Przepiórkowski-inspired Quantification in TRALE

Jonathan Khoo

jkhoo@sfs.uni-tuebingen.de

Grammar Engineering
Summer Semester 2006

Agenda

1. Background
2. Przepiórkowski 1998
3. Development of the Grammar
4. In Action
5. Summary

Agenda

1. Background
2. Przepiórkowski 1998
3. Development of the Grammar
4. In Action
5. Summary

Quantifiers and Quantificational NPs

- Representing quantifiers:

every car	**a** car
$\forall x(\textsc{car}(x))$	$\exists x(\textsc{car}(x))$
Universal quantification	Existential quantification

Quantifier Scope Ambiguity

A representative visits each customer.

- There is a different representative for each customer.
- There is one representative for all customers.

Quantifier Scope Ambiguity

A representative visits each customer.

- There is a different representative for each customer.
  $\forall y(\text{CUSTOMER}(y) \rightarrow \exists x(\text{REPRESENTATIVE}(x) \wedge \text{VISITS}(x, y)))$
- There is one representative for all customers.
  $\exists x(\text{REPRESENTATIVE}(x) \wedge \forall y(\text{CUSTOMER}(y) \rightarrow \text{VISITS}(x, y)))$

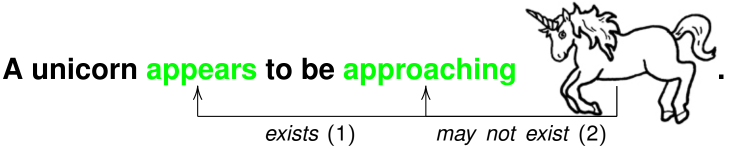
Given that we only have one syntactic structure, how can we represent the ambiguity?

Quantifier Storage to the Rescue!

- “Cooper Storage”
- As a sentence is parsed, quantifiers go into *storage* as they are encountered
- They can be *retrieved* appropriately when enough information
- Goal: Represent all possibilities

Quantifier Scope Ambiguity

A unicorn appears to be approaching.



A unicorn appears to be approaching .

exists (1)

may not exist (2)

1. Something appears to be approaching, and it is a unicorn.
2. Something appears to be approaching, and it appears to be a unicorn.

Development of Quantification in HPSG

- Pollard and Sag (1994) (from Pollard and Yoo (1998))

$$\begin{bmatrix} \textit{sign} & \\ \text{PHONOLOGY} & \langle \textit{every student} \rangle \\ \text{SYNSEM} & \begin{bmatrix} \text{LOCAL} & \begin{bmatrix} \text{CATEGORY} \mid \text{HEAD} & \textit{noun} \\ \text{CONTENT} & \textit{npro} \end{bmatrix} \\ \text{NONLOCAL} & \textit{nonlocal} \end{bmatrix} \\ \text{QSTORE} & \left\{\boxed{1}\right\} \\ \text{RETRIEVED} & \langle\rangle \end{bmatrix} \qquad \boxed{1} = [\forall y \mid \textit{student}(y)]$$

Development of Quantification in HPSG

- Pollard and Yoo (1998)

$$\begin{bmatrix} \textit{sign} & \\ \text{PHONOLOGY} & \textit{list(phonstring)} \\ \text{SYNSEM} & \begin{bmatrix} \text{LOCAL} & \begin{bmatrix} \text{CATEGORY} & \textit{category} \\ \text{CONTENT} & \textit{content} \\ \text{QSTORE} & \textit{set(quantifier)} \\ \text{POOL} & \textit{set(quantifier)} \end{bmatrix} \end{bmatrix} \\ \text{RETRIEVED} & \textit{list(quantifier)} \end{bmatrix}$$

Fixed: Filler-gap and raising constructions

Agenda

1. Background
2. **Przepiórkowski 1998**
3. Development of the Grammar
4. In Action
5. Summary

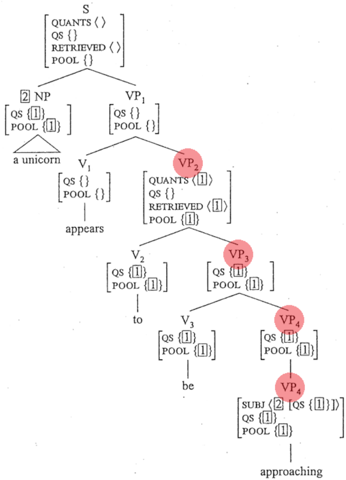
Fixes

- Simpler analysis: completely lexical
  - No complex constraints
  - Semantics completely in CONTENT
- Works with traceless extractions [ARG-ST]
- PY: Retrieval at all *psoas* → spurious ambiguities [word restriction]

Spurious Ambiguities in PY

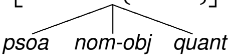
- Retrievals at VP_2, VP_3, VP_4, and V_4 yield the same reading

(25) *Narrow scope reading*



Overview

(1.2a) $\begin{bmatrix} \textit{content} & \\ \text{QSTORE} & \left\{ \textit{quant*} \right\} \end{bmatrix}$



(1.2b) $\begin{bmatrix} \textit{word} & \\ \ldots & \\ \text{NEW-QUANTIFIERS} & \left\{ \textit{quant*} \right\} \end{bmatrix}$

(1.3) $\textit{word} \rightarrow \text{Desc}_1 \vee \text{Desc}_2$

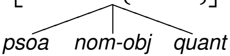
(1.4) $\text{Desc}_1 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \begin{bmatrix} \textit{nom-obj} \vee \textit{quant} & \\ \text{QSTORE} & \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \textit{psoa} & \\ \text{QSTORE} & \boxed{2} \\ \text{QUANTS} & \boxed{3} \end{bmatrix} \\ \text{NEW-QUANTIFIERS} & \boxed{5} \end{bmatrix}$

where $\boxed{1} = \boxed{5} \uplus$ union QSTOREs of selected arguments
$\boxed{4} =$ set of elements of $\boxed{3}$
$\boxed{1} = \boxed{2} \uplus \boxed{4}$

(1.5) $\text{Desc}_2 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \\ \text{ARG-ST} & \left\langle \ldots, \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$

Overview

(1.2a) $\begin{bmatrix} \textit{content} & \\ \text{QSTORE} & \left\{\textit{quant*}\right\} \end{bmatrix}$



(1.2b) $\begin{bmatrix} \textit{word} & \\ \ldots & \\ \text{NEW-QUANTIFIERS} & \left\{\textit{quant*}\right\} \end{bmatrix}$

(1.3) $\textit{word} \rightarrow \text{Desc}_1 \vee \text{Desc}_2$

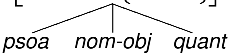
(1.4) $$\text{Desc}_1 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \begin{bmatrix} \textit{nom-obj} \vee \textit{quant} & \\ \text{QSTORE} & \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \textit{psoa} & \\ \text{QSTORE} & \boxed{2} \\ \text{QUANTS} & \boxed{3} \end{bmatrix} \\ \text{NEW-QUANTIFIERS} & \boxed{5} \end{bmatrix}$$

where $\boxed{1} = \boxed{5} \uplus$ union QSTOREs of selected arguments
$\boxed{4} =$ set of elements of $\boxed{3}$
$\boxed{1} = \boxed{2} \uplus \boxed{4}$

(1.5) $$\text{Desc}_2 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \\ \text{ARG-ST} & \left\langle \ldots, \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$$

Overview

(1.2a) $$\begin{bmatrix} \textit{content} & \\ \text{QSTORE} & \left\{ \textit{quant}^{*} \right\} \end{bmatrix}$$



(1.2b) $$\begin{bmatrix} \textit{word} & \\ \ldots & \\ \text{NEW-QUANTIFIERS} & \left\{ \textit{quant}^{*} \right\} \end{bmatrix}$$

(1.3) $\textit{word} \rightarrow \text{Desc}_1 \vee \text{Desc}_2$

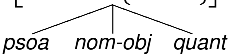
(1.4) $$\text{Desc}_1 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \begin{bmatrix} \textit{nom-obj} \vee \textit{quant} & \\ \text{QSTORE} & \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \textit{psoa} & \\ \text{QSTORE} & \boxed{2} \\ \text{QUANTS} & \boxed{3} \end{bmatrix} \\ \text{NEW-QUANTIFIERS} & \boxed{5} \end{bmatrix}$$

where $\boxed{1} = \boxed{5} \uplus$ union QSTOREs of selected arguments
$\boxed{4} =$ set of elements of $\boxed{3}$
$\boxed{1} = \boxed{2} \uplus \boxed{4}$

(1.5) $$\text{Desc}_2 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \\ \text{ARG-ST} & \left\langle \ldots, \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$$

Overview

(1.2a) $\begin{bmatrix} \textit{content} & \\ \text{QSTORE} & \left\{ \textit{quant*} \right\} \end{bmatrix}$



(1.2b) $\begin{bmatrix} \textit{word} & \\ \ldots & \\ \text{NEW-QUANTIFIERS} & \left\{ \textit{quant*} \right\} \end{bmatrix}$

(1.3) $\textit{word} \rightarrow \text{Desc}_1 \vee \text{Desc}_2$

(1.4)
$$\text{Desc}_1 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \begin{bmatrix} \textit{nom-obj} \vee \textit{quant} \\ \text{QSTORE} \ \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \textit{psoa} & \\ \text{QSTORE} & \boxed{2} \\ \text{QUANTS} & \boxed{3} \end{bmatrix} \\ \text{NEW-QUANTIFIERS} & \boxed{5} \end{bmatrix}$$

where $\boxed{1} = \boxed{5} \uplus$ union QSTOREs of selected arguments
$\boxed{4} =$ set of elements of $\boxed{3}$
$\boxed{1} = \boxed{2} \uplus \boxed{4}$

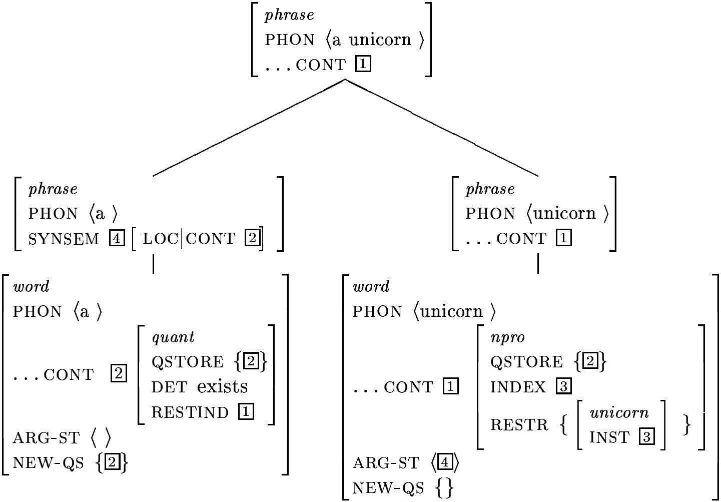
(1.5)
$$\text{Desc}_2 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \\ \text{ARG-ST} & \left\langle \ldots, \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} \ \boxed{1} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$$

Concepts

- QSTORE filled from *selected arguments*
  - QSTORE accumulates quantifiers from QSTOREs of those members of ARG-ST ***not*** raised from other arguments
- ARGUMENT-STRUCTURE
  - Semantics-driven subcategorization frame
- Devolution of Semantics Principle
  - "The CONTENT value of a phrase is token-identical to that of the head daughter." (PS94)

A unicorn appears to be approaching.

(1.6)



phrase
PHON ⟨a unicorn ⟩
. . . CONT $\boxed{1}$

phrase
PHON ⟨a ⟩
SYNSEM $\boxed{4}$ [LOC|CONT $\boxed{2}$]

word
PHON ⟨a ⟩
. . . CONT $\boxed{2}$ [*quant* QSTORE {$\boxed{2}$} DET exists RESTIND $\boxed{1}$]
ARG-ST ⟨ ⟩
NEW-QS {$\boxed{2}$}

phrase
PHON ⟨unicorn ⟩
. . . CONT $\boxed{1}$

word
PHON ⟨unicorn ⟩
. . . CONT $\boxed{1}$ [*npro* QSTORE {$\boxed{2}$} INDEX $\boxed{3}$ RESTR { [*unicorn* INST $\boxed{3}$] }]
ARG-ST ⟨$\boxed{4}$⟩
NEW-QS { }

A unicorn appears to be approaching. (bottom)

NP

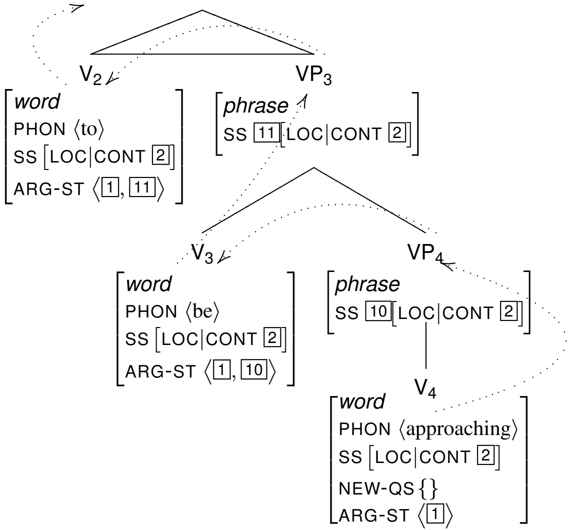
$$\left[\begin{array}{l} \textit{phrase} \\ \text{PHON } \langle \text{a unicorn} \rangle \\ \text{SS } \boxed{1}\left[\text{LOC|CONT|QS } \left\{\boxed{4}\right\}\right] \end{array}\right]$$

narrow $\boxed{2}$:

$$\left[\begin{array}{ll} \textit{psoa} & \\ \text{QSTORE} & \{\} \\ \text{QUANTS} & \left\langle\boxed{4}\right\rangle \\ \text{NUCL} & \text{approach} \end{array}\right]$$

wide $\boxed{2}$:

$$\left[\begin{array}{ll} \textit{psoa} & \\ \text{QSTORE} & \left\{\boxed{4}\right\} \\ \text{QUANTS} & \langle\rangle \\ \text{NUCL} & \text{approach} \end{array}\right]$$



V_2

$$\left[\begin{array}{l} \textit{word} \\ \text{PHON } \langle \text{to} \rangle \\ \text{SS } \left[\text{LOC|CONT } \boxed{2}\right] \\ \text{ARG-ST } \left\langle \boxed{1}, \boxed{11} \right\rangle \end{array}\right]$$

VP_3

$$\left[\begin{array}{l} \textit{phrase} \\ \text{SS } \boxed{11}\left[\text{LOC|CONT } \boxed{2}\right] \end{array}\right]$$

V_3

$$\left[\begin{array}{l} \textit{word} \\ \text{PHON } \langle \text{be} \rangle \\ \text{SS } \left[\text{LOC|CONT } \boxed{2}\right] \\ \text{ARG-ST } \left\langle \boxed{1}, \boxed{10} \right\rangle \end{array}\right]$$

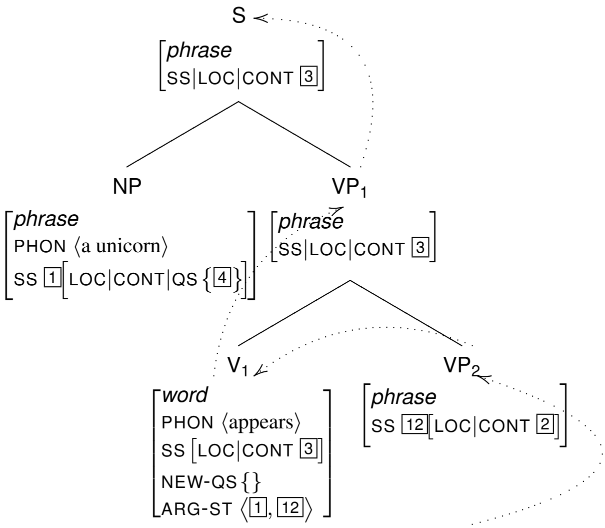
VP_4

$$\left[\begin{array}{l} \textit{phrase} \\ \text{SS } \boxed{10}\left[\text{LOC|CONT } \boxed{2}\right] \end{array}\right]$$

V_4

$$\left[\begin{array}{l} \textit{word} \\ \text{PHON } \langle \text{approaching} \rangle \\ \text{SS } \left[\text{LOC|CONT } \boxed{2}\right] \\ \text{NEW-QS } \{\} \\ \text{ARG-ST } \left\langle \boxed{1} \right\rangle \end{array}\right]$$

A unicorn appears to be approaching. (top)



S

phrase
SS|LOC|CONT $\boxed{3}$

NP

phrase
PHON ⟨a unicorn⟩
SS $\boxed{1}$ [LOC|CONT|QS $\{\boxed{4}\}$]

VP$_1$

phrase
SS|LOC|CONT $\boxed{3}$

V$_1$

word
PHON ⟨appears⟩
SS [LOC|CONT $\boxed{3}$]
NEW-QS { }
ARG-ST ⟨$\boxed{1}$, $\boxed{12}$⟩

VP$_2$

phrase
SS $\boxed{12}$ [LOC|CONT $\boxed{2}$]

V$_2$

word
PHON ⟨to⟩
SS [LOC|CONT $\{\boxed{2}\}$]
ARG-ST ⟨$\boxed{1}$, $\boxed{11}$⟩

narrow $\boxed{3}$:

psoa
QSTORE { }
QUANTS ⟨⟩
NUCL appear

wide $\boxed{3}$:

psoa
QSTORE { }
QUANTS ⟨$\boxed{4}$⟩
NUCL appear

Agenda

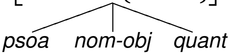
1. Background
2. Przepiórkowski 1998
3. **Development of the Grammar**
4. In Action
5. Summary

End Point

- End Points
  - **Primary goal:**
    "A representative visits each customer."
    (two quantifiers, one retrieval site)
  - **Secondary goal:**
    "A unicorn appears to be approaching."
    (one quantifier, two retrieval sites)

At First Glance...

(1.2a) $\begin{bmatrix} \textit{content} & \\ \text{QSTORE} & \left\{ \textit{quant*} \right\} \end{bmatrix}$ (1.2b) $\begin{bmatrix} \textit{word} & \\ \ldots & \\ \text{NEW-QUANTIFIERS} & \left\{ \textit{quant*} \right\} \end{bmatrix}$



(1.3) $\textit{word} \rightarrow \text{Desc}_1 \vee \text{Desc}_2$

(1.4) $$\text{Desc}_1 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \begin{bmatrix} \textit{nom-obj} \vee \textit{quant} \\ \text{QSTORE} \ \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \textit{psoa} & \\ \text{QSTORE} & \boxed{2} \\ \text{QUANTS} & \boxed{3} \end{bmatrix} \\ \text{NEW-QUANTIFIERS} & \boxed{5} \end{bmatrix}$$

where $\boxed{1} = \boxed{5} \uplus$ union QSTOREs of selected arguments
$\boxed{4} =$ set of elements of $\boxed{3}$
$\boxed{1} = \boxed{2} \uplus \boxed{4}$

(1.5) $$\text{Desc}_2 = \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} & \boxed{1} \\ \text{ARG-ST} & \left\langle \ldots, \begin{bmatrix} \text{SS}|\text{LOC}|\text{CONT} \ \boxed{1} \end{bmatrix}, \ldots \right\rangle \end{bmatrix}$$

Starting Point

- Given this preliminary information, what would make sense?
- Choices
    - Scratch
    - Group Project Grammar
    - Core Fragment from Richter (2005)
- Why Core Fragment?
    - ARG_ST set up
    - Basic principles set up (Subcat, Semantics)
    - Repurpose LEs

Preliminary Signature Changes

- Sign level of *word*: NEWQS { }, CR *boolean*
- Attribute of *content*: QSTORE { }
- Subsorts of *content*
    - *psoa* (already present)
        - *visit_rel*: VISITOR:*ref* VISITEE:*ref*
    - *nom_obj*
    - *quant*
- Subsorts of *quantifier*
    - *forall_quant*
    - *exists_quant*

Preliminary Goals for the Theory

- New quantifiers are placed in NEWQS
- Move NEWQS to QSTORE
- Amalgamate QSTOREs of selected arguments
- Pass CONTENT values up
- ARG_ST captures valence information
- Semantically vacuous words take CONTENT value from argument
- Retrieve by moving quantifiers from QSTORE to QUANTS @ *psoa*s

Fist Step: NPs

- “a representative”
- “each customer”

Lexical Entries for the Nouns

- Use “Mary” as the basis for “representative” and “customer”

```
representative ~~> (synsem:loc:(cat:head:(noun,
                                          pred:minus),
                                cont:(nom_obj,index:(ref,
                                                     num:sg,
                                                     pers:third,
                                                     gen:neut))),
                    arg_st:e_list).
```

Lexical Entries for Quantifiers

- How to represent quantifiers in the QSTORE?
  - In PS94: $\begin{bmatrix} \textit{quantifier} & \\ \textrm{DET} & \textit{semdet} \\ \textrm{RESTIND} & \textit{npro} \end{bmatrix}$
  - In Przepiórkowski: *quant* is a subsort of *content*
    No separate sort for quantifiers – makes it easier!
  - Instead of setting up QSTORE and NEWQS in the LE, do it via a principle

Lexical Entries for Quantifiers

- Very simple:

```
a ~~> (word, synsem:loc:(cont:(quant, det:exists_quant),
                         cat:val:comps:e_list)).

each ~~> (word, synsem:loc:(cont:(quant, det:forall_quant),
                            cat:val:comps:e_list)).
```

New Quantifier Principle

- Sets the NEWQS and QSTORE for quantifiers

```
(word, synsem:loc:cont:(quant)) *>
      (synsem:Synsem, newqs:[Synsem], synsem:loc:cont:qstore:[Synsem]).
```

“A representative”

- At this point, 2 results
- Both take the quantifier as the CONTENT
- One has the noun in SUBJ, the other in COMPS
  - Ran into trouble with Subj-Aux Inversion and Head-Complement Rule, and later, Head-Adjunct Rule
- Thought about using something like the Functional Preposition Principle to set SUBJ and COMPS:

```
(word,
phon:ne_list,
synsem:loc:cat:head:(prep,
                     pform:non_lexical))
*>
(synsem:loc:(cat:(head:(mod:none,pred:minus)),
             cont:Cont),
arg_st:([(loc:(cat:val:(subj:[],comps:[]),
               cont:Cont))])
).
```

Head Adjunct Rule for Quantifiers

- New PSR by reversing HA

```
head_adjunct_rule_q ##
(phrase,
 synsem:loc:cat:val:(subj:List,
                     comps:e_list),
 daughters:(qh_struc,
            hdtr:Hdtr,
            ndtr:Ndtr))
   ===>
cat> (Ndtr, synsem:loc:cat:(head:mod:Synsem,
                            val:(subj:e_list,
                                 comps:e_list))),
cat> (Hdtr, synsem:(Synsem,
                    loc:(cat:val:(subj:List,
                                  comps:e_list),
                         cont:nom_obj))).
```

- New subsort of *const_struc*: *qh_struc*
- Added `cat:val:comps:e_list` to the SAI phrase structure rule to prevent application

Lexical Entry for the Verb

- Use “likes” as the basis for “visits”

```
visits ~~>  (synsem:loc:(cat:(head:(verb,
                                    vform: fin,
                                    pred: plus,
                                    aux: minus),
                              val:subj:[(loc:cont:(psoa;index:(pers:third,
                                                                num:sg)))]),
                         cont:(visit_rel,
                               visitor:Index1,
                               visitee:Index2)),
            arg_st:[(loc:(cat:(head:noun,
                                val:(subj:e_list,
                                     comps:e_list)),
                           cont:index:Index1)),
                      (loc:(cat:(head:noun,
                                val:(subj:e_list,
                                     comps:e_list)),
                           cont:index:Index2))]).
```

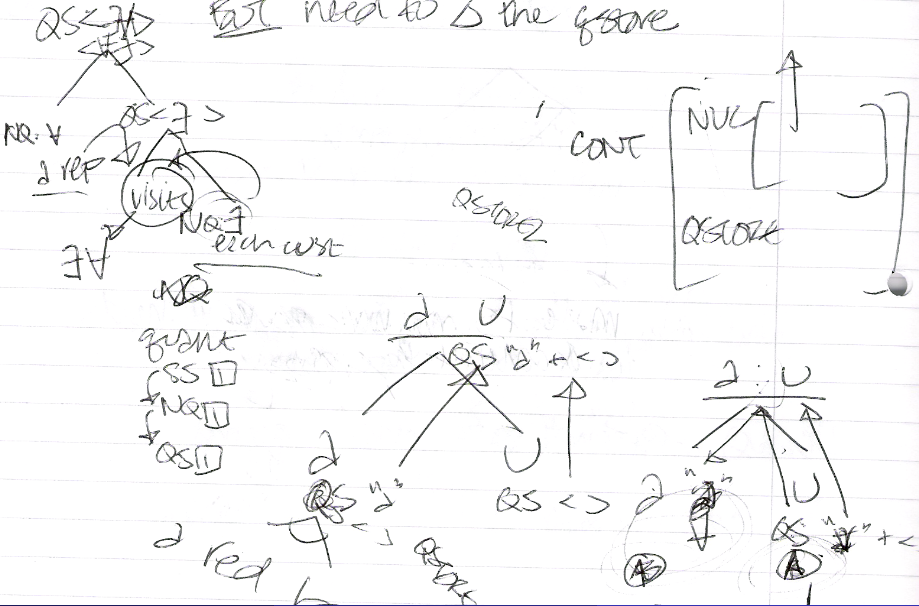
QSTORE Accumulation and Problems with the Content Principle

- Make quantifier accumulation part of phrase structure rule?

- Semantics principle says CONTENT of mother = CONTENT of hdtr
- **BUT** QSTORE involves ndtr
- Conflict because parent QSTORE (and thus, CONTENT) different from hdtr QSTORE

- Problem: semantics principle says mother CONT = hdtr CONT

BUT need to Δ the qstore



Possible Solutions to the Accumulation Problem

At this point...

- Continue and try to find a solution
- Separate the quantifiers from the “nucleus” inside CONTENT
- Move the quantifiers from CONTENT
- Have some sort of temporary storage (QSTORETEMP external to CONTENT)

Possible Solutions to the Accumulation Problem

At this point...

- Continue and try to find a solution
- Separate the quantifiers from the "nucleus" inside CONTENT
- Move the quantifiers from CONTENT
- Have some sort of temporary storage (QSTORETEMP external to CONTENT)

Possible Solutions to the Accumulation Problem

At this point...

- Continue and try to find a solution
- Separate the quantifiers from the “nucleus” inside CONTENT
- Move the quantifiers from CONTENT
- Have some sort of temporary storage (QSTORETEMP external to CONTENT)

Possible Solutions to the Accumulation Problem

At this point...

- Continue and try to find a solution
- Separate the quantifiers from the “nucleus” inside CONTENT
- Move the quantifiers from CONTENT
- Have some sort of temporary storage (QSTORETEMP external to CONTENT)

Digging a Hole

```
% Quantifier Accumulation and Distribution Principle for psoa
(phrase, daughters:(hs_struc)) *>
      (daughters:ndtr:synsem:loc:cont:qstore:QstoreA,
       daughters:hdtr:synsem:loc:cont:qstore:QstoreB,
       daughters:ndtr:qstoretemp:QstoreC,
       daughters:hdtr:qstoretemp:QstoreD,
       qstoretemp:Qcombo)
goal
     append(QstoreA,QstoreC,Qcombo1),
     append(QstoreB,QstoreD,Qcombo2),
     append(Qcombo1,Qcombo2,Qcombo).

(phrase, daughters:(hc_struc)) *>
      (daughters:ndtr:synsem:loc:cont:qstore:QstoreA,
       qstoretemp:QstoreA).
```

New Direction: A Principled Decision

- Move from using DTRS to having principles on *words* only
- Returns back to original Przepiórkowski theory

First Version of Quantifier Accumulation Principle

```
(word, synsem:loc:(cont:psoa,
                   cat:val:(subj:ne_list,comps:ne_list))
) *>
     (synsem:loc:(cat:val:(subj:[(loc:cont:qstore:QstoreA)|Rest1],
                          comps:[(loc:cont:qstore:QstoreB)|Rest2]),
                  cont:qstore:Qcombo))
goal
     append(QstoreA,QstoreB,Qcombo).
```

Combinatorics

- Six possibilities
- Realized QSTORE + QUANTS must be the sum of the QSTOREs of the selected arguments

QSTORE	**QUANTS**
$\langle \exists \forall \rangle$	$\langle \rangle$
$\langle \forall \exists \rangle$	$\langle \rangle$
$\langle \forall \rangle$	$\langle \exists \rangle$
$\langle \exists \rangle$	$\langle \forall \rangle$
$\langle \rangle$	$\langle \exists \forall \rangle$
$\langle \rangle$	$\langle \forall \exists \rangle$

Final Quantifier Accumulation Principle

- Three parts, (*ne_list*/*ne_list*, *e_list*/*ne_list*, *ne_list*/*e_list*)
- Retrieval (all combinations from QSTORE to QUANTS)

```
(word, synsem:loc:(cont:psoa,
                   cat:(val:(subj:ne_list,comps:ne_list),
                       head:aux:minus))
) *>
     (synsem:loc:(cat:val:(subj:[(loc:cont:qstore:QstoreA)|Rest1],
                           comps:[(loc:cont:qstore:QstoreB)|Rest2]),
                  cont:(qstore:Qstore,quants:Quants)))
goal
     ((append(QstoreA,QstoreB,TotalQs);append(QstoreB,QstoreA,TotalQs)),
     append(Qstore,Quants,TotalQs)).
```

Elimination of Invalid Combinations

- We need all combinations if there are two retrieval sites
- Also need to ensure that QSTORE empty at the top of the tree

```
head_subject_rule ##
(phrase,
 synsem:loc:(cat:(val:(subj:e_list,
                       comps:e_list)),
             cont:qstore:e_list),
 daughters:(hs_struc,
            hdtr:Hdtr,
            ndtr:Ndtr))
   ===>
cat> (Ndtr, synsem:Synsem),
cat> (Hdtr, synsem:loc:(cat:val:(subj:[Synsem],
                                  comps:e_list),
                        cont:psoa)).
```

- ...2 results!

Agenda

1. Background
2. Przepiórkowski 1998
3. Development of the Grammar
4. **In Action**
5. Summary

Agenda

1. Background
2. Przepiórkowski 1998
3. Development of the Grammar
4. In Action
5. **Summary**

Summary

- Quantifier storage viable option for quantifier semantics
- System inspired by Przepiórkowski can be successfully implemented in TRALE
  - At least for “A representative visits each customer.”
- Lessons learned
  - TRALE is intimidating
  - But, comfort level $\propto$ time spent working on it
  - Learn the syntax
  - Path errors won’t be caught; principles appear not to work
  - Draw things out, keep notes
  - Overgeneration is better than undergeneration
  - Chip away at the problem little by little

Questions?

References

Carl Pollard and Ivan A. Sag.
Head-Driven Phrase Structure Grammar.
University of Chicago Press and CSLI Publications, Chicago, Illinois, 1994.

Carl Pollard and Eun Jung Yoo.
A unified theory of scope for quantifiers and wh-phrases.
J. Linguistics, 34:415–445, 1998.

Adam Przepiórkowski.
Quantifiers, adjuncts as complements and scope ambiguities.
Unpublished manuscript, December 1997.

Adam Przepiórkowski.
'A Unified Theory of Scope' revisited: Quantifier retrieval without spurious ambiguities.
In Gosse Bouma, Geert-Jan Kruijff, and Richard Oehrle, editors, *Proceedings of FHCG'98*, 1998.
To appear.

Frank Richter.
A Web-based Course in Grammar Formalisms and Parsing.
http://milca.sfs.uni-tuebingen.de/A4/Course/PDF/gramandpars.pdf, 2005.
Electronic textbook.