this year.

Imagine a conference of lawyers and policemen where normally 60 lawyers and 40 policemen attend. Also, on average, only 10 attendants are women. This year, there are only 20 lawyers, but a staggering 80 policemen. Strikingly, all the lawyers happen to be women and all the policemen are men.

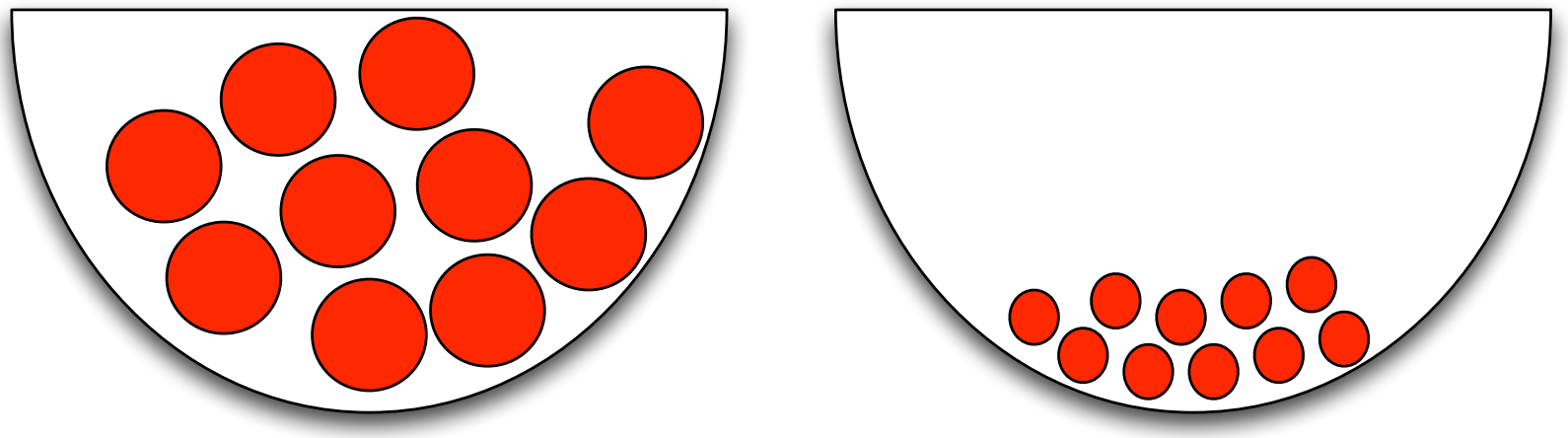
Many is non-extensional

$$[\![\text{many}]\!] = \lambda A_{\langle s,\langle e,t\rangle\rangle}.\lambda B_{\langle s,\langle e,t\rangle\rangle}.$$

$$\forall w \in CONB : |A(w^*) \cap B(w^*)| > |A(w) \cap B(w)|$$

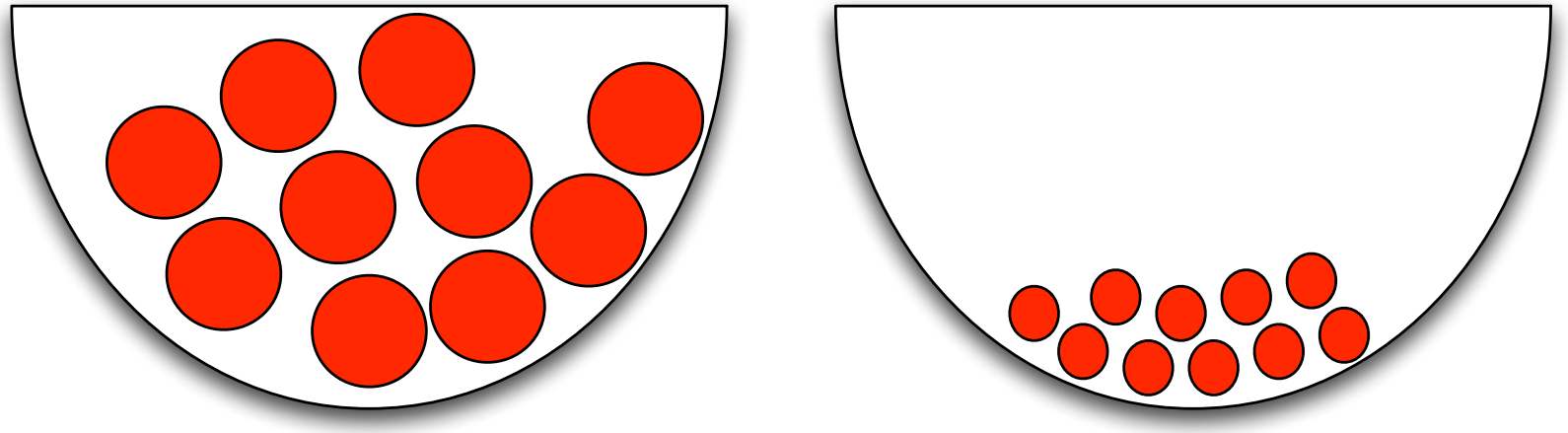
Shalom Lappin, 2000

Newstead & Coventry 2000



There are many marbles in the bowl

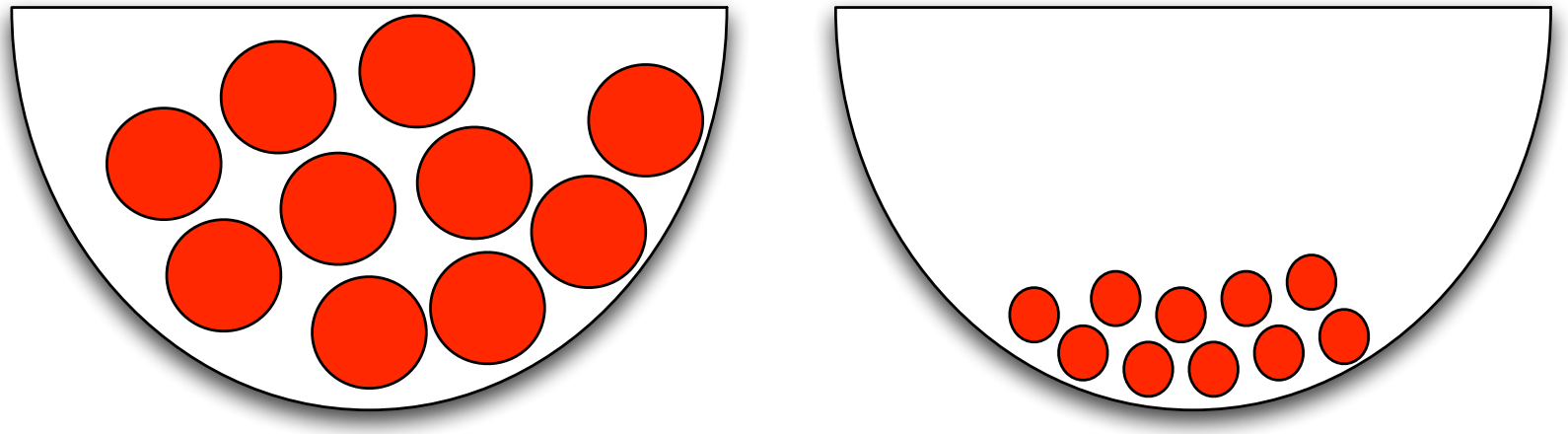
Newstead & Coventry 2000



There are many marbles in the bowl

"The studies all used a task in which participants rated the appropriateness of quantifiers describing the number of balls in a bowl. The size of the balls was found to have an effect: Identical numbers of balls were given different ratings depending on ball size." Newstead & Coventry 2000

Newstead & Coventry 2000

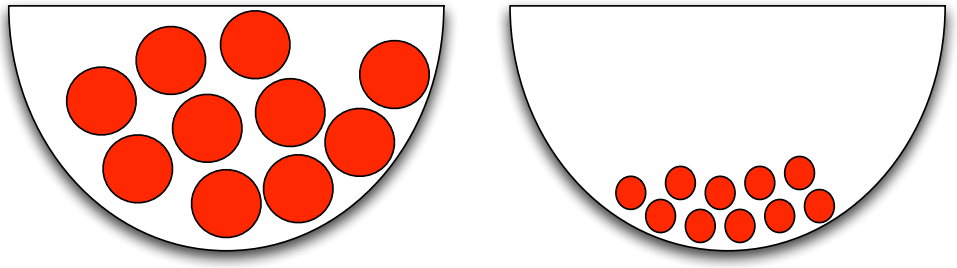


There are many marbles in the bowl

"The results are interpreted as indicating that quantifiers carry little specific meaning in themselves but instead derive their meaning from the context in which they occur." Newstead & Coventry 2000

The vagueness of *many*

- The conclusion of Newstead & Coventry becomes trivial if we do not think of many as a quantifier
- but if we instead think of it as a relative adjective
- i.e. what N&C uncovered is simply standard context-dependence and vagueness
- the effects are clearly limited to a subset of the set of GQs



There are more than seven marbles in the bowl

Many as a relative adjective

John is a tall basketball player

John is a tall toddler

There are many ants in my back garden

There are many mole hills in my back garden

Vagueness

A predicate is vague

- If it has borderline cases (and if there are cases that are borderline borderline, etc.)
- If it can be part of a sorites paradox

Vagueness in relative adjective

- Key semantic contrast:
  - the positive form: John is tall — vague
  - the comparative form: John is taller than Bill — crisp

Comparison and Vagueness

Kennedy 2007

Uranus is big, compared to Venus.

Uranus is bigger than Venus.

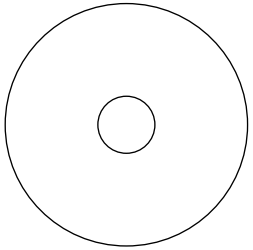


Figure 1: Uranus (51,118 km) vs. Venus (12,100 km)

Uranus is bigger than Neptune.

#Uranus is big, compared to Neptune.

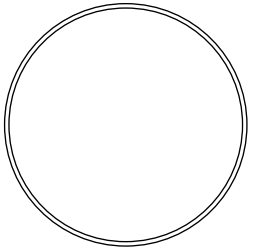


Figure 2: Uranus (51,118 km) vs. Neptune (49,500)

Vagueness with Many

There are many mole hills in my garden

There are more mole hills in my garden than in yours

Many as a relative adjective

cf. Solt 2006, 2007

- Distribution of very: modifies adjectives
  - I am very (*much) tall
  - I like you very *(much)
  - I am very *(much) into heavy metal music
- I found very many (*much) mistakes
- His good qualities are many
- The flaws in the proposal were many and serious

Vagueness and Informativity

To use words specifically you also have to avoid vague terms like ”many,” ”few,” and ”difficult.” In their place you should use precise words like ”four” or ”illegal.” What does many mean? It means different things to different people. But four (whether it is four or four million) is a measurable amount. If you wanted to refer to how many widgets your company had you might be tempted to reply ”a lot” if you found that your company had an entire warehouse full of them. However, your boss might respond ”that’s not even a year’s worth.” [..] The words ”many,” ”large,” and ”important” mean something different to each of us. As a writer you should constantly strive to select simple, straightforward words that mean the same thing to most people.

(University of Florida Precize Writing Guide)

http://edis.ifas.ufl.edu/WC004

Vagueness and informativity

Be specific with numbers and avoid vague terms like many, a lot, and most.

(Associated Press Stylebook and Libel Manual)

http://academics.smcvt.edu/dlynch/apstyle.htm

How to be precise

- Message: vagueness (and imprecision) leads to uninformativity

  (i) There were exactly 34 people at my party last week.
  (ii) There were many people at my party last week.
  (iii) There were more than 10 people at my party last week.

- All three sentences are about how many people attended my party. But only (i) gives a precise answer.

How to be precise

- Message: vagueness (and imprecision) leads to uninformativity

  (i) There were exactly 34 people at my party last week.
  (ii) There were many people at my party last week.
  (iii) There were more than 10 people at my party last week.

- All three sentences are about how many people attended my party. But only (i) gives a precise answer.
- All three can give informative answers:
  - (i): the number of guests was 34
  - (ii): the number of guests was satisfactory
  - (iii): the number of guests was sufficient

Moxey and Sanford's perspective approach

Moxey & Sanford 2000

- Logicality has it that quantifiers express cardinality relations
- Moxey and Sanford: Quantifiers express *a perspective on a quantity*

- Rather than providing a quantity
- they *describe* it from a certain perspective

Moxey and Sanford's perspective approach

Sanford et al. 2002

In the train disaster, a few people were seriously injured, which is a #good/bad thing.

In the train disaster, few people were seriously injured, which is a good/#bad thing.

Moxey and Sanford's perspective approach

Sanford et al. 2002

Thankfully, not quite all passengers died in the crash.

#Thankfully, almost all passengers died in the crash.

Thankfully, few passengers died in the crash.

#Thankfully, a few passengers died in the crash.

Perspective

Moxey and Sanford 1993, Nouwen 2003 — complement anaphora

Nearly all of the fans went to the match.
They cheered their team on at every opportunity.

Not quite all of the fans went to the match.
They watched it at home on TV instead.

Perspective

Horn 2002

Few students got this question right. For example, Bill didn't / ?Bill did.

A few students got this question right. For example, Bill did / ???Bill didn't

Perspective effects and GQT

A set of sets Q is MON↑ iff $Q(X) \wedge X \subseteq X' \Rightarrow Q(X')$
A set of sets Q is MON↓ iff $Q(X) \wedge X' \subseteq X \Rightarrow Q(X')$

a few passengers is MON↑
few passengers is MON↓

Perspective and monotonicity

Nouwen 2003

Most students went to the party.
They had a lot of fun.

Most students went to the party.
#They were too busy.

Very few of the students went to the party.
They (still) had a lot of fun.

Very few of the students went to the party.
They were too busy.

However. . .

The limits of monotonicity

Thankfully, not quite all politicians are corrupt

#Thankfully, almost all politicians are corrupt

The limits of monotonicity

Thankfully, not quite all politicians are corrupt

#Thankfully, almost all politicians are corrupt

You have to answer almost all questions correctly if you want to pass

#You have to answer not quite all questions correctly if you want to pass

almost X entails but does not assert ¬X

not quite X entails and asserts ¬X

Schwenter 2002, Horn 2002

The limits of monotonicity

SALE! Up to 60% reduction!

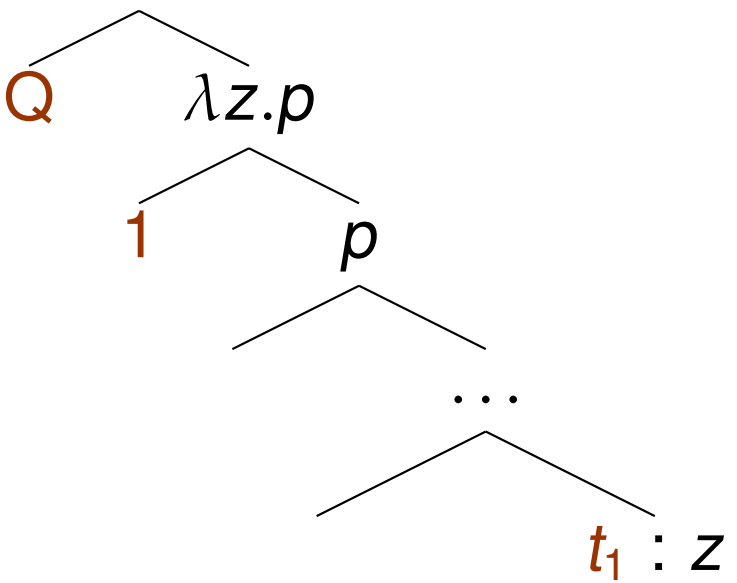
#SALE! At most 60% reduction!

Interim summary

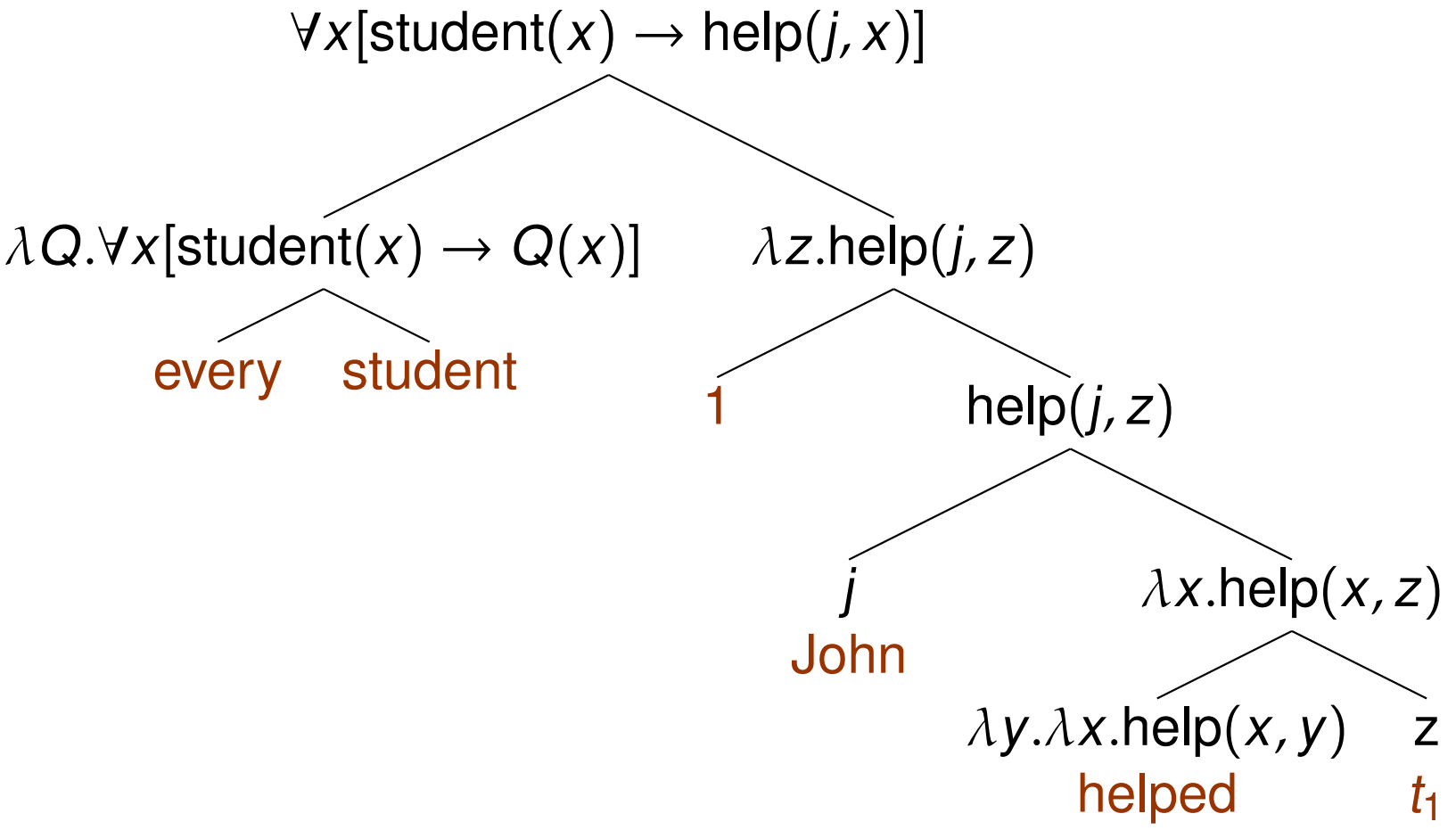
- There is more to quantifiers than cardinality
- or cardinality comparison
  - intensionality
  - vagueness and context-dependence
  - perspective
- There is no *one* semantic template for quantity expressions
- Next: some more complications
- But: the tools of GQT are indirectly relevant

The syntactic force of $\langle\langle e, t\rangle, t\rangle$

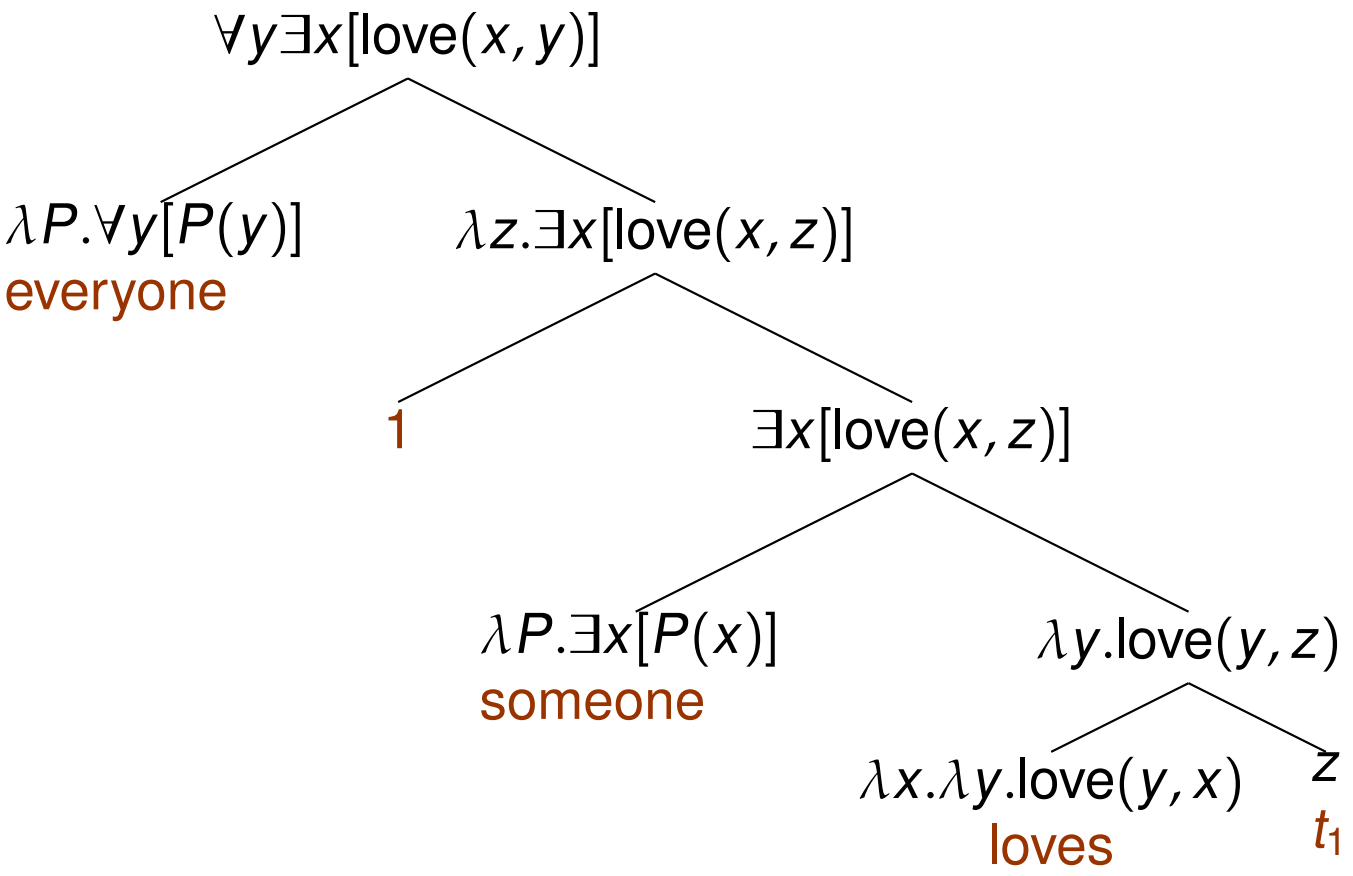
- Quantifiers (type $\langle\langle e, t\rangle, t\rangle$) may move and adjoin at a higher node (of type t)
- leaving behind a trace of type e



Quantifier raising



Someone loves everyone



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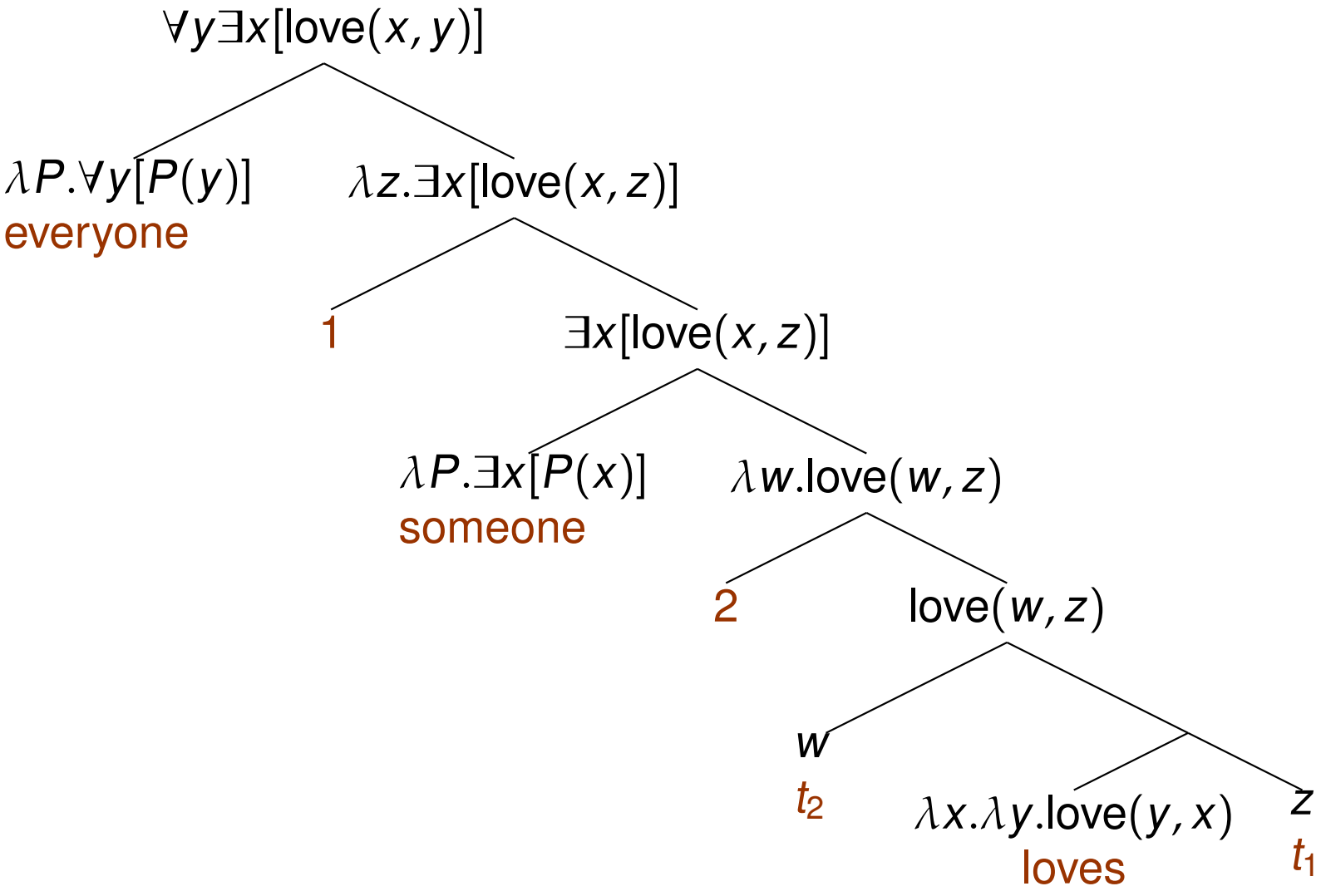

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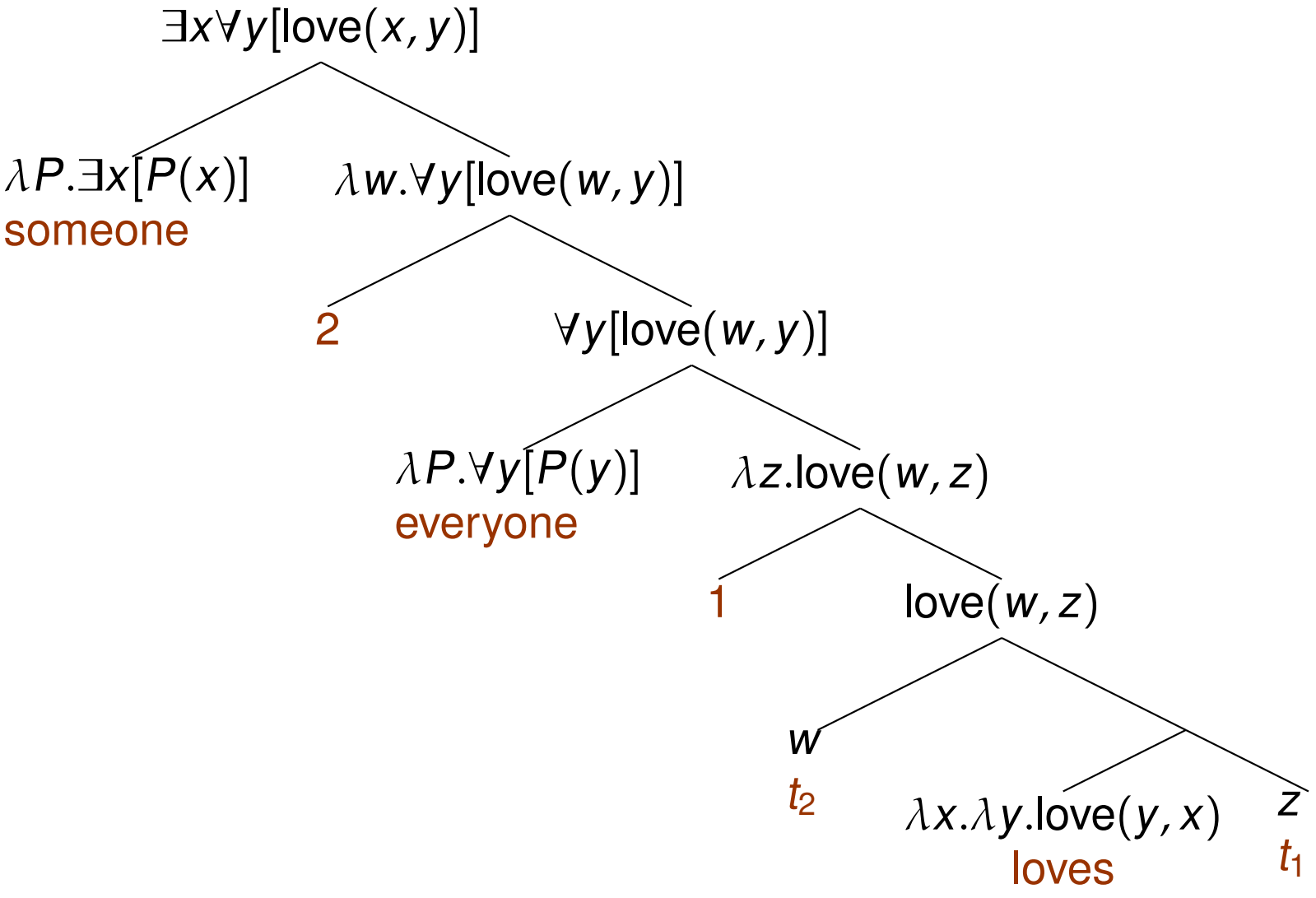
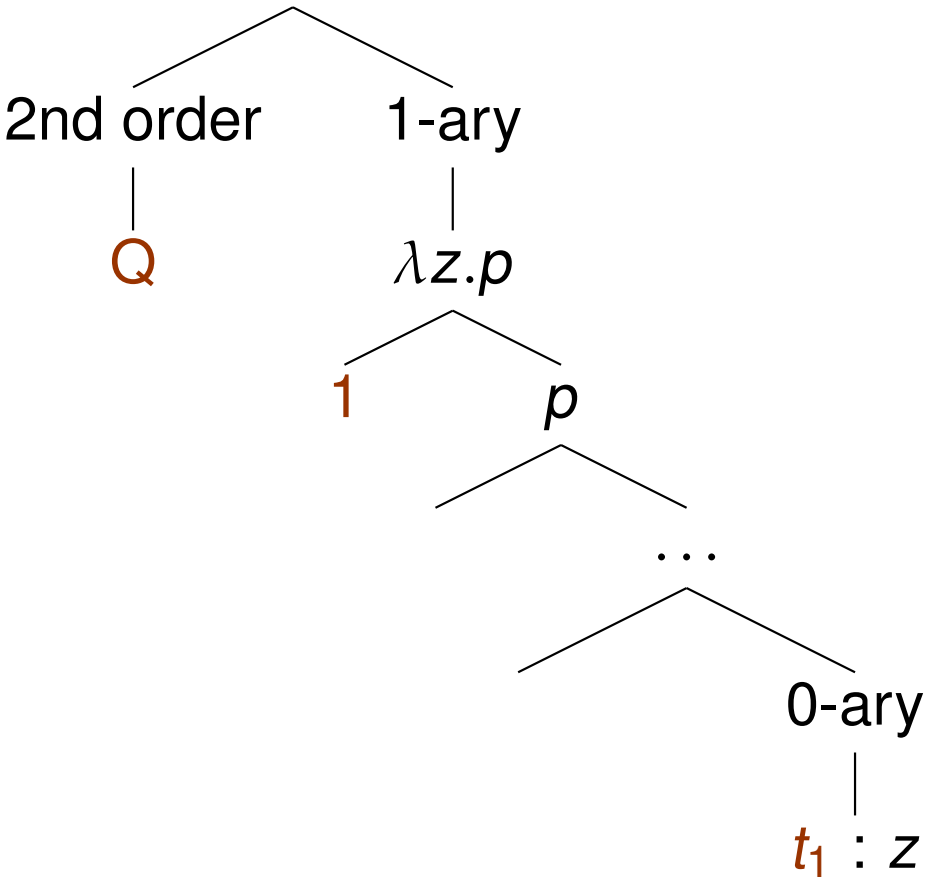


The versatility of QR



The versatility of QR

- Operators that raise are of type $\langle\langle \alpha, t\rangle, t\rangle$
- There is α-lambda abstraction over the landing site's sister
- Traces are of a simplex type (α)

- Example: the comparative

DegP movement

Heim 2000

- What does the comparative express?
- First attempt: $[\![\text{taller}]\!] = \lambda x.\lambda y.y$'s height$>x$'s height
- John is taller than Bill is true iff John's height exceeds Bill's
- John is taller than 6'
- The table is longer than the room is wide
- Second attempt: $[\![\text{taller}]\!] = \lambda d.\lambda y.y$'s height$>d$

The comparative

Heim 2000

- $\lambda d.\lambda y.y$'s height>d
- How does a than-clause denote a degree? (It doesn't)

- than WH$_i$ Bill is t_i tall

- *John is healthier than Mary wants to do fitness in order to be
- How healthy does Mary want to do fitness in order to be?

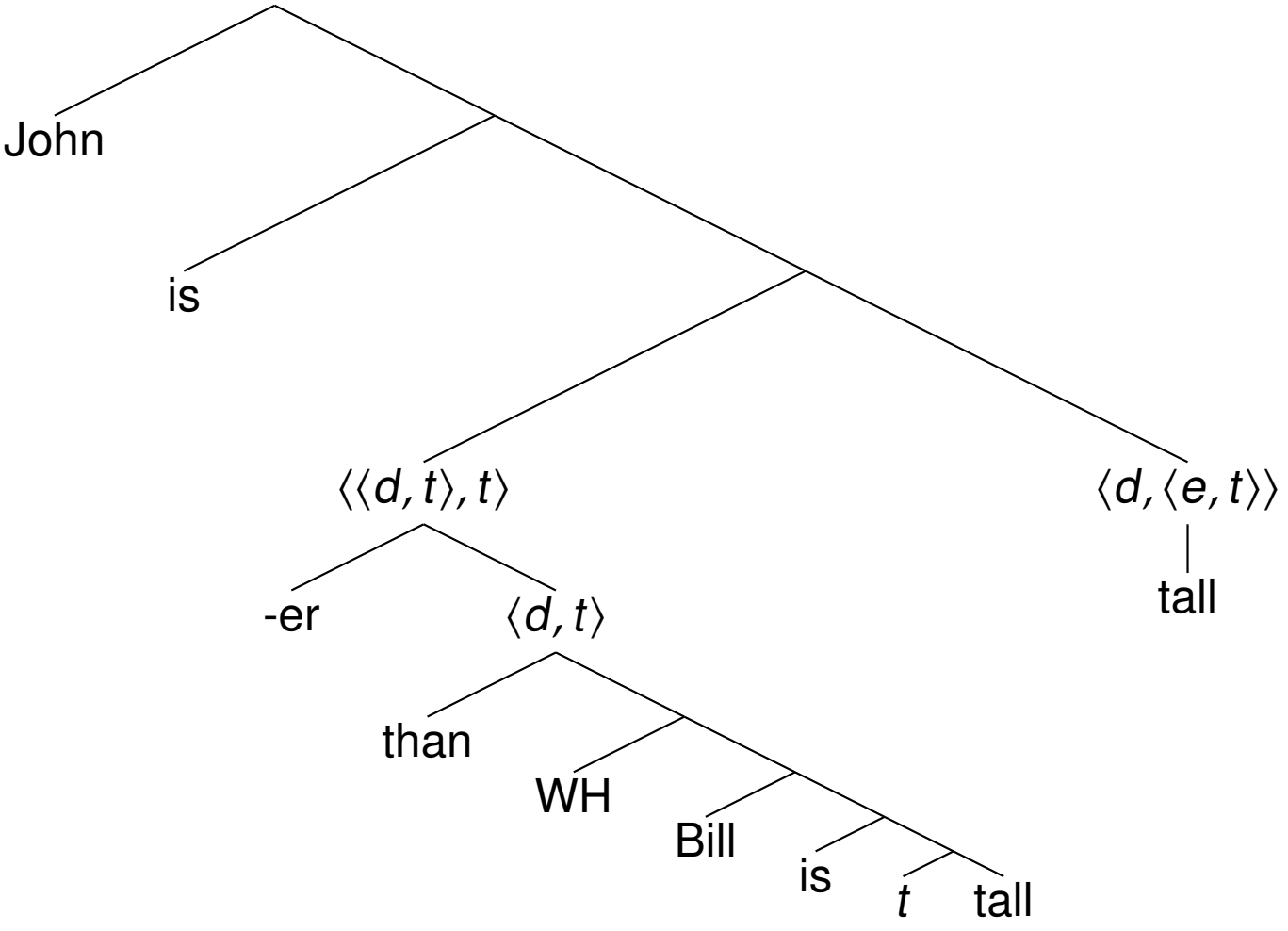
- λd.Bill is d tall

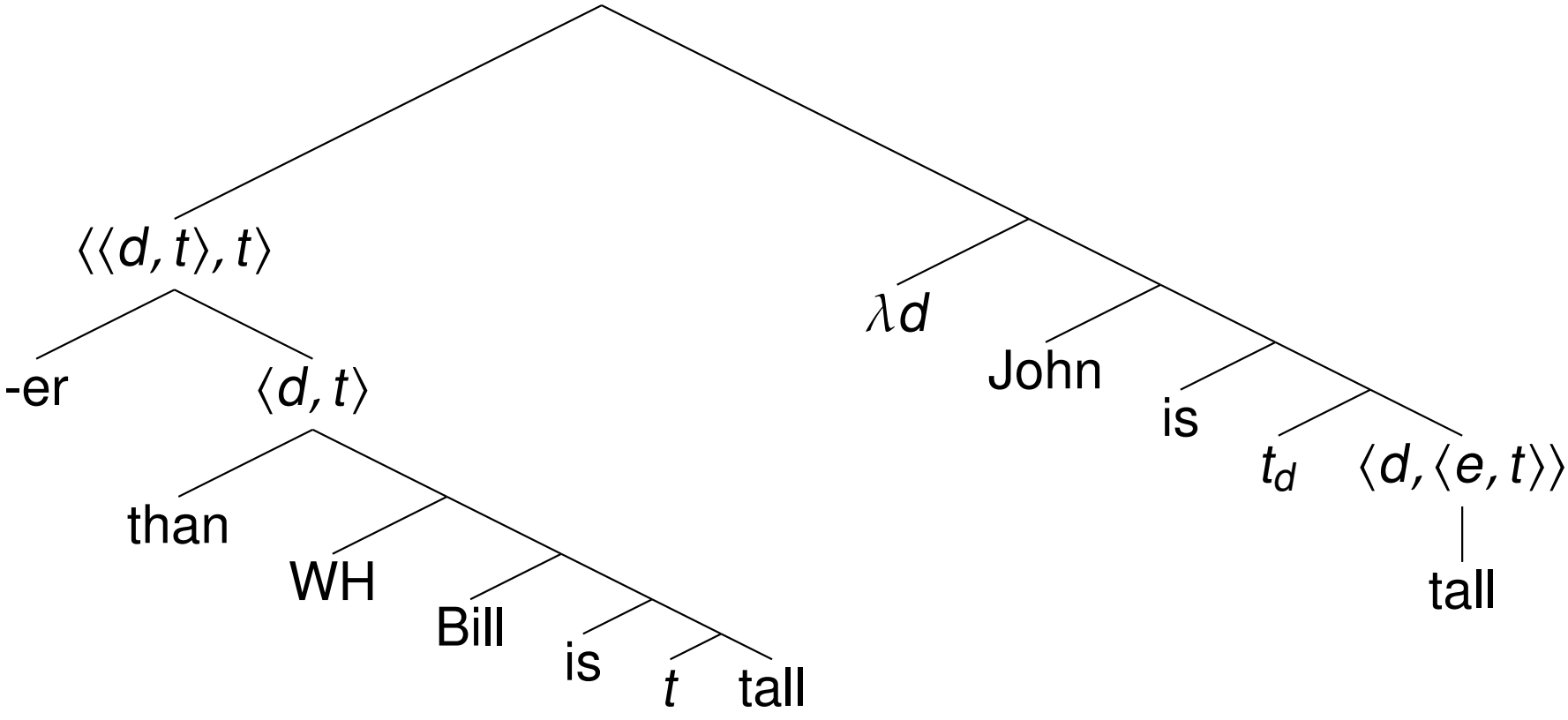
Consequence: $[\![$-er$]\!] = \lambda D_{\langle d,t\rangle}.\lambda y.y$'s height> $max(D)$

Comparative morphology as a generalised quantifier

Heim 2000

$$[\![\text{-er}]\!] = \lambda D_{\langle d,t\rangle}.\lambda D'_{\langle d,t\rangle}.max(D') > max(D)$$




⟨⟨d, t⟩, t⟩
-er
⟨d, t⟩
than
WH
Bill
is
t
tall
λd
John
is
t_d
⟨d, ⟨e, t⟩⟩
tall

The comparative

Heim 2000

(This draft is 10 pages.)

The paper is required to be exactly 5 pages longer than that.

- $\Box[max(\lambda d.long(p,d))] = 15pp$
  the paper should be 15 pages long
- $max(\lambda.\Box long(p,d)) = 15pp$
  the minimum number of pages that is acceptable for the paper is 15

(This draft is 10 pages.)

The paper is allowed to be exactly 5 pages longer than that.

- $\Diamond[max(\lambda d.long(p,d))] = 15pp$
  it's okay if the paper turns out 15 pages long
- $max(\lambda.\Diamond long(p,d)) = 15pp$
  the upper page limit is 15 pages

The comparative

Heim 2000

(This draft is 10 pages.)

The paper is required to be less long than that.

- the paper should be shorter
- the minimum number of pages that is acceptable for the paper < 10

The second reading might be difficult to get, but it is available. Try:

(For the Nigella Lawson version of this cake I used 6 sticks of butter.) The Delia Smith version requires less butter than that.

The comparative

Heim 2000

Not all intensional verbs behave similarly. Heim's examples:

The paper should be less long than that.

- #It's not required for it to be as long as that

The paper is supposed to be less long than that.

- #It's not required for it to be as long as that

I want the paper to be less long than that.

- #I don't require it to be as long as that

(My prediction: Bill will break the world record long jump (8m95cm). It turned out he only jumped 8m80cm.) I predicted Bill to jump exactly 15cm further than that.

New interim summary

- There is more to quantifiers than quantity
- Some quantity expressions simply are not quantifiers
- Some quantifiers are not quantity expressions

many almost all / not quite all -er

- There is no homogeneous class of *quantifiers*, unless we focus on very narrow properties
  - syntactic mobility
  - logicality?

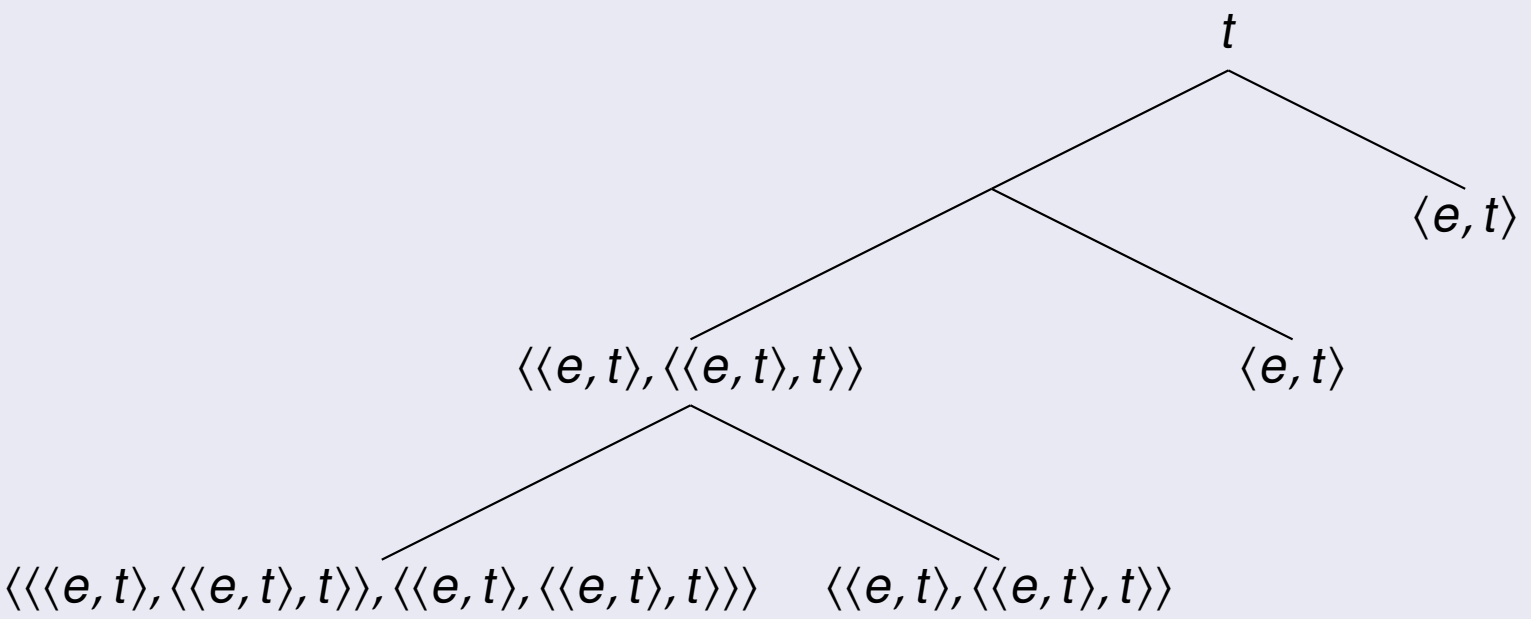
Two issues

Three supposedly equivalent determiners

more than two
at least three
three

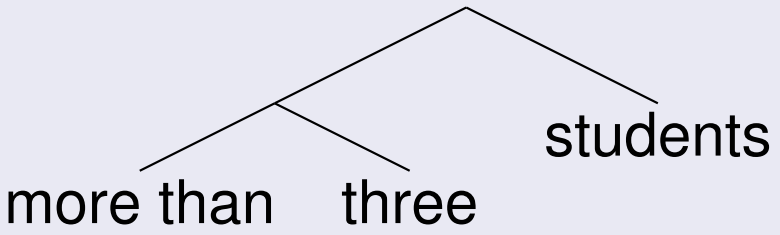
$\lambda X.\lambda Y.|X \cap Y| \geq 3$

A universal structure for quantified expressions

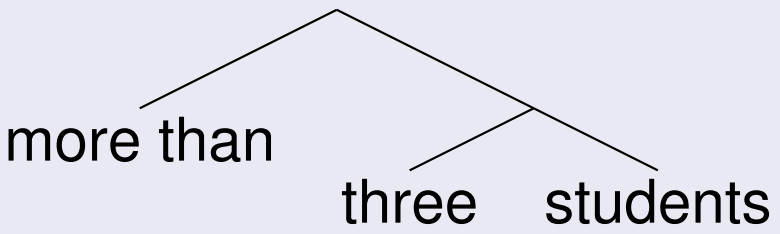


The structure of modified numerals

GQT



An alternative



The structure of modified numerals: Hackl 2001

(i) #More than one student is meeting
(ii) At least two students are meeting

(iii) #More than 9 people got married on Saturday
(iv) At least 10 people got married on Saturday

(v) #John separated more than one animal
(vi) John separated at least two animals

Hackl's proposal: [more than [two NP VP]]

The structure of modified numerals: Focus-sensitivity

Krifka 1999, Geurts & Nouwen 2007

At least THREE boys left. (Maybe four)

At least three BOYS left. (Maybe some girls too)

At least it isn't RAINING. (Maybe the sun will even shine)

This behaviour is unexpected if at least modifies three.

Modified numerals show signs of DegP movement

Hackl 2000

Bill needs to score fewer than 10 points to win.

- Bill will win only if he doesn't score 10 or more points (available, but unlikely)
- The minimum number of points Bill needs to score to win is 9 or fewer. (available)

Bill is allowed to eat fewer than 10 cookies.

- It's okay if Bill eats 9 or fewer cookies. (available)
- Bill shouldn't eat more than 9 cookies. (available)

Hackl's comparative semantics

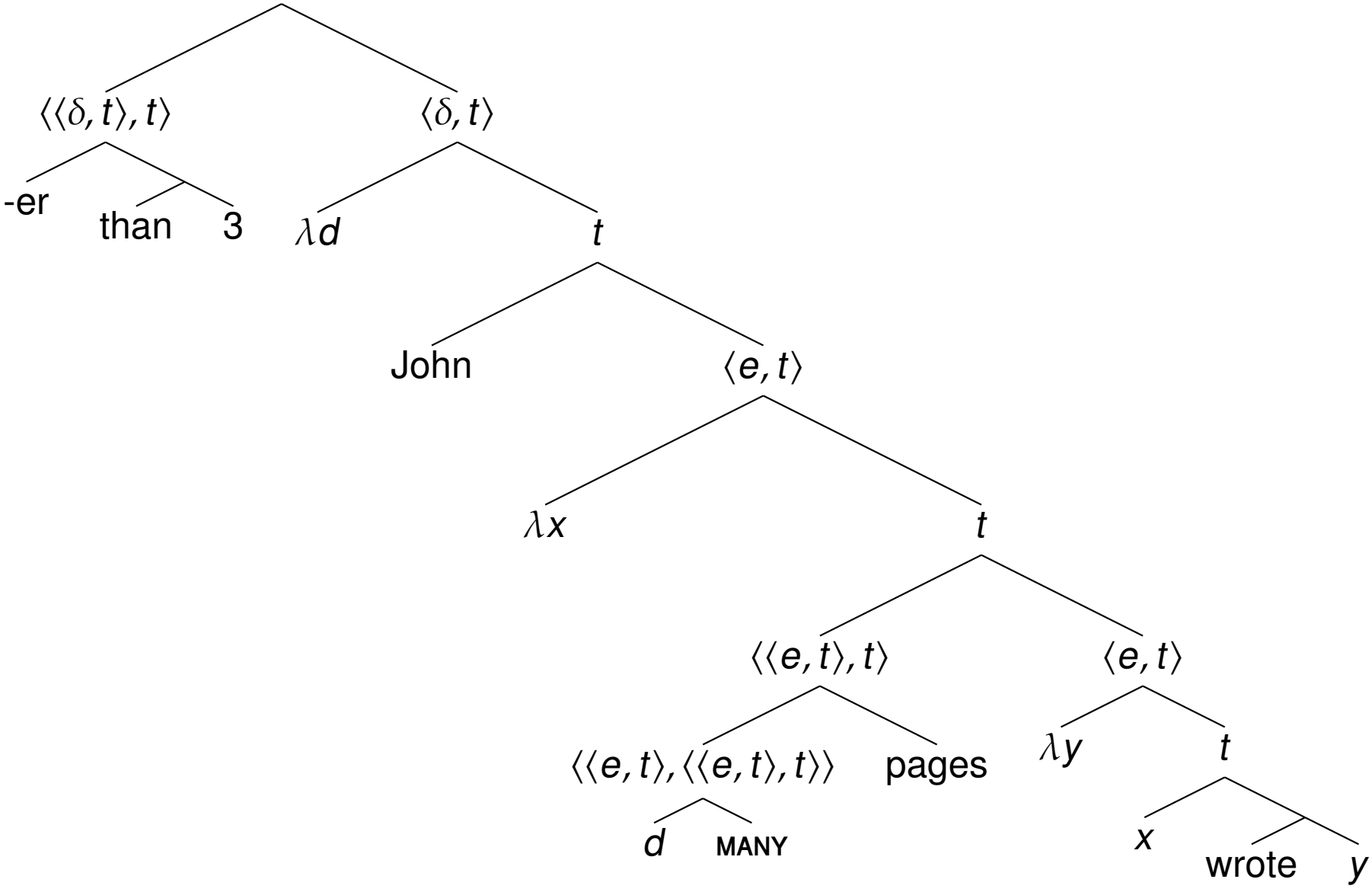
Hackl 2000

$[\![\textsc{many}]\!] = \lambda d.\lambda X.\lambda Y.\exists x[\#x = d \wedge X(x) \wedge Y(x)]$

$[\![3]\!] = 3$

3 pages $\rightsquigarrow$ [[3 MANY] pages] $\rightsquigarrow \lambda Y.\exists x[page(x) \wedge Y(x) \wedge \#x = 3]$

John wrote more than three pages.



Hackl's comparative semantics

Hackl 2000

[allowed [[fewer than 10] [λd [[d many] cookies] [λx [Bill eat x]]]]]

$[\![\lambda d$ Bill eat d many cookies$]\!]$ =
$\lambda d.\exists x[cookies(x) \wedge eat(b,x) \wedge \#x = d]$

$[\![$fewer than 10$]\!] = \lambda D.max(D) < 10$

Sentence:
$\Diamond[max(\lambda d.\exists x[cookies(x) \wedge eat(b,x) \wedge \#x = d]) < 10]$

Hackl's comparative semantics

Hackl 2000

[[fewer than 10] [λd [allowed [[*d* many] cookies] [λx [Bill eat *x*]]]]]

Sentence: $max(\lambda d.\Diamond\exists x[cookies(x) \wedge eat(b,x) \wedge \#x = d]) < 10$

The semantics of modified numerals

Geurts & Nouwen 2007

According to a simple GQT analysis $[\![\text{at least three}]\!] = [\![\text{more than two}]\!]$. This turns out wrong for several reasons.

Specificity

(i) I will invite at most two people, namely Cody and Vic.

(ii) I will invite fewer than two people, namely Cody and Vic.

The semantics of modified numerals

Geurts & Nouwen 2007

According to a simple GQT analysis $[\![\text{at least three}]\!] = [\![\text{more than two}]\!]$. This turns out wrong for several reasons.

Inference

There are 10 marbles in the bag

$\Rightarrow$ There are more than 4 marbles in the bag

?? $\Rightarrow$ There are at least 4 marbles in the bag

Tomorrow

Why are there so many different modified numerals?

more than 100 pages
fewer than 100 pages
as many as 100 pages
as few as 100 pages
at least 100 pages
at most 100 pages
no fewer than 100 pages
no more than 100 pages

over 100 pages
under 100 pages
up to 100 pages
100 pages or more
100 pages or fewer
maximally 100 pages
minimally 100 pages
100 pages tops

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