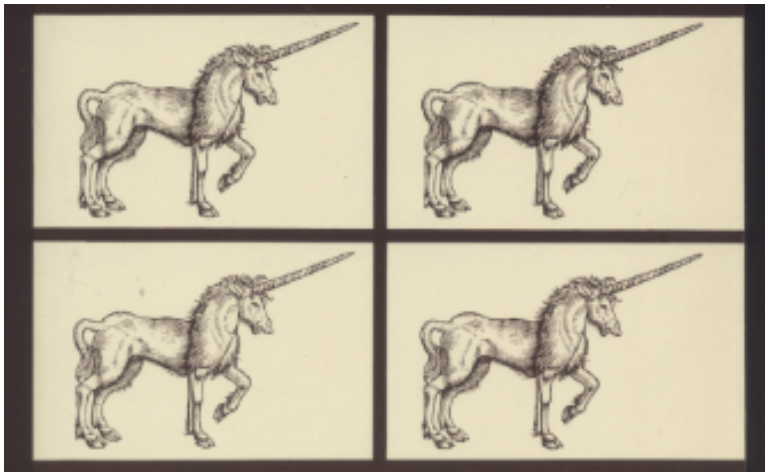
Montague semantics

Christopher Potts

Symbolic Systems 100
April 26

Overview

1. Some of the history of Montague semantics
2. Quick review of lambdas in linguistics
3. Case studies:
   - Conjunction reduction
   - Negative polarity



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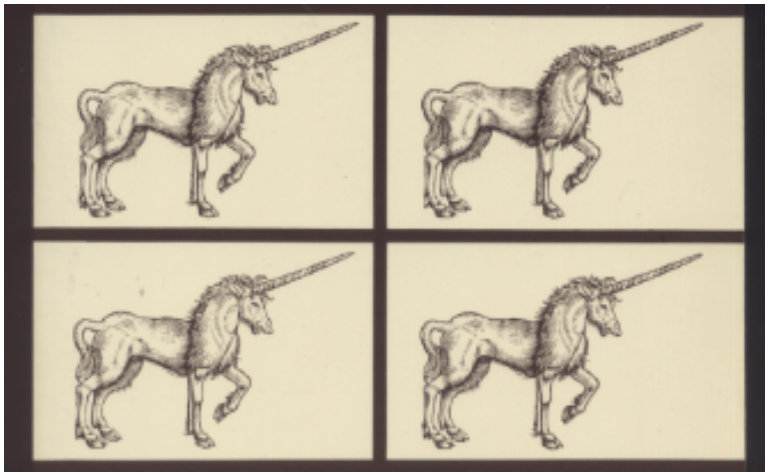


The most famous sentences in formal semantics:

- John found a unicorn.
- John is seeking a unicorn.

History: how did you get here?

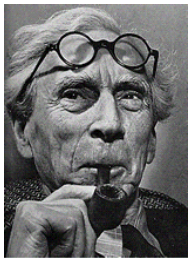
- Where did formal semantics come from?
- How did you get here?
- That is, how did there come to be a course like Symbolic Systems 100 at Stanford?

Higher-order intensional logics and their models


Gottlob Frege


Rudolph Carnap


C. I. Lewis


Bertrand Russell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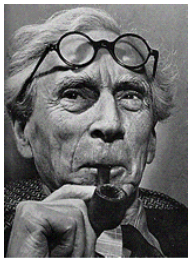
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Willard van Orman Quine (1947): "When modal logic is extended [...] to include quantification theory, on the other hand, serious obstacles to interpretation are encountered."

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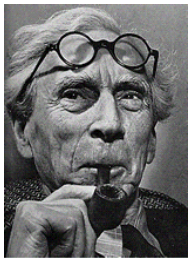
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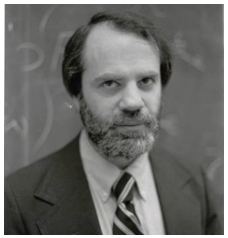
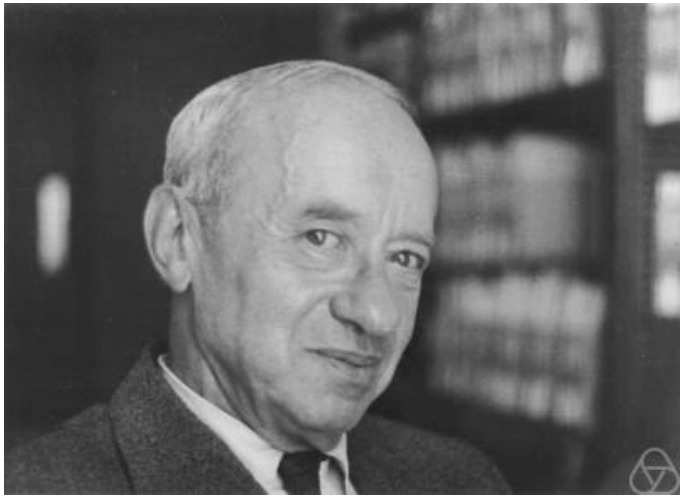
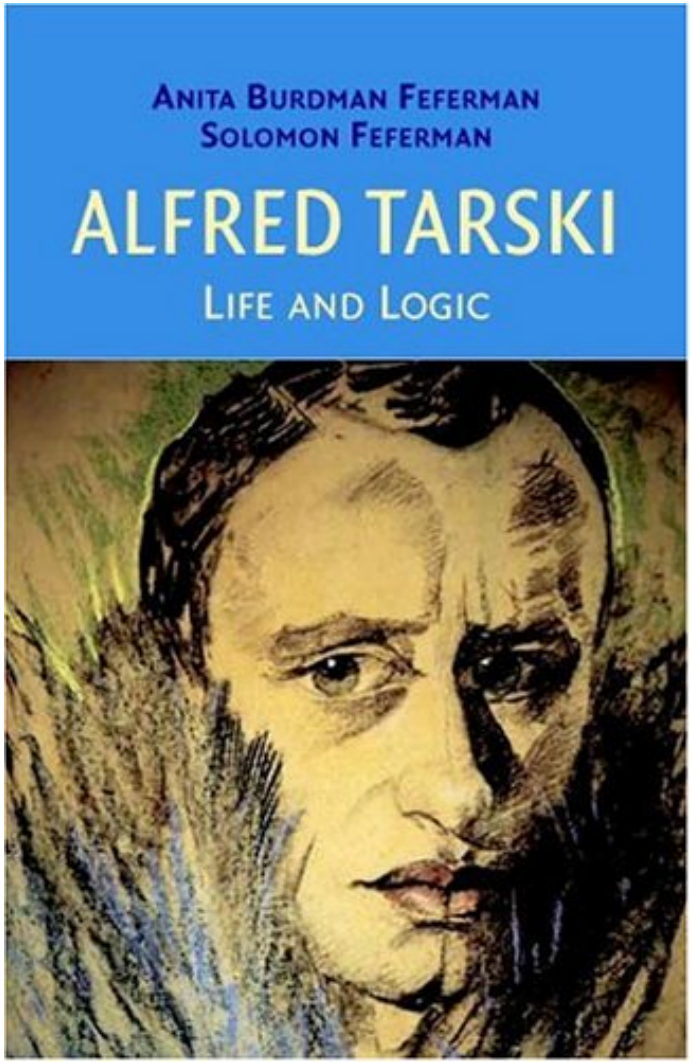
Ruth Barcan Marcus (1946): "The deduction theorem in a functional calculus of first order based on strict implication"



Saul Kripke (1959) (at age 19): 'A completeness theory in modal logic'

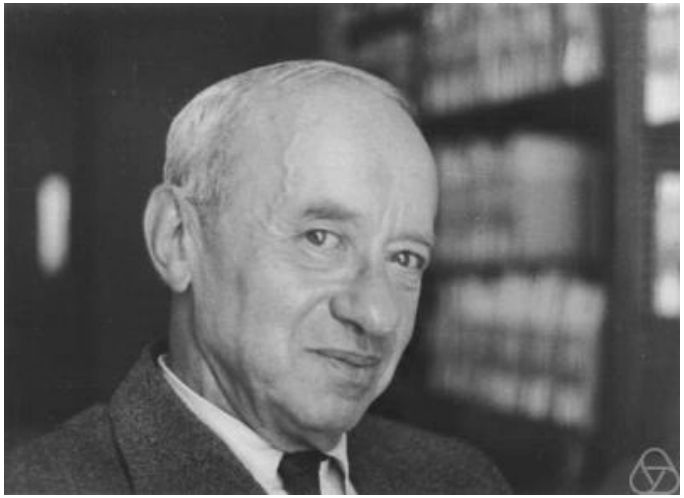
Alfred Tarski (1901-1983)





Feferman and Feferman 2004

Alfred Tarski (1901-1983)



Alfred Tarski

Biography MathSciNet

Ph.D. Uniwersytet Warszawski 1924

Dissertation: *O wyrazie pierwotnym logistyki*

Mathematics Subject Classification: 03—Mathematical logic and foundations

Advisor: Stanislaw Lesniewski

Students:
Click here to see the students ordered by family name.

Name	School	Year	Descendants
Andrzej Mostowski	Uniwersytet Warszawski	1938	195
Bjarni Jónsson	University of California, Berkeley	1946	62
Louise Lim	University of California, Berkeley	1948	
Julia Robinson	University of California, Berkeley	1948	
Wanda Szmielew	University of California, Berkeley	1950	1
Frederick Thompson	University of California, Berkeley	1952	29
Anne Morel	University of California, Berkeley	1953	2
Leonard Gillman	Columbia University	1953	6
Robert Vaught	University of California, Berkeley	1954	93
Edgar Smith, Jr.	Brown University	1955	
Chen Chang	University of California, Berkeley	1955	73
Solomon Feferman	University of California, Berkeley	1957	33
Richard Montague	University of California, Berkeley	1957	16
H. Jerome Keisler	University of California, Berkeley	1961	51
James Monk	University of California, Berkeley	1961	92
Haim Gaifman	University of California, Berkeley	1962	4
William Hanf	University of California, Berkeley	1963	3
Robert Bradford	University of California, Berkeley	1965	
Haragauri Gupta	University of California, Berkeley	1965	1
John Doner	University of California, Berkeley	1968	1
Don Pigozzi	University of California, Berkeley	1970	5
George McNulty	University of California, Berkeley	1972	7
Charles Martin	University of California, Berkeley	1973	
Roger Maddux	University of California, Berkeley	1978	3
Benjamin Wells, III	University of California, Berkeley	1982	
Judith (Kan) Ng	University of California, Berkeley	1984	

Alfred Tarski: choice snippets from the Fefermans' bio

"Alfred Tarski was one of the greatest logicians of all time."

"Tarski played the role of the "great man" to the hilt, not only through his fundamental work but also by his zealous promotion of the field of logic, his personal identification with the subject, and his charismatic teaching."

"Over time, Tarski laid claim to a great deal of territory in the world of logic, mathematics, and philosophy, especially in the areas of set theory, model theory, semantics of formal languages, decision procedures, universal algebra, geometry, and algebras of logic and topology. Between the 1940s and 1980 he created a mecca in Berkeley to which the logicians of the world made pilgrimage"

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Alfred Tarski: choice snippets from the Fefermans' bio

"They would start at about 9 P.M. when Tarski was just getting going. He always smoked, and he kept the door of his study closed so the smoke would stay in the room because he thought that made him concentrate better. "It was awful for me," Chang said, "because I had asthma, but what could I do? I was his student I wasn't really a night person either and after a while it was a struggle to keep my eyes open. Around 2 A.M. he'd ask me if I wanted some coffee and I'd say yes. Sitting at his desk, with the door closed, he'd scream 'Mariaahh, Mariaahh,' as loud as he could. If there was no answer, he'd repeat it, sometimes three or four times until Maria finally opened the door, half asleep, saying 'Yes, Alfred?' He'd ask her to bring us two cups of coffee and she trudged into the kitchen to make the coffee and bring it to us. I've never seen anything like it before or after."

Richard Montague (1930-1971)

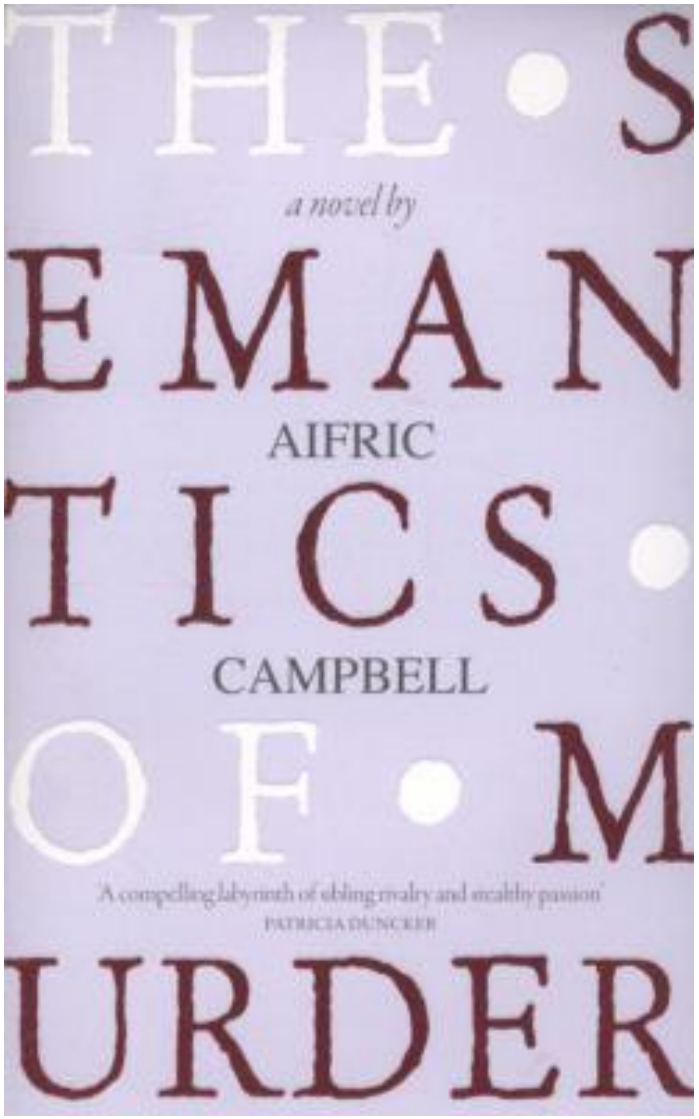
From the Fefermans' bio:

"A prodigy, small and brilliantly quick, Montague was one of the students who idolized Tarski and took up his problems and systems with manic enthusiasm, to the latter's obvious satisfaction."

"Although most of Tarski's disciples took a page from his book, insisting on precision in their own students' work, none was more like him in this respect than Montague. Nino Cocchiarella, a Montague student, labeled him a "little tyrant" [. . .]"

"Not all of Montague's problems as a student were Tarski's doing; in his private life he was in constant trouble of his own making."

Richard Montague (1930-1971)



Richard Montague (1930-1971)

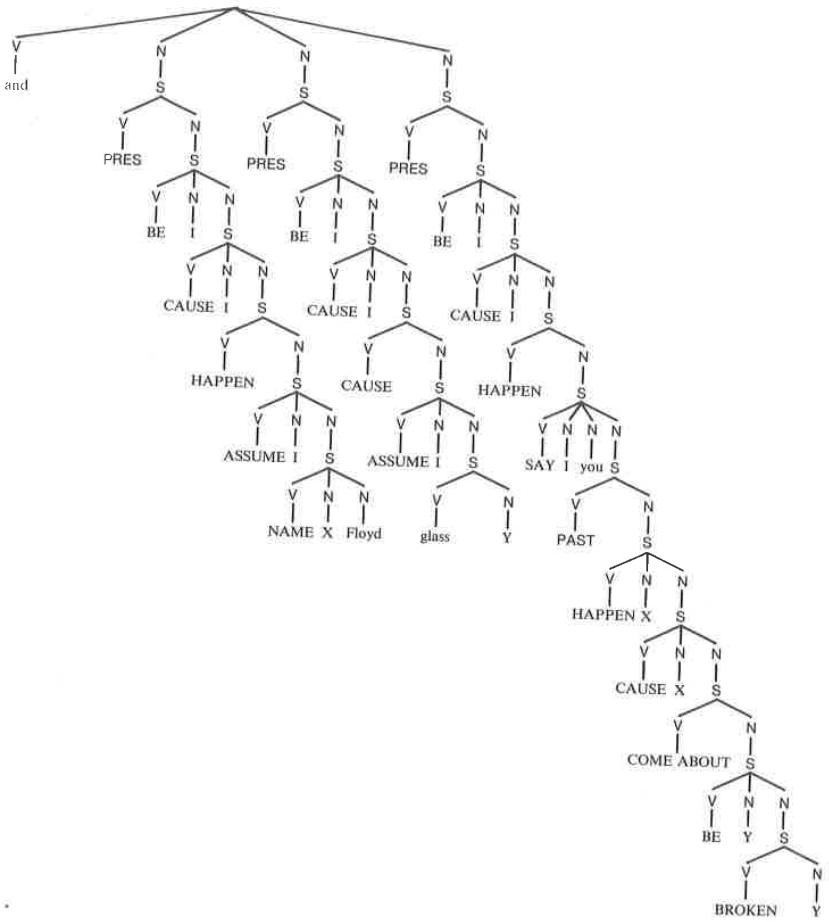
Montague grammar:

- 1970a: ‘English as a formal language’
- 1970b: ‘Universal grammar’
- 1973: ‘The proper treatment of quantification in ordinary English’ (PTQ)

Meanwhile, back in linguistics, . . .

The generative semanticists were working to use basically Chomskyan ideas to understand how meaning is expressed. See in particular Katz and Postal (1964).

The Chomskyans went after them, they went after the Chomskyans, and then the philosophers of language entered the fray with criticisms of both sides.



"Floyd broke the glass"

Lewis on Markerese

David Lewis (1970): ‘General semantics’, a more readable and philosophically revealing counterpart to Montague’s PTQ.

Lewis on Markerese

My proposals regarding the nature of meanings will not conform to the expectations of those linguists who conceive of semantic interpretation as the assignment to sentences and their constituents of compounds of ‘semantic markers’ or the like. (Katz and Postal, 1964, for instance.) Semantic markers are *symbols*: items in the vocabulary of an artificial language we may call *Semantic Markerese*. Semantic interpretation by means of them amounts merely to a translation algorithm from the object language to the auxiliary language Markerese. But we can know the Markerese translation of an English sentence without knowing the first thing about the meaning of the English sentence: namely, the conditions under which it would be true. Semantics with no treatment of truth conditions is not semantics. (p. 18)

Montague's PTQ

From the opening:

"Patrick Suppes claims [. . .] that "at the present time the semantics of natural languages are less satisfactorily formulated than the grammars . . . [and] a complete grammar for any significant fragment of natural language is yet to be written." This claim would of course be accurate if restricted in its application to the attempts emanating from the Massachusetts Institute of Technology, but fails to take into account the syntactic and semantic treatments proposed in Montague (1970a, b). Thus the present paper cannot claim to present the first complete syntax (or grammar, in Suppes' terminology) and semantics for a significant fragment of natural language [. . .]"

Montague's inspiring idea

Montague (1970b): "I reject the contention that an important theoretical difference exists between formal and natural languages."

Montague's inspiring idea

Montague (1970b): "I reject the contention that an important theoretical difference exists between formal and natural languages."

"To us, *the* revolutionary idea in Montague's PTQ paper (and earlier papers) is the claim that natural language is not impossibly incoherent, as his teacher Tarski had led us to believe, but that large portions of its semantics can be treated by combining known tools from logic, tools like functions of finite type, the λ-calculus, generalized quantifiers, tense and modal logic, and all the rest."

"Montague had a certain job that he wanted to do and used whatever tools he had at hand to do it. If the product looks a bit like a Rube Goldberg machine, well, at least it works pretty well." (Barwise and Cooper 1981:204)

Montague's inspiring idea

Montague (1970b): "I reject the contention that an important theoretical difference exists between formal and natural languages."

"Montague grammar is a very elegant and a very simple theory of natural language semantics. Unfortunately its elegance and simplicity are obscured by a needlessly baroque formalization." (Muskens 1995:7)

Montague's inspiring idea

Montague (1970b): "I reject the contention that an important theoretical difference exists between formal and natural languages."

"Montague revolutionized the field of semantic theory. He introduced methods and tools from mathematical logic, and set standards for explicitness in semantics. Now all semanticists know that logic has more to offer than first order logic only. Finally, recall that Barbara Partee said: 'lambdas really changed my life'; in fact lambdas changed the lives of all semanticists." (Janssen 2011:§4.1)

Barbara Partee (1940–)

Montague, spring 1970: “Barbara, I think that you are the only linguist who it is not the case that I can’t talk to.”

Barbara Partee (1940–)

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Barbara Partee (1940–)

- 1973: ‘Some transformational extensions of Montague grammar’
- 1974: ‘Opacity and scope’
- 1975: ‘Deletion and variable binding’
- 1980: ‘Semantics – mathematics or psychology?’
- 1981: ‘Montague Grammar, mental representations, and reality’

Montague, spring 1970: “Barbara, I think that you are the only linguist who it is not the case that I can’t talk to.”

Typed lambda calculus in linguistic semantics

The tools semanticists reach for when they want to explore language, state hypotheses, and discuss their ideas.

Truth, but not just truth

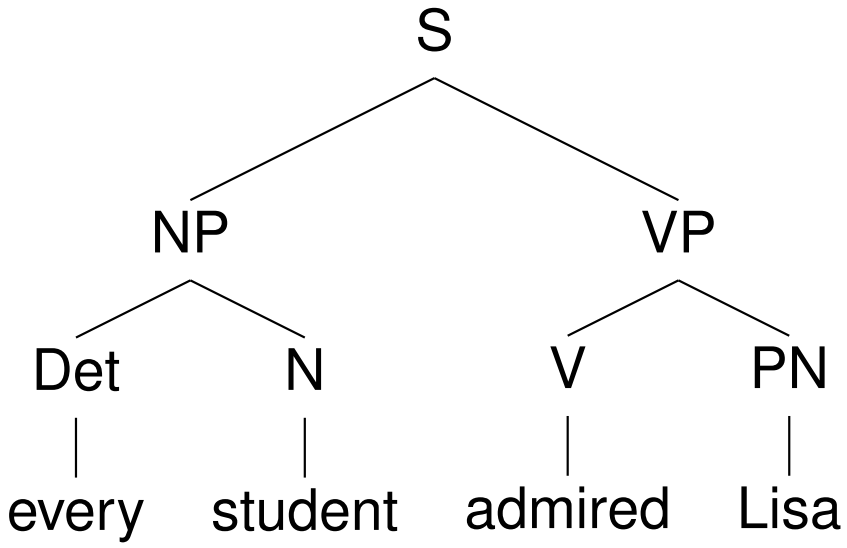
Lewis (1970):

"Intensions, our functions from indices to extensions, are designed to do part of what meanings do. Yet they are not meanings; for there are differences in meaning unaccompanied by differences in intension. It would be absurd to say that all tautologies have the same meaning, but they have the same intension; the constant function having at every index the value truth. Intensions are part of the way to meanings, however, and they are of interest in their own right." (p. 25)

Compositionality

Compositionality

The meaning of a phrase is a function of the meanings of its immediate syntactic constituents and the way they are combined.



Function application and beta reduction

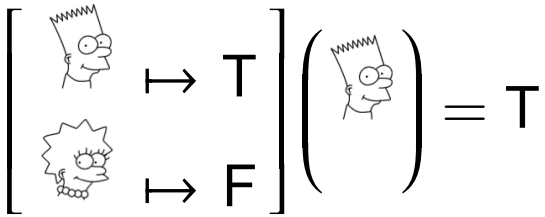
Function application

Syntax

(**skateboard bart**)

skateboard **bart**

Semantics



Beta reduction (syntactic simplification)

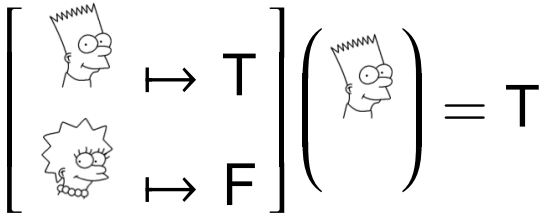
Syntax

$$\Big((\lambda x\ (\textbf{skateboard}\ x))\ \textbf{bart}\Big)$$

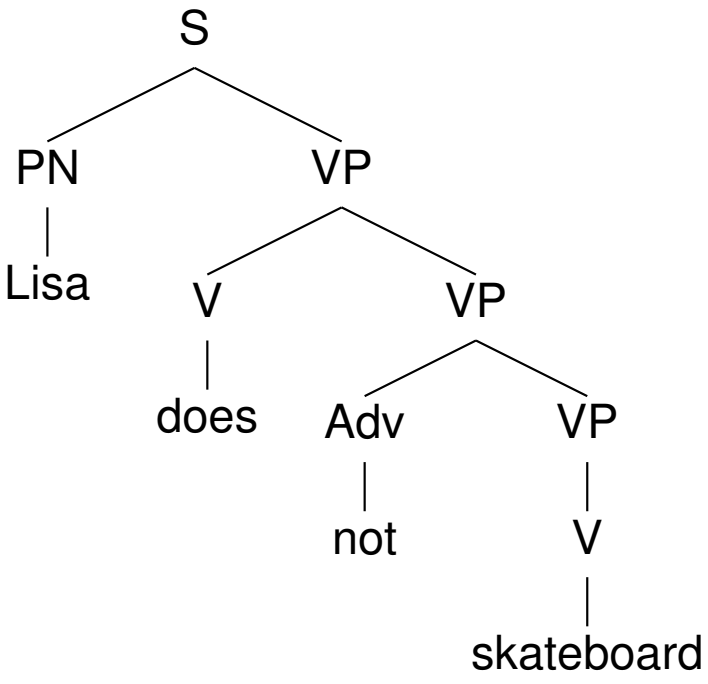
$$\Downarrow$$

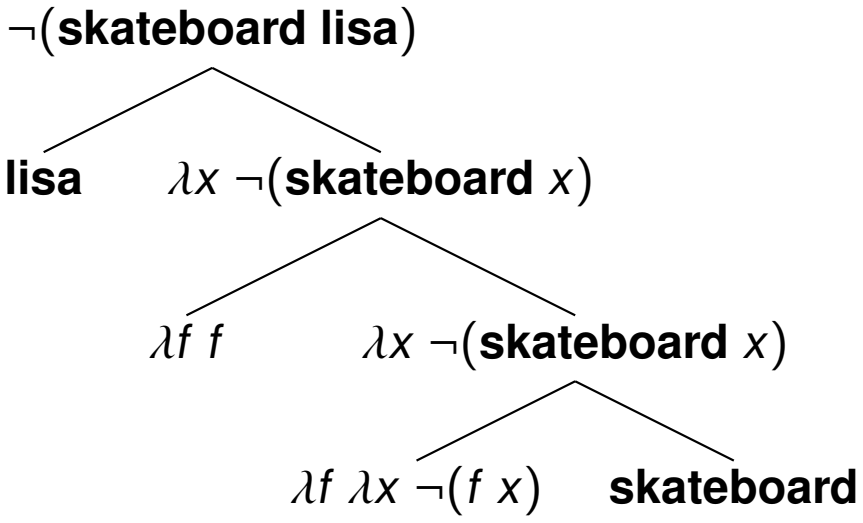
(**skateboard bart**)

Semantics



Translation: natural language into lambda terms





A note on the VP negation

$\neg$

$$\begin{bmatrix} \mathsf{T} & \mapsto & \mathsf{F} \\ \mathsf{F} & \mapsto & \mathsf{T} \end{bmatrix}$$

$\lambda f\ \lambda x\ \neg(f\ x)$

$$\begin{bmatrix}
\begin{bmatrix} \text{\scriptsize\textbf{Bart}} & \mapsto & \mathsf{T} \\ \text{\scriptsize\textbf{Lisa}} & \mapsto & \mathsf{T} \end{bmatrix} & \mapsto & \begin{bmatrix} \text{\scriptsize\textbf{Bart}} & \mapsto & \mathsf{F} \\ \text{\scriptsize\textbf{Lisa}} & \mapsto & \mathsf{F} \end{bmatrix} \\
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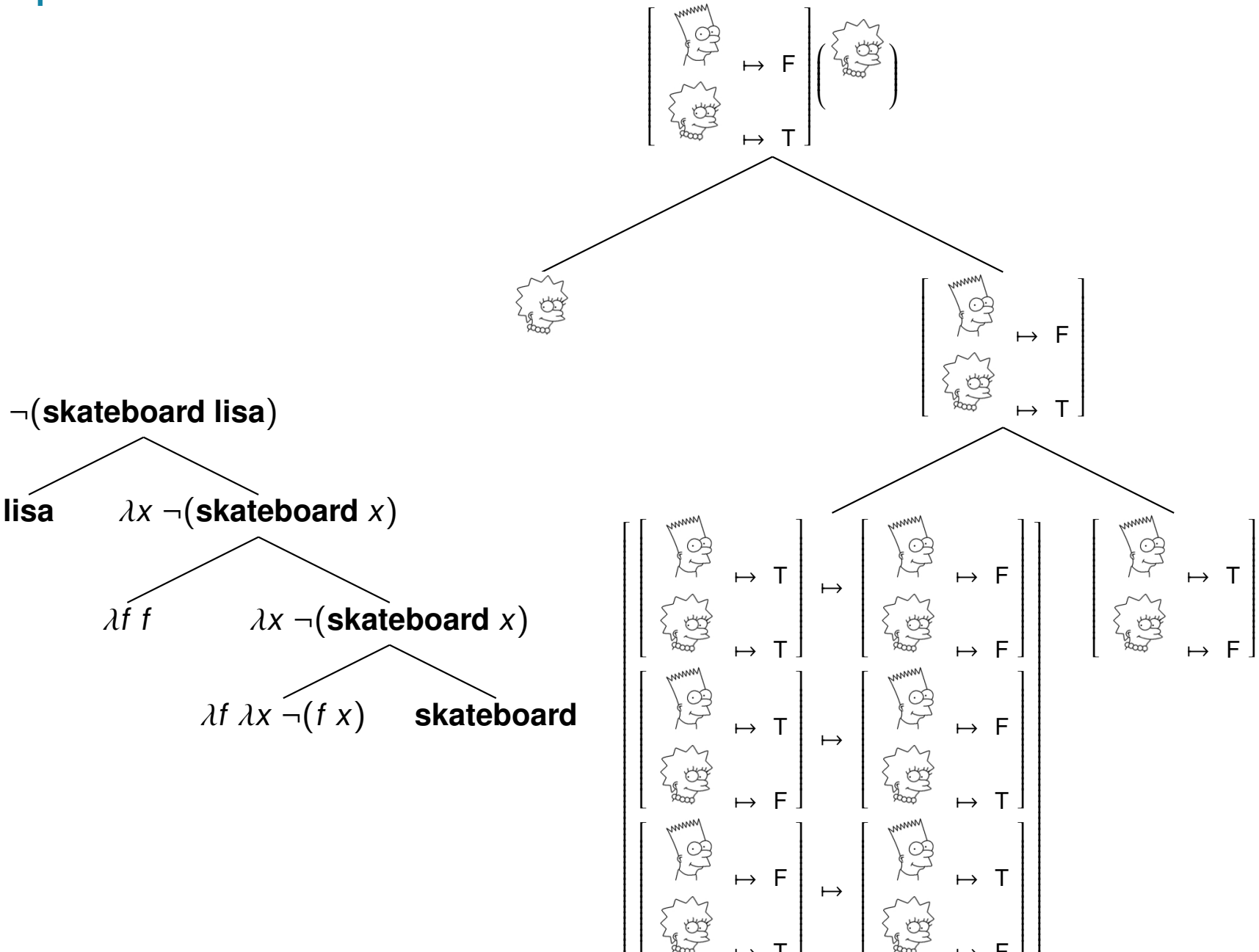
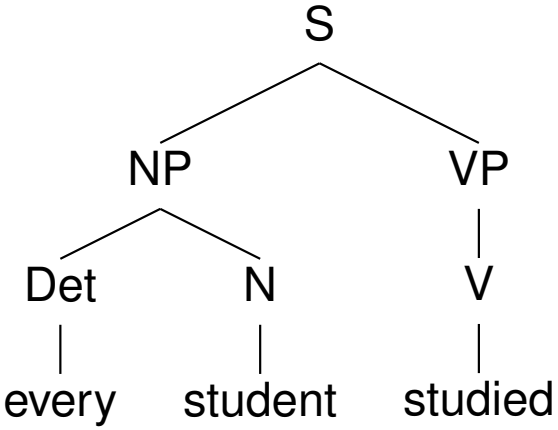
\end{bmatrix}$$

Interpretation: lambdas into the world



Quantifiers, compositionally



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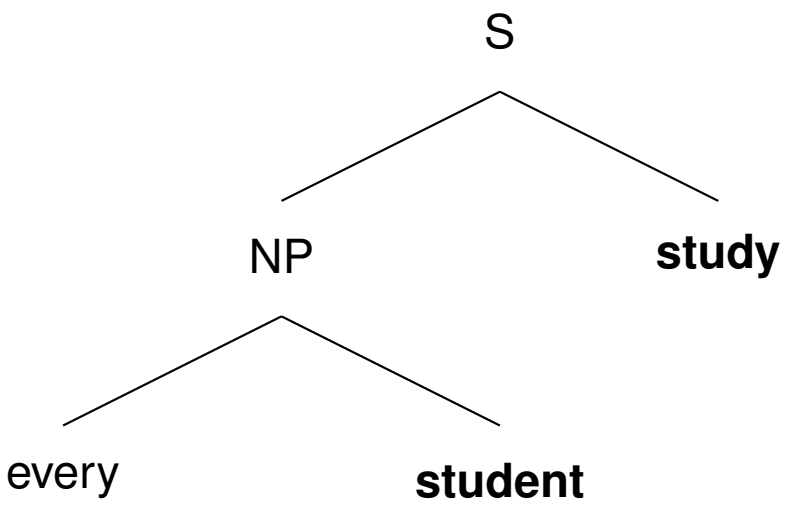
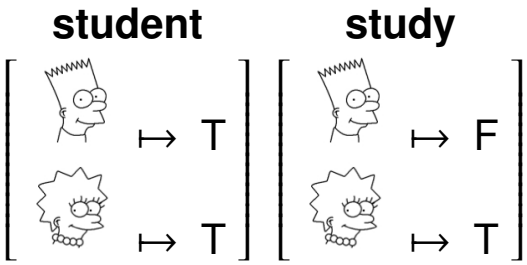
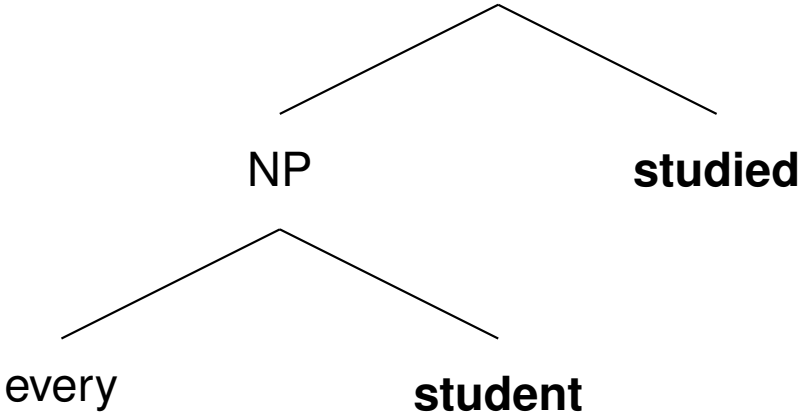


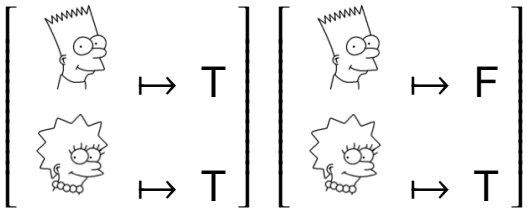


Quantifiers, compositionally

$$\forall x\,\big((\textbf{student}\ x) \rightarrow (\textbf{study}\ x)\big)$$



student **study**



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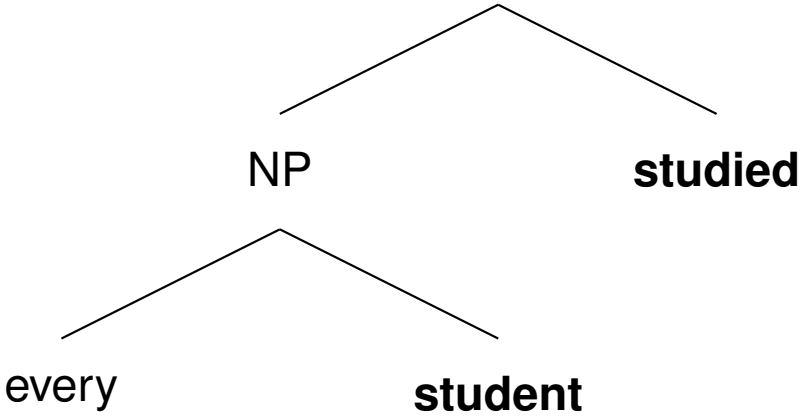
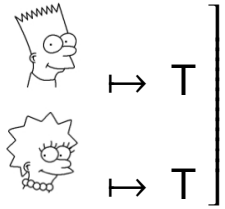
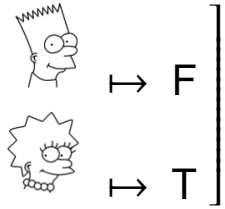


student



study



$$\Big(\forall x \quad \big((\textbf{student}\ x) \quad \rightarrow \quad (\textbf{study}\ x)\big)\Big)$$

Quantifiers, compositionally

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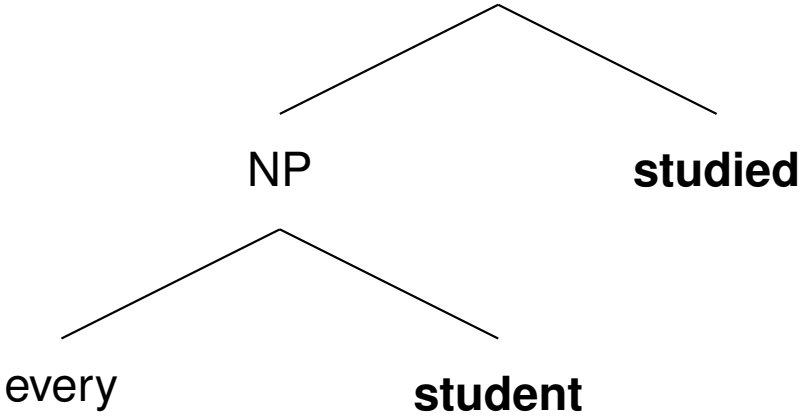
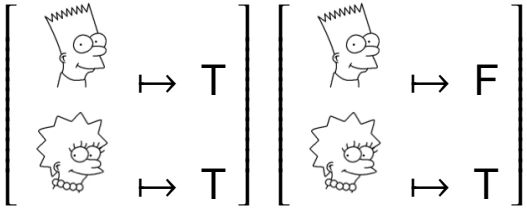


student **study**



$$\begin{array}{lllll} & \big(\forall x & \big((\textbf{student}\ x) & \rightarrow & (\textbf{study}\ x)\big)\big) \\ \lambda g & \big(\forall x & \big((\textbf{student}\ x) & \rightarrow & (g\ x)\big)\big) \end{array}$$

Quantifiers, compositionally

$$\forall x\,\big((\textbf{student}\ x) \to (\textbf{study}\ x)\big)$$

$$\lambda g\,\Big(\forall x\,\big((\textbf{student}\ x) \to (g\ x)\big)\Big)\quad \textbf{studied}$$

every **student**

student **study**

$$\begin{bmatrix} \text{  } & \mapsto \mathsf{T} \\ \text{  } & \mapsto \mathsf{T} \end{bmatrix} \begin{bmatrix} \text{  } & \mapsto \mathsf{F} \\ \text{  } & \mapsto \mathsf{T} \end{bmatrix}$$

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every **student**

student **study**

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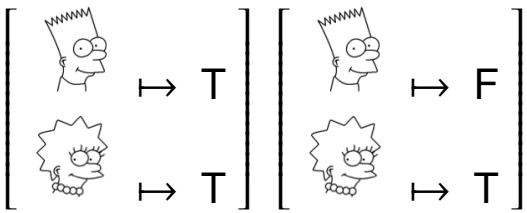
Quantifiers, compositionally

$$\forall x\,\big((\textbf{student}\ x) \to (\textbf{study}\ x)\big)$$

$$\lambda g\,\Big(\forall x\,\big((\textbf{student}\ x) \to (g\ x)\big)\Big) \quad \textbf{studied}$$

$$\lambda f\ \lambda g\,\Big(\forall x\,\big((f\ x) \to (g\ x)\big)\Big) \quad \textbf{student}$$

student **study**



$$\begin{array}{lllll} & \Big(\forall x & \big((\textbf{student}\ x) & \to & (\textbf{study}\ x)\big)\Big) \\ \lambda g & \Big(\forall x & \big((\textbf{student}\ x) & \to & (g\ x)\big)\Big) \\ \lambda f\ \ \lambda g & \Big(\forall x & \big((f\ x) & \to & (g\ x)\big)\Big) \end{array}$$

A few more quantifiers

1. *a* or *some*
   a. $\lambda g\ \lambda f\ \Big(\exists x\ \big((f\ x)\ \&\ (g\ x)\big)\Big)$
   b. $\exists x\ \big((\textbf{student}\ x)\ \&\ (\textbf{study}\ x)\big)$
2. *no*
   a. $\lambda g\ \lambda f\ \neg\Big(\exists x\ \big((f\ x)\ \&\ (g\ x)\big)\Big)$
   b. $\neg\Big(\exists x\ \big((\textbf{student}\ x)\ \&\ (\textbf{study}\ x)\big)\Big)$
3. *exactly two*
   a. $\lambda g\ \lambda f\ \Big(\big|\{x : (f\ x)\ \&\ (g\ x)\}\big| = 2\Big)$

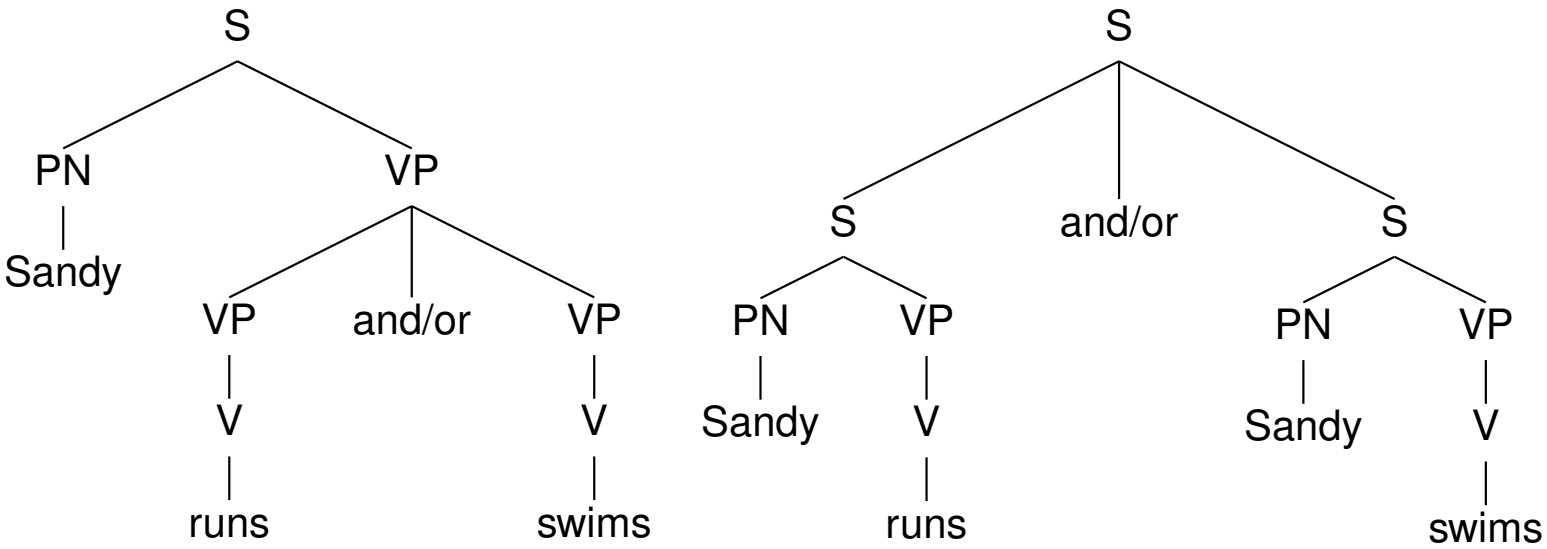
      where $|A|$ is the cardinality of the set A
   b. $\big|\{x : (\textbf{student}\ x)\ \&\ (\textbf{study}\ x)\}\big| = 2$

Conjunction reduction

In which lambdas save us from deriving the wrong meanings . . .

The old transformation

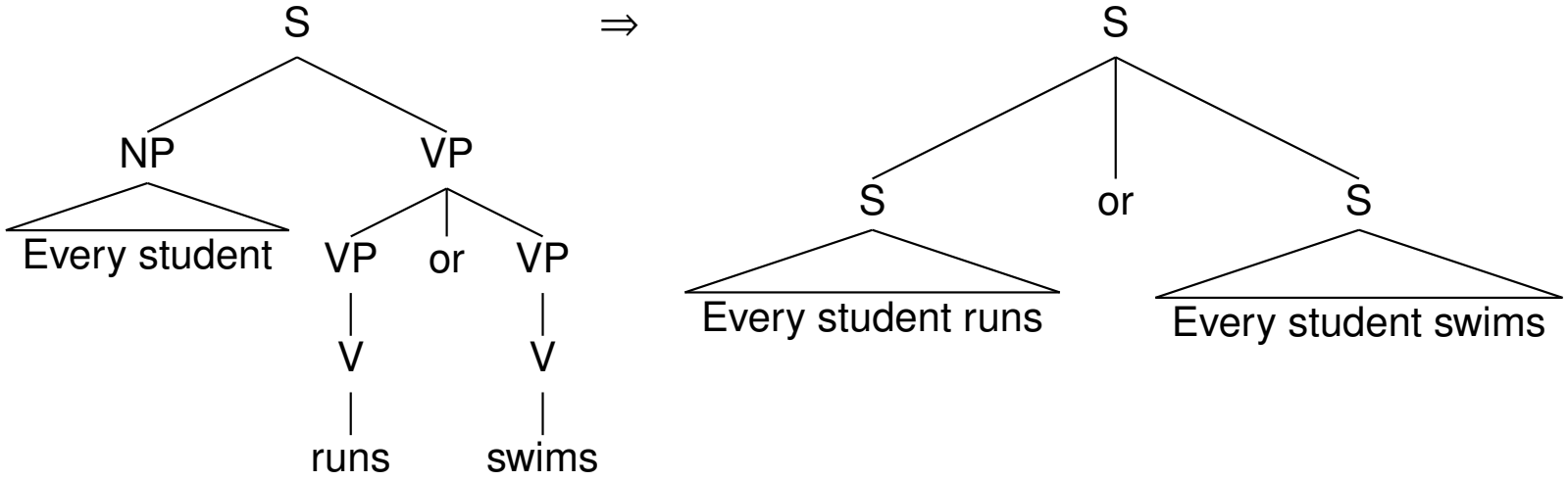
1. Sandy runs and swims. $\rightsquigarrow$ (**run sandy**) & (**swim sandy**)
2. Sandy runs or swims. $\rightsquigarrow$ (**run sandy**) $\vee$ (**swim sandy**)



The conceptual puzzle

1. Every student runs or swims.

2. Every student runs or every student swims.

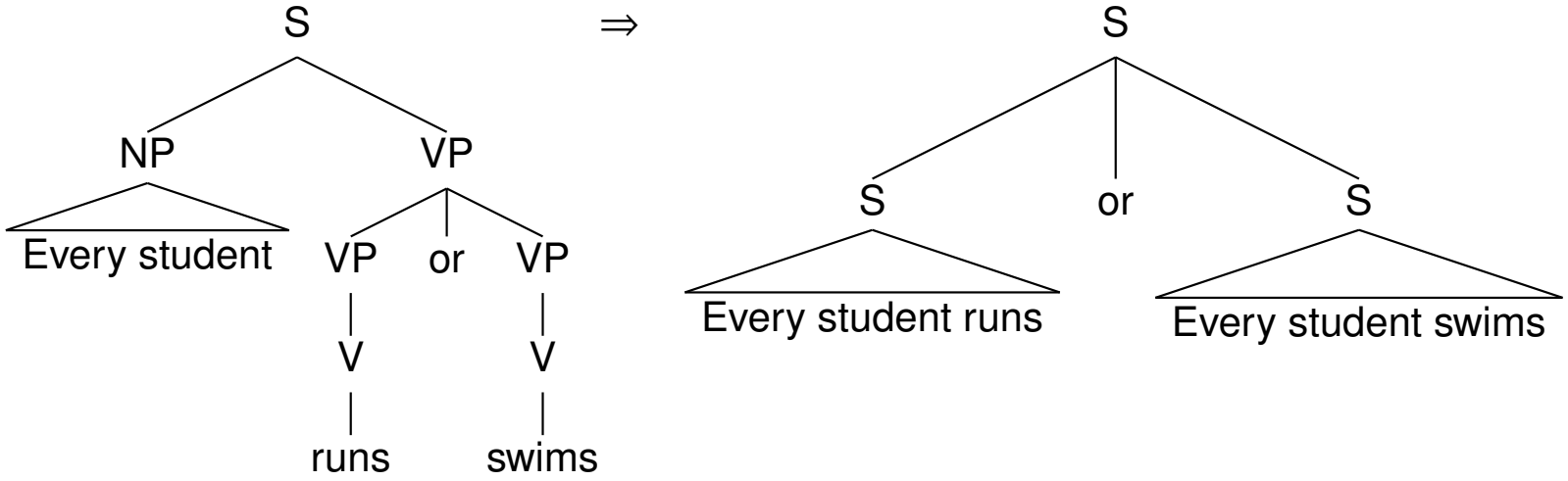


The conceptual puzzle

1. Every student runs or swims.

   $\Uparrow \not\Downarrow$

2. Every student runs or every student swims.



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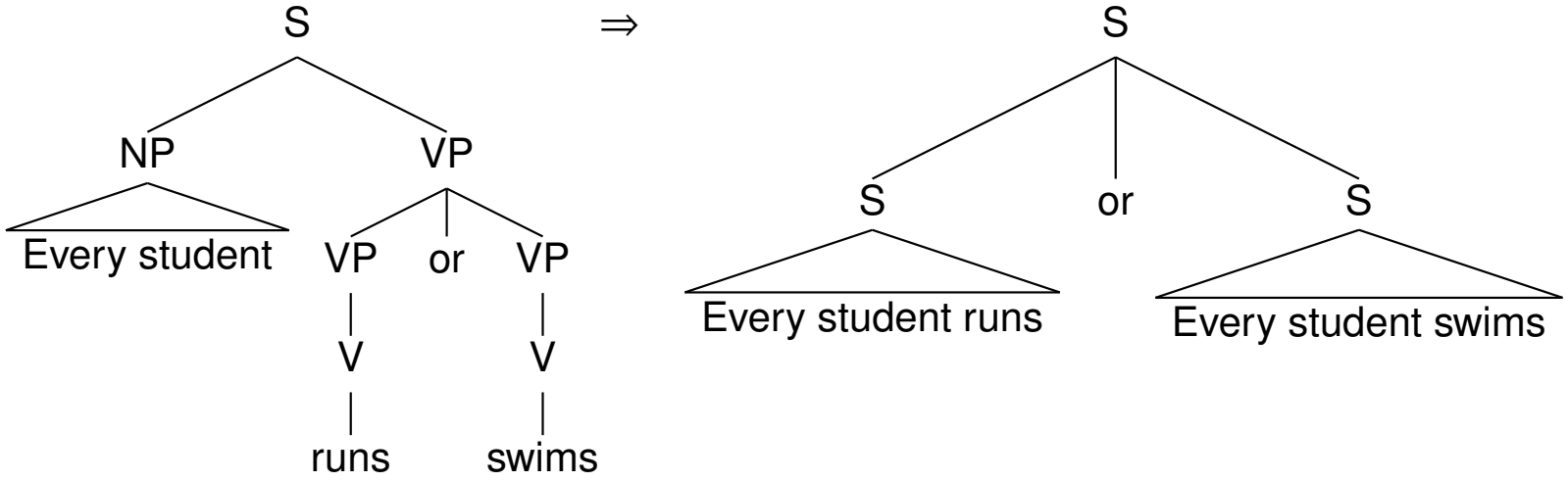

The conjunction-reduction analysis wrongly predicts that these two sentences have the same logical form and thus the same meaning!

The solution: generalized conjunction

$$\vee$$

$$\left[\begin{array}{ll} \mathsf{T} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{T} \end{bmatrix} \\ \mathsf{F} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{F} \end{bmatrix} \end{array}\right]$$

$$\lambda f\ \lambda g\ \lambda x\ \big((f\ x) \vee (g\ x)\big)$$

This function is too big to draw; examples:

$$\left\langle \begin{bmatrix} \text{\image{1}} & \mapsto \mathsf{T} \\ \text{\image{2}} & \mapsto \mathsf{F} \end{bmatrix}, \begin{bmatrix} \text{\image{1}} & \mapsto \mathsf{F} \\ \text{\image{2}} & \mapsto \mathsf{T} \end{bmatrix} \right\rangle \Rightarrow \begin{bmatrix} \text{\image{1}} & \mapsto \mathsf{T} \\ \text{\image{2}} & \mapsto \mathsf{T} \end{bmatrix}$$

The solution: generalized conjunction

$$\vee$$

$$\left[\begin{array}{ll} \mathsf{T} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{T} \end{bmatrix} \\ \mathsf{F} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{F} \end{bmatrix} \end{array}\right]$$

$$\lambda f\ \lambda g\ \lambda x\ \big((f\ x) \vee (g\ x)\big)$$

This function is too big to draw; examples:

$$\left\langle \begin{bmatrix} \mapsto \mathsf{T} \\ \mapsto \mathsf{F} \end{bmatrix}, \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{T} \end{bmatrix} \right\rangle \Rightarrow \begin{bmatrix} \mapsto \mathsf{T} \\ \mapsto \mathsf{T} \end{bmatrix}$$

$$\left\langle \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{F} \end{bmatrix}, \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{T} \end{bmatrix} \right\rangle \Rightarrow$$

The solution: generalized conjunction

$$\vee$$

$$\left[\begin{array}{ll} \mathsf{T} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{T} \end{bmatrix} \\ \mathsf{F} \mapsto & \begin{bmatrix} \mathsf{T} \mapsto \mathsf{T} \\ \mathsf{F} \mapsto \mathsf{F} \end{bmatrix} \end{array}\right]$$

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This function is too big to draw; examples:

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$$\left\langle \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{F} \end{bmatrix}, \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{T} \end{bmatrix} \right\rangle \Rightarrow \begin{bmatrix} \mapsto \mathsf{F} \\ \mapsto \mathsf{T} \end{bmatrix}$$

An example: compositional analysis

1. Every student runs or swims.

$$\left(\forall y\,\left((\textbf{student}\ y) \to \left((\textbf{run}\ y) \vee (\textbf{swim}\ y)\right)\right)\right)$$

$$\lambda k\,\left(\forall y\,\left((\textbf{student}\ y) \to (k\ y)\right)\right) \qquad \lambda x\,\left((\textbf{run}\ x) \vee (\textbf{swim}\ x)\right)$$

$$\textbf{run} \qquad \lambda f\,\lambda g\,\lambda x\,\left((f\ x) \vee (g\ x)\right) \qquad \textbf{swim}$$

2. Every student runs or every student swims.

$$\left(\begin{array}{c} \forall y\,\left((\textbf{student}\ y) \to (\textbf{run}\ y)\right) \\ \vee \\ \forall y\,\left((\textbf{student}\ y) \to (\textbf{swim}\ y)\right) \end{array}\right)$$

An example: truth conditions

1. $\Big(\forall y\,\big((\textbf{student}\ y) \rightarrow \big((\textbf{run}\ y) \vee (\textbf{swim}\ y)\big)\big)$
2. $\left(\begin{array}{c} \forall y\,\big((\textbf{student}\ y) \rightarrow (\textbf{run}\ y)\big) \\ \vee \\ \forall y\,\big((\textbf{student}\ y) \rightarrow (\textbf{swim}\ y)\big) \end{array}\right)$

$\left[\begin{array}{l} \text{  } \mapsto \mathrm{T} \\ \text{  } \mapsto \mathrm{T} \end{array}\right]$

student

$\left[\begin{array}{l} \text{  } \mapsto \mathrm{T} \\ \text{  } \mapsto \mathrm{F} \end{array}\right]$

run

$\left[\begin{array}{l} \text{  } \mapsto \mathrm{F} \\ \text{  } \mapsto \mathrm{T} \end{array}\right]$

swim

Negative polarity

In which a syntactic mess is unified semantically . . .

Polarity sensitivity

Natural languages abound with items that are sensitive to the *polarity* of the environment they appear in.

* = ungrammatical or uninterpretable

1. a. *Sandy has ever been to Peru.
   b. Sandy has not ever been to Peru.
2. a. *Sandy gave a red cent to charity.
   b. Sandy didn't give a red cent to charity.
3. a. *A student has ever been to Peru.
   b. No student has ever been to Peru.
4. a. *Kim always visited us at all.
   b. Kim never visited us at all.

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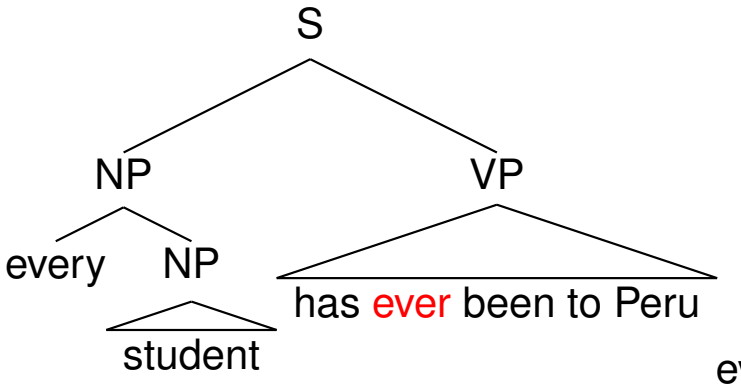
4. a. *Kim always visited us at all.
   b. Kim never visited us at all.

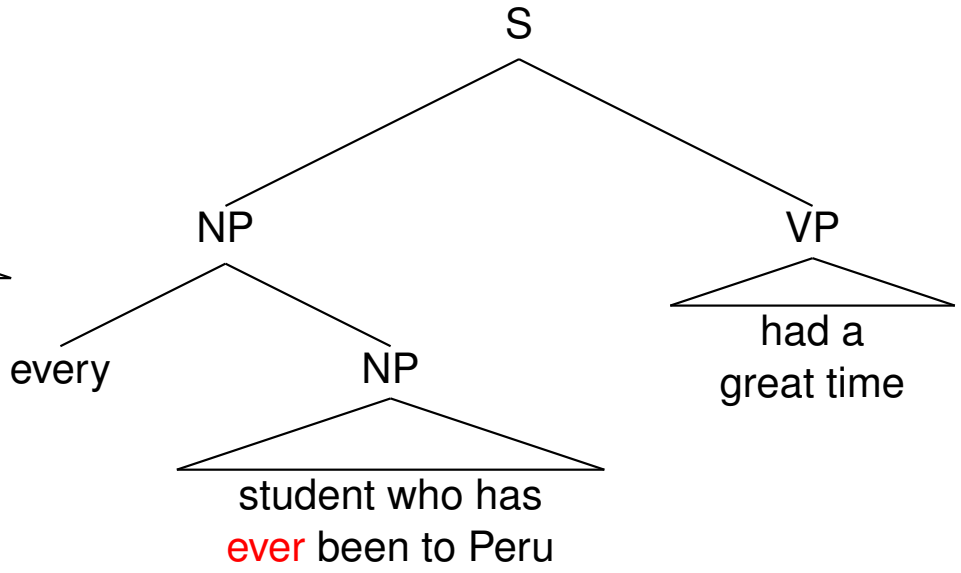
Initial generalization

Negative polarity items must appear in the scope of negation.

Puzzles for the initial generalization

1. Sandy has yet to visit us at all.
2. Sandy welcomed us before she knew us at all.
3. Few linguists have ever been to Peru.
4. At most ten linguists have ever been to Peru.
5. a. *Every student has ever been to Peru.
   b. Every student who has ever been to Peru had a great time.





Klima's (1964) feature Affective

- Klima studied NPIs in great detail, and he saw that they can appear in a wider range of environments than just negation.
- He proposed a feature [Affective] to single out the NPI-licensing environments.
- He conjectured that we would one day have a deeper explanation for which words and constructions had this feature.
- Ladusaw (1980) made the first major step in this direction with a semantic generalization (building on insights by Klima (1964), Borkin (1971), Fauconnier (1975), Ducrot (1972)).

Entailment patterns

A student smoked.

A Swedish student smoked. A student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

No student smoked.

No Swedish student smoked. No student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

Every student smoked.

Every Swedish student smoked. Every student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

Every student smoked.

$\Swarrow$ $\Nwarrow$

Every Swedish student smoked. Every student smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

Every student smoked.

$\Swarrow$ $\Nwarrow$

Every Swedish student smoked. Every student smoked cigars.

Few students smoked.

Few Swedish students smoked. Few students smoked cigars.

Entailment patterns

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. | A student smoked cigars.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. | No student smoked cigars.

Every student smoked.

$\Swarrow$ $\Nwarrow$

Every Swedish student smoked. | Every student smoked cigars.

Few students smoked.

$\Swarrow$ $\Searrow$

Few Swedish students smoked. | Few students smoked cigars.

Monotonicity and Ladusaw's proposal

Definition (Upward monotonicity)

An operator δ is upward monotone iff for all expressions α in the domain of δ:

$$\text{if } \alpha \subseteq \beta, \text{ then } (\delta\ \alpha) \subseteq (\delta\ \beta)$$

Definition (Downward monotonicity)

An operator δ is downward monotone iff for all expressions α in the domain of δ:

$$\text{if } \alpha \subseteq \beta, \text{ then } (\delta\ \beta) \subseteq (\delta\ \alpha)$$

Ladusaw's generalization

An NPI is licensed if only if it appears in a downward monotone context.

The generalization at work

1. *A student has ever smoked.
2. *A student who has ever smoked was at the party.

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

The generalization at work

1. *A student has ever smoked.
2. *A student who has ever smoked was at the party.

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

3. No student has ever smoked.
4. No student who has ever smoked was at the party.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

The generalization at work

1. *A student has ever smoked.
2. *A student who has ever smoked was at the party.

A student smoked.

$\Nearrow$ $\Nwarrow$

A Swedish student smoked. A student smoked cigars.

3. No student has ever smoked.
4. No student who has ever smoked was at the party.

No student smoked.

$\Swarrow$ $\Searrow$

No Swedish student smoked. No student smoked cigars.

5. *Every student has ever smoked.
6. Every student who has ever smoked was at the party.

Every student smoked.

$\Swarrow$ $\Nwarrow$

Every Swedish student smoked. Every student smoked cigars.

Current concerns and puzzles

- It is now clear that Ladusaw's (1980) proposal merely approximates the underlying truth about NPI licensing.
- There are examples in which NPIs are fine even when the environment is not strictly downward entailing:
  1. If Sandy strikes a match, it lights.
  2. If Sandy plunges a match in water and strikes it, it lights.
  3. If Sandy has ever been to Peru, she's not talking about it.
- There are also examples in which NPIs are unlicensed even when the environment is strictly downward entailing:
  4. Every restaurant that charges a red cent for bread should be run out of business.
  5. *Every restaurant that charges a red cent for bread has two Michelin stars.
- For critical discussion, see Linebarger 1987; Giannakidou 1999; Israel 1996.

The present and beyond

- Barbara Partee says it's a good time to be a formal semanticist! `http://vimeo.com/20664367`
- Semantics is increasingly merged with pragmatics, the study of how we enrich the meanings of the sentences we hear using what we know about the context and about each other.
- For more:
  - Linguist 130a: Introduction to Semantics and Pragmatics (next in Winter 2013)
  - CS 224u: Natural Language Understanding (next in Winter 2013)

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