Erich Rast: Talk at IFL on 19th November 2008

Contextual Domain Restriction in Categorial Grammar

Contextual Domain Restriction

- Contextual Domain Restriction is the **restriction of the domain of a quantifier or quantifying expression** (QP, NP, etc.) within an utterance or sentence-in-a-context.

(1) Every woman dances.
(2) The woman dances.

- Quantifying determiner: *every*, *the*
- Quantifier: *everyone*

A Closer Look

(1) Every woman dances.
(2) The woman dances.

- (1) may be read generically as *Usually woman like dancing* or *Usually women dance*.
- If it is not read generically, the domain might still be restricted (by speaker and/or interpreter).
- (2) may be uttered felicitously in situations in which more than one woman is present.
- Domain in (2) may be restricted to contextually salient individual.

2 Main Approaches

Nominal Restriction (NR)
- Lit.: Stanley&Szabó 2000, Stanley 2002
The restriction is applied to the noun and at LF located at N.

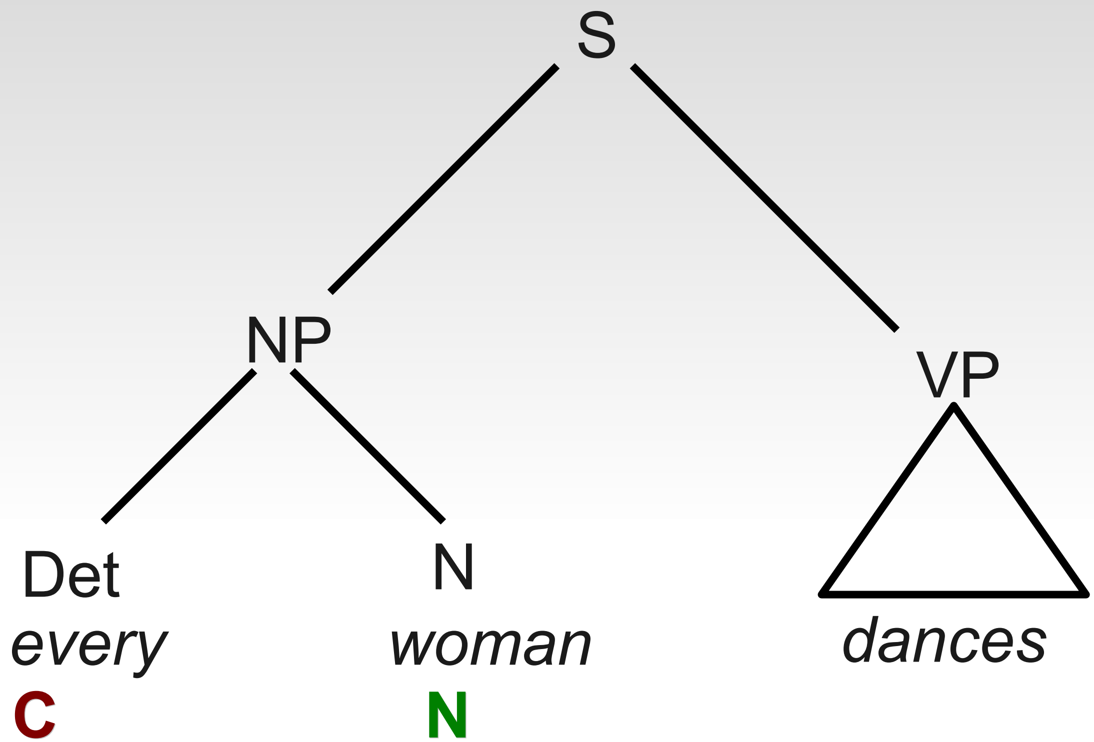
Quantifier Domain Restriction (QDR)

«quantifier domain variable view»

- Lit.: Westerståhl 1984, von Fintel 1994, etc.

The restriction is applied to domain of quantifying determiner and at LF located at DET.

What does that mean?

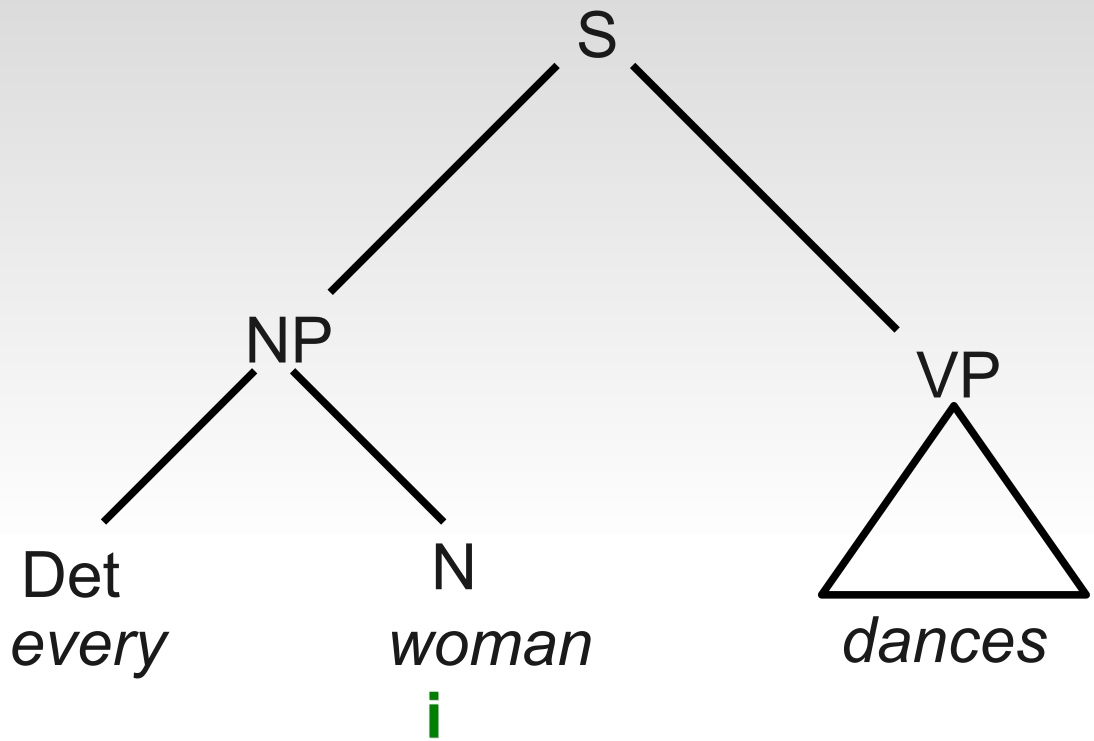


No restriction: $\forall x[Woman(x) \rightarrow Dance(x)]$

QDR: $\forall x \in (D \cap C)[Woman(x) \rightarrow Dance(x)]$

NR: $\forall x[(Woman \cap N)(x) \rightarrow Dance(x)]$

A Closer Look at Stanley's NR



1. Contextual variable *i* located at N.
2. Variable bound by previous expression or a value is contextually assigned to it.
3. Context also provides function $f: D \to 2^D$
4. Final nominal restriction $f(i) \cap Woman$

What is the Difference?

(1) Every woman dances.
(2) The woman dances.

- QDR: Restrict domain to all persons in the discotheque, then quantify over them.
- NR: Don’t restrict domain and quantify over all womens in the discotheque.
- There is **no semantic difference** between QDR and NR **in this case**.
- **But in other cases**, there are differences...

Data pro NR

[Stanley 2002]

(3) The tallest person is nice.
(4) Every sailor waved at every sailor.

- Stanley: In QDR *tallest* picks the tallest person in the total domain, and then *the* is applied. → wrong result, but: Composition can work in another way.
- Stanley: Every sailor in the group of sailors on the boat waved at every sailor in the group of sailors on the shore. → This poses a problem to QDR.

Data pro QDR

[Kratzer 2004]

(5) Every fake philosopher is from Ohio.

- NR predicts reading *Every fake American philosopher is from Ohio.* → wrong result
- QDR predicts reading *Every American fake philosopher is from Ohio.* → right result (according to Kratzer)
- *Fake* is an intensional adjective. Side note: But does this also hold for *potential, alleged,* etc.?

Problem and Solution

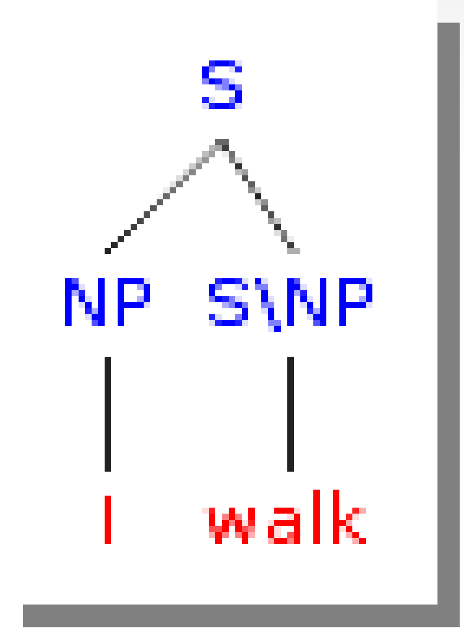
- My goal: **Implement contextual domain** restriction in dependence of an **interpretation operator**.
- Problem: **Conflicting evidence** for/against NR and QDR.
- Solution: **Implement both NR and QDR** and see how far we get.
- Choice of Grammar Framework: Categorial Grammar (aka Montague Semantics)
- Why? - Standard framework in semantics.

Categorial Grammar

- Old tradition: Ajdukiewicz (1935), Bar-Hillel (1953), Lambek (1958), Lewis (1970), Montague (1970, 1973)
- Serious uses in syntax: **Combinatory Categorial Grammar**, Steedman (1996, 2000); **Type Logical Grammar**, Carpenter (1998), Morill (1994, 1995, etc.), Jäger (2005), Moortgat (1999)
- All versions of CG are highly **lexicalized**: Very **few derivation rules** are used and almost all of the combinatory potential of expressions is expressed in lexicon entries.

Categorial Grammar

- Standard CG (Lambek calculus)
  - Two directional string concatenation operators: / and \
  - Rule for /: **A/B B → A**
  - Rule for \: **B A\B → A**



Unextended CGs are equivalent to context-free phrase structure grammars:

S → NP VP
NP → I
VP → walk

Type-driven Derivation

- Syntactic base types: S, N, NP, ...
- Compound syntactic types: S\NP, S/(S\NP), ...
- Type-correspondence: To each syntactic type belongs some semantic type.
- Applications of / and \ correspond to functional application:

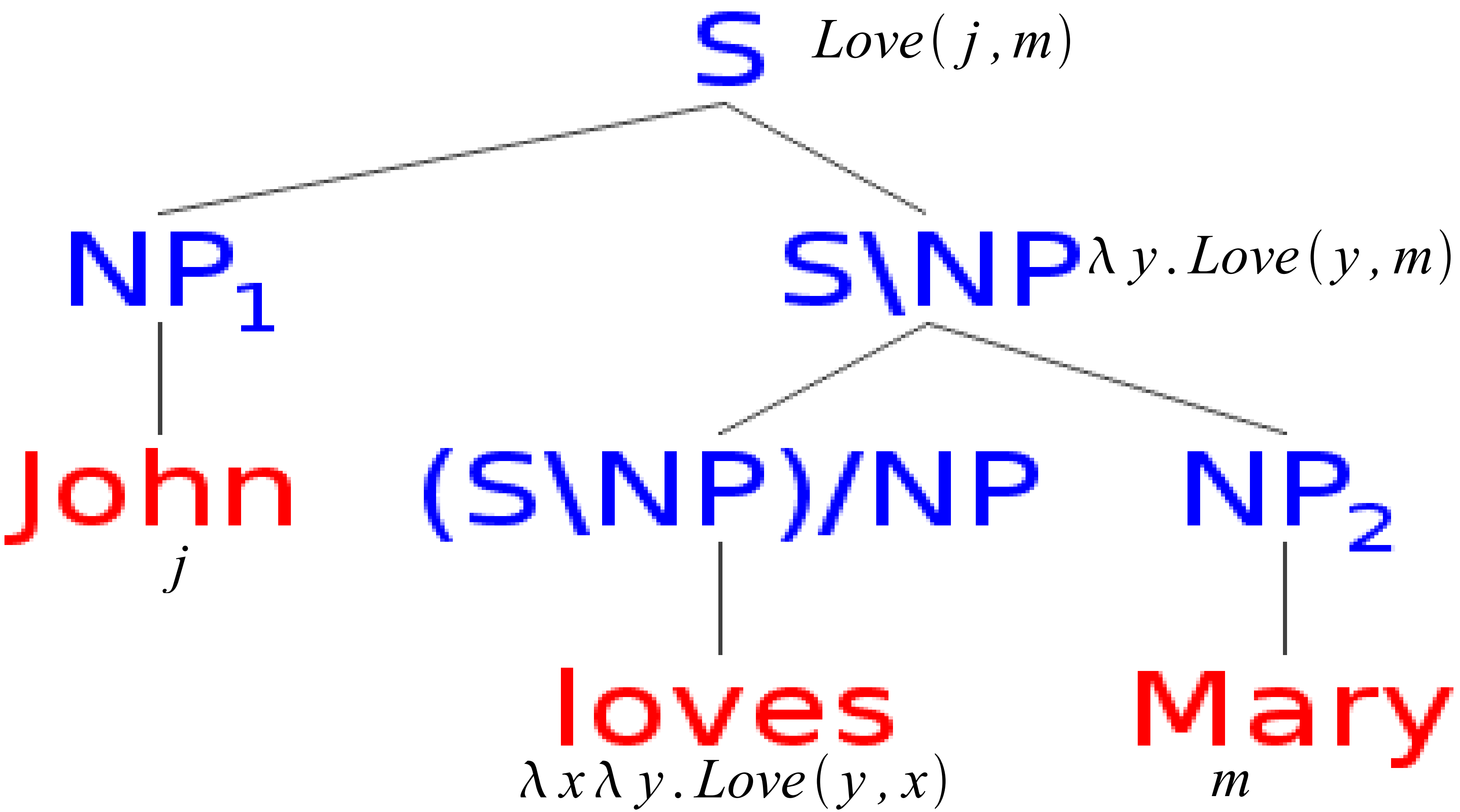
  Rule for /: $X/Y : \alpha_{ab} \quad Y : \beta_{a} \quad \rightarrow \quad X : \alpha(\beta)$

  Rule for \\: $Y : \beta_{a} \quad X \backslash Y : \alpha_{ab} \quad \rightarrow \quad X : \alpha(\beta)$

- Using λ-Calculus: $\lambda x.Hungry(x)(a) \rightarrow Hungry(a)$

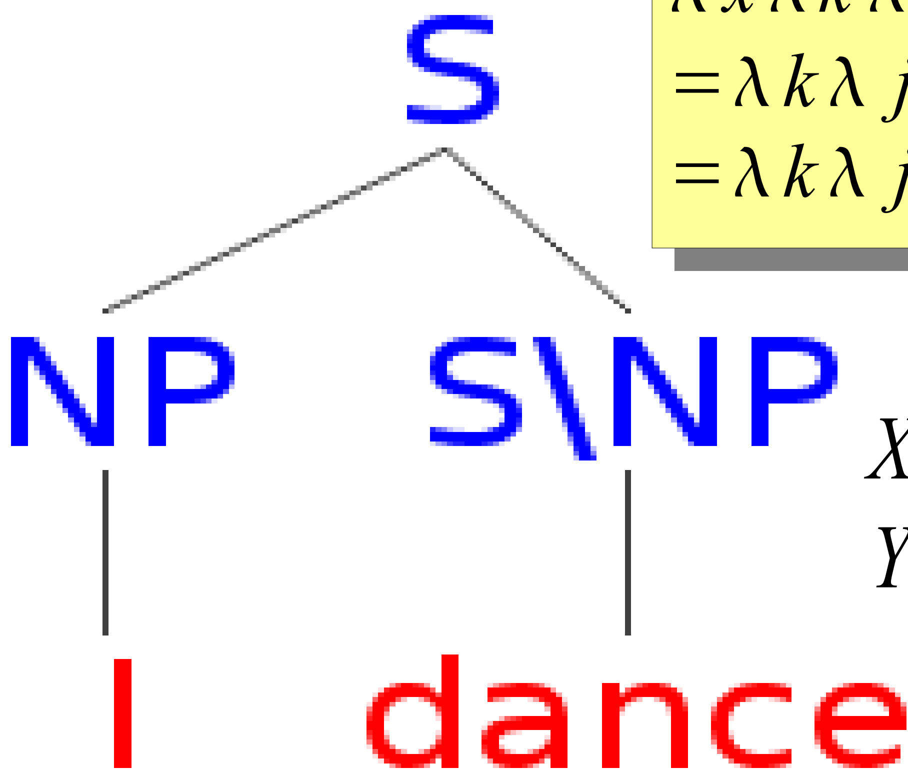
Example

$$X/Y : \alpha_{ab} \quad Y : \beta_{a} \quad \rightarrow \quad X : \alpha(\beta)$$
$$Y : \beta_{a} \quad X\backslash Y : \alpha_{ab} \quad \rightarrow \quad X : \alpha(\beta)$$



Indexicals in CG

$$\lambda x \lambda k \lambda j. Dance(j, x(k)(j))(\lambda c \lambda i. a(c))$$
$$= \lambda k \lambda j. Dance(j, \lambda c \lambda i. a(c)(k)(j))$$
$$= \lambda k \lambda j. Dance(j, a(k))$$



$$X/Y : \alpha_{ab} \quad Y : \beta_{a} \quad \rightarrow \quad X : \alpha(\beta)$$
$$Y : \beta_{a} \quad X \backslash Y : \alpha_{ab} \quad \rightarrow \quad X : \alpha(\beta)$$

$$\lambda c \lambda i. a(c)$$

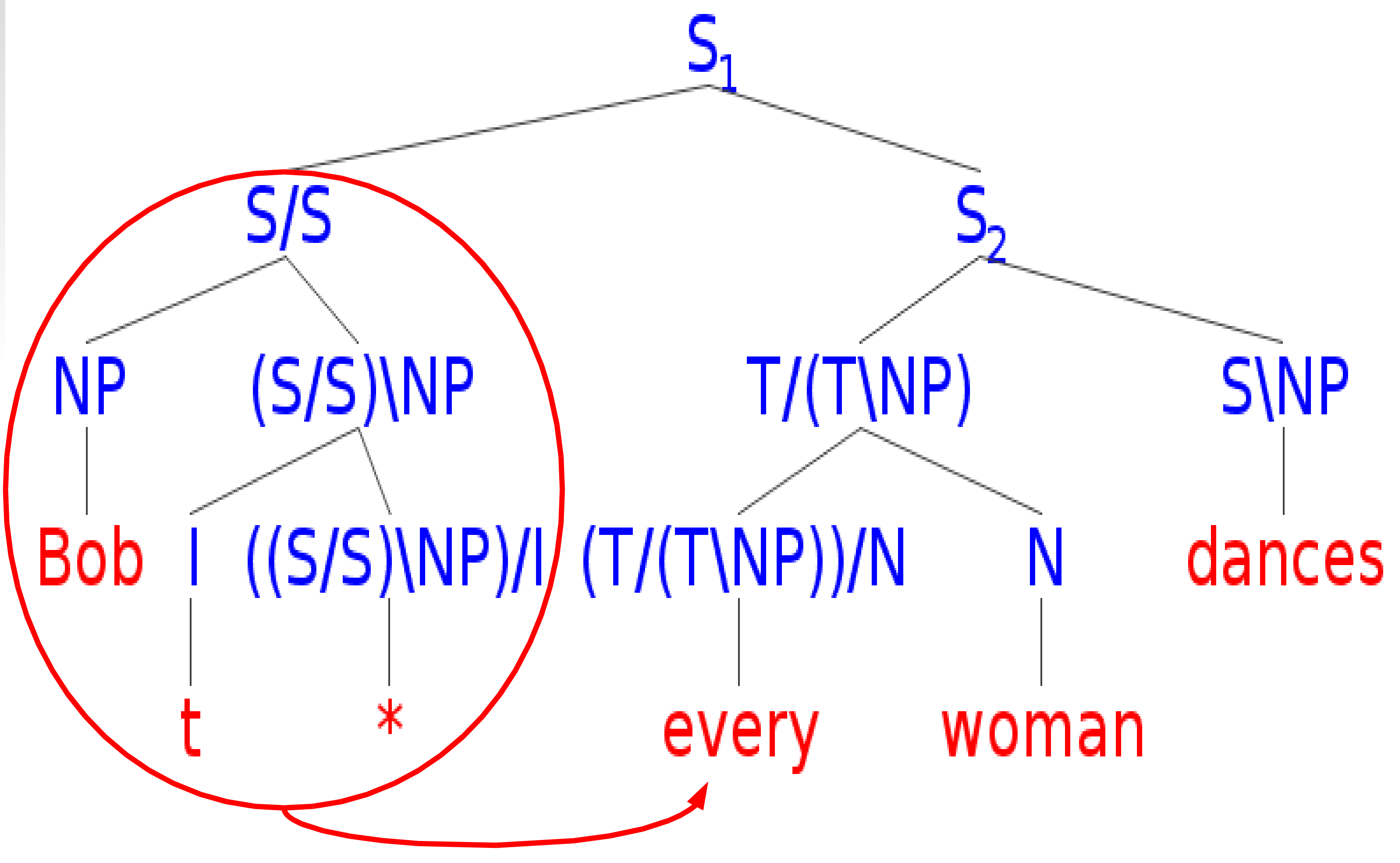
$$\lambda x \lambda k \lambda j. Dance(j, x(k)(j))$$

Hereby *w(j)* is the world of *j, a(j)* the agent of *j*, etc.

QDR in CG

- General Outline:
  - Introduce a sentential **interpretation operator** that depends on an interpreter and interpretation time.
  - Put a **domain restriction function** into the lexical entries.
  - **Compose** sentence-type **characters out of characters** of subexpressions.
  - If there is an **interpreter** and an **interpretation time**, restrict the domain accordingly, otherwise leave it unrestricted.
  - The account is **compositional**, because CG is compositional.

Illustration of QDR



Implementation of QDR

Interpreter Variant (informal version)

$k^{a,t}$ is the same context as k except that the interpreter of $k^{a,t}$ is a and the interpretation time of $k^{a,t}$ is t.

☆ **Definition 2 (Partial Interpretation Operator.)**

$$\star_{i(\epsilon(\tau\tau))} := ((S/S)\backslash NP)\backslash I : \lambda x_i \lambda y_\epsilon \lambda S_\tau \lambda k \lambda j . S(k^{y(k)(j),x})(j)$$

We ‘store’ the interpreter and the interpretation time in the context.

Adjusting the Lexicon

$$\mathbf{Bob}_{\epsilon} := NP : \lambda c \lambda i.b$$

$$\mathbf{every}_{(\epsilon\tau)((\epsilon\tau)\tau)} := (S/(S\backslash NP))/N : \lambda P_{\epsilon\tau} \lambda Q_{\epsilon\tau} \lambda k \lambda j.$$

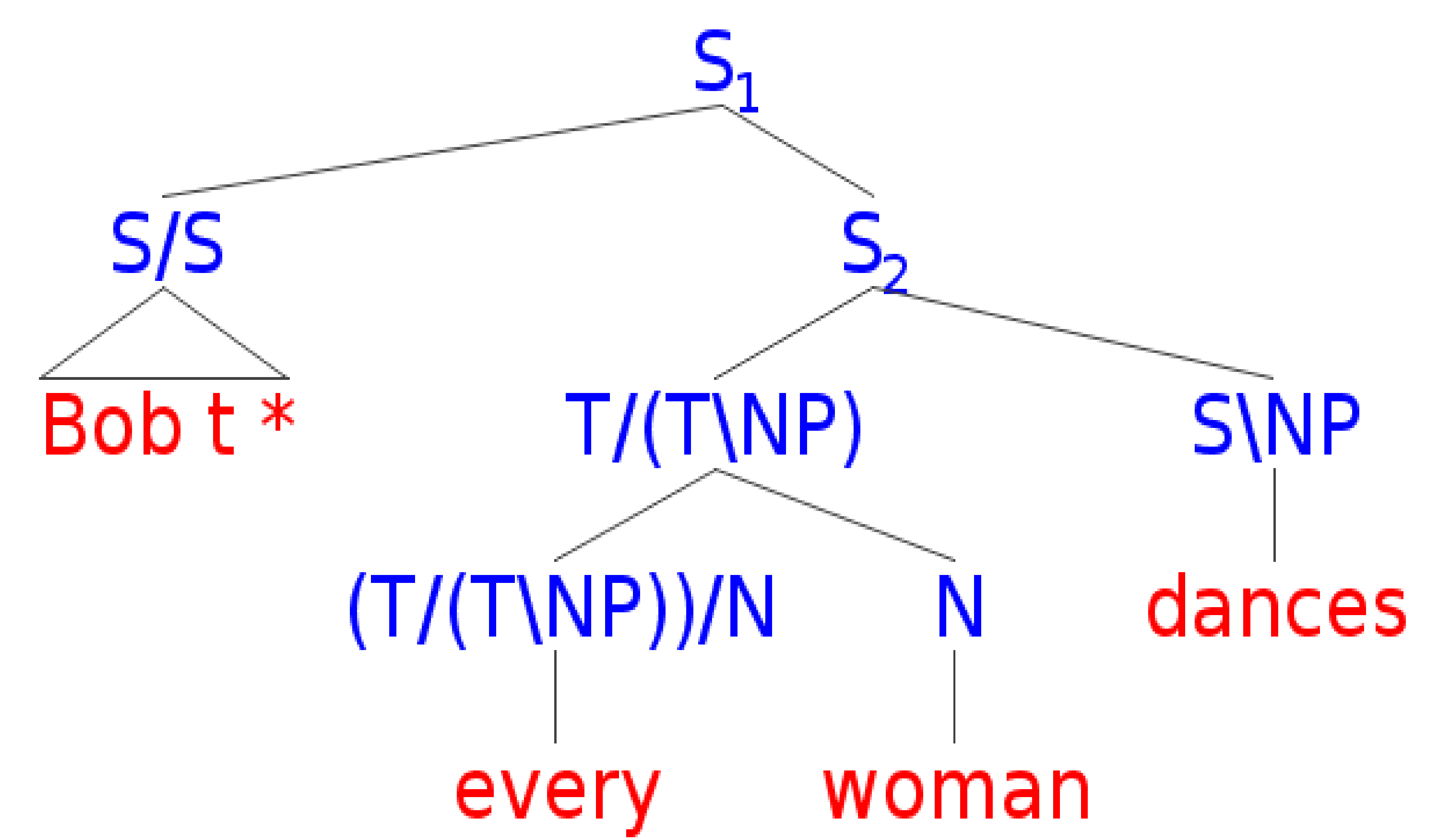
$$\forall x[(C(x,k,j) \& P(\hat{x})(k)(j \sim \mathrm{w}k)) \rightarrow Q(\hat{x})(k)(j)]$$

$$\mathbf{woman}_{\epsilon\tau} := N : \lambda x_{\epsilon} \lambda k \lambda j.Woman(\mathrm{w}j, \mathrm{t}j, x(k)(j))$$

$$\mathbf{dance}_{\epsilon\tau} := S\backslash NP : \lambda x_{\epsilon} \lambda k \lambda j.Dance(\mathrm{w}j, \mathrm{t}j, \mathrm{p}j, x(k)(j))$$

Example

Bob t * every woman dances



Simplified Calculation

Bob t $\star$ **every woman dances**

Bob $(S/S)\backslash NP : \lambda y_{\epsilon} \lambda P_{\tau} \lambda k \lambda j . S(k^{y(k)(j),t})(j)$ **every woman dances**

$S/S : \lambda y_{\epsilon} \lambda S_{\tau} \lambda k \lambda j . S(k^{y(k)(j),t})(j)(\lambda c \lambda i . b)$ **every woman dances**

$S/S : \lambda S_{\tau} \lambda k \lambda j . S(k^{b,t})(j)$ **every woman dances**

$$S : \lambda S_{\tau} \lambda k \lambda j . S(k^{b,t})(j)(\lambda k \lambda j . \forall x[(C(x,k,j) \wedge Woman(\mathrm{w}k, \mathrm{t}j, x)) \rightarrow Dance(\mathrm{w}j, \mathrm{t}j, \mathrm{p}j, x)])$$

$$S : \lambda k \lambda j . \forall x[(C(x, k^{b,t}, j) \& Woman(\mathrm{w}k, \mathrm{t}j, x)) \rightarrow Dance(\mathrm{w}j, \mathrm{t}j, \mathrm{p}j, x)]$$

Things to Note

- This account strictly combines Kaplanian **characters with characters**.
- The end result is a formula that in a model takes a context and an index and yields a truth value.
- To derive the result, basically only the **syntactic and semantic combination** rules and **β-reduction** are needed.
- Stipulation: When the interpreter of *k* is not defined, then *C*(*x*, *k*, *j*) yields the whole domain.
- The account is **fully compositional**.

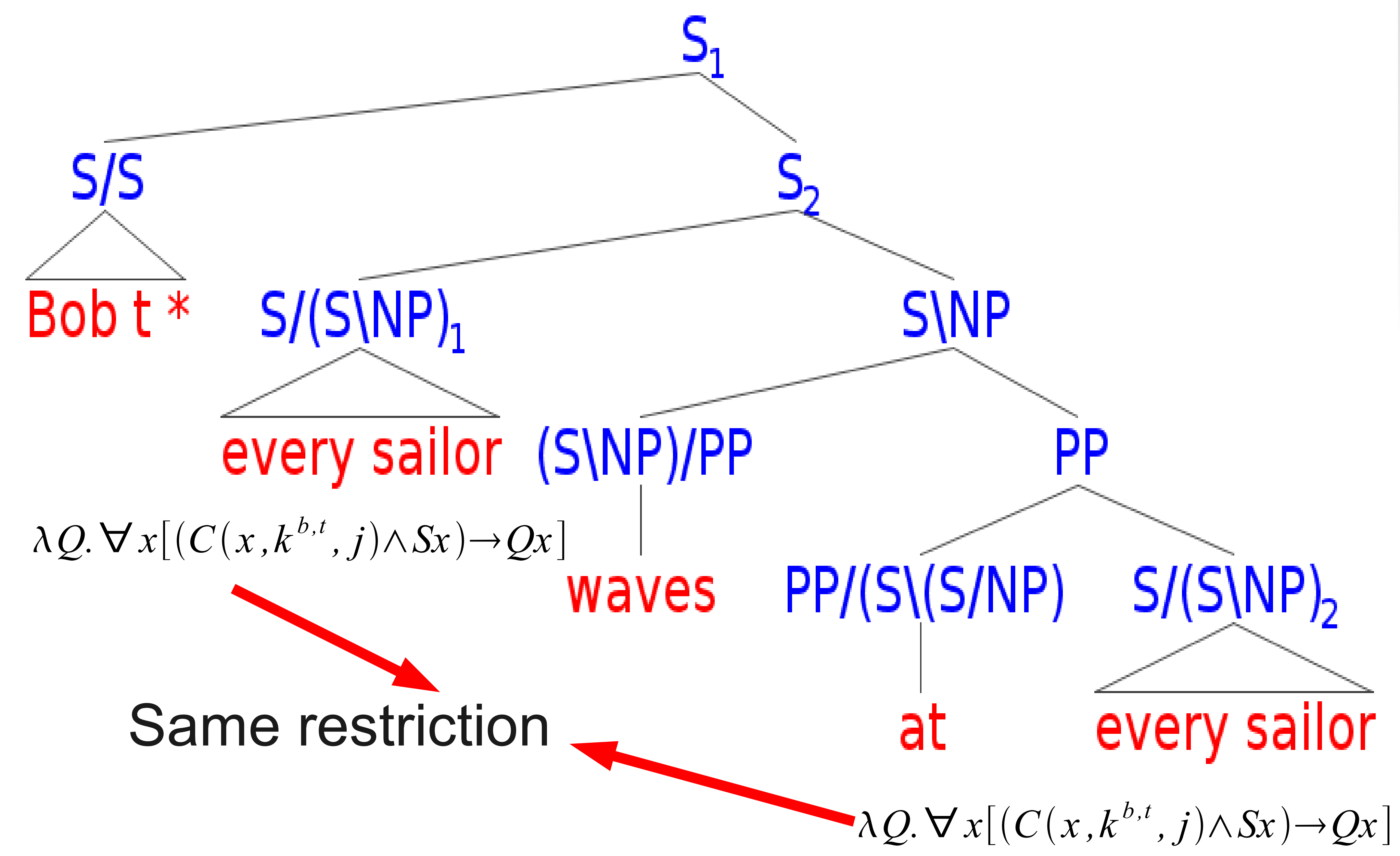
Not a Limitation of QDR

- Superlatives pose no general problem to QDR
- Stanley's Assumption: Combination of extensions during semantic composition
- Instead: Composition of characters out of characters (no evaluation during composition)
- *Tallest* can be regarded context-sensitive

$$\mathbf{tallest}_{(\epsilon\tau)(\epsilon\tau)} := N/N : \lambda P_{\epsilon\tau} \lambda x_{\epsilon} \lambda c \lambda i . P(x)(c)(i)$$

$$\& \forall y [(C(y,c,i) \& P(\hat{y})(c)(i)) \rightarrow height(x(c)(i)) \geq height(y)]$$

A Limitation of QDR



Nominal Restriction

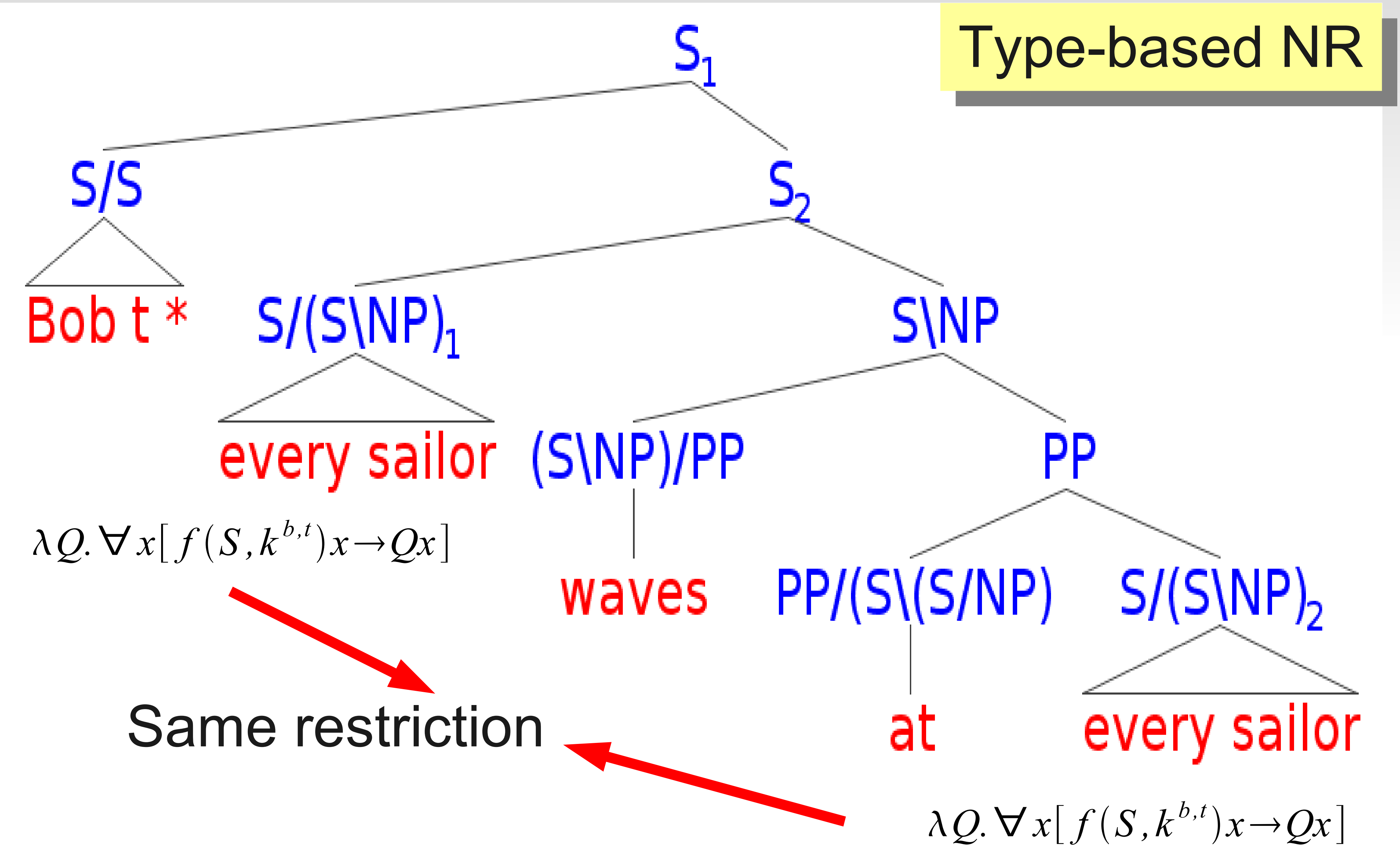
Let a **nominal restriction function** *f* be a function from characters of unary predicates and contexts to characters of unary predicates such that if *f(P, k)(â)(c)(i),* then *P(â)(c)(i)* for any *a* in the domain of objects and contexts or indices *c, i.*

Example Lexicon Entry

$$\mathbf{the}_{(\epsilon\tau)((\epsilon\tau)\tau))} := (S/(S\backslash NP))/N : \lambda P_{\epsilon\tau}\lambda Q_{\epsilon\tau}\lambda k\lambda j.$$

$$\imath x[C(x,k,j)\,\&\,f(P,k)(\hat{x})(k)(j\sim \mathrm{w}k)][Q(\hat{x})(k)(j)]$$

A Limitation of NR



Difference to QDR

- Type-based QDR: Same restriction for any two embedded quantified NPs with the same quantifying determiner. *Every woman knows every man*.
- Type-based NR: Same restriction for any two embedded quantified NPs with the same quantifying determiner and the same base noun. *Every sailor waves at every sailor*.
- Token-based NR: May have different restrictions for each occurrence of a noun in a quantified NP.

(4) Every sailor^1 waved at every sailor^2

Token-based NR

- Give expressions in the target language optional indices, marking an occurrance (token) of a corresponding source language expression.
- Make the nominal restriction function sensitive to the index. $s : D_{(w,i,e)t} \times D_c \times \mathbb{N} \longrightarrow D_{(w,i,e)t}$
- And put the index directly into the lexicon:

$$\mathbf{sailor}^{\alpha}_{\epsilon\tau} ::= N : \lambda x_\epsilon \lambda c \lambda i.s(Sailor, k, \alpha)(\mathrm{w}i, \mathrm{t}i, x(c)(i))$$

(4) Every sailor[1] waved at every sailor[2]

Token-based NR

$$s : D_{(w,i,e)t} \times D_c \times \mathbb{N} \longrightarrow D_{(w,i,e)t}$$

$$\mathbf{sailor}^{\alpha}_{\epsilon\tau} ::= N : \lambda x_{\epsilon} \lambda c \lambda i.s(Sailor, k, \alpha)(\mathrm{w}i, \mathrm{t}i, x(c)(i))$$

(4) Every sailor[1] waved at every sailor[2]

$$S : \lambda k \lambda j.\forall x[(C(x, k^{b,t}, j)\& s(Sailor, k^{b,t}, 1)(\mathrm{w}k, \mathrm{t}j, x)) \rightarrow \forall z[(C(z, k^{b,t}, j)$$

$$\& s(Sailor, k^{b,t}, 2)(\mathrm{w}k, \mathrm{t}j, z)) \rightarrow WaveAt(\mathrm{w}j, \mathrm{t}j, \mathrm{p}j, x, z)]]$$

Lessons Learned

- Both QDR and NR can be implemented in CG within a standard two-dimensional semantic framework.
- QDR alone is inadequate.
- Type-based NR is either inadequate (above implementation) or underspecified (Stanley's version) with regards to his sailor example.
- Token-based NR is needed in rare circumstances.
- Both QDR and token-based NR is needed to account for all examples from the literature.
- Not all of Stanley's arguments pro NR are conclusive.