

MRS

Ling 567

February 6, 2024

Overview

- MRS
 - Goals, design principles
 - Flat semantics
 - Underspecified quantifier scope
 - Linguistic questions
 - MRS in feature structures
- Lab 5 preview

MRS Preface

- Most of today's lecture covers stuff that is already implemented in the Matrix.
- The goal of this presentation is to increase your understanding of what's already there, and how to have your code interact with it.
- In the near term, you'll need to be able to look at the semantic representations and understand them.
- In later labs, you'll also be working on compositionality.

MRS: Goals

- The design of the MRS formalism answers the following four general goals:
 - Adequate representation of NL semantics
 - Grammatical compatibility
 - Computational tractability
 - Underspecifiability

MRS: Design Principles

- The design of the representations of particular linguistic phenomena follow the following general strategies/design principles
 - Represent all semantic distinctions which are syntactically or morphologically marked
 - Underspecify semantic distinctions which aren't: These can be spelled-out/ambiguated if necessary in post-processing
 - Abstract away from non-semantic information (word order, case, ...)
 - Close paraphrases should have comparable or identical MRS representations
 - Aim for consistency across languages
 - Allow for semantic differences across languages

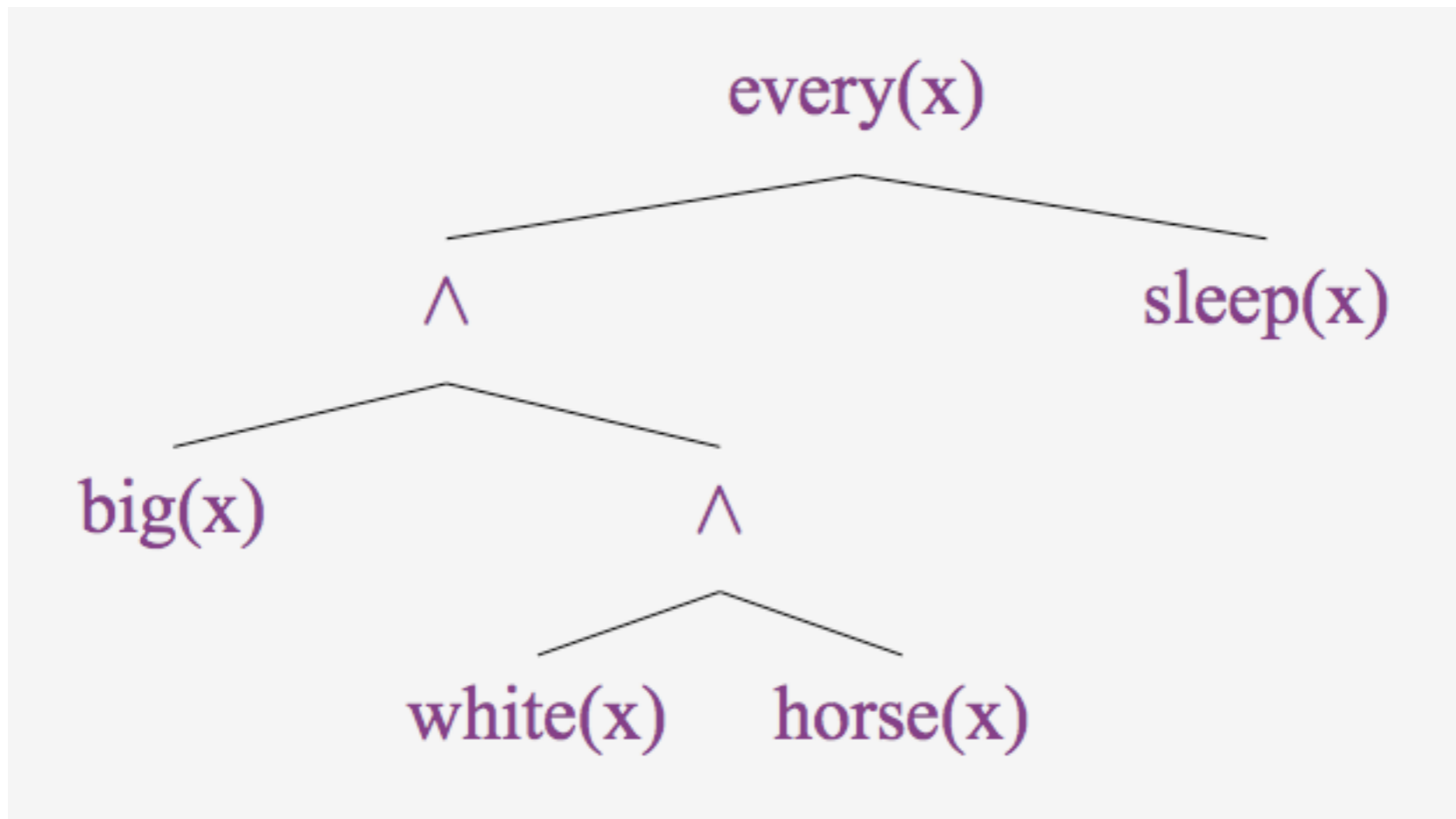
A quick reminder about quantifier scope

- Quantifiers (predicate logic or NL) take three arguments:
 - A variable to bind
 - A restriction
 - A body
- Every dog sleeps: $\forall x \text{ dog}(x) \text{ sleep}(x)$
- When one quantifier appears within the restriction or body of another, we say the second has wider scope: $\forall x \text{ dog}(x) \exists y \text{ cat}(y) \text{ see}(x, y)$

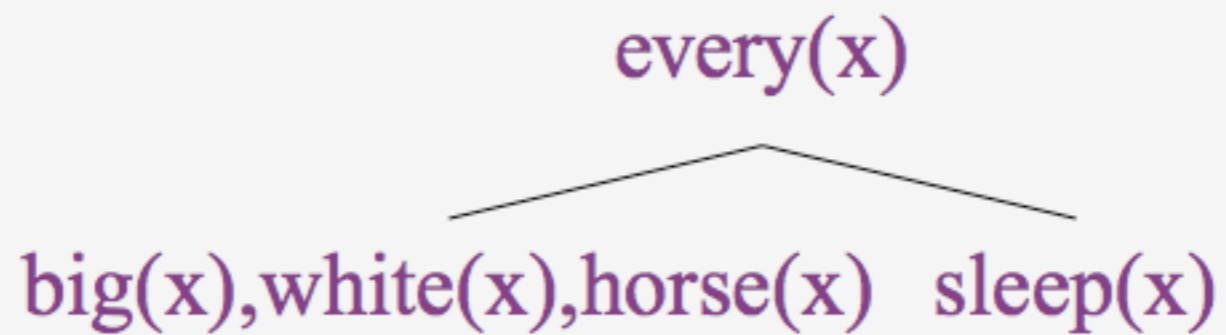
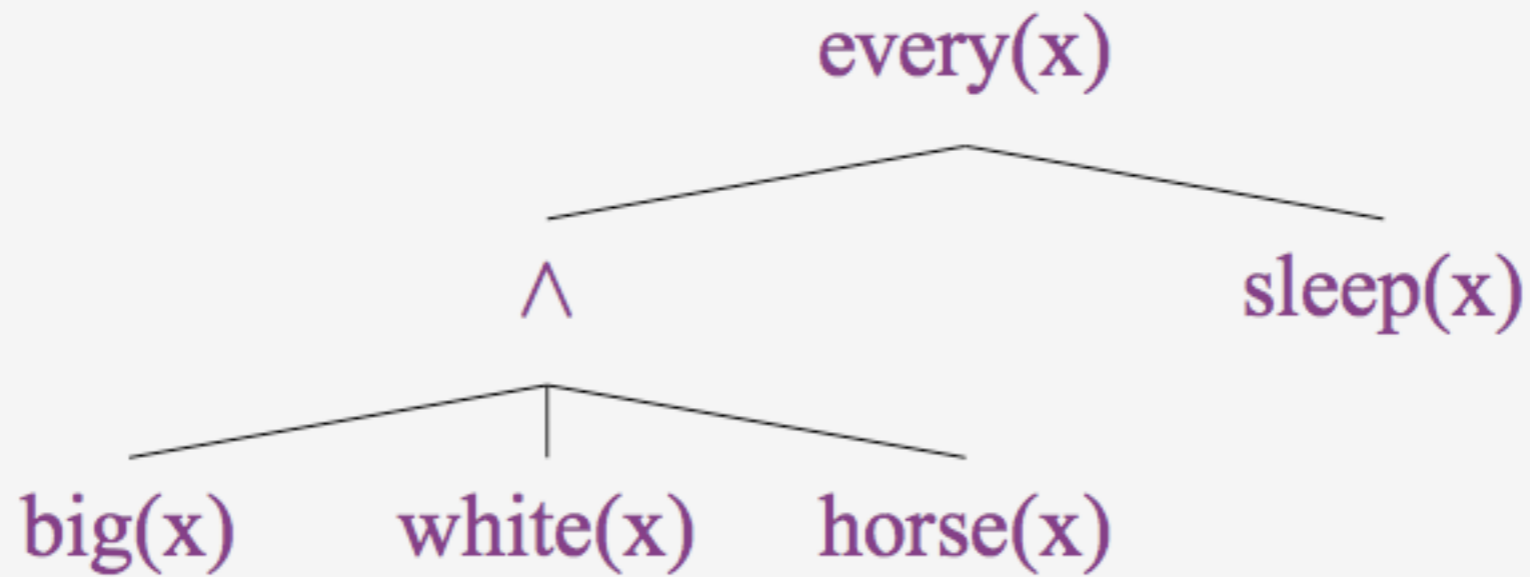
Working towards MRS (1/4)

- Every big white horse sleeps

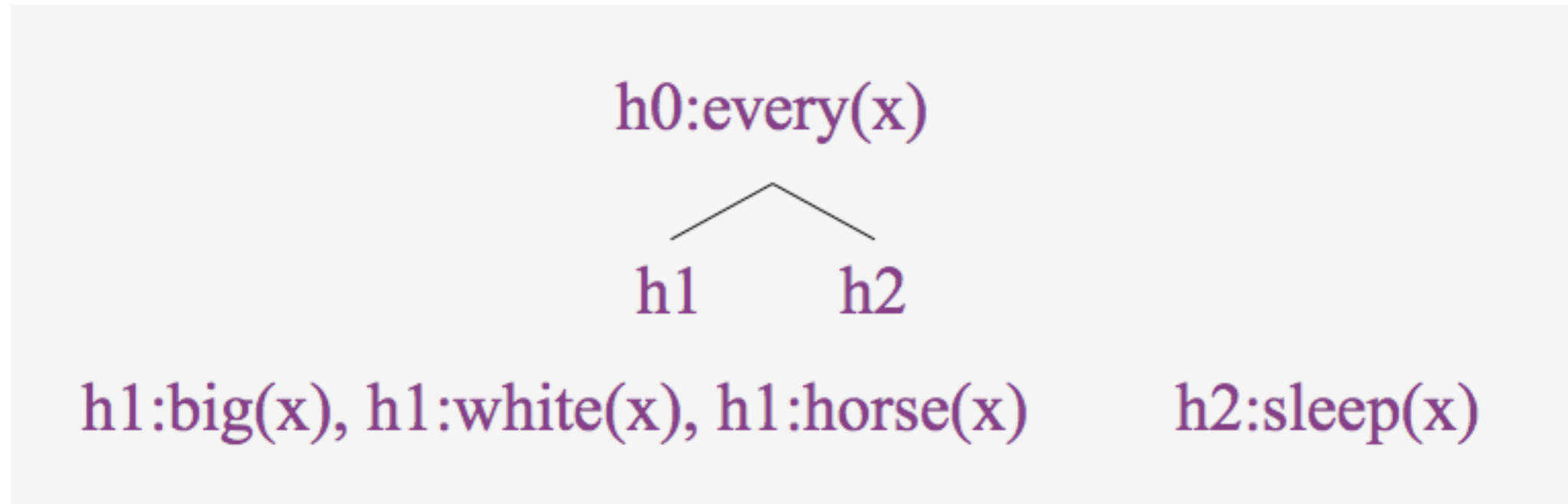
$\text{every}(x, \wedge \text{big}(x), \wedge(\text{white}(x), \text{horse}(x))), \text{sleep}(x))$



Working towards MRS (2/4)



Working towards MRS (3/4)



- And finally:

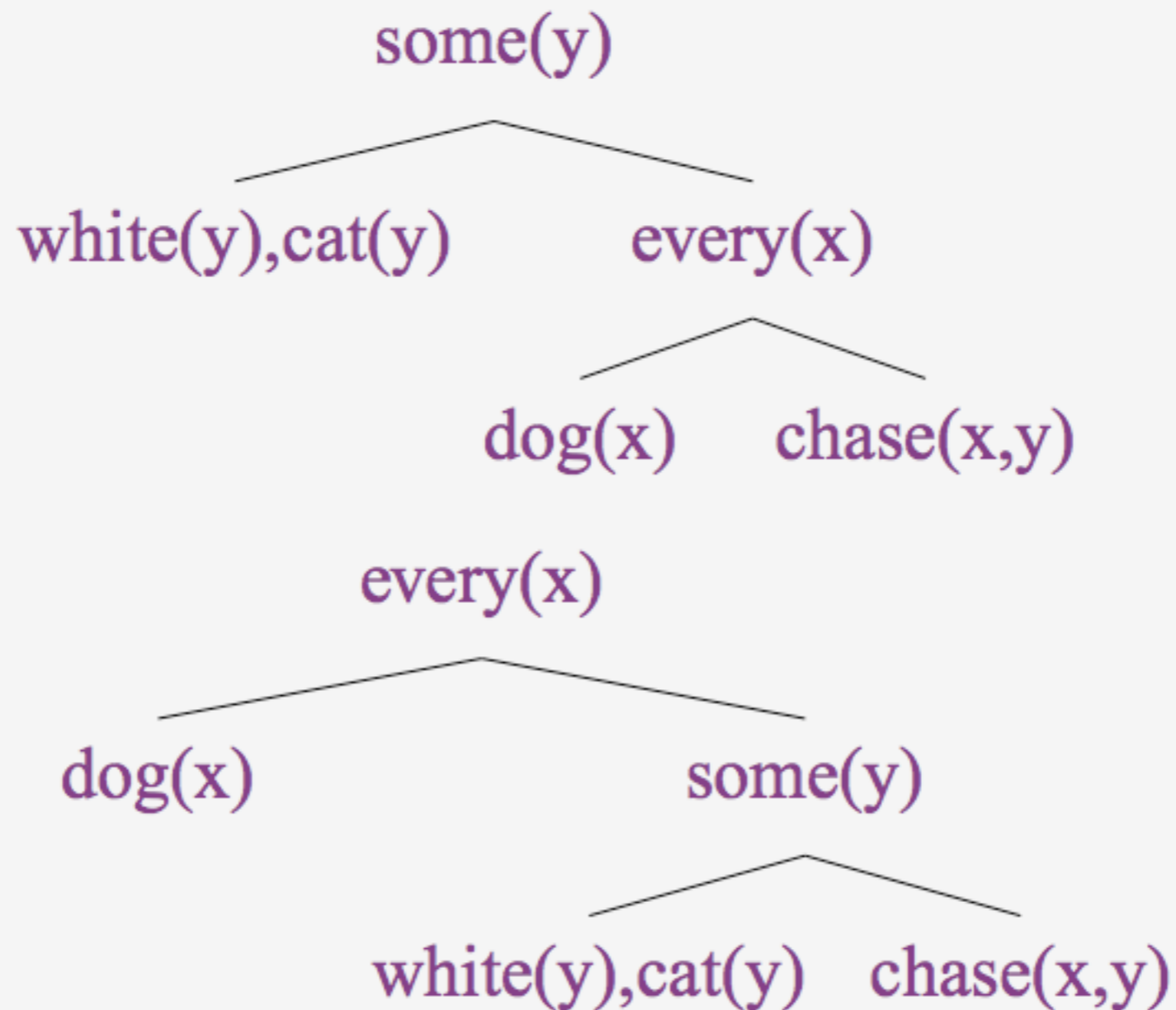
h0:every(x, h1, h2), h1:big(x), h1:white(x), h1:horse(x), h2:sleep(x)

Working towards MRS (4/4)

- This is a flat representation, which is a good start.
- Next we need to underspecify quantifier scope, and it's easier to see why with multiple quantifiers.
- At the same time, we want to be able to partially specify it, since this is required for adequate representations of NL semantics.

Underspecified quantifier scope (1/2)

- Every dog chases some white cat.



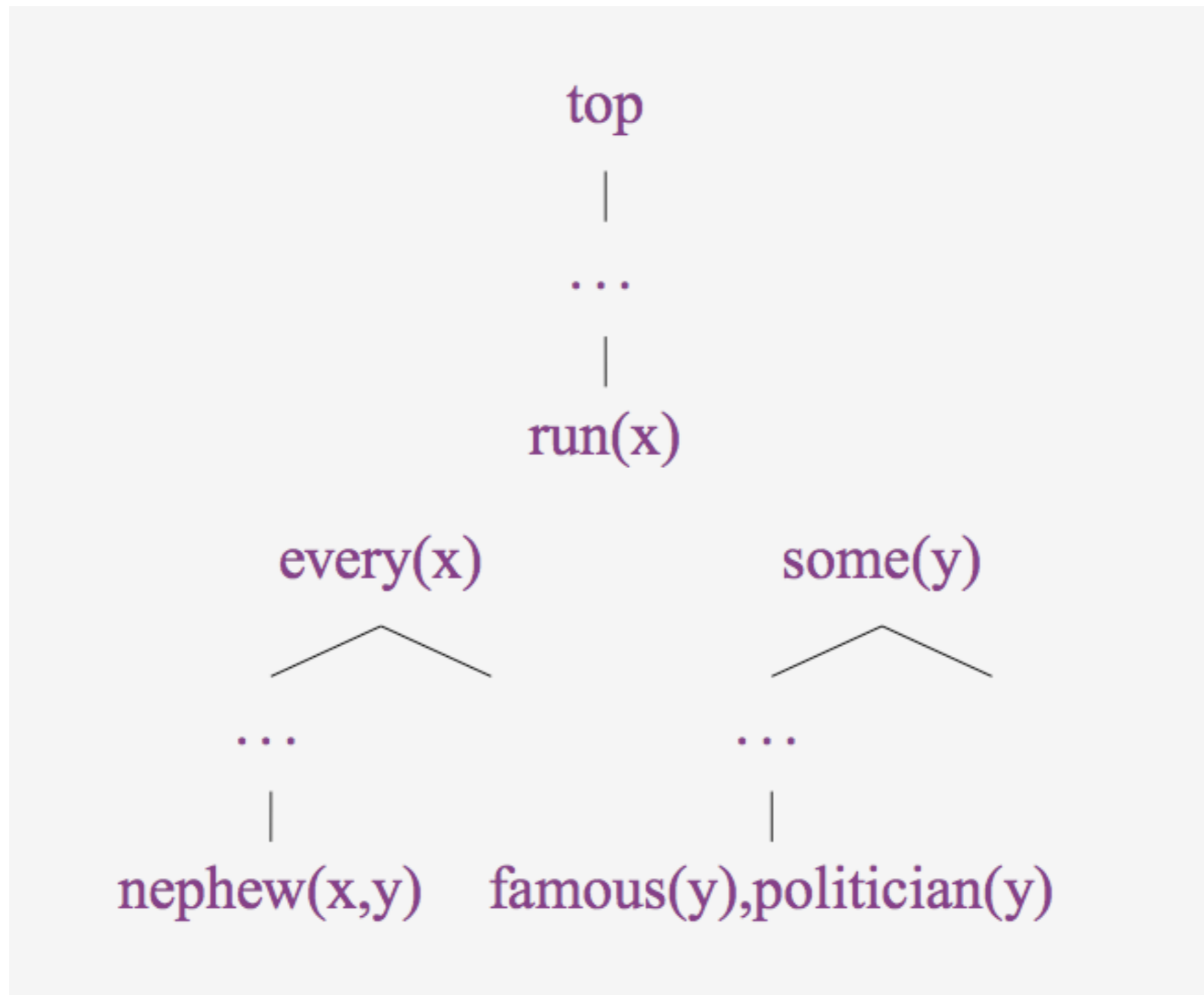
Underspecified quantifier scope (2/2)

- $h1:\text{every}(x, h3, h4)$, $h3:\text{dog}(x)$, $h7:\text{white}(y)$, $h7:\text{cat}(y)$,
 $h5:\text{some}(y, h7, h1)$, $h4:\text{chase}(x, y)$
- $h1:\text{every}(x, h3, h5)$, $h3:\text{dog}(x)$, $h7:\text{white}(y)$, $h7:\text{cat}(y)$,
 $h5:\text{some}(y, h7, h4)$, $h4:\text{chase}(x, y)$
- $h1:\text{every}(x, h3, hA)$, $h3:\text{dog}(x)$, $h7:\text{white}(y)$, $h7:\text{cat}(y)$,
 $h5:\text{some}(y, h7, hB)$, $h4:\text{chase}(x, y)$

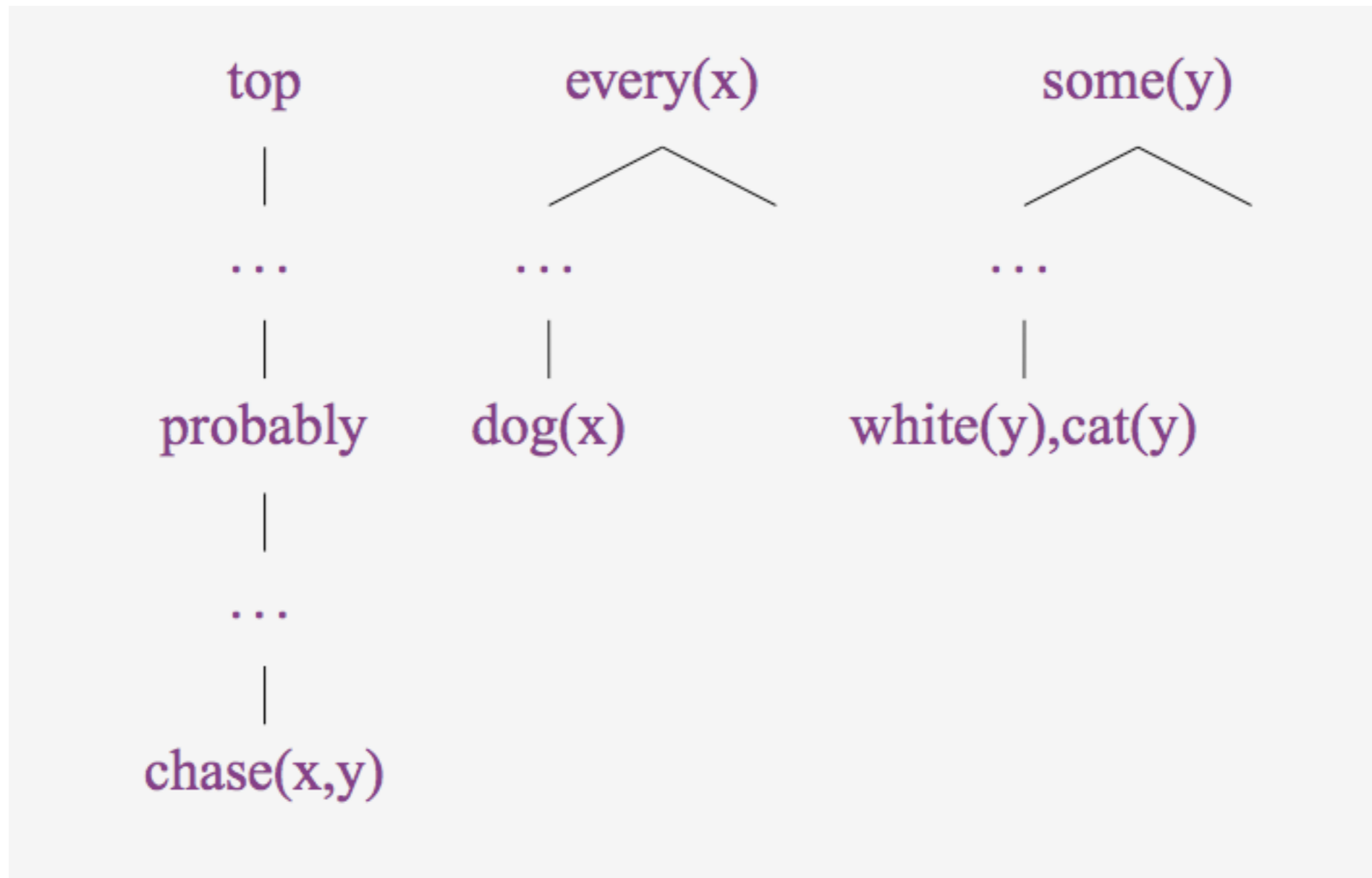
Partially constrained quantifier scope (1/4)

- For the BODY of quantifiers, we have no particular constraints to add.
- It turns out that the RESTRICTION needs to have partially underconstrained scope:
 - Every nephew of some famous politician runs.
 - $\text{every}(x, \text{some}(y, \text{famous}(y) \wedge \text{politician}(y)), \text{nephew}(x, y)), \text{run}(x))$
 - $\text{some}(y, \text{famous}(y) \wedge \text{politician}(y)), \text{every}(x, \text{nephew}(x, y), \text{run}(x))$
 - But not:
 - $\text{every}(x, \text{run}(x), \text{some}(y, \text{famous}(y) \wedge \text{politician}(y)), \text{nephew}(x, y))$
 - ‘Everyone who runs is a nephew of a famous politician.’

Partially constrained quantifier scope (2/4)



Partially constrained quantifier scope (3/4)



Partially constrained quantifier scope (4/4)

$\langle h0, \{h2 : \text{every}(x, h3, h4), h5 : \text{nephew}(x, y),$
 $h6 : \text{some}(y, h7, h8), h9 : \text{politician}(y), h9 : \text{famous}(y),$
 $h10 : \text{run}(x)\},$
 $\{h0 =_q h10, h7 =_q h9, h3 =_q h5\}\rangle$

$\langle h0, \{h1 : \text{every}(x, h2, h3), h4 : \text{dog}(x),$
 $h5 : \text{probably}(h6), h7 : \text{chase}(x, y),$
 $h8 : \text{some}(y, h9, h10), h11 : \text{white}(y), h11 : \text{cat}(y)\},$
 $\{h0 =_q h5, h2 =_q h4, h6 =_q h7, h9 =_q h11\}\rangle$

We've arrived at MRS!

- Flat structure
- Underspecification & partial specification of quantifier scope are possible

Linguistic Questions

- How do we build MRS representations compositionally?
- Is it linguistically adequate to insist that no process suppress relations?
- Under what circumstances do NLS (partially) constrain scope?
- Is it linguistically adequate to give scopal elements (esp. quantifiers, but also scopal modifiers) center-stage?

MRS in feature structures

- RELS: List (append-list) of relations
- HCONS: List (append-list) of handle constraints
- ICONS: List (append-list) of individual constraints
- HOOK: Collection of features 'published' for further composition: INDEX, LTOP, XARG
- ARGn: Roles within relations

Quick comparison to 566

- SWB RESTR = Matrix RELS
- SWB INDEX = Matrix HOOK.INDEX
- New here:
 - HCONS, ICONS
 - HOOK.LTOP, HOOK.XARG
 - C-CONT

Anatomy of an MRS

- An MRS consists of:
 - A top handle
 - A list of relations, each labeled by a handle
 - A list of handle constraints
 - (A list of individual constraints)
- An (underspecified) MRS is well-formed iff the constraints can be resolved to form one or more trees (singly-rooted, connected, directed acyclic graphs).

Anatomy of a relation

- A relation has:
 - A predicate (string or type)
 - A label (handle)
 - One or more arguments: ARG0-n (ARG0 canonically being the event or individual introduced by the relation)
- The value of each ARGn is either:
 - An index, canonically identified with the ARG0 of another relation
 - A handle: identified with the label of another relation, the HARG of a handle constraint, or not identified with anything

Anatomy of a handle constraint

- Current sole handle constraint type: qeq
- ‘Equal modulo quantifiers’
- Features: HARG, LARG
- → Unless some quantifier scopes in between, the value of this ARGn is the same as the label of that relation.
- When the label of a relation is the value of an ARGn, this corresponds to a branch in an MRS tree.
- When the value of an ARGn is qeq the label of a relation, this corresponds to a ‘dotted’ branch – i.e., a dominance relation.

When else are handles identified?

- Relations with the same handle value share the same scope.
- Typically, we see this with non-scopal modifiers (adverbs, adjectives, PPs) which share their handles with their modifiees.

Composition: Overview

- RELS and HCONS (and ICONS) on mother nodes
- HOOK, LKEYS
- ARGn <> indices
- ARGn <> handles
- LBL <> LBL
- Building *qeqs*

RELS and HCONS on mother nodes

- The RELS and HCONS (and ICONS) value of the mother is the append of the values from the daughter(s) and the C-CONT of the mother.
- C-CONT is the ‘constructional content’: allows phrase structure rules to introduce relations.
- Examples?
- From a semantic point of view, the C-CONT is just another daughter.

Now what?

- Phrase structure rules (and lexical rules) gather up RELS and HCONS from daughters.
- Phrase structure rules also (optionally) introduce further RELS and HCONS.
- How do we link the ARGn positions of the relations to the right things?
- How do we link the HARG/LARG of qeqs to the right things?

HOOK

- The CONT.HOOK is the information that a given sign exposes for further composition.
- By hypothesis, this includes only:
 - INDEX (the individual or event denoted by the sign, linked to some ARG0)
 - LTOP (the local top handle of the sign)
 - XARG (the external argument of the sign)
- The HOOK of a sign is identified with the C-CONT.HOOK.
- The C-CONT.HOOK in turn is identified with the semantic head daughter, if there is one.
- Otherwise, the LTOP, INDEX, and XARG inside C-CONT.HOOK need to be constrained appropriately.

LKEYS

- The feature LKEYS houses pointers to important relations on the RELS list, most notably LKEYS.KEYREL.
- Only appropriate for lexical items.
- Serves as a uniform place to state linking constraints.
- Linking constraints: equality between HOOK.INDEX or HOOK.LTOP of arguments/modifiees and LKEYS.KEYREL.ARGn.

```
norm-ltop-lex-item := lex-item &
  [ SYNSEM [ LOCAL.CONT [ HOOK [ LTOP #ltop ],
                              RELS.LIST.FIRST #keyrel ],
    LKEYS.KEYREL #keyrel & [ LBL #ltop ] ] ] .
```

ARGn <> indices

```
intransitive-lex-item := basic-one-arg-no-hcons &  
  [ ARG-ST < [ LOCAL.CONT.HOOK.INDEX ref-ind &  
              #ind ] >,  
    SYNSEM.LKEYS.KEYREL.ARG1 #ind ].
```

```
intersective-mod-lex := no-hcons-lex-item &  
  [ SYNSEM [ LOCAL.CAT.HEAD.MOD  
            < [ ..INDEX #ind ] ] >,  
    LKEYS.KEYREL.ARG1 #ind ] ].
```

ARGn <> handles (1/2)

```
clausal-second-arg-trans-lex-item := basic-two-arg &
[ ARG-ST < [ LOCAL.CONT.HOOK.INDEX ref-ind & #ind ],
          [ LOCAL.CONT.HOOK.LTOP #larg ] >,
  SYNSEM [ LOCAL.CONT.HCONS <! qeq &
          [ HARG #harg,
            LARG #larg ] !>,
          LKEYS.KEYREL [ ARG1 #ind,
                        ARG2 #harg ] ] ] .
```


ARGn <> handles (2/2)

```
basic-determiner-lex := norm-hook-lex-item &
  [ SYNSEM [ LOCAL
    [ CAT [ HEAD det,
      VAL..HOOK [ INDEX #ind,
        LTOP #larg ]],
    CONT [ HCONS <! qeq &
      [ HARG #harg,
        LARG #larg ] !>,
      RELS <! relation !> ] ],
    LKEYS.KEYREL quant-relation &
      [ ARG0 #ind,
        RSTR #harg ] ] ] .
```

LBL <> LBL

```
isect-mod-phrase :=  
  head-mod-phrase-simple &  
  head-compositional &  
  [ HEAD-DTR.SYNSEM.LOCAL.CONT.HOOK.LTOP #hand ],  
  NON-HEAD-DTR.SYNSEM.LOCAL.CONT.HOOK.LTOP #hand
```

- The rule for non-scopal modifiers identifies the LTOP of the two daughters, and thus the LBL of the main relation introduced by each.
- The HOOK value of the whole thing comes from the syntactic head, thanks to the type head-compositional.

Scopal modifiers (1/2)

```
scopal-mod-phrase :=  
  head-mod-phrase-simple &  
  [ NON-HEAD-DTR.SYNSEM.LOCAL  
    [ CAT.HEAD.MOD < [ LOCAL scopal-mod ] >,  
      CONT.HOOK #hook ],  
    C-CONT [ HOOK #hook,  
            HCONS <! !> ] ] .
```

- No identification of LTOPs.
- Non-head (adjunct) daughter is the semantic head.

Scopal modifiers (2/2)

```
scopal-mod-lex := lex-item &
  [ SYNSEM [ LOCAL [
    CAT.HEAD.MOD < [ LOCAL scopal-mod &
                    [ ..LTOP #larg ] ] >,
    CONT.HCONS <! qeq &
                [ HARG #harg,
                  LARG #larg ] !> ],
    LKEYS.KEYREL.ARG1 #harg ]].
```

- Builds qeq between its ARG1 and the MOD's LTOP

Building qeqs

- Determiners
- Scopal adverbs
- Clausal complement verbs (and nouns, adjectives, adpositions...)

Summary

- Phrase structure and lexical rules:
 - ... gather up RELS and HCONS (and ICONS)
 - ... potentially add further RELS and HCONS
 - ... unify elements on valence/mod lists with signs
- ... pass up and/or modify HOOK information
- Lexical entries:
 - ... orchestrate the linking between valence/mod lists and the ARGn positions in the relations they contribute
 - ... expose certain information in the HOOK

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