Resource Grammars and Language Learning and Evolution

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Outline

Resources for building (formal) languages (with Aarne Ranta)

Language learning and evolution (with Staffan Larsson)

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Natural and formal languages in 20th century linguistics

- languages as sets of strings and early transformational grammar

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Natural and formal languages in 20th century linguistics

- languages as sets of strings and early transformational grammar
- interpreted languages as sets of string-meaning pairs
- Montague in 'Universal Grammar':

> *There is in my opinion no important theoretical difference between natural languages and the artificial languages of logicians; indeed I consider it possible to comprehend the syntax and semantics of both kinds of languages within a single natural and mathematically precise theory.*

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- a basis for much computational processing of language

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  - abstract or theoretical concepts like democracy or meaning

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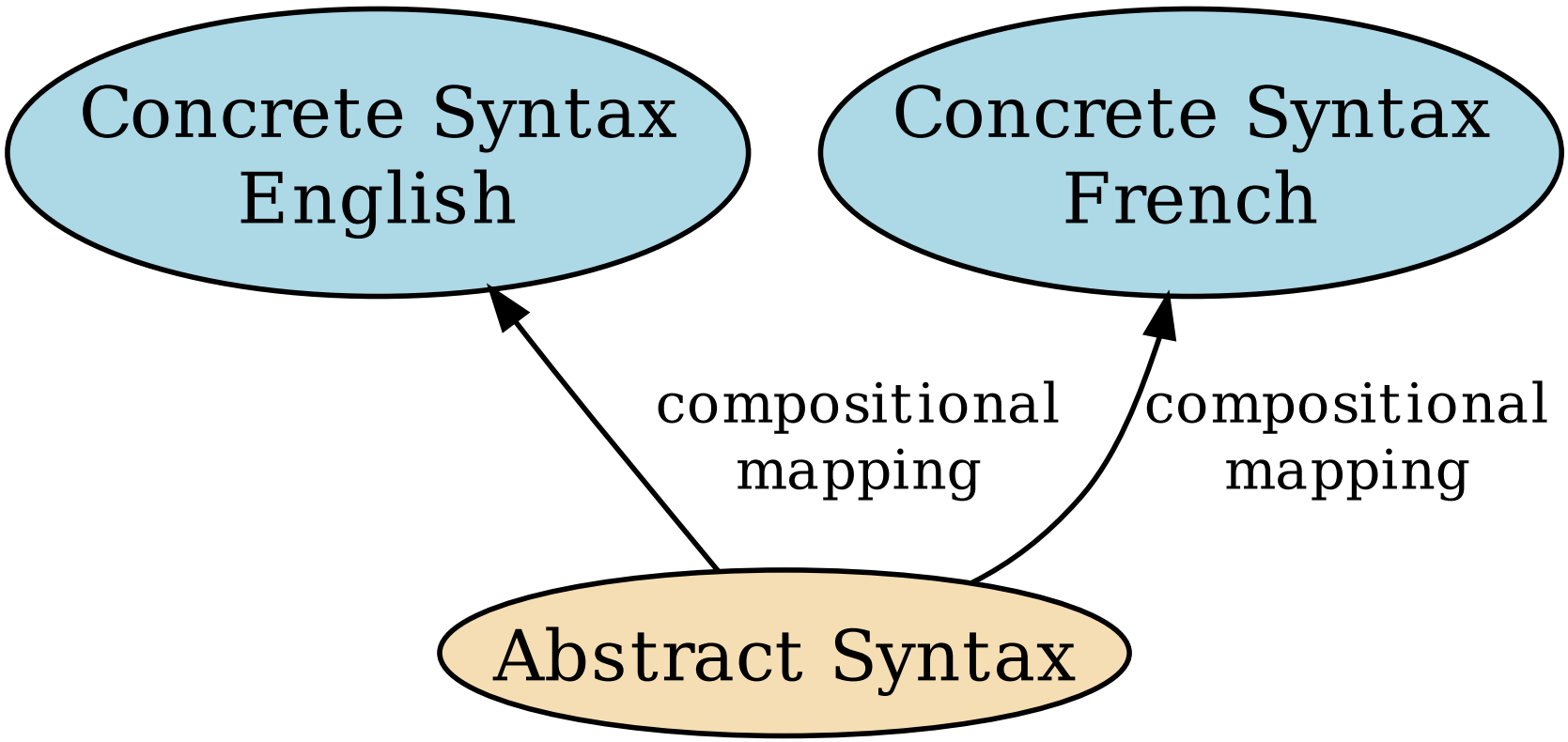
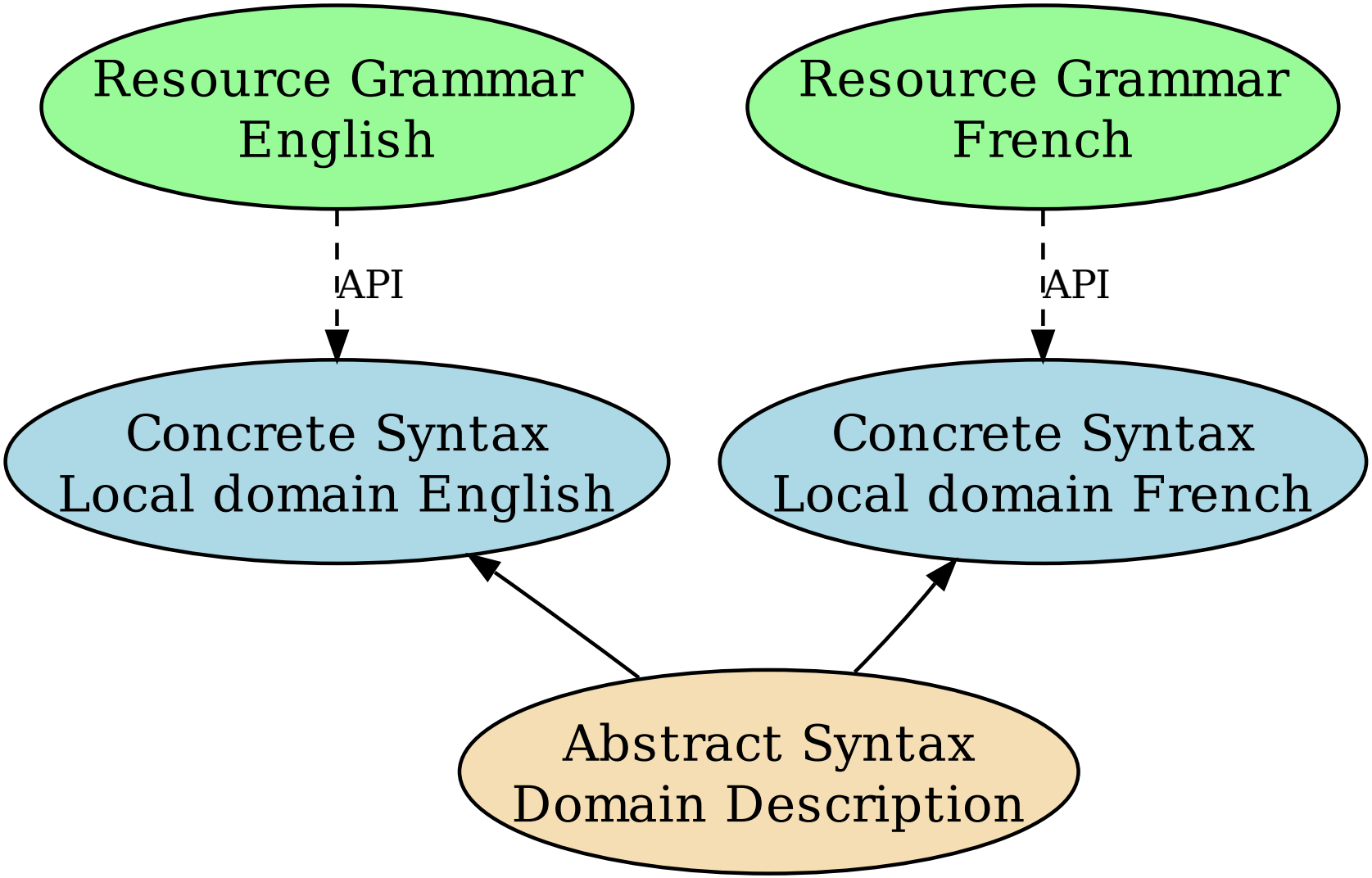
- maintain the insights and precision gained from the formal language view
- speakers of natural languages are constantly in the process of creating new language to meet the needs of novel situations in which they find themselves
- A corpus of natural language data (even a single dialogue) is not required to be consistent either in terms of grammaticality or in terms of meaning since it represents output based on a collection of related grammars rather than a single grammar.

Scaling up to multilingual grammar the GF way

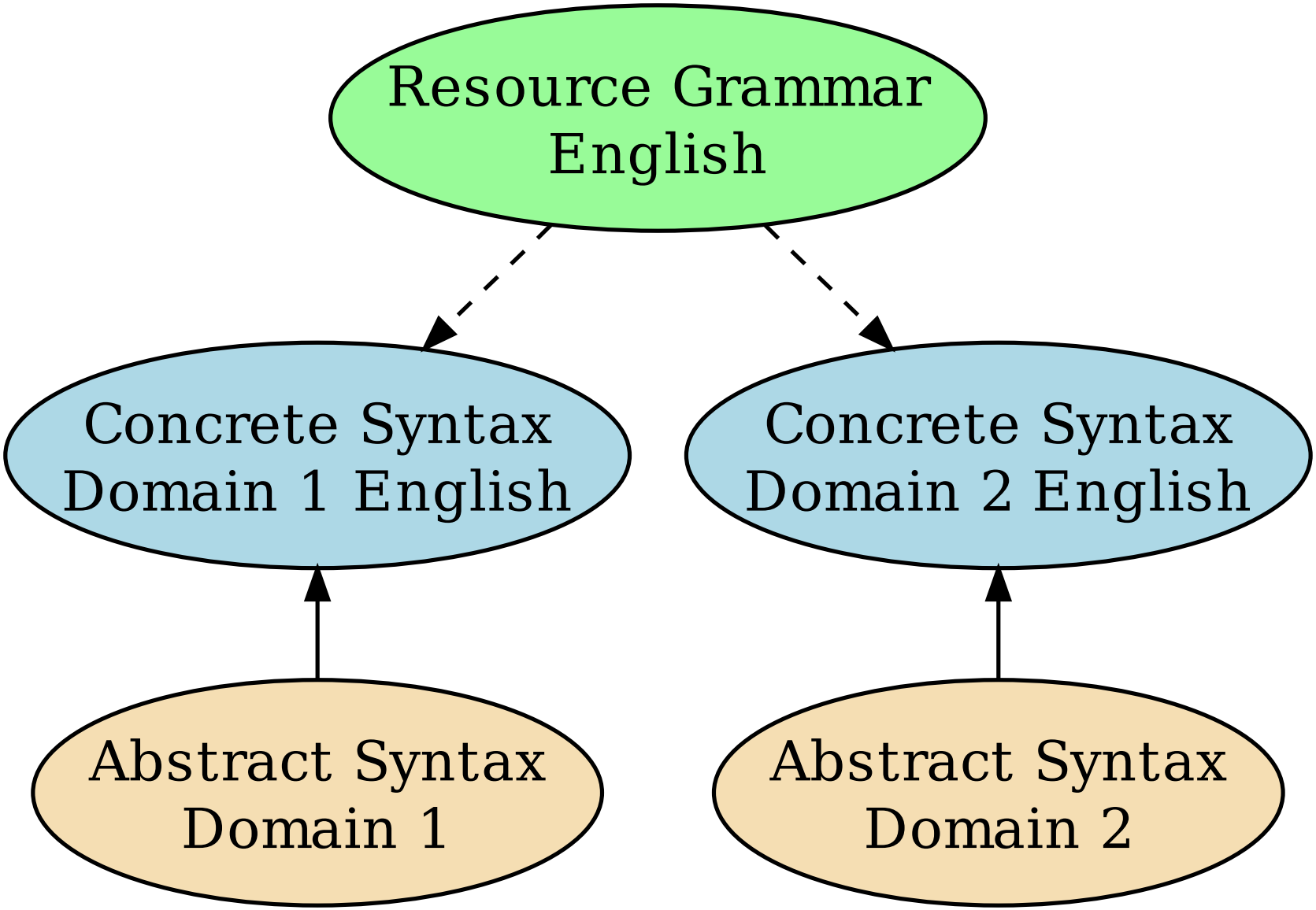


Scaling up/down to local domain grammars the GF way

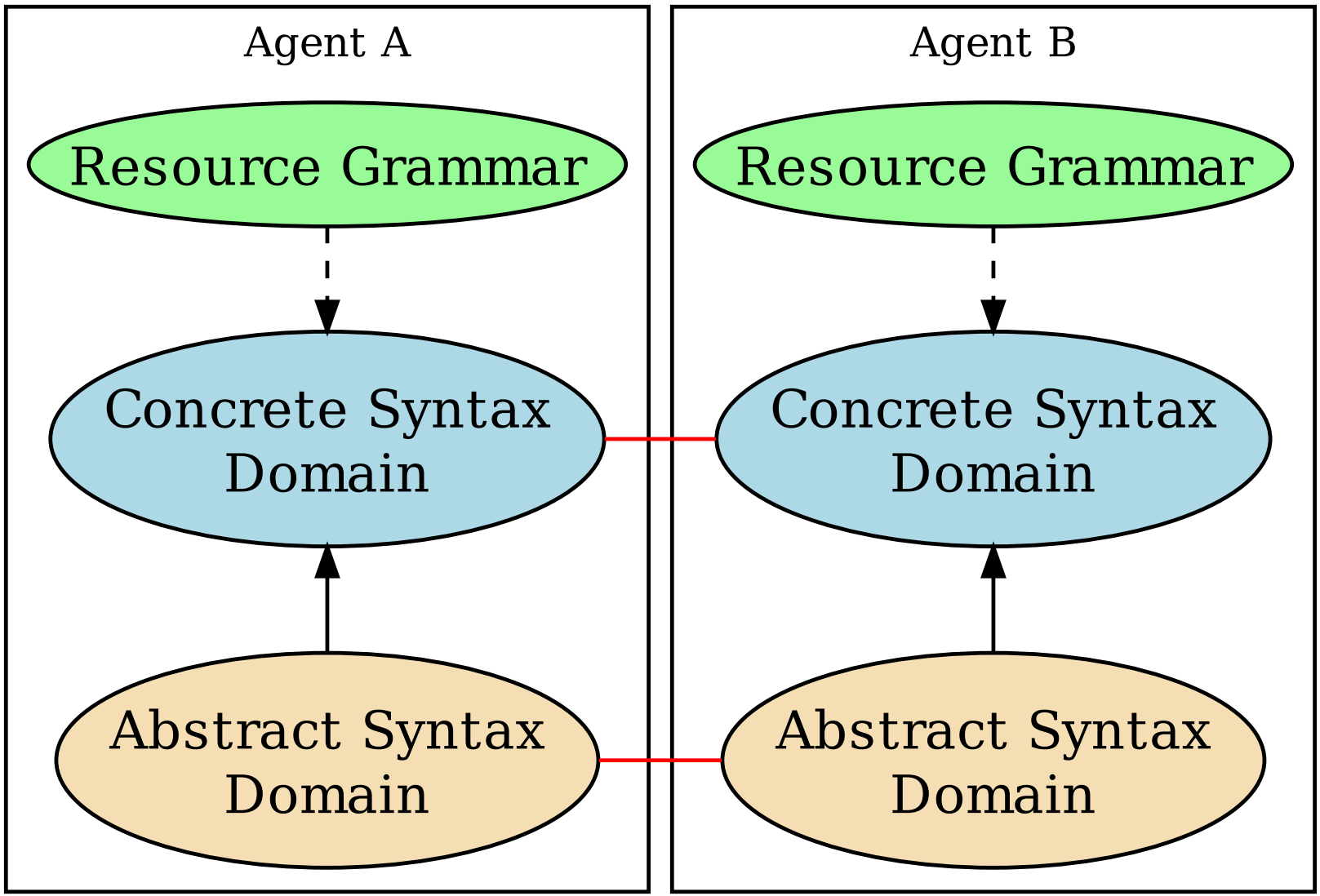


API = Application Programming Interface
Importation of definitions

Reusing the resource grammar in GF



Coordination



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Semantic coordination

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Requirements for a theory of semantic coordination

- semantics: an account of how meanings (and concepts) can be updated
  - dynamic representations of concepts which can be modified in various ways (Type theory with records, TTR)

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  - dynamic representations of concepts which can be modified in various ways (Type theory with records, TTR)
- pragmatics: an account of how meanings (and concepts) are coordinated in dialogue and how dialogue moves governing coordination are related to semantic updates
  - a description of dialogue strategies involved in semantic coordination (Information State Update, ISU)

Corrective feedback

A frequent pattern in corrective feedback is the following:

original utterance A says something

innovative utterance B says something parallel to A's utterance, containing a use which is innovative for A

learning step A learns from the innovative use

In-repair

Abe: I'm trying to tip this over, can you tip it over? Can you tip it over?

Mother: Okay I'll turn it over for you.

- **offer-form:in-repair**("turn", "_ it over")
- **offer-form**("turn", "tip")

Clarification request

Adam: Mommy, where my plate?

Mother: You mean your saucer?

- **offer-form:cr**(“saucer”, “[poss] _ ”)
- **offer-form**(“saucer”, “plate”)

Explicit replace

Naomi: Birdie birdie.

Mother: Not a birdie, a seal.

- **offer-form:explicit-replace**(“seal”, “birdie”)
- **offer-form**(“seal”, “birdie”)

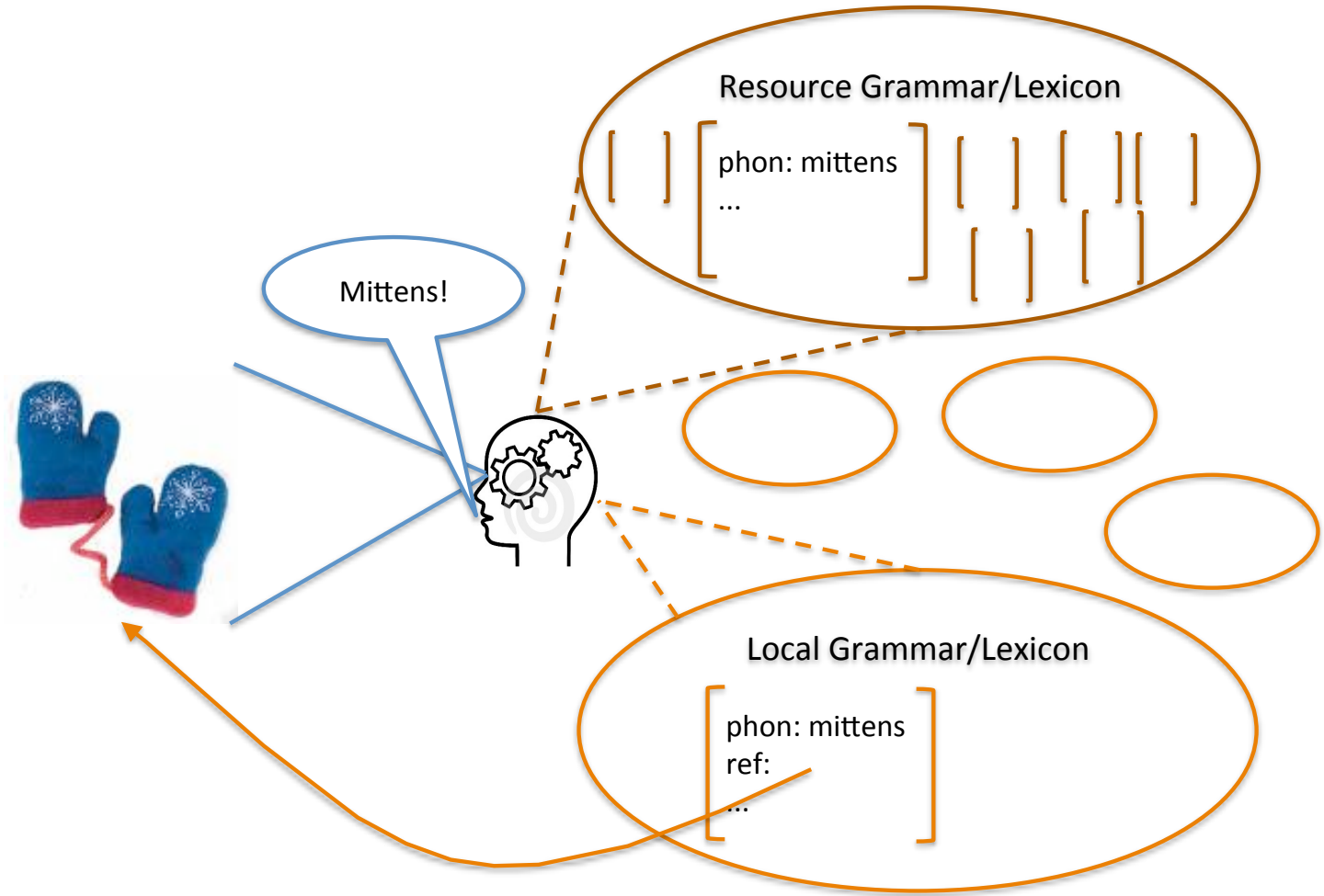
Bare correction

Naomi: mittens.

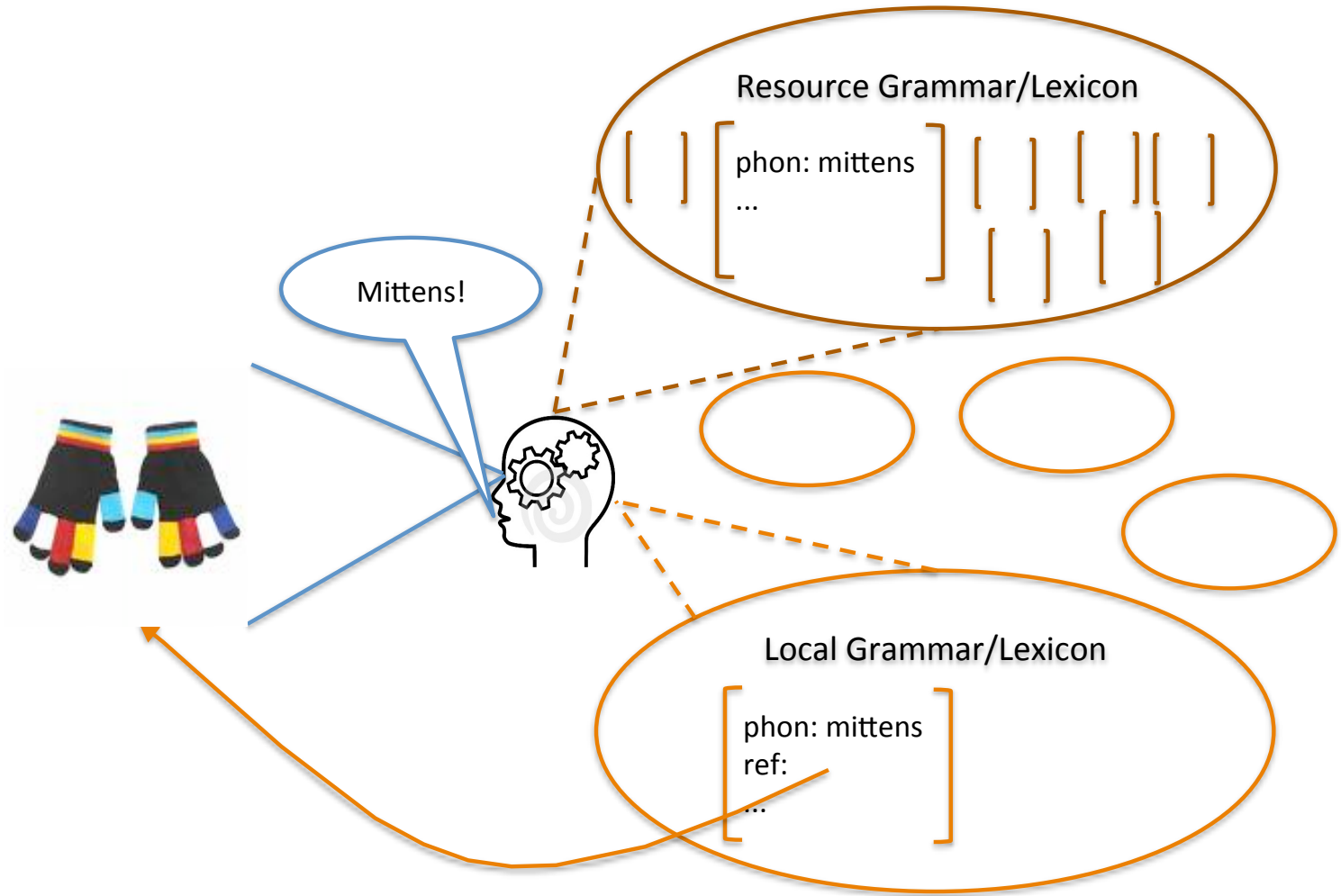
Father: gloves.

- **offer-form:bare**(“gloves”)
- **offer-form**(“gloves” , “mittens”)

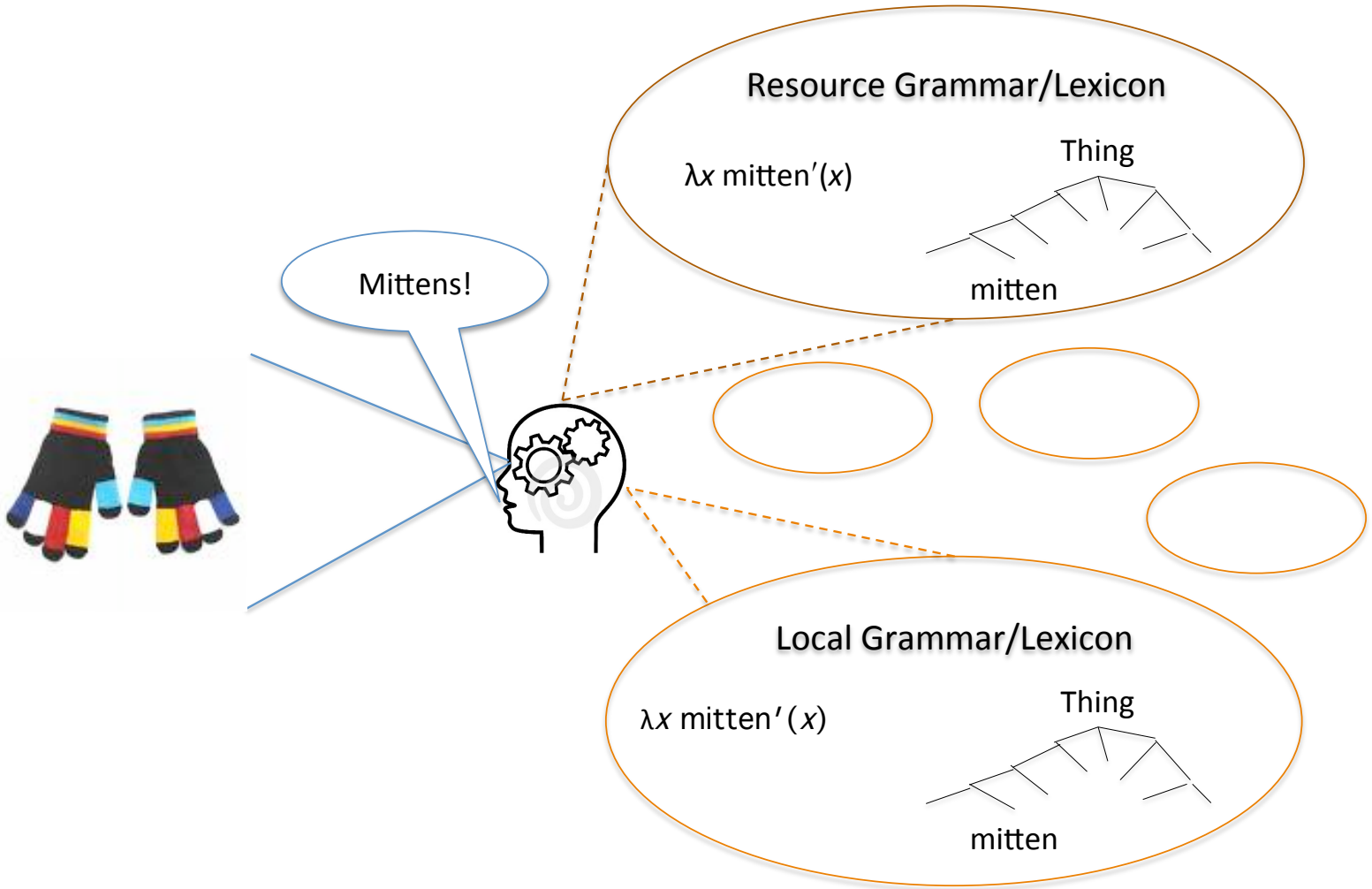
Talking about mittens



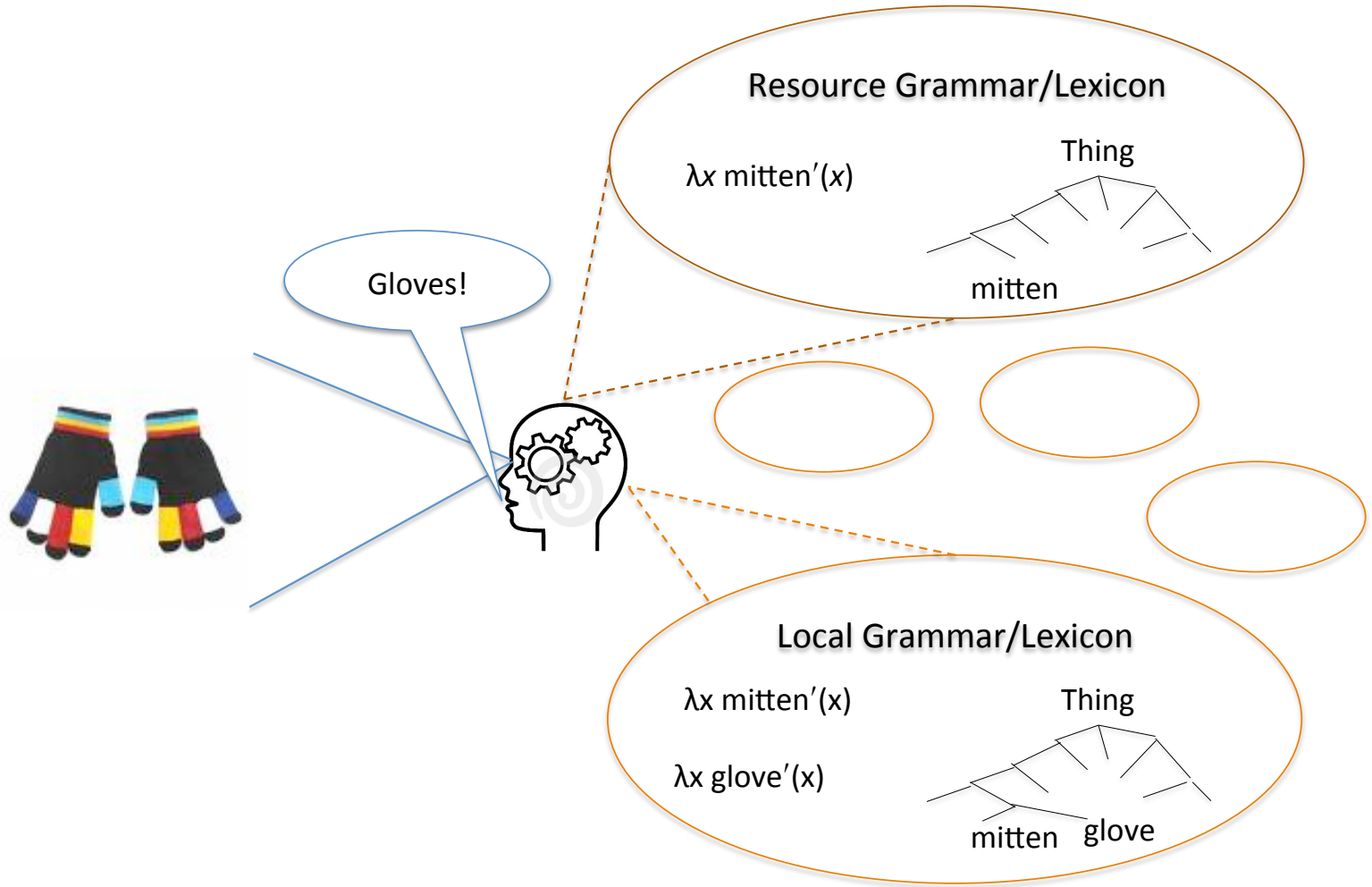
Talking about gloves (when you only know about mittens)



Compositional and ontological semantics



Enriching the local lexicon



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- semantic coordination updates involve linguistic resources (grammar, lexicon, semantic interpretation rules, . . .), i.e. *not* the standard conversational scoreboard
- agents construct local resources for sublanguages used in specific situations

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- this will not be the case in general, e.g. *black hole* in physics not a black hole in the general sense, variables in logic and experimental psychology

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- $[\mathrm{c}]^A_s$ may be anchored to the specific objects under discussion in s

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- $[c]^A$ - a domain independent linguistic resource

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- $c' \in [\mathrm{c}]^A$, i.e. part of a domain independent generic resource

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- positive or negative feedback obtained when using the pairing in a communicative situation

Representing concepts using TTR

Type Theory with Records

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- feature structure like properties are important for developing similarity metrics on meanings and for the straightforward definition of meanings modifications involving refinement and generalization
- logical aspects are important for relating our semantics to the model and proof theoretic tradition associated with compositional semantics

Records and record types

Record type

$$\begin{bmatrix} \text{ref} & : & \text{Ind} \\ \text{size} & : & \text{size(ref, MuchBiggerThanMe)} \\ \text{shape} & : & \text{shape(ref, BearShape)} \end{bmatrix}$$

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Record

$$\begin{bmatrix} \text{ref} & = & \text{obj123} \\ \text{size} & = & \text{sizesensorreading85} \\ \text{shape} & = & \text{shapesensorreading62} \\ \text{colour} & = & \text{coloursensorreadning78} \end{bmatrix}$$

Types containing manifest fields

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Type hierarchies

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as is also

$$\left[\begin{array}{lcl} \text{ref=obj123} & : & \text{Ind} \end{array}\right]$$

The panda

A: That's a nice bear
B: Yes, it's a nice panda

offer-form:in-repair("panda", "is a nice _")

offer-form("panda", "bear")

A's concept "bear" in the "zoo" domain

We assume that, before B's utterance, A has a single concept of "bear" in a domain called "zoo", that is, a unique member of the collection $[\text{bear}]^A_{zoo}$.

$$\begin{bmatrix} \text{ref} & : & \text{Ind} \\ \text{phys} & : & \text{phys-obj(ref)} \\ \text{anim} & : & \text{animate(ref)} \\ \text{size} & : & \text{size(ref, MuchBiggerThanMe)} \\ \text{shape} & : & \text{shape(ref, BearShape)} \\ \text{bear} & : & \text{bear(ref)} \end{bmatrix}$$

A's take on the communicative situation

A's dialogue information state at the time of B's utterance (much simplified)

$$\begin{bmatrix} \text{domain} & : & \text{zoo} & & & \\ \text{shared} & : & \begin{bmatrix} \text{foo}=obj123 & & & : & \text{Ind} \\ \text{com}=\begin{bmatrix} c_1 & : & \text{nice(foo)} \\ c_2 & : & \text{bear(foo)} \end{bmatrix} & & & : & \text{RecType} \end{bmatrix} & & & \end{bmatrix}$$

A creates a local "panda"-concept

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- assuming the principle of contrast (Clark), find a way in which pandas differ from bears
- create first a local situated interpretation $[\text{panda}]^A_s$ based on $[\text{bear}]^A_{zoo}$

$[\text{panda}]_s^A$

$$\begin{bmatrix} \text{ref}{=}obj123 & : & \text{Ind} \\ \text{phys} & : & \text{phys-obj(ref)} \\ \text{anim} & : & \text{animate(ref)} \\ \text{size} & : & \text{size(ref, MuchBiggerThanMe)} \\ \text{shape} & : & \text{shape(ref, BearShape)} \\ \text{colour} & : & \text{colour(ref, BlackAndWhite)} \\ \text{panda} & : & \text{panda(ref)} \end{bmatrix}$$

$[\text{bear}]_s^A$

A refines the local "bear"-concept corresponding to the newly formed local "panda"-concept

$$\begin{bmatrix} \text{ref} & : & \text{Ind} \\ \text{phys} & : & \text{phys-obj(ref)} \\ \text{anim} & : & \text{animate(ref)} \\ \text{size} & : & \text{size(ref, MuchBiggerThanMe)} \\ \text{shape} & : & \text{shape(ref, BearShape)} \\ \text{colour} & : & \text{colour(ref, Brown)} \\ \text{bear} & : & \text{bear (ref)} \end{bmatrix}$$

A's updated dialogue information state

$$\left[\begin{array}{lcl} \text{domain} & : & \text{zoo} \\ \text{shared} & : & \left[\begin{array}{lcll} \text{foo}=obj123 & & & : \text{Ind} \\ \text{com}=\left[\begin{array}{lcl} c_1 & : & \text{nice(foo)} \\ c_2 & : & \text{panda(foo)} \end{array}\right] & & & : \text{RecType} \end{array}\right] \end{array}\right]$$

A dereferenced panda-concept

$$\begin{bmatrix} \text{ref} & : & \text{Ind} \\ \text{phys} & : & \text{phys-obj(ref)} \\ \text{anim} & : & \text{animate(ref)} \\ \text{size} & : & \text{size(ref, MuchBiggerThanMe)} \\ \text{shape} & : & \text{shape(ref, BearShape)} \\ \text{colour} & : & \text{colour(ref, BlackAndWhite)} \\ \text{panda} & : & \text{panda(ref)} \end{bmatrix}$$

Available for use as $[\text{panda}]^{A}_{zoo}$, and for progression through the meaning hierarchy.

Further reading

- http://www.ling.gu.se/~cooper/records
- http://www.flov.gu.se/english/research/Semantic_Coordination_in_Dialogue/