

- Noah likes expensive restaurants.
- $\forall x \ Restaurant(x), \ Expensive(x) \Rightarrow Likes(Noah, x)$

```
NNP \rightarrow Noah { Noah }

VP

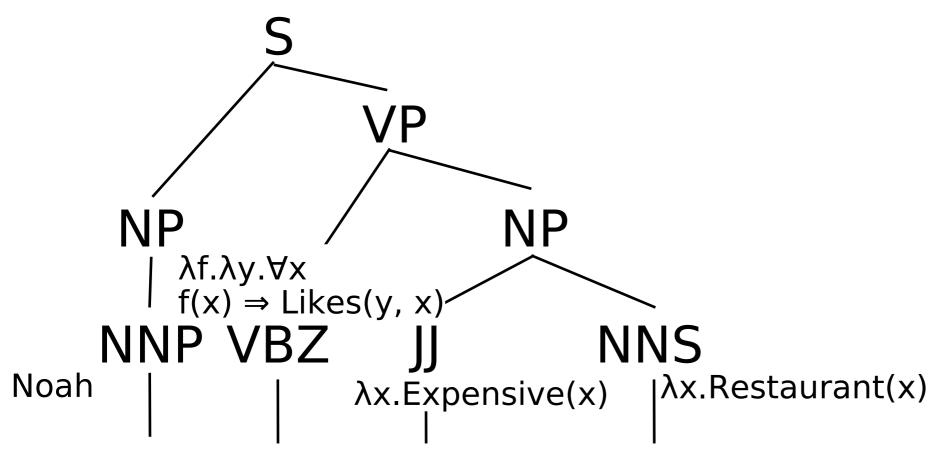
VBZ \rightarrow likes { \lambda f. \lambda y. \forall x \ f(x) \Rightarrow Likes(y, x) }

JJ <math>\rightarrow expensive { \lambda x. Expensive(x) }

NNP VBZ

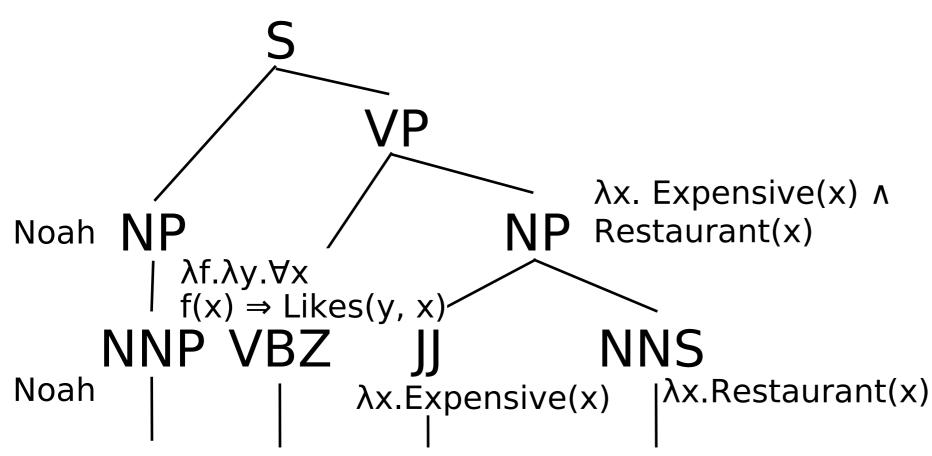
NNS \rightarrow restaurants { \lambda x. Restaurant(x) }
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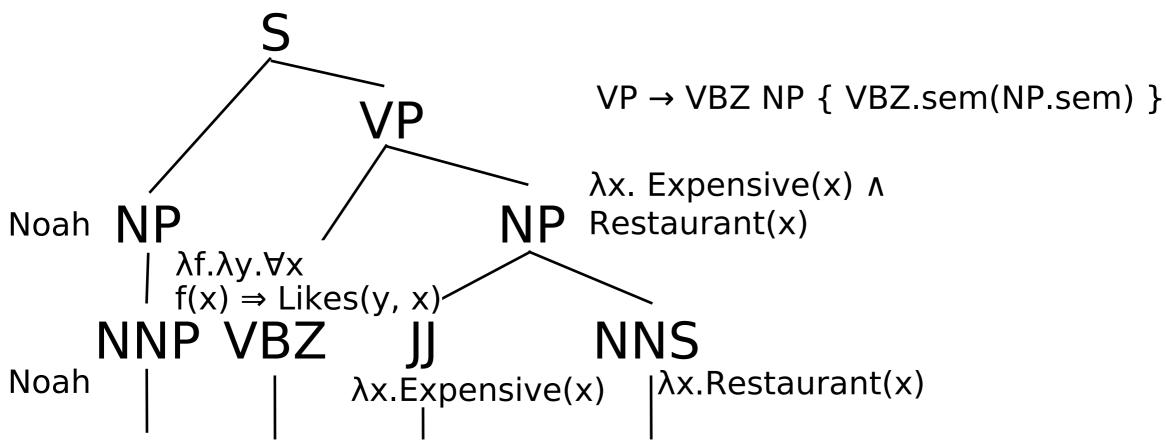


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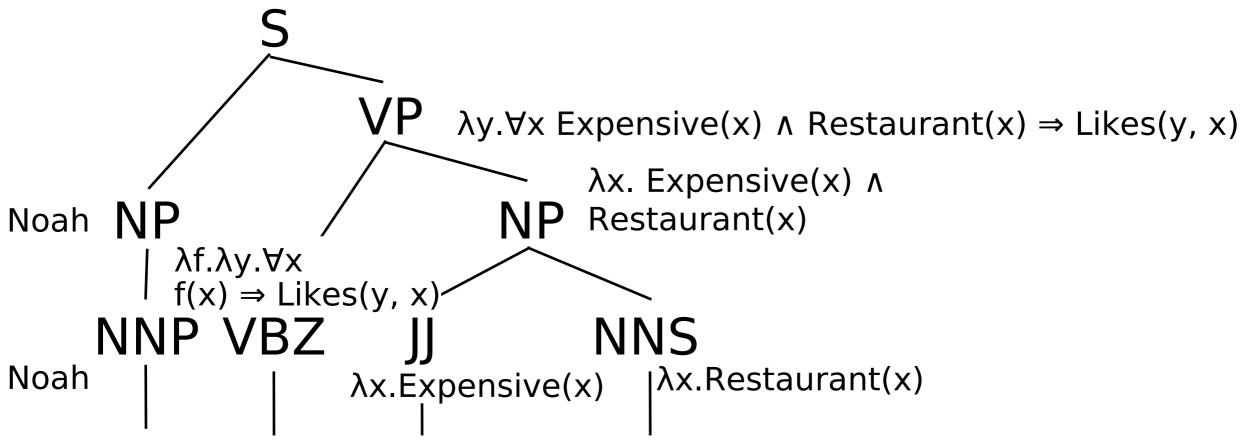
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```
S \rightarrow \text{NP VP \{ VP.sem(NP.sem) \}}
VP \quad \lambda y. \forall x \; \text{Expensive}(x) \; \Lambda \; \text{Restaurant}(x) \Rightarrow \text{Likes}(y, x)
\lambda x. \; \text{Expensive}(x) \; \Lambda
NOah \quad NP \quad NP \; \text{Restaurant}(x)
| \quad \lambda f. \lambda y. \forall x \\ f(x) \Rightarrow \text{Likes}(y, x) \quad NNS
NNP \; VBZ \quad JJ \quad NNS
Noah \quad | \quad \lambda x. \text{Expensive}(x) \quad | \quad \lambda x. \text{Restaurant}(x)
```

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S \quad \forall x \; \mathsf{Expensive}(x) \; \Lambda \; \mathsf{Restaurant}(x) \Rightarrow \mathsf{Likes}(\mathsf{Noah}, x) \\ \qquad \qquad VP \quad \lambda y. \forall x \; \mathsf{Expensive}(x) \; \Lambda \; \mathsf{Restaurant}(x) \Rightarrow \mathsf{Likes}(y, \, x) \\ \mathsf{Noah} \quad \mathsf{NP} \quad \mathsf{NP} \quad \mathsf{NNP} \quad \mathsf{NNS} \\ \mathsf{NNP} \quad \mathsf{VBZ} \quad \mathsf{JJ} \quad \mathsf{NNS} \\ \mathsf{Noah} \quad \mathsf{NNS} \quad \mathsf{Noah} \quad \mathsf{NNS} \\ \mathsf{Noah} \quad \mathsf{NNS} \quad \mathsf{Noah} \quad \mathsf{NNS} \\ \mathsf{Noah} \quad \mathsf{NNS} \\ \mathsf{NS} \quad \mathsf{NS} \\ \mathsf{NS} \quad \mathsf{NS
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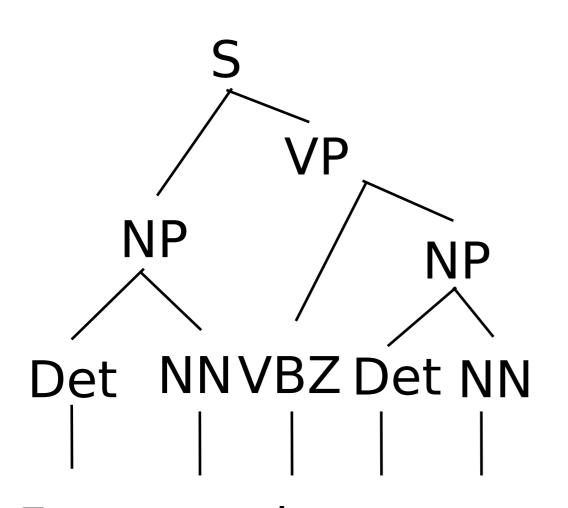
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Alternative (Following SLP)

```
S \forall x \; Expensive(x) \; \Lambda \; Restaurant(x) \Rightarrow Likes(Noah, x)
VP \quad \lambda y. \forall x \; Expensive(x) \; \Lambda \; Restaurant(x) \Rightarrow Likes(y, x)
\lambda f. f(Noah) \quad \lambda f. \lambda y. \forall x \quad If(x) \Rightarrow Likes(y, x)
NNP \quad VBZ \quad JJ \quad NNS
\lambda f. f(Noah) \quad \lambda x. Expensive(x) \quad \lambda x. Restaurant(x)
```

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Quantifier Scope Ambiguity



```
S \rightarrow NP VP { NP.sem(VP.sem) }

NP \rightarrow Det NN { Det.sem(NN.sem) }

VP \rightarrow VBZ NP { VBZ.sem(NP.sem) }

Det \rightarrow every { \lambda f. \lambda g. \forall u \ f(u) \Rightarrow g(u) }

Det \rightarrow a { \lambda m. \lambda n. \exists x \ m(x) \ \Lambda \ n(x) }

NN \rightarrow man { \lambda v. Man(v) }

NN \rightarrow woman { \lambda y. Woman(y) }

VBZ \rightarrow loves { \lambda h. \lambda k. h(\lambda w. Loves(k, w)) }
```

- Every man loves a woman.
- $\forall u \, Man(u) \Rightarrow \exists x \, Woman(x) \, \wedge \, Loves(u, x)$
- ∃x Woman(x) ∧ ∀u Man(u) ⇒ Loves(u, x)

This Isn't Quite Right!

- "Every man loves a woman" really is ambiguous.
 - A seat was available for every customer
 - A toll free number was available for every customer
 - A secretary phoned up each director
 - A letter was sent to each customer
- This gives only one of the two meanings.
- One approach is to delay the quantifier processing until the end, then permit any ordering.