A Computational Model of Natural Language Communication

Interpretation, Inference, and Production in Database Semantics

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Part I.
The Communication Mechanism of Cognition

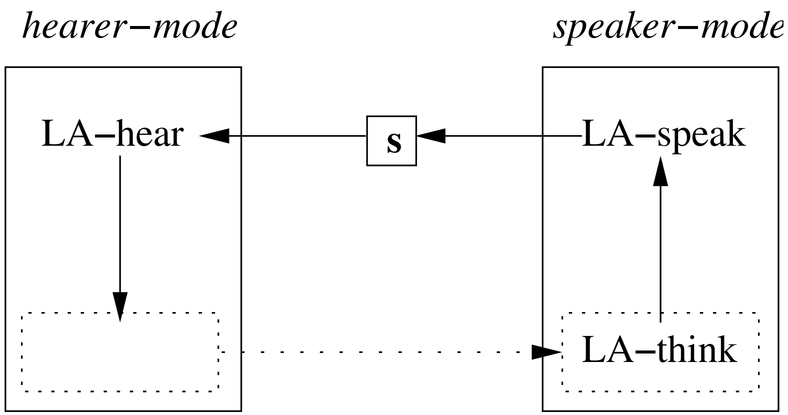
1. Matters of Method

1.1 Sign- or Agent-Oriented Analysis of Language?

The goal of Database Semantics is a theory of natural language communication which is complete with respect to function and data coverage, of low mathematical complexity, and suitable for an efficient implementation on the computer. The central question of Database Semantics is

How does communicating with natural language work?

1.1.1 THE BASIC MODEL OF TURN-TAKING



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1.1.2 Two views of turn-taking

1. *Viewed from the outside:*
   Two communicating agents are observed as they are taking turns. This is represented by 1.1.1 when the two boxes are taken to be two different agents, one in the hearer- and the other in the speaker-mode.
2. *Viewed from the inside:*
   One communicating agent is observed as it switches between being the speaker and the hearer. This is represented by 1.1.1 when the two boxes are taken to be the same agent switching between the speaker- and the hearer-mode (with the dotted right-hand arrow indicating the switch).

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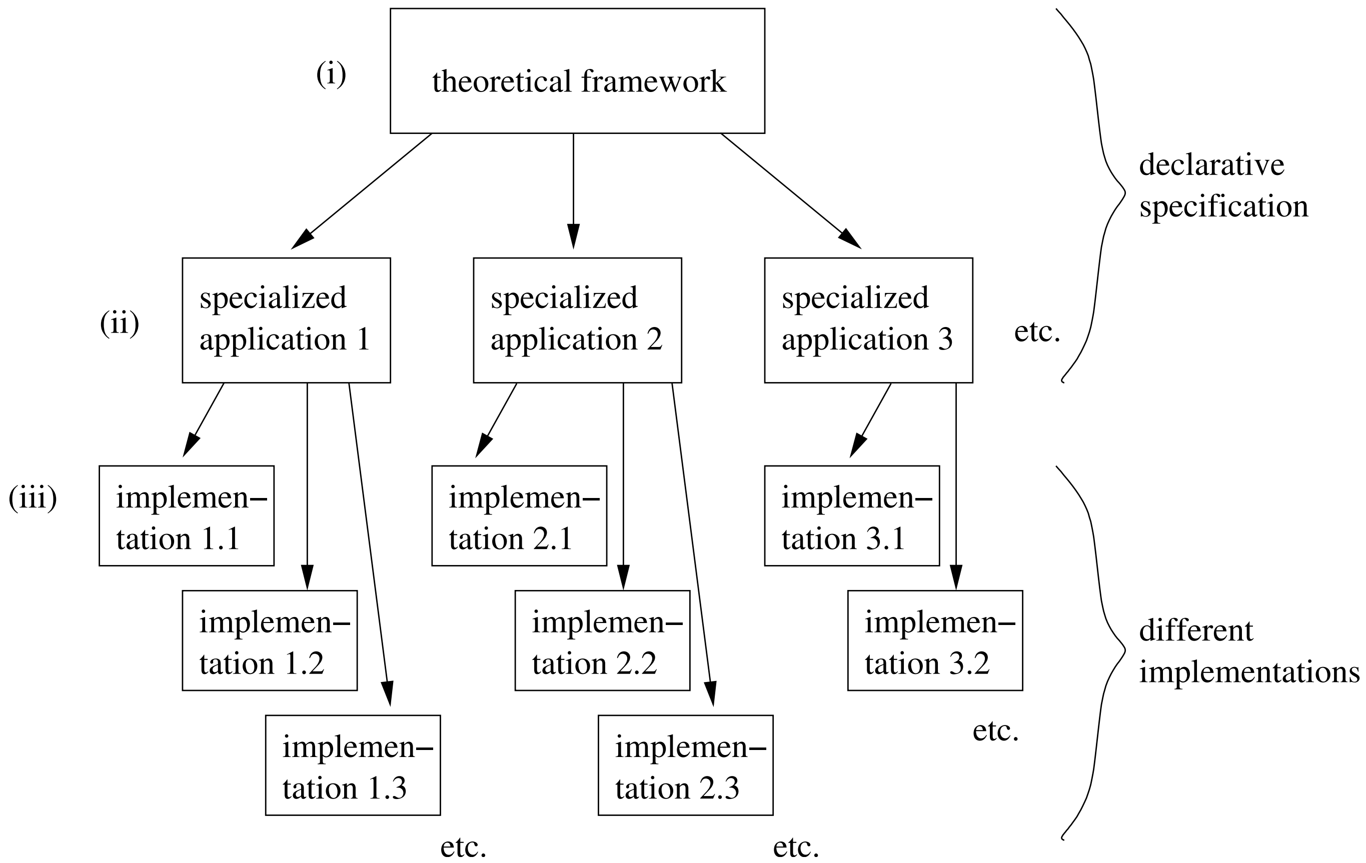
1.2 Verification Principle

1.2.1 Correlation of declarative specification and implementations



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1.3 Equation Principle

1.3.1 The equation principle of Database Semantics

1. The more realistic the reconstruction of cognition, the better the functioning of the model.
2. The better the functioning of the model, the more realistic the reconstruction of cognition.

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1.4 Objectivation Principle

1.4.1 Constellations providing different kinds of data

1. Interaction between (i) the user and (iii) the robot
2. Interaction between (i) the user and (ii) the scientist
3. Interaction between (ii) the scientist and (iii) the robot

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1.4.2 Data channels of communicative interaction

1. The *auto-channel*
   processes input automatically and produces output autonomously, at the context as well as the language level. In natural cognitive agents, i.e. the user and the scientist, the auto-channel is present from the very beginning in its full functionality. In artificial agents, in contrast, the auto-channel must be reconstructed – and it is the goal of Database Semantics to reconstruct it as realistically as possible.
2. The *extrapolation of introspection*
   is a specialization of the auto-channel and results from the scientists' effort to improve man-machine communication by taking the view of the human user. This is possible because the scientist and the user are natural agents.
3. The *service channel*
   is designed by the scientist for the observation and control of the artificial agent. It allows direct access to the robot's cognition because its cognitive architecture and functioning is a construct which in principle may be understood completely by the scientist.

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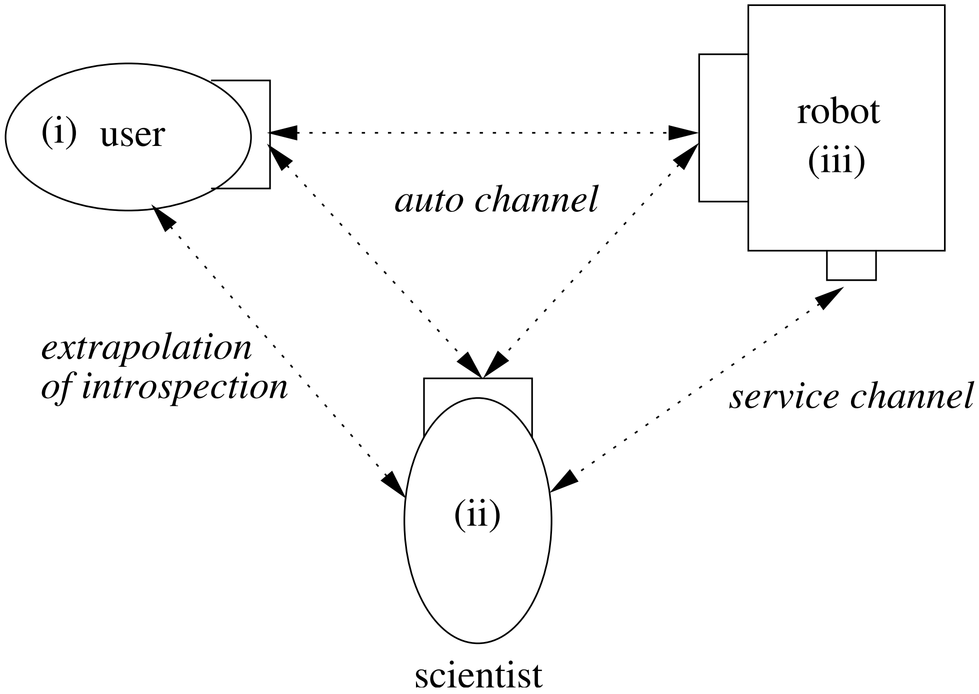
1.4.3 Interaction between user, robot, and scientist



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1.5 Equivalence Principles for Interfaces and for Input/Output

The methodological principles of Database Semantics presented so far, namely

1. the *Verification Principle*
   i.e. the development of the theory in the form of a declarative specification which is continuously verified by means of an implemented prototype (cf. Section 1.2),
2. the *Equation Principle*
   i.e. the equating of theoretical correctness with the behavioral adequacy of the prototype during longterm up-scaling (cf. Section 1.3), and
3. the *Objectivation Principle*
   i.e. the establishing of objective channels for observing language communication between natural and artificial agents (cf. Section 1.4),

are constrained by

4. the *Interface Equivalence Principle* and
5. the *Input/Output Equivalence Principle.*

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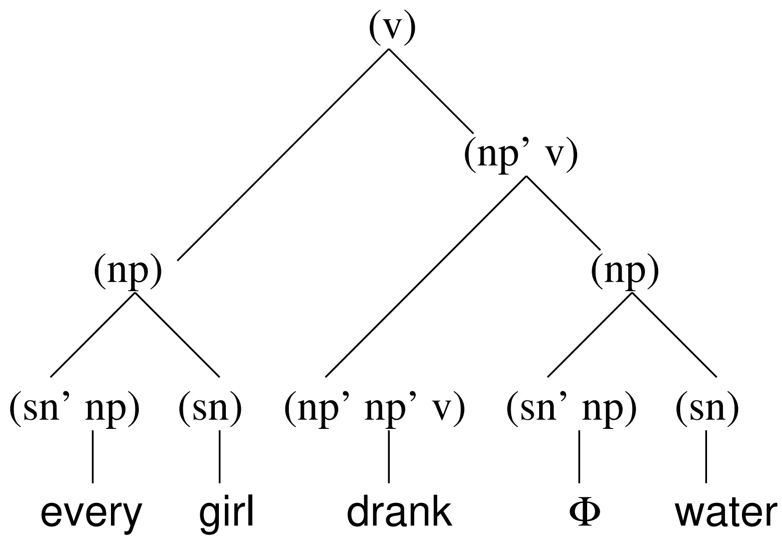
1.6 Surface Compositionality and Time-Linearity

1.6.1 Surface Compositionality

A grammatical analysis is surface compositional if it uses only the concrete word forms as the building blocks of composition, such that all syntactic and semantic properties of a complex expression derive systematically from the syntactic category and the literal meaning of the lexical items.

1.6.2 Analysis violating Surface Compositionality



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1.6.3 The categories of 1.6.2

(sn' np)	= *determiner*, takes a singular noun sn' and makes a noun phrase np.
(sn)	= *singular noun*, fills a valency position sn' in the determiner.
(np' np' v)	= *transitive verb*, takes a noun phrase np and makes a (np' v).
(np)	= *noun phrase*, fills a valency position np' in the verb.
(np' v)	= *intransitive verb*, takes a noun phrase np and makes a (v).
(v)	= *verb* with no open valency positions (sentence).

1.6.4 Rules computing possible substitutions for deriving 1.6.2

(v)	$\longrightarrow$ (np) (np' v)
(np)	$\longrightarrow$ (sn' np) (sn)
(np' v)	$\longrightarrow$ (np' np' v) (np)
(sn' np)	$\longrightarrow$ every, Φ
(sn)	$\longrightarrow$ girl, water
(np' np' v)	$\longrightarrow$ drank

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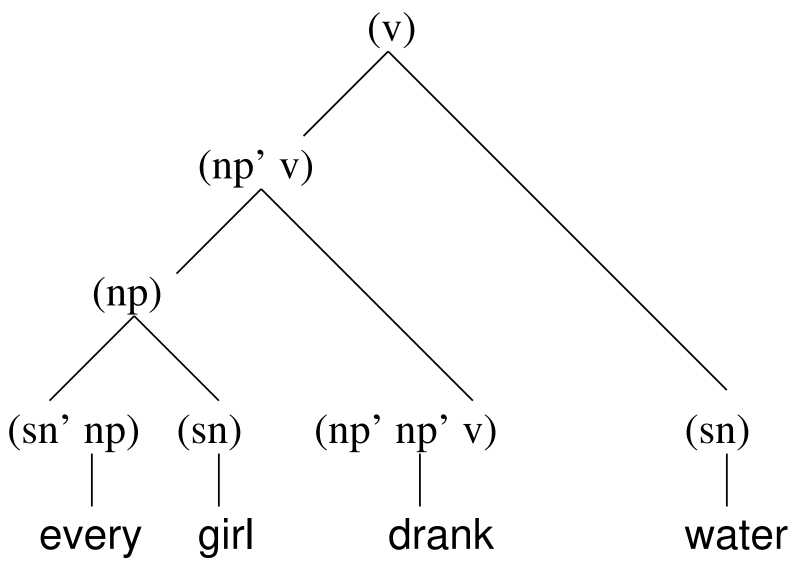
1.6.5 Satisfying Surface Compositionality and Time-Linearity



1.6.6 Rules computing the possible continuations for deriving 1.6.5

(VAR' X) (VAR) $\longrightarrow$ (X)
(VAR) (VAR' X) $\longrightarrow$ (X)

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1.6.7 Application of a rule computing a possible continuation

	ss		*nw*		*ss'*	
rule patterns	(VAR'	X)	(VAR)	$\rightarrow$	(X)	
						matching and binding
categories	(sn'	np)	(sn)		(np)	
surfaces	every		girl		every girl	

1.6.8 Variable definition of the time-linear rules for deriving 1.6.5

If VAR' is sn', then VAR is sn. (*identity-based agreement*)
If VAR' is np', then VAR is np, sn, or pn. (*definition-based agreement*)

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2. Interfaces and Components

2.1 Cognitive Agents with and without Language

2.1.1 Support for building the context component first

1. Constructs from the context-level may be re-used at the language level. This holds for (i) the concepts, as types and as token, (ii) the external interfaces for input and output, (iii) the data structure, (iv) the algorithm, and (v) the inferences.
2. The context is universal – in the sense of being independent of a particular language, yet all the different languages may be interpreted relative to the same kind of context component.
3. In phylogeny (evolution) and ontogeny (child development) the context component comes first.

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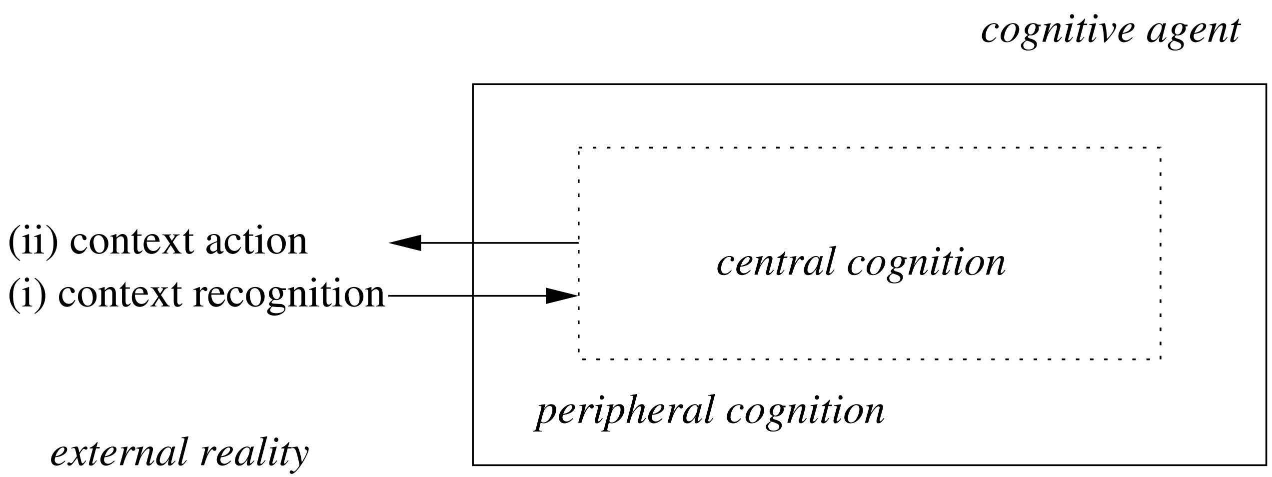
2.1.2 External interfaces of a cognitive agent without language



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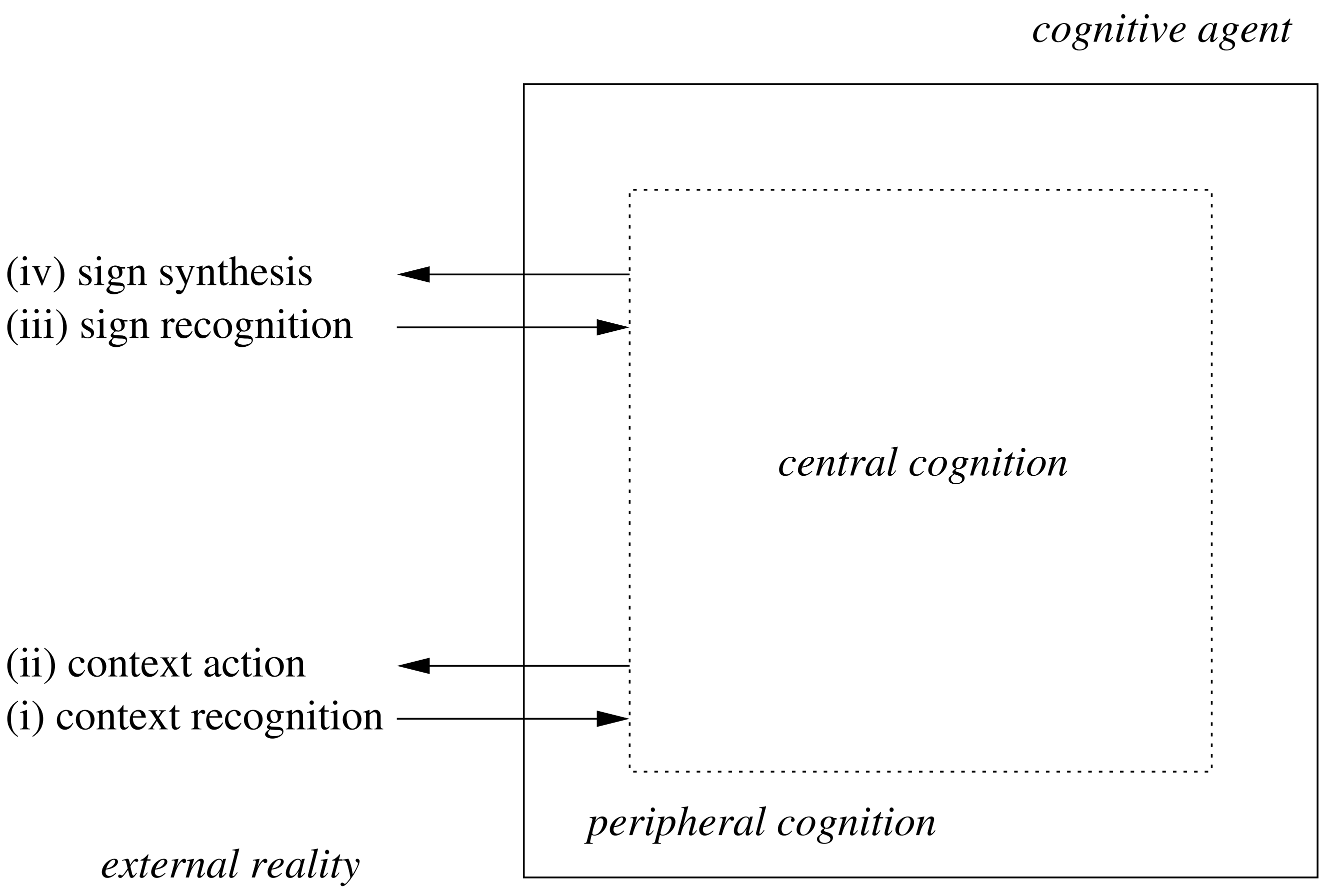
2.1.3 External Interfaces of a cognitive agent with language



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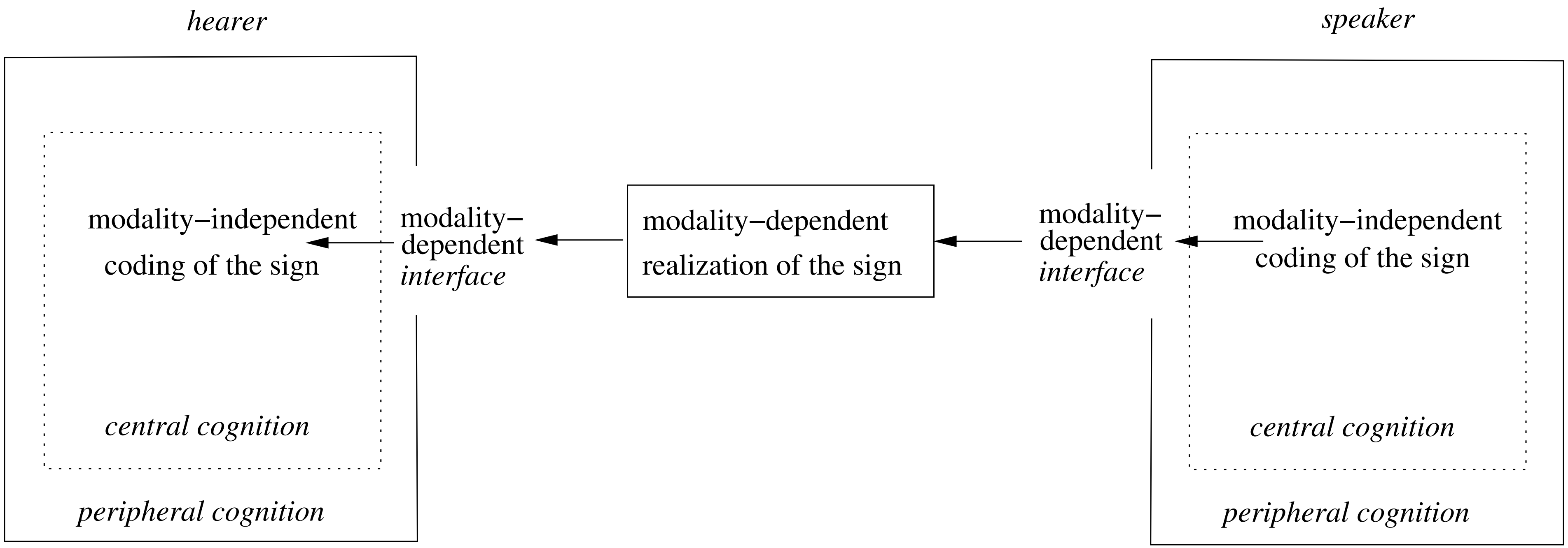
2.2 Modalities and Media

2.2.1 Modality-independent and modality-dependent coding



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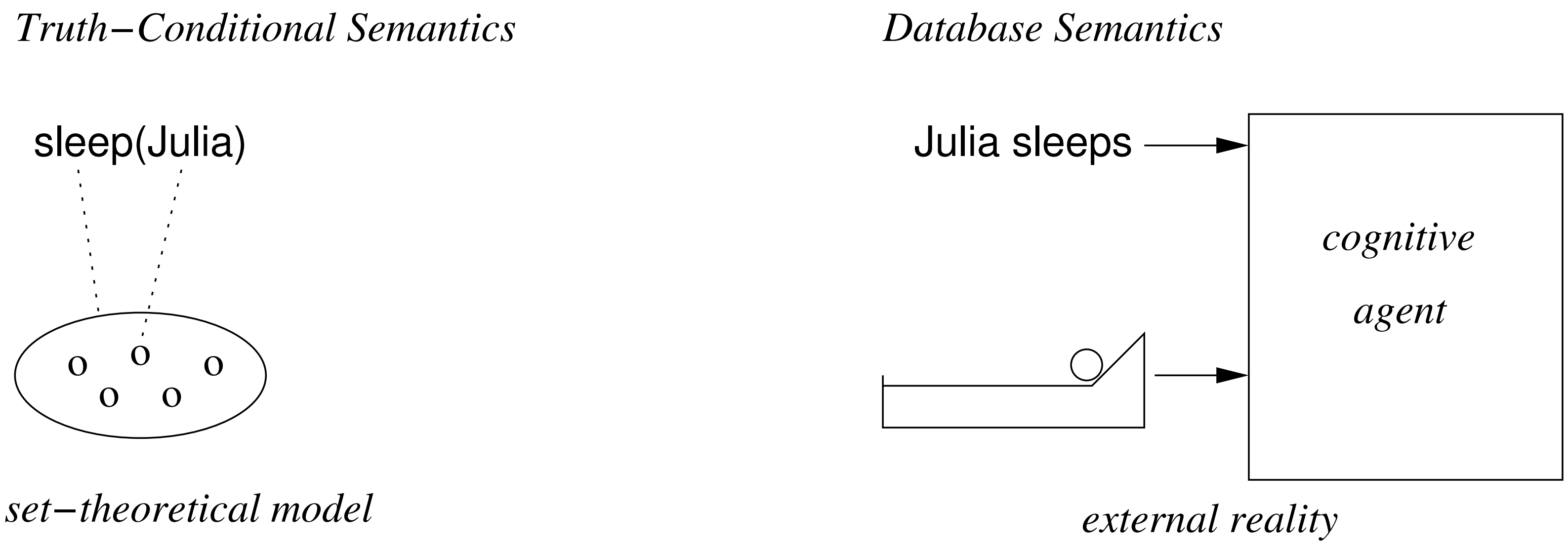
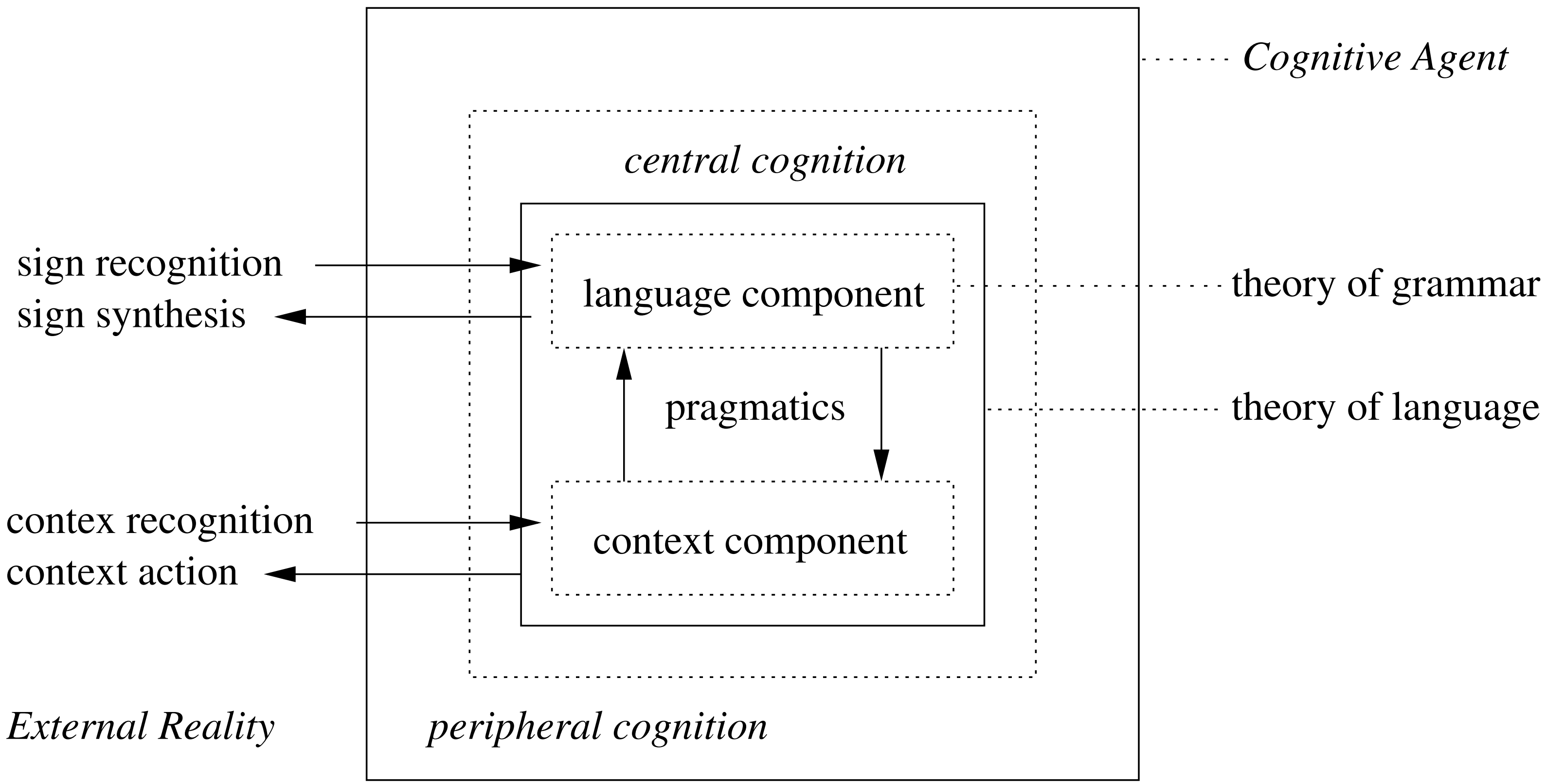
2.3 Alternative Ontologies for Referring with Language

2.3.1 Reference in alternative ontologies



2.4 Theory of Language and Theory of Grammar

2.4.1 STRUCTURING CENTRAL COGNITION IN AGENTS WITH LANGUAGE



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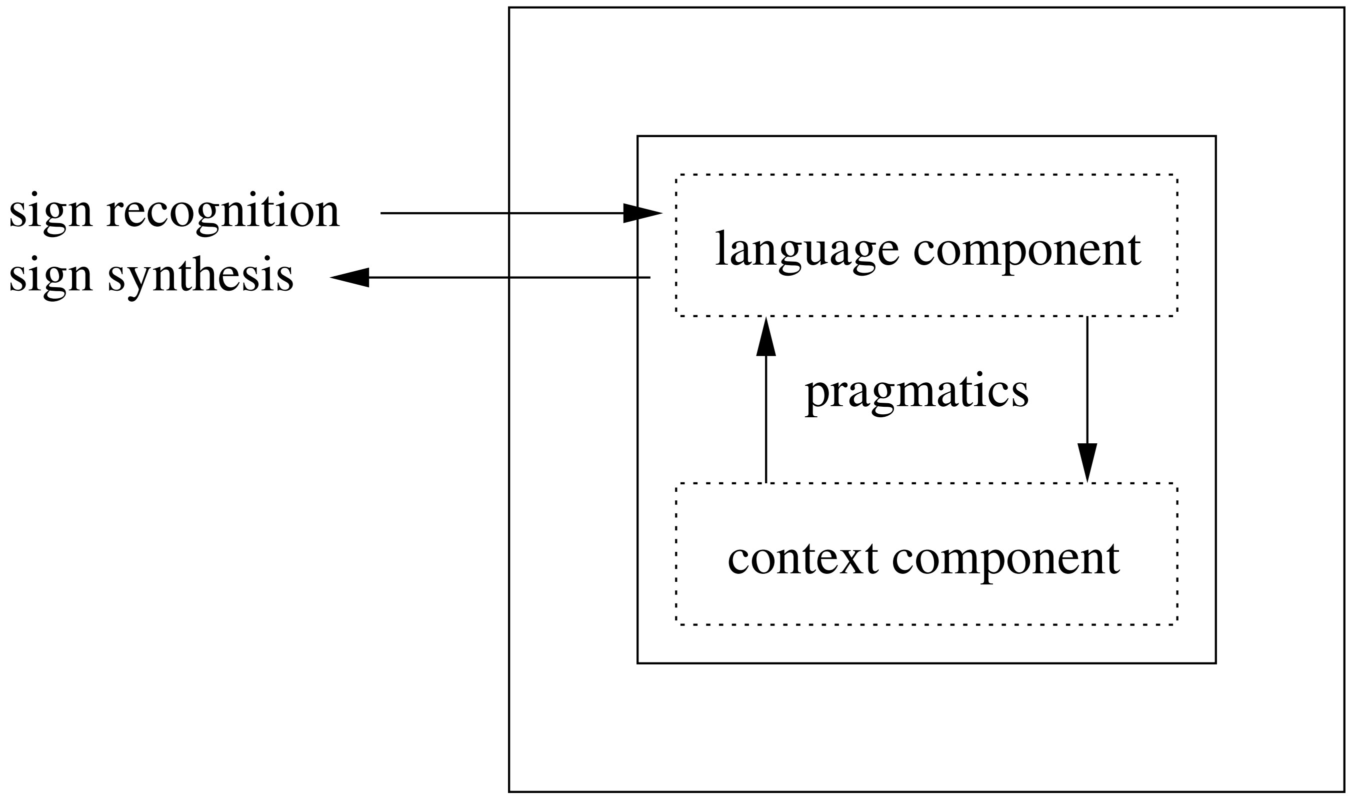
2.5 Immediate Reference and Mediated Reference

2.5.1 USE OF EXTERNAL INTERFACES IN MEDIATED REFERENCE



2.5.2 Disadvantages of not having contextual interfaces

1. *The conceptual core of language meanings remains undefined.*
   Most basic concepts originate in agents without language as recognition and action procedures of their contextual interfaces, and are re-used as the core of language meanings in agents with language.Therefore, agents with language but without contextual interfaces use meanings which are void of a conceptual core – though the relations between the concepts, represented by place holder words, may still be defined, both absolutely (for example in the *is-a* or *is-part-of* hierarchies) and episodically.

2. *The coherence or incoherence of content cannot be judged autonomously.*
   The coherence of stored content originates in the coherence of the external world.Therefore, only agents with contextual interfaces are able to relate content 'imported' by means of language to the data of their own experience. An agent without contextual interfaces, in contrast, has nothing but imported data – which is why the responsibility for their coherence lies solely with the users who store the data in the agent.

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2.6 The SLIM Theory of Language

S = **S**urface Compositionality (methodological principle, cf. 1.6.1):

> Syntactic-semantic composition assembles only concrete word forms, excluding the use of zero-elements, identity mappings, or transformations.

L = time-**L**inearity (empirical principle, cf. 1.6.5):

> Interpretation and production of utterances are based on a strictly time-linear derivation order.

I = **I**nternal (ontological principle, cf. 2.3.1):

> Interpretation and production of utterances are analyzed as cognitive procedures located inside the speaker-hearer.

M = **M**atching (functional principle, cf. 3.2.3):

> Referring with language to past, current, or future objects and events is modeled in terms of pattern matching between language meanings and a context.

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2.6.1 First principle of pragmatics (PoP-1)

> The speaker's utterance meaning$_2$ is the use of the sign's literal meaning$_1$ relative to an internal context.

Meaning$_1$ is the *literal meaning* of the sign, meaning$_2$ is the *speaker meaning* of an utterance in which the sign's meaning$_1$ is used. Even in the hearer-mode, meaning$_2$ is called the 'speaker meaning' because communication is successful only if the hearer uses the sign's meaning$_1$ to refer to the same objects or events as the speaker.

A sign can only be used successfully if the context of interpretation has been determined (and delimited) correctly. Finding the context is based on the sign's STAR:

S = space (location where the sign has been uttered)
T = time (time when the sign has been uttered)
A = author (agent who produced the sign)
R = recipient (agent intended to receive the sign)

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2.6.2 Second principle of pragmatics (PoP-2)

A sign's STAR determines the *entry context* of production and interpretation in the contextual databases of the speaker and the hearer.

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2.6.3 Third principle of pragmatics (PoP-3)

The matching of signs with their respective sub-contexts is incremental, whereby in production the elementary signs follow the time-linear order of the underlying thought path, while in interpretation the thought path follows the time-linear order of the incoming elementary signs.

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2.6.4 Fourth principle of pragmatics (PoP-4)

The reference mechanism of a *symbol* is based on a meaning$_1$ which is defined as a concept type. Symbols refer from their place in a positioned sentence by matching their meaning$_1$ with corresponding concept tokens at the context level.

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2.6.5 Fifth principle of pragmatics (PoP-5)

The reference mechanism of an *indexical* is based on a meaning$_1$ which is defined as one of two characteristic pointers. The first points into the agent's context and is called the context pointer or C. The second points at the agent and is called the agent pointer or A.

2.6.6 Indexicals as nouns and adjectives with A and C pointers

noun A	*noun C*	*adj A*	*adj C*
I, we	you he, she, it this, they	here now	there then

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2.6.7 Sixth principle of pragmatics (PoP-6)

The reference mechanism of a *name* is based on a private marker which matches a corresponding marker contained in the cognitive representation of the object referred to.

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2.6.8 Seventh principle of pragmatics (PoP-7)

Symbols occur as verbs, adjectives, and nouns. *Indexicals* occur as adjectives and nouns. *Names* occur only as nouns.

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2.6.9 Relation between the kinds of sign and the parts of speech

name	Fido		
indexical	this	here	
symbol	dog	black	see
	noun	*adj.*	*verb*

2.6.10 Correlation of part of speech and kind of sign in sentences

	noun	verb	adjective
name	John		
symbol		slept	
symbol			in the kitchen
indexical	he		
symbol		slept	
indexical			there

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3. Data Structure and Algorithm

3.1 Proplets for Coding Propositional Content

3.1.1 CONTEXT PROPLETS REPRESENTING *dog barks. (I) run.*

sur:	sur:	sur:
noun: *dog*	verb: *bark*	verb: *run*
fnc: bark	arg: dog	arg: moi
prn: 22	nc: 23 run	pc: 22 bark
	prn: 22	prn: 23

3.1.2 CODING OF RELATIONS BETWEEN CONCEPTS VIA PROPLETS

context level:

sur:	sur:	sur:
noun: *dog*	verb: *bark*	verb: *run*
fnc: bark	arg: dog	arg: moi
prn: 22	nc: 23 run	pc: 22 bark
	prn: 22	prn: 23

3.2 Internal Matching between Language and Context Proplets

3.2.1 LANGUAGE PROPLETS REPRESENTING *dog barks. (I) run.*

$$\begin{bmatrix} \text{sur: Hund} \\ \text{noun: } \textit{dog} \\ \text{fnc: bark} \\ \text{prn: 122} \end{bmatrix} \begin{bmatrix} \text{sur: bellt} \\ \text{verb: } \textit{bark} \\ \text{arg: dog} \\ \text{nc: 123 run} \\ \text{prn: 122} \end{bmatrix} \begin{bmatrix} \text{sur: fliehe} \\ \text{verb: } \textit{run} \\ \text{arg: moi} \\ \text{pc: 122 bark} \\ \text{prn: 123} \end{bmatrix}$$

3.2.2 KEYS FOR LEXICAL LOOKUP IN THE SPEAKER- AND THE HEARER-MODE

$$\begin{bmatrix} \text{sur: Hund} \\ \text{noun: dog} \\ \text{fnc:} \\ \text{prn} \end{bmatrix} \begin{array}{l} \leftarrow \textit{key for lexical lookup in the hearer-mode} \\ \leftarrow \textit{key for lexical lookup in the speaker-mode} \\ \\ \\ \end{array}$$

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3.2.3 Conditions on successful matching

1. *Attribute condition*
   The matching between two proplets A and B requires that the intersection of their attributes contains a predefined list of attributes regarded as relevant:

   $$\{\text{list}\} \subseteq \{\{\text{proplet-A-attributes}\} \cap \{\text{proplet-B-attributes}\}\}$$

2. *Value condition*
   The matching between two proplets requires that the variables (and a fortiori the constants) of their common attributes are compatible.

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3.2.4 IMPACT OF INTER-PROPLET RELATIONS ON MATCHING

language level: *(horizontal relations)*	sur: Hund noun: *dog* fnc: bark prn: 122	sur: bellt verb: *bark* arg: dog nc: 123 run prn: 122	sur: fliehe verb: *run* arg: moi pc: 122 bark prn: 123
	internal	*matching*	*(vertical relations)*
context level: *(horizontal relations)*	sur: noun: *dog* fnc: bark prn: 22	sur: verb: *bark* arg: dog nc: 23 run prn: 22	sur: verb: *run* arg: moi pc: 22 bark prn: 23

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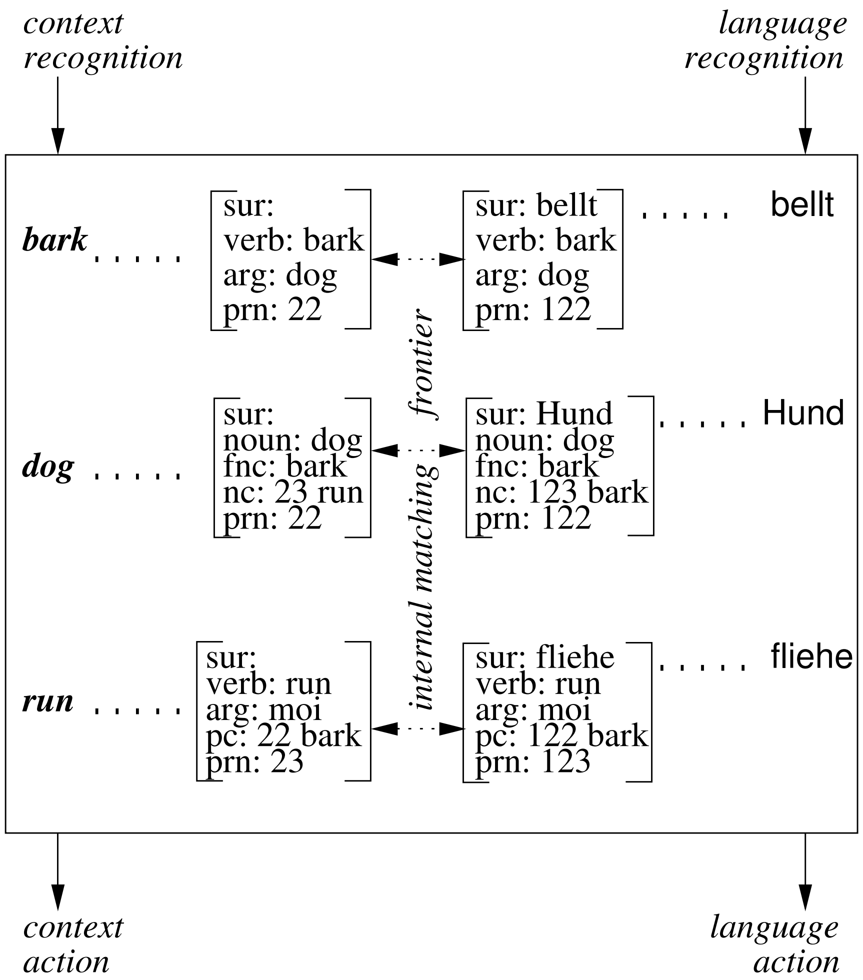
3.3 Storage of Proplets in a Word Bank

3.3.1 DATA STRUCTURE OF A WORD BANK



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3.4 Time-linear Algorithm of LA-Grammar

3.4.1 Applying the Input/Output Equivalence Principle to language

1. Input and output at the language level are signs of natural language, such as phrases, sentences, or texts.
2. The parts into which the signs of natural language disassemble during intake and discharge are word forms.
3. The order of the parts during intake and discharge is time-linear.

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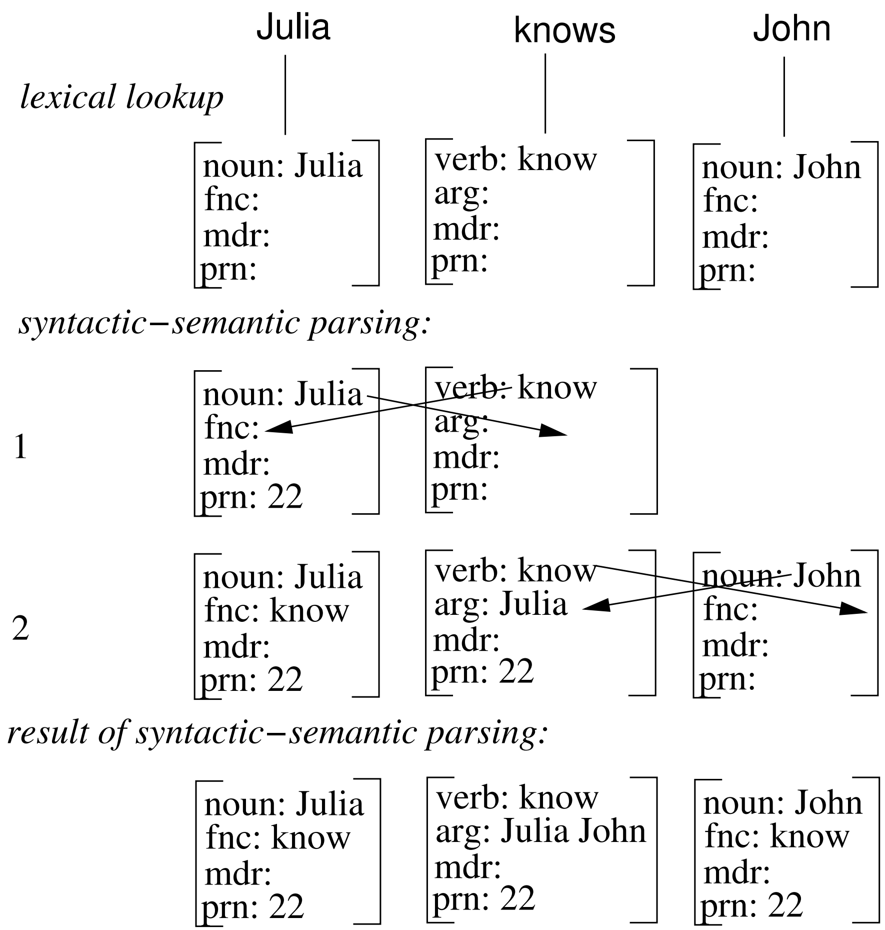
3.4.2 TIME-LINEAR DERIVATION (PRINCIPLE OF POSSIBLE CONTINUATIONS)



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3.4.3 Example of an **LA-hear** rule application

	rule name	*ss pattern*	*nw pattern*	*operations*	*rule package*
rule level	NOM+FV:	$\begin{bmatrix}\text{noun: } \alpha \\ \text{fnc:}\end{bmatrix}$	$\begin{bmatrix}\text{verb: } \beta \\ \text{arg:}\end{bmatrix}$	copy α nw.arg copy β ss.fnc	{FV+OBJ, ...}
proplet level		$\begin{bmatrix}\text{noun: Julia} \\ \text{fnc:} \\ \text{mdr:} \\ \text{prn: 22}\end{bmatrix}$	$\begin{bmatrix}\text{verb: know} \\ \text{arg:} \\ \text{mdr:} \\ \text{prn:}\end{bmatrix}$		

3.4.4 Result of the **LA-hear** rule application

$$\begin{bmatrix}\text{noun: Julia} \\ \text{fnc: know} \\ \text{mdr:} \\ \text{prn: 22}\end{bmatrix} \quad \begin{bmatrix}\text{verb: know} \\ \text{arg: Julia} \\ \text{mdr:} \\ \text{prn: 22}\end{bmatrix}$$

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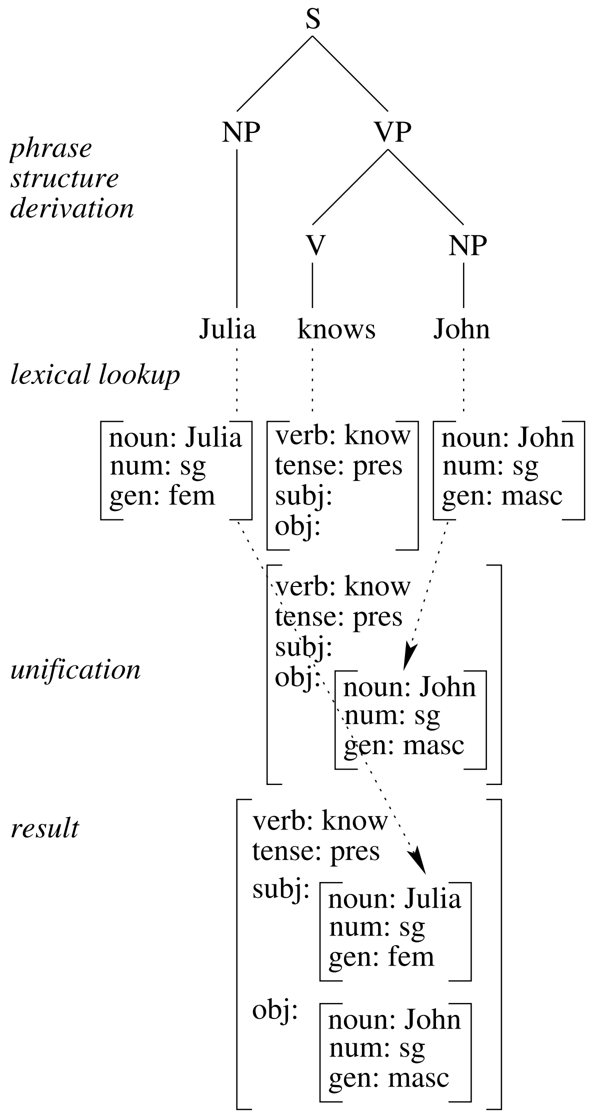
3.4.5 Non-time-linear Derivation (Principle of Poss. Substitutions)



3.5 Cycle of Natural Language Communication

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3.5.1 EXAMPLE OF AN **LA-think** RULE APPLICATION

$$
\begin{array}{llllll}
 & \textit{rule name} & \textit{ss pattern} & \textit{nw pattern} & \textit{operations} & \textit{rule package} \\
\textit{rule level} & \text{V\_N\_V:} & \begin{bmatrix} \text{verb: } \beta \\ \text{arg: X } \alpha \text{ Y} \\ \text{prn: k} \end{bmatrix} & \begin{bmatrix} \text{noun: } \alpha \\ \text{fnc: } \beta \\ \text{prn: k} \end{bmatrix} & \begin{array}{l} \text{output position ss} \\ \text{mark } \alpha \text{ ss} \end{array} & \{\text{V\_N\_V, ...}\} \\
 & & & & & \\
\textit{proplet level} & & \begin{bmatrix} \text{verb: know} \\ \text{arg: Julia John} \\ \text{mdr:} \\ \text{prn: 22} \end{bmatrix} & & &
\end{array}
$$

3.5.2 RESULT OF THE **LA-think** RULE APPLICATION

$$
\begin{bmatrix} \text{verb: know} \\ \text{arg: !Julia John} \\ \text{mdr:} \\ \text{prn: 22} \end{bmatrix}
\begin{bmatrix} \text{noun: Julia} \\ \text{fnc: know} \\ \text{mdr:} \\ \text{prn: 22} \end{bmatrix}
$$

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3.5.3 SCHEMATIC PRODUCTION OF Julia knows John.

	activated sequence			*realization*
i				
	V			
i.1		n		n
	V	N		
i.2	fv	n		n fv
	V	N		
i.3	fv	n	n	n fv n
	V	N	N	
i.4	fv p	n	n	n fv n p
	V	N	N	

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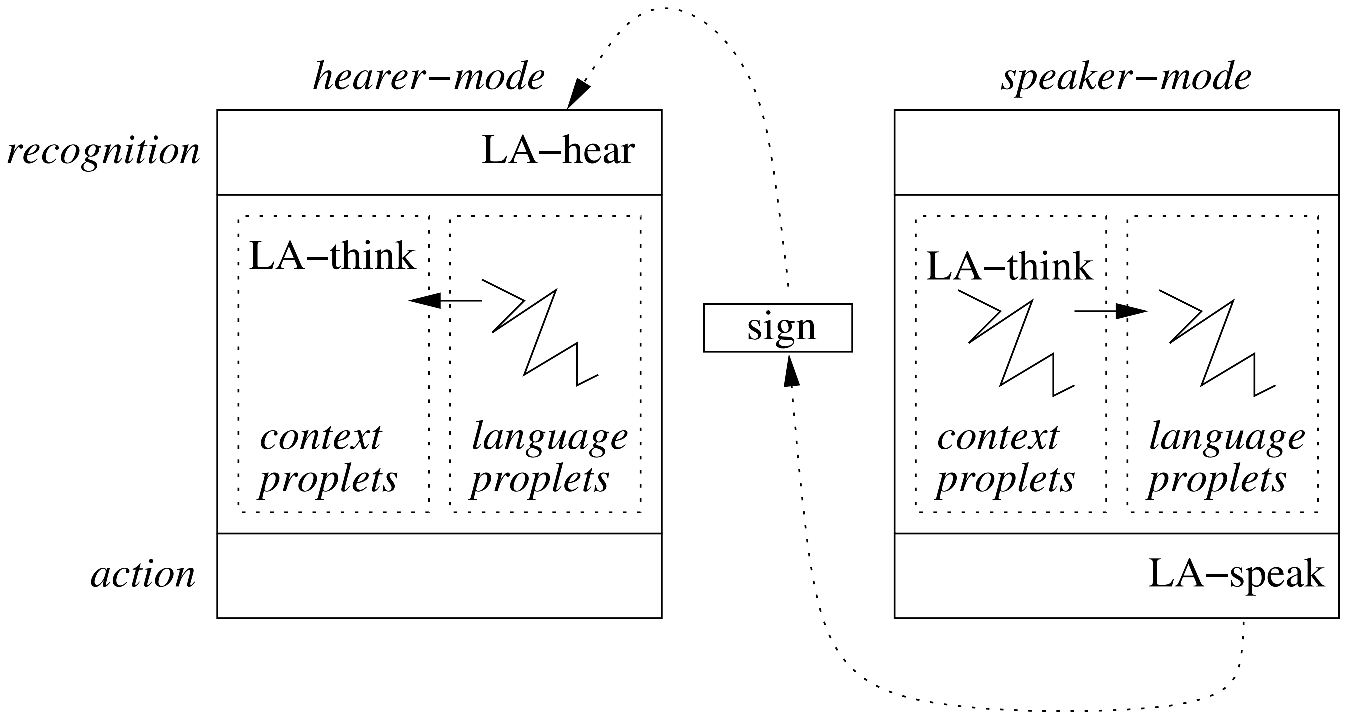
3.5.4 The cycle of natural language communication



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3.6 A Bare Bone Example of Database Semantics: DBS-letter

3.6.1 Isolated proplets representing the letters A, E, L, O, S, V

$$\begin{bmatrix}\text{lett: A}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix} \begin{bmatrix}\text{lett: E}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix} \begin{bmatrix}\text{lett: L}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix} \begin{bmatrix}\text{lett: O}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix} \begin{bmatrix}\text{lett: S}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix} \begin{bmatrix}\text{lett: V}\\ \text{prev:}\\ \text{next:}\\ \text{wrd:}\end{bmatrix}$$

3.6.2 DEFINITION OF **LA-letter-IN** FOR CONNECTING ISOLATED PROPLETS

ST_S = {(lett: α, {r-in})}

$$\text{r-in:} \quad \begin{bmatrix}\text{lett: } \alpha\\ \text{prev:}\\ \text{next:}\end{bmatrix} \begin{bmatrix}\text{lett: } \beta\\ \text{prev:}\\ \text{next:}\end{bmatrix} \quad \begin{matrix}\text{copy } \alpha \text{ nw.prev}\\ \text{copy } \beta \text{ ss.next}\end{matrix} \qquad \{\text{r-in}\}$$

ST_F = {(lett: β, rp_{r-in}) }

3.6.3 Example of an LA-letter-IN rule application

	rule name	*ss pattern*	*nw pattern*	*operations*	*rule package*
rule level	r-in:	$\begin{bmatrix}\text{lett: }\alpha\\ \text{prev: }\\ \text{next: }\end{bmatrix}$	$\begin{bmatrix}\text{lett: }\beta\\ \text{prev: }\\ \text{next: }\end{bmatrix}$	copy α nw.prev copy β ss.next	{r-in}
proplet level		$\begin{bmatrix}\text{lett: L}\\ \text{prev: }\\ \text{next: }\\ \text{wrd: }\end{bmatrix}$	$\begin{bmatrix}\text{lett: O}\\ \text{prev: }\\ \text{next: }\\ \text{wrd: }\end{bmatrix}$		

3.6.4 Result of the rule application 3.6.3

$$\begin{bmatrix}\text{lett: L}\\ \text{prev: }\\ \text{next: O}\\ \text{wrd: 1}\end{bmatrix} \begin{bmatrix}\text{lett: O}\\ \text{prev: L}\\ \text{next: }\\ \text{wrd: 1}\end{bmatrix}$$

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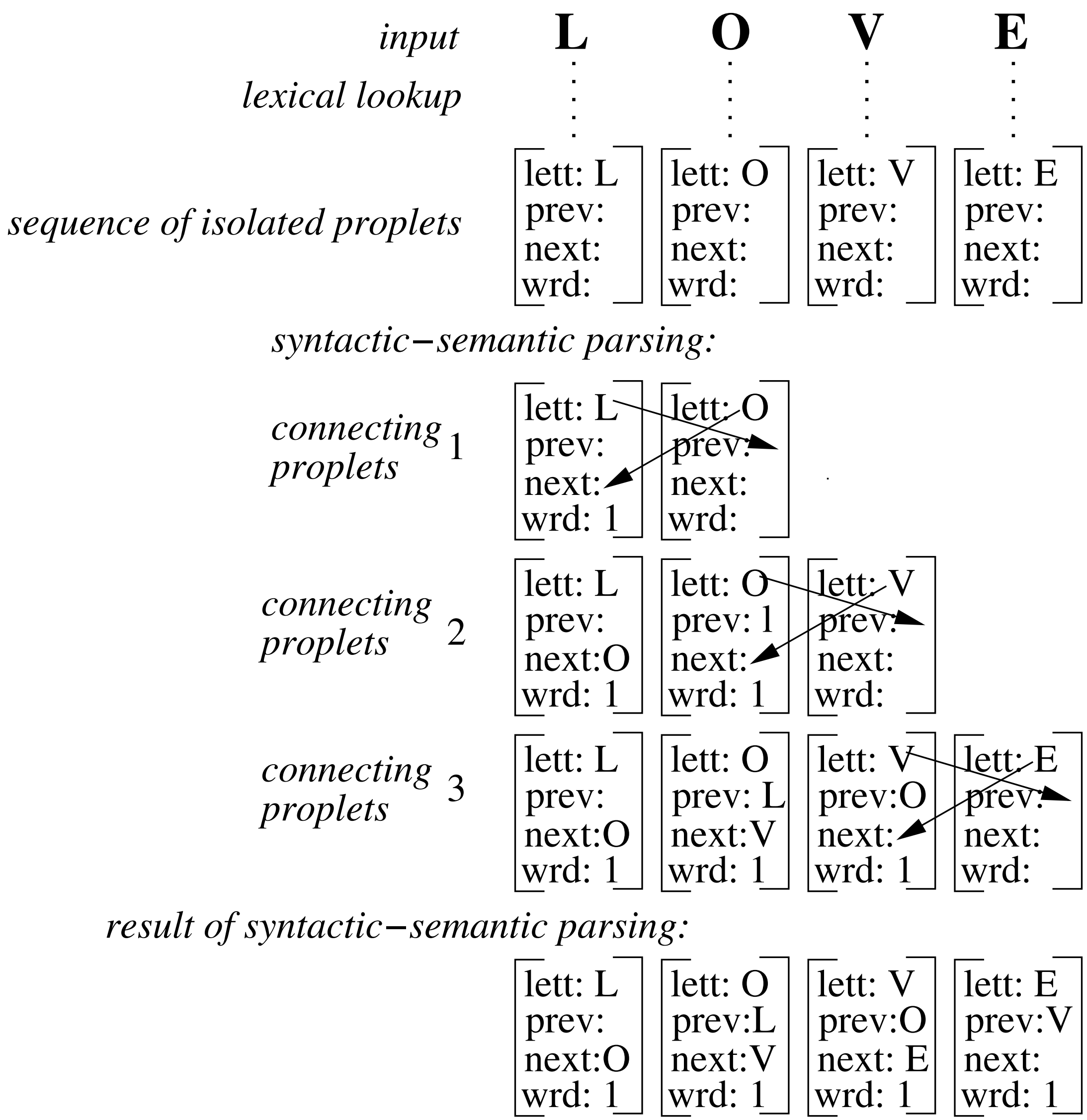
3.6.5 Time-linear derivation connecting the letters of love



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3.6.6 Proplets for LOVE, LOSS, and ALSO in a Word Bank

owner records	*member records*		
$\left[\text{lett: A}\right]$			$\left[\begin{array}{l}\text{lett: A}\\ \text{prev:}\\ \text{next: L}\\ \text{wrd: 3}\end{array}\right]$
$\left[\text{lett:E}\right]$	$\left[\begin{array}{l}\text{lett: E}\\ \text{prev: V}\\ \text{next:}\\ \text{wrd: 1}\end{array}\right]$		
$\left[\text{lett:L}\right]$	$\left[\begin{array}{l}\text{lett: L}\\ \text{prev:}\\ \text{next: O}\\ \text{wrd: 1}\end{array}\right]$	$\left[\begin{array}{l}\text{lett: L}\\ \text{prev:}\\ \text{next: O}\\ \text{wrd: 2}\end{array}\right]$	$\left[\begin{array}{l}\text{lett: L}\\ \text{prev: A}\\ \text{next: S}\\ \text{wrd: 3}\end{array}\right]$

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owner records	*member records*			
[lett: O]	[lett: O prev: L next: V wrd: 1]	[lett: O prev: L next: S wrd: 2]		[lett: O prev: S next: wrd: 3]
[lett: S]		[lett: S prev: O next: S wrd: 2]	[lett: S prev: S next: wrd: 2]	[lett: S prev: L next: O wrd: 3]
[lett: V]	[lett: V prev: O next: E wrd: 1]			

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3.6.7 Definition of **LA-letter-OUT** for traversing connected proplets

ST_S = {(lett: α, { r-out})}

$$\text{r-out:} \begin{bmatrix}\text{lett: } \alpha \\ \text{next: } \beta \\ \text{wrd: k}\end{bmatrix} \begin{bmatrix}\text{lett: } \beta \\ \text{prev: } \alpha \\ \text{wrd: k}\end{bmatrix} \quad \text{output position nw} \quad \{\text{r-out}\}$$

ST_F = {(lett: β, rp$_{r-out}$) }

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3.6.8 Example of an **LA-letter-OUT** rule application

	rule name	*ss pattern*	*nw pattern*	*operations*	*rule package*
rule level	r-out:	$\begin{bmatrix}\text{lett: } \alpha \\ \text{next: } \beta \\ \text{wrn: k}\end{bmatrix}$	$\begin{bmatrix}\text{lett: } \beta \\ \text{prev: } \alpha \\ \text{wrn: k}\end{bmatrix}$	output position nw	{r-out}
proplet level		$\begin{bmatrix}\text{lett: L} \\ \text{prev: } \\ \text{next: O} \\ \text{wrn: 1}\end{bmatrix}$			

3.6.9 Result of the **LA-letter-OUT** rule application

$$\begin{bmatrix}\text{lett: L} \\ \text{prev: } \\ \text{next: O} \\ \text{wrn: 1}\end{bmatrix} \quad \begin{bmatrix}\text{lett: O} \\ \text{next: V} \\ \text{prev: L} \\ \text{wrn: 1}\end{bmatrix}$$

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3.6.10 Extensions needed for natural language communication

1. *Automatic word form recognition and production*
   Instead of LA-letter-IN recognizing only elementary letters like L or O, a full system must recognize complex word forms in different languages, and similarly for LA-letter-OUT and word form production.

2. *Separation of navigation and language realization*
   Instead of LA-letter-OUT treating the core values of proplets in the database and the surface items of the output as the same, a full system must handle the functions of navigation and language realization separately by means LA-think and LA-speak, respectively (cf. 3.5.4). This requires a distinction between the core and the surface attributes of proplets (cf. 3.2.2).

3. *Distinction between language and context data*
   The distinction between language and context requires a division of the Word Bank into a context and a language area (compare 3.6.6 and 3.3.1). Reference to the external world requires that the input-output component of the language level is complemented with an input-output component at the context level (compare 2.5.1 and 2.4.1).

4. *Extending the navigation into a control structure*
   Instead of LA-letter-OUT merely following the continuations coded into the proplets, a full system must extend the navigation into a method of inferencing. This requires a distinction between absolute propositionsand episodic propositions (cf. Section 5.2). After complementing the agent with a value structure, the inferencing must be extended into a control structure.

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4. Concept Types and Concept Tokens

4.1 Kinds of Proplets

4.1.1 Examples of the three main kinds of proplets

noun proplet	*verb proplet*	*adj proplet*
sur:	sur:	sur:
noun: book	verb: read	adj: blue
cat: sn	cat: decl	cat: adn
sem: def sg	sem: pres	sem:
mdr: blue	mdr:	mdr: B
fnc: buy	arg: John book	mdd: book 3
idy: 3	pc: 15 sit	idy: B
nc:	nc: 17 sleep	nc:
pc:	prn: 16	pc:
prn: 11		prn: 20

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4.1.2 Proplet attributes and their values

1. Surface attribute: sur
   All proplets have a surface attribute. If it has the value NIL, the proplet is a context proplet. In language proplets, it gets its non-NIL value from the lexicon.

2. Core attributes: noun, verb, adj
   The core attribute of a proplet gets its unique value from the lexicon. From a sign-theoretic point of view,the core values may be a *concept*, a *pointer*, or a *marker*, which corresponds to the sign kinds of *symbol, indexical* and *name*.

3. Grammatical attributes: cat, sem
   The grammatical attributes cat (category) and sem (semantics) get their initial values from the lexicon; they may be modified during the derivation.

4. Intra-propositional continuation attributes: fnc, arg, mdd, mdr
   The intra-propositional continuation attributes get their value(s) by copying during the time-linear composition of proplets (cf. 3.4.2). The values consist of characters (char), which represent the names of other proplets. In complete propositions, the values of fnc (functor), arg (argument), and mdd (modified) must be non-NIL (obligatory continuation attributes), while that of mdr (modifier) may be NIL (optional continuation attribute).

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5. Extra-propositional continuation attributes: nc, pc, idy
   The extra-propositional continuation attributes nc (next conjunct), pc (previous conjunct), and idy (identity) are used extra- and intra-propositionally. Their extra-propositional use is obligatory (in a text, at least one of these attributes must have a non-NIL value), while their intra-propositional use is optional. Like intra-propositional continuation attributes, they get their values by copying.

6. Book-keeping attribute: prn
   The book-keeping attribute prn (proposition number) gets its value from the control structure of the parser and consists of a number (integer). Additional book-keeping attributes are wrn (word number), and trc (transition counter), which serve in the implementation.

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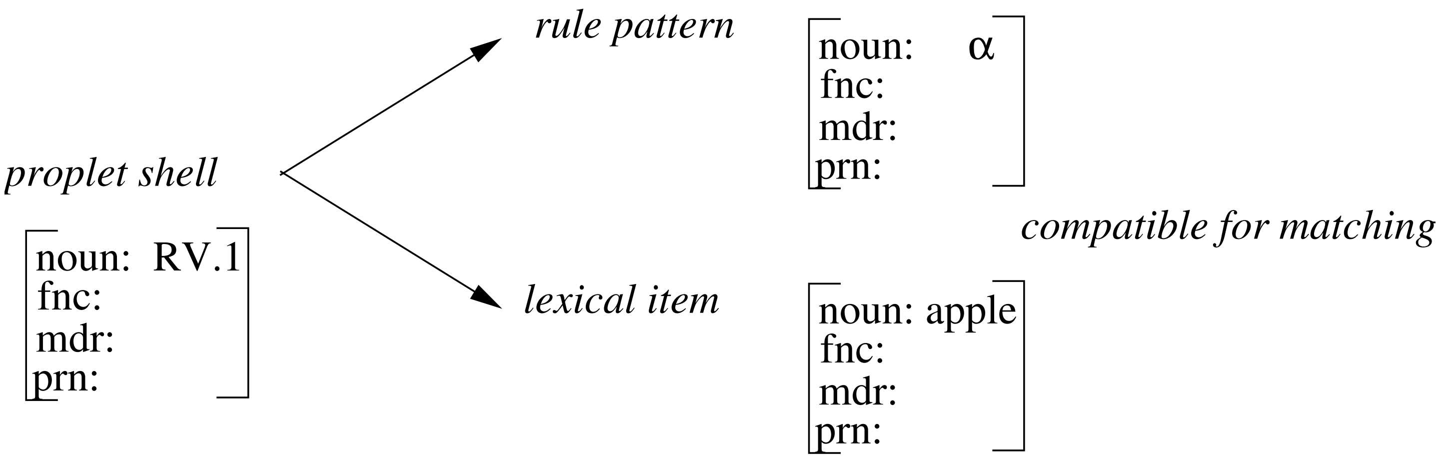
4.1.3 Substituting a replacement variable with a core value

semantic core	*proplet shell*	*lexical proplet*
apple	$\begin{bmatrix}\text{noun: RV.1}\\ \text{fnc:}\\ \text{mdr:}\\ \text{prn:}\end{bmatrix}$	$\begin{bmatrix}\text{noun: apple}\\ \text{fnc:}\\ \text{mdr:}\\ \text{prn:}\end{bmatrix}$

4.1.4 Relating proplet shells, lexical items, and rule patterns



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4.2 Type-Token Relation for Establishing Reference

4.2.1 Type and token of the concept *square*

$$\begin{array}{ll}
\textit{type} & \textit{token} \\
\begin{bmatrix}
\text{edge 1: } \alpha \\
\text{angle 1/2: } 90^o \\
\text{edge 2: } \alpha \\
\text{angle 2/3: } 90^o \\
\text{edge 3: } \alpha \\
\text{angle 3/4: } 90^o \\
\text{edge 4: } \alpha \\
\text{angle 4/1: } 90^o
\end{bmatrix}
&
\begin{bmatrix}
\text{edge 1: 2cm} \\
\text{angle 1/2: } 90^o \\
\text{edge 2: 2cm} \\
\text{angle 2/3: } 90^o \\
\text{edge 3: 2cm} \\
\text{angle 3/4: } 90^o \\
\text{edge 4: 2cm} \\
\text{angle 4/1: } 90^o
\end{bmatrix}
\end{array}$$

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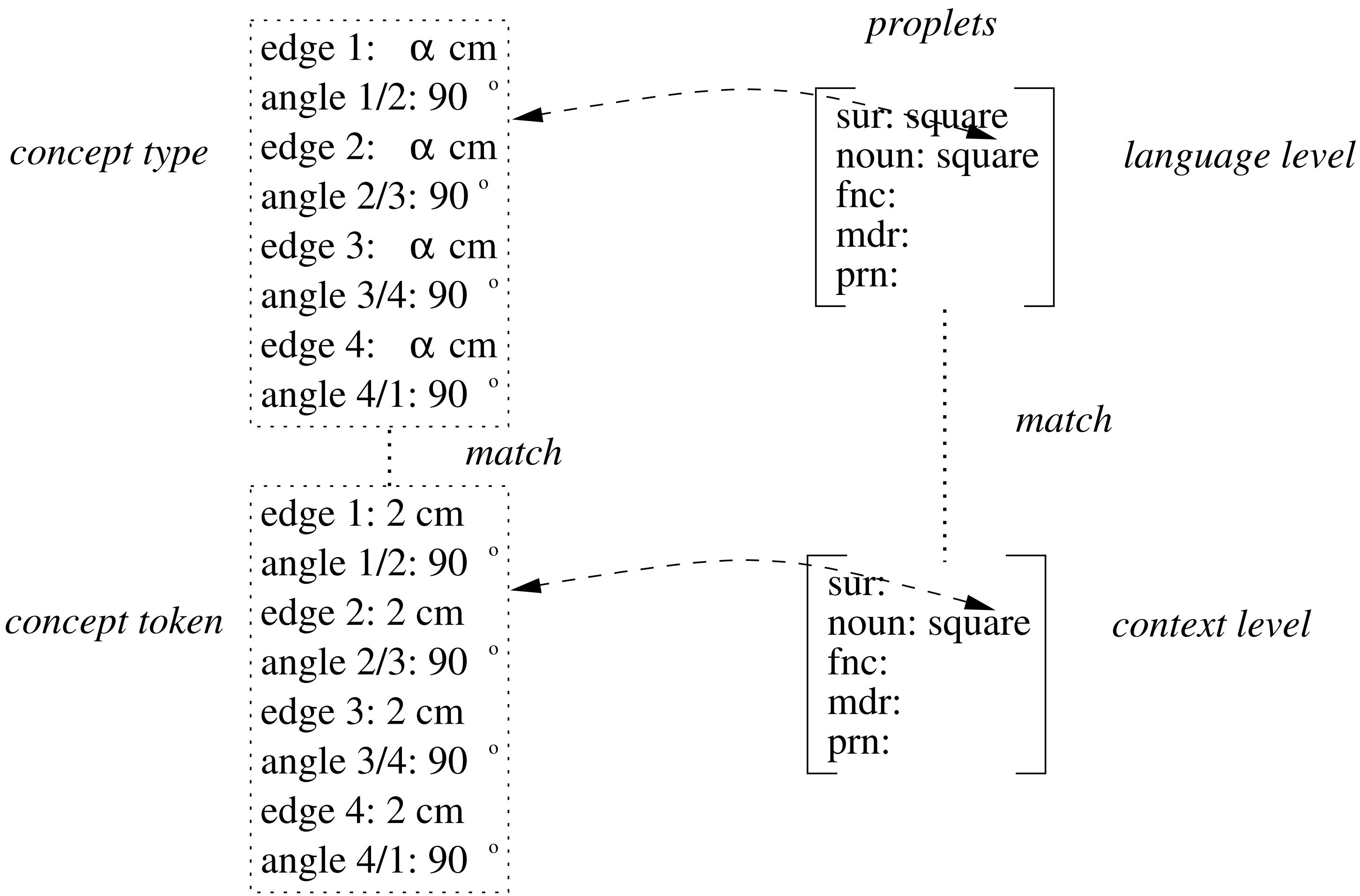
4.2.2 CONCEPTS AS VALUES OF THE CORE ATTRIBUTES



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4.2.3 Why the type-token relation is important

Type-token relations based on feature structures with variables and constants are easily computed. Procedures matching the concept type of a language proplet with the concept token of a context proplet enable the language proplet to refer in different utterance situations to different context proplets, including reference to items never encountered before.

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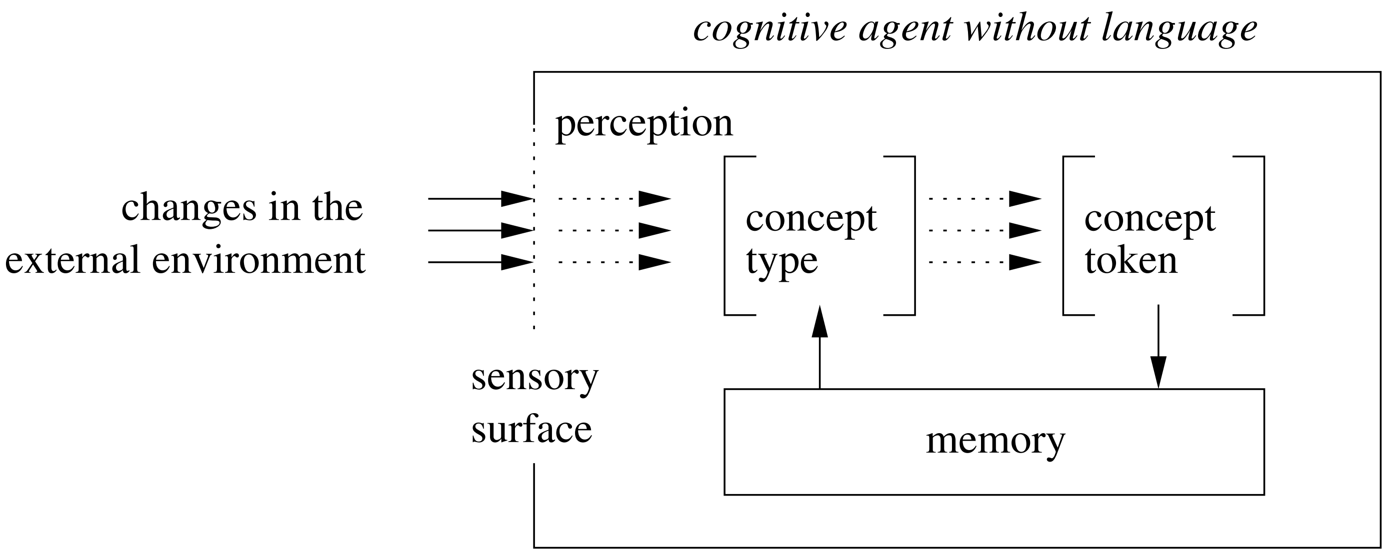
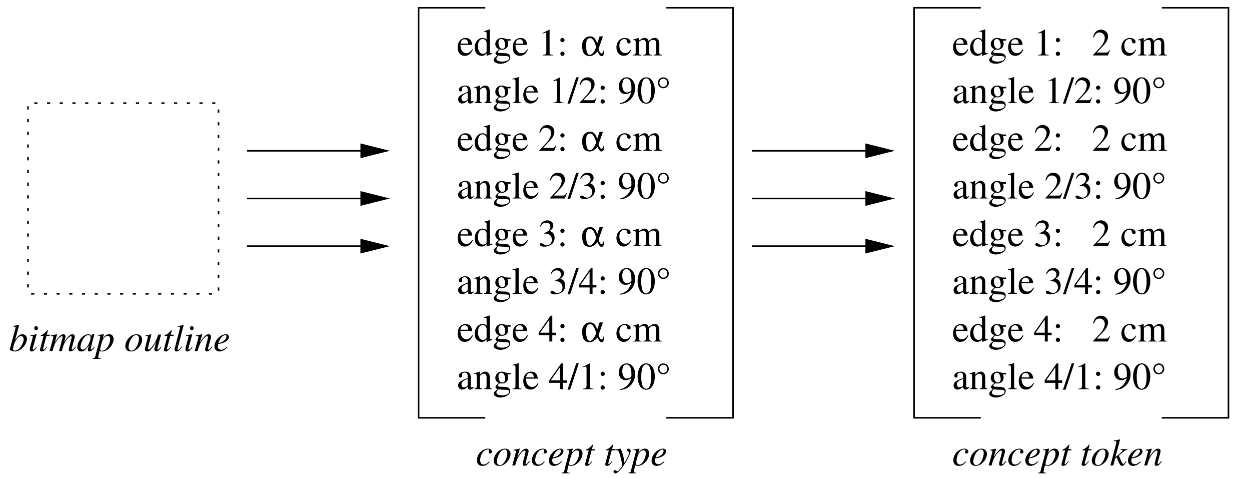
4.3 Context Recognition

4.3.1 Concept type and concept token in contextual recognition



4.3.2 CONCEPT TYPE AND CONCEPT TOKEN IN RECOGNIZING A SQUARE



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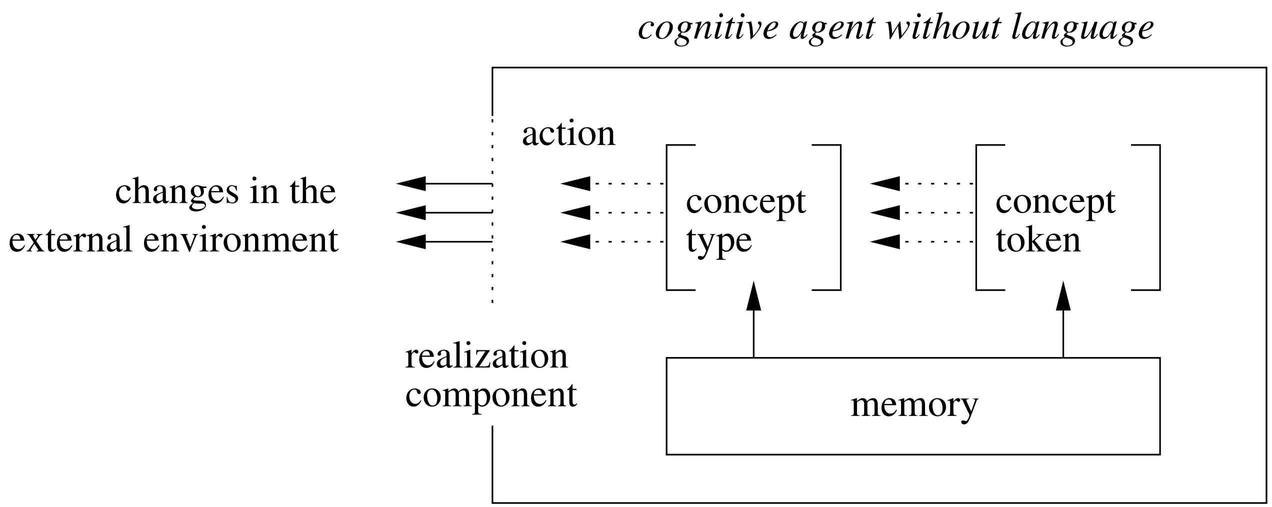
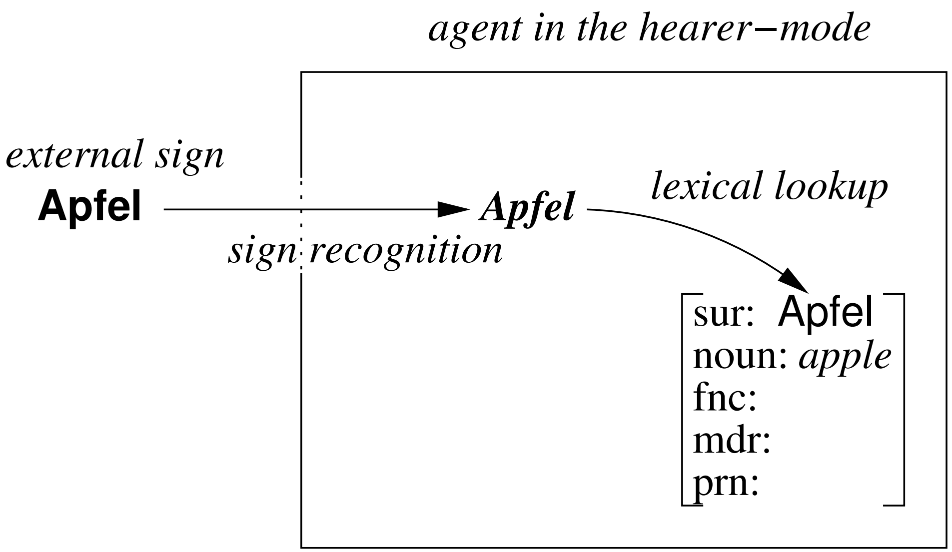
4.4 Context Action

4.4.1 CONCEPT TYPES AND CONCEPT TOKENS IN ACTION

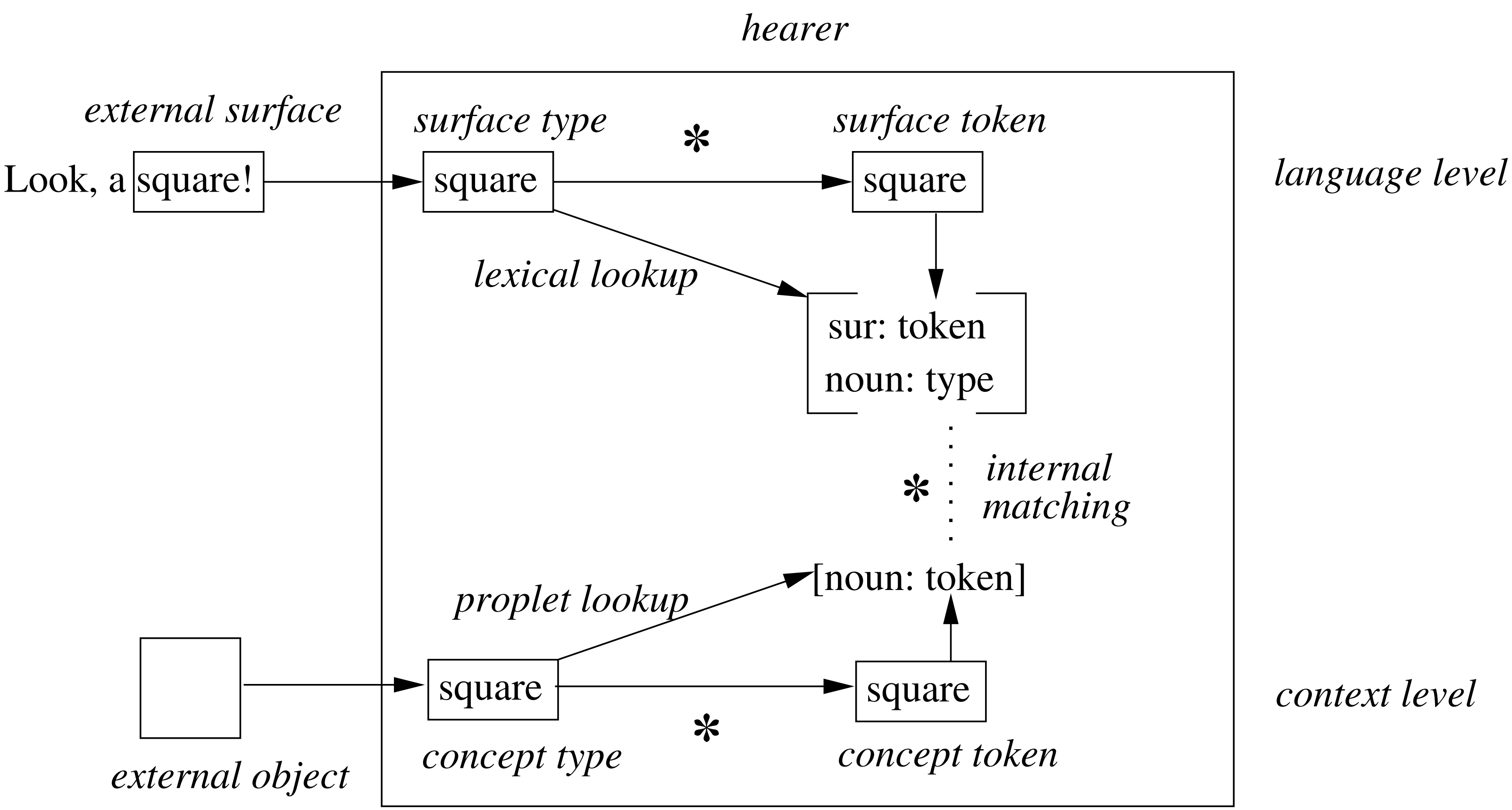


4.5 Sign Recognition and Production

4.5.1 LEXICAL LOOKUP OF GERMAN Apfel IN THE HEARER-MODE

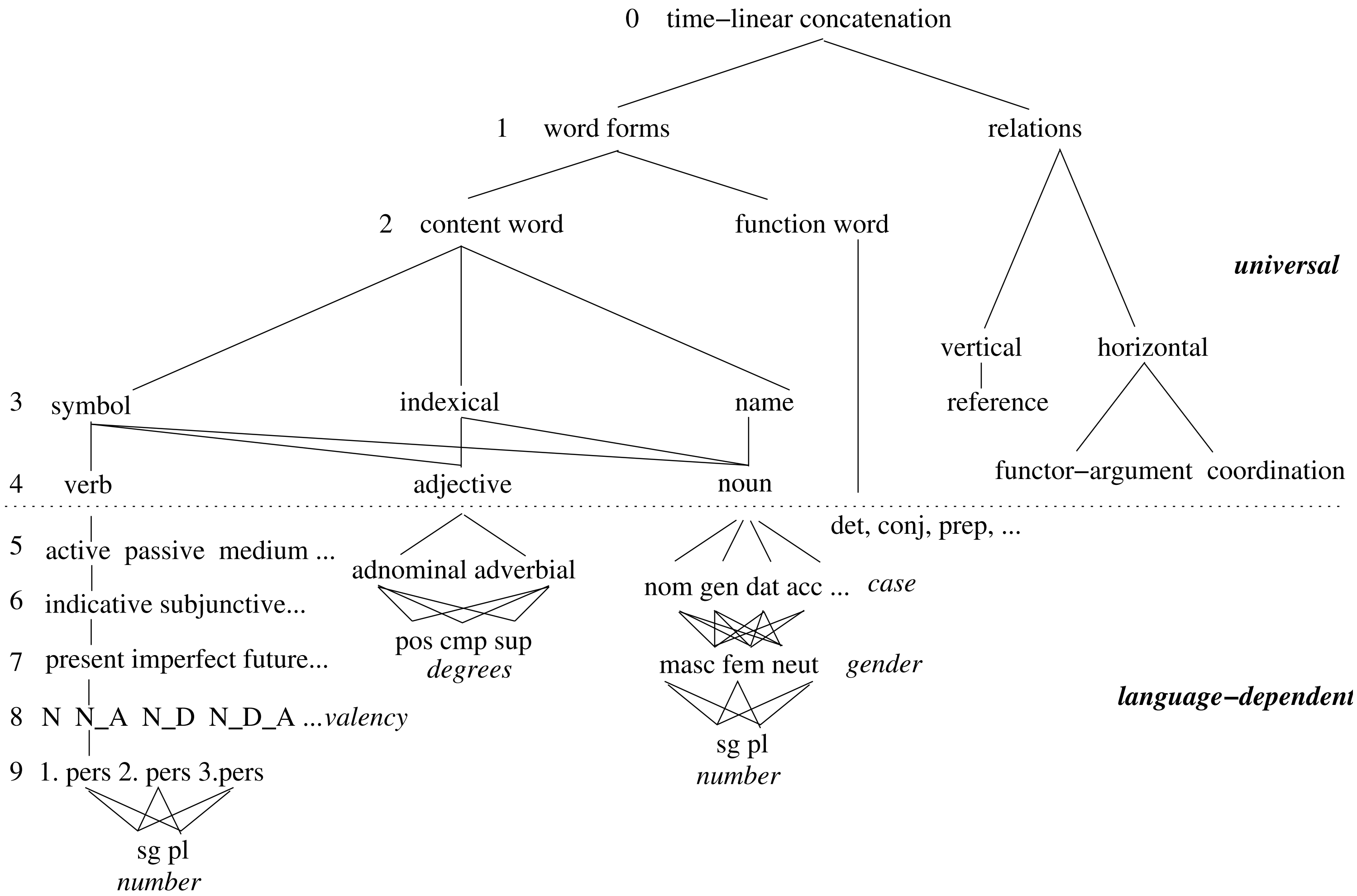


4.5.2 THREE TYPE-TOKEN RELATIONS IN THE CYCLE OF COMMUNICATION



4.6 Universal versus Language-Dependent Properties

4.6.1 Hierarchy of notions and distinctions in Database Semantics



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5. Forms of Thinking

5.1 Retrieving Answers to Questions

5.1.1 Example of a token line

$$
\begin{array}{ccccc}
\textit{owner record} & \textit{member records} & & & \\
\begin{bmatrix}\text{noun: } \textit{girl}\end{bmatrix} &
\begin{bmatrix}\text{noun: girl}\\ \text{fnc: walk}\\ \text{mdr: young}\\ \text{prn: 10}\end{bmatrix} &
\begin{bmatrix}\text{noun: girl}\\ \text{fnc: sleep}\\ \text{mdr: blond}\\ \text{prn: 12}\end{bmatrix} &
\begin{bmatrix}\text{noun: girl}\\ \text{fnc: eat}\\ \text{mdr: small}\\ \text{prn: 15}\end{bmatrix} &
\begin{bmatrix}\text{noun: girl}\\ \text{fnc: read}\\ \text{mdr: smart}\\ \text{prn: 19}\end{bmatrix}
\end{array}
$$

5.1.2 Definition of **LA-think.LINE**

$$\text{ST}_S\text{: } \{([\text{RA.1: } \alpha]\{1\ \text{r}_{forwd}\ 2\ \text{r}_{bckwd}\})\}$$

$$\text{r}_{forwd} \quad \begin{bmatrix}\text{RA.1: } \alpha\\ \text{prn: } n\end{bmatrix} \begin{bmatrix}\text{RA.1: } \alpha\\ \text{prn: } n{+}1\end{bmatrix} \quad \text{output position nw} \quad \{\text{r}_{forwd}\}$$

$$\text{r}_{bckwd} \quad \begin{bmatrix}\text{RA.1: } \alpha\\ \text{prn: } n\end{bmatrix} \begin{bmatrix}\text{RA.1: } \alpha\\ \text{prn: } n\text{-}1\end{bmatrix} \quad \text{output position nw} \quad \{\text{r}_{bckwd}\}$$

$$\text{ST}_F\text{: } \{([\text{RA.1: } \alpha]\ \text{rp}_{forwd}),\ ([\text{RA.1: } \alpha]\ \text{rp}_{bckwd})\}$$

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5.1.3 Example of an **LA-think.LINE** rule application

	rule name	*ss pattern*	*nw pattern*	*operations*	*rule package*
rule level	r_{forwd}:	$\begin{bmatrix}\text{RA.1: } \alpha \\ \text{prn: n}\end{bmatrix}$	$\begin{bmatrix}\text{RA.1: } \alpha \\ \text{prn: n+1}\end{bmatrix}$	output position nw	$\{\mathrm{r}_{forwd}\}$
proplet level		$\begin{bmatrix}\text{noun: girl} \\ \text{fnc: sleep} \\ \text{mdr: blonde} \\ \text{prn: 12}\end{bmatrix}$			

5.1.4 Result of the **LA-think.LINE** rule application

$$\begin{bmatrix}\text{noun: girl} \\ \text{fnc: sleep} \\ \text{mdr: blonde} \\ \text{prn: 12}\end{bmatrix} \begin{bmatrix}\text{noun: girl} \\ \text{fnc: eat} \\ \text{mdr: small} \\ \text{prn: 15}\end{bmatrix}$$

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5.1.5 Basic kinds of query in natural language

wh-question	*yes/no-question*
Which girl walked?	Did the young girl walk?

5.1.6 Search proplets illustrating the two basic types of questions

wh-question

$$\begin{bmatrix} \text{noun:}\,\textit{girl} \\ \text{fnc: walk} \\ \text{mdr: } \sigma \\ \text{prn: } n \end{bmatrix}$$

yes/no-question

$$\begin{bmatrix} \text{noun:}\,\textit{girl} \\ \text{fnc: walk} \\ \text{mdr: young} \\ \text{prn: } n \end{bmatrix}$$

5.1.7 wh-search pattern checking a token line

$$\begin{bmatrix} \text{noun:}\,\textit{girl} \\ \text{fnc: walk} \\ \text{mdr: } \sigma \\ \text{prn: n} \end{bmatrix} \quad \textit{search pattern}$$

matching?

$$\begin{bmatrix} \text{noun: } \textit{girl} \end{bmatrix} \begin{bmatrix} \text{noun: girl} \\ \text{fnc: walk} \\ \text{mdr: young} \\ \text{prn: 10} \end{bmatrix} \begin{bmatrix} \text{noun: girl} \\ \text{fnc: sleep} \\ \text{mdr: blonde} \\ \text{prn: 12} \end{bmatrix} \begin{bmatrix} \text{noun: girl} \\ \text{fnc: eat} \\ \text{mdr: small} \\ \text{prn: 15} \end{bmatrix} \begin{bmatrix} \text{noun: girl} \\ \text{fnc: read} \\ \text{mdr: smart} \\ \text{prn: 19} \end{bmatrix} \quad \textit{token line}$$

5.1.8 Definition of LA-think.Q1 (*wh-question*)

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$$\text{ST}_S\text{: }\{(\begin{bmatrix}\text{noun: RV.1}\\ \neg\text{ fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\end{bmatrix}\{\text{r}_1, \text{r}_2\}), (\begin{bmatrix}\text{noun: RV.1}\\ \text{fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\end{bmatrix}\{\ \}) \}$$

$$\text{r}_1\text{: } \begin{bmatrix}\text{noun: RV.1}\\ \neg\text{ fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\end{bmatrix} \begin{bmatrix}\text{noun: RV.1}\\ \neg\text{ fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\text{-}1\end{bmatrix} \text{ output position nw } \{\text{r}_1\ \text{r}_2\}$$

$$\text{r}_2\text{: } \begin{bmatrix}\text{noun: RV.1}\\ \neg\text{ fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\end{bmatrix} \begin{bmatrix}\text{noun: RV.1}\\ \text{fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\text{-}1\end{bmatrix} \text{ output position nw } \{\ \}$$

$$\text{ST}_F\text{: }\{(\begin{bmatrix}\text{noun: RV.1}\\ \neg\text{ fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\text{-}1\end{bmatrix}\text{rp}_1), (\begin{bmatrix}\text{noun: RV.1}\\ \text{fnc: RV.2}\\ \text{mdr: }\sigma\\ \text{prn: }n\text{-}1\end{bmatrix}\text{rp}_2) \}$$

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5.1.9 DEFINITION OF **LA-think.Q2** (*yes/no-question*)

$$\mathrm{ST}_S\text{: } \{ (\begin{bmatrix} \text{noun: RV.1} \\ \neg\ \text{fnc: RV.2} \\ \neg\ \text{mdr: RV.3} \\ \text{prn: } n \end{bmatrix} \{\mathrm{r}_1, \mathrm{r}_2\}),\ (\begin{bmatrix} \text{noun: RV.1} \\ \text{fnc: RV.2} \\ \text{mdr: RV.3} \\ \text{prn: } n \end{bmatrix} \{\ \}) \}$$

$$\mathrm{r}_1\text{: } \begin{bmatrix} \text{noun: RV.1} \\ \neg\ \text{fnc: RV.2} \\ \neg\ \text{mdr: RV.3} \\ \text{prn: } n \end{bmatrix} \begin{bmatrix} \text{noun: RV.1} \\ \neg\ \text{fnc: RV.2} \\ \neg\ \text{mdr: RV.3} \\ \text{prn: } n\text{-}1 \end{bmatrix} \quad \text{output position nw} \quad (\{\mathrm{r}_1\ \mathrm{r}_2\})$$

$$\mathrm{r}_2\text{: } \begin{bmatrix} \text{noun: RV.1} \\ \neg\ \text{fnc: RV.2} \\ \neg\ \text{mdr: RV.3} \\ \text{prn: } n \end{bmatrix} \begin{bmatrix} \text{noun: RV.1} \\ \text{fnc: RV.2} \\ \text{mdr: RV.3} \\ \text{prn: } n\text{-}1 \end{bmatrix} \quad \text{output position nw} \quad (\{\ \})$$

$$\mathrm{ST}_F\text{: } \{ (\begin{bmatrix} \text{noun: RV.1} \\ \neg\ \text{fnc: RV.2} \\ \neg\ \text{mdr: RV.3} \\ \text{prn: } n\text{-}1 \end{bmatrix} \mathrm{rp}_1),\ (\begin{bmatrix} \text{noun: RV.1} \\ \text{fnc: RV.2} \\ \text{mdr: RV.3} \\ \text{prn: } n\text{-}1 \end{bmatrix} \mathrm{rp}_2) \}$$

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5.2 Episodic versus Absolute Propositions

5.2.1 Absolute and episodic proplets in a Word Bank (context level)

owner records		*absolute proplets*		*episodic proplets*
[noun: animal]	. . .	[noun: animal fnc: is mdr: prn: a-11]		
[verb: be]	. . .	[verb: be arg: dog animal mdr: prn: a-11]	. . .	[verb: be arg: dog mdr: tired prn: e-23]
[noun: dog]	. . .	[noun: dog fnc: be mdr: prn: a-11]	. . .	[noun: dog fnc: be mdr: prn: e-23]
[adj: tired]	. . .		. . .	[adj: tired mdd: be mdr: prn: e-23]

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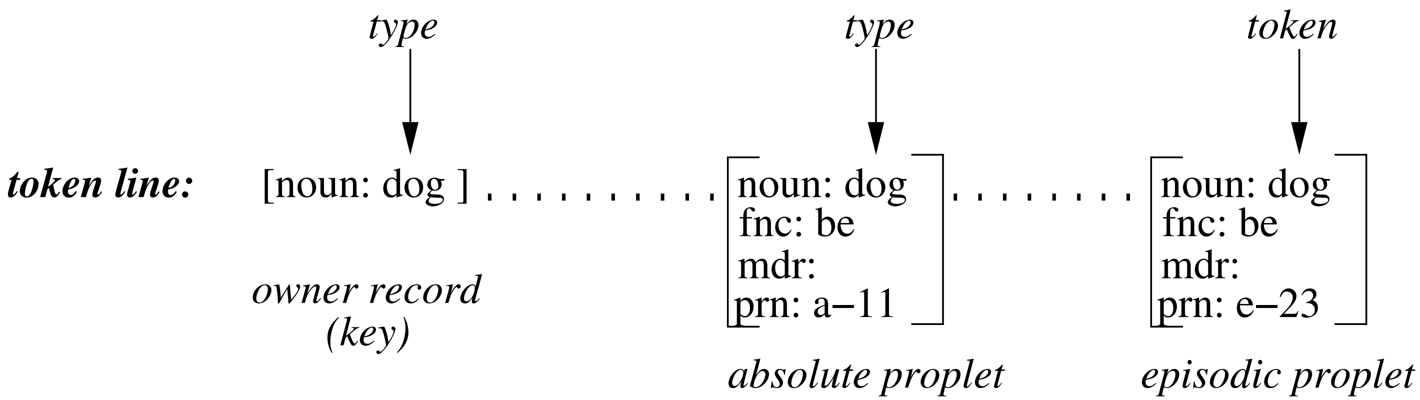
5.2.2 Core values as concept types and concept tokens



5.2.3 Areas of episodic vs. absolute proplets in a Word Bank

context owner records	*absolute context proplets*	*episodic context proplets*	*episodic language proplets*	*absolute language proplets*	*language owner records*
1	2	3	4	5	6

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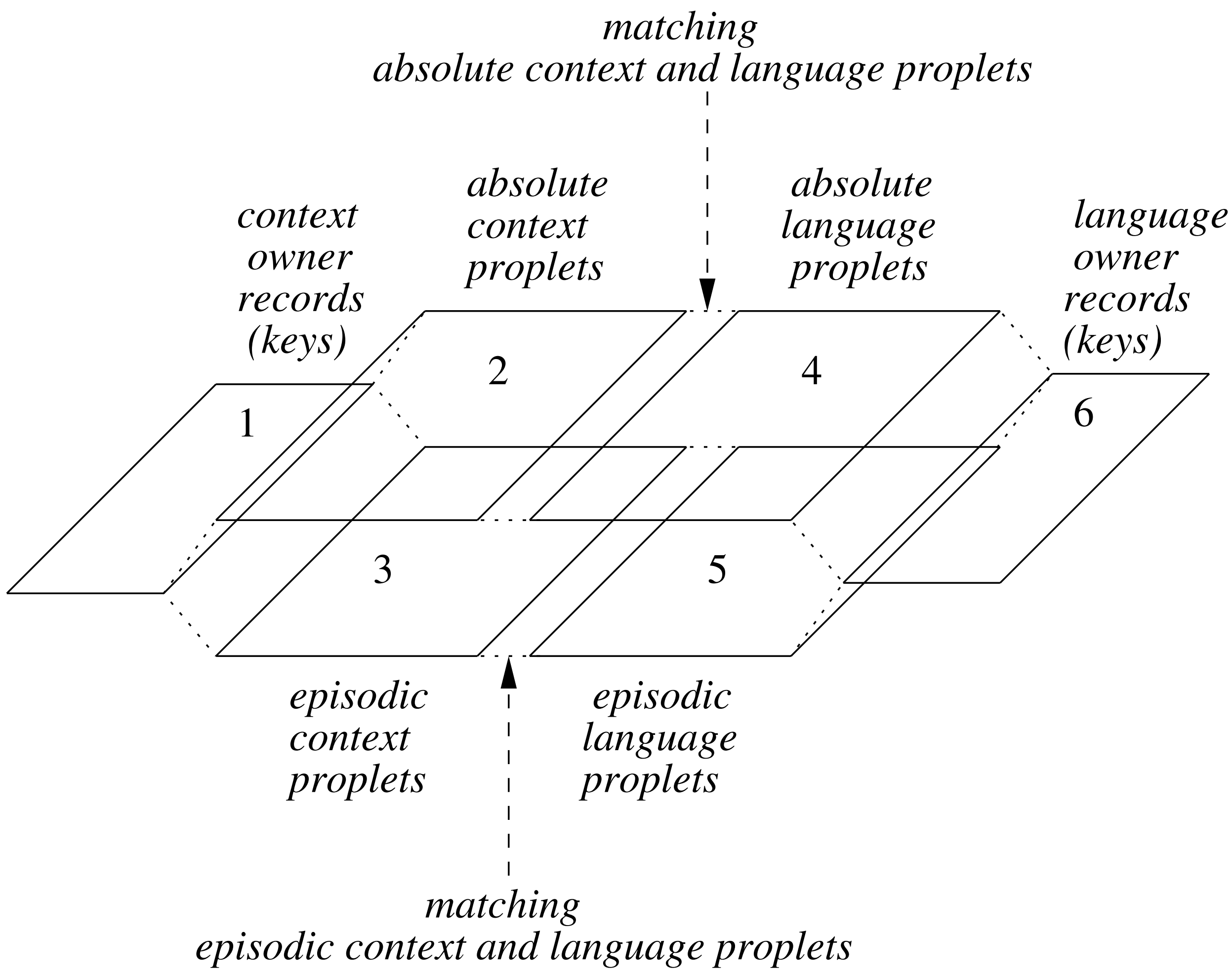
5.2.4 3-dimensional representation indicating matching frontiers



5.2.5 From episodic propositions to an absolute proposition

Mary takes a nap after lunch. *absolute proposition*

(Friday) Mary takes a nap after lunch.

(Thursday) Mary takes a nap after lunch.

(Wednsday) Mary takes a nap after lunch. *episodic propositions*

(Tuesday) Mary takes a nap after lunch.

(Monday) Mary takes a nap after lunch.

5.3 Inference: Reconstructing *Modus Ponens*

5.3.1 Inference schemata of Propositional Calculus

1. $\dfrac{A, B}{\vdash\ A \& B}$ 2. $\dfrac{A \lor B, \neg A}{\vdash B}$ 3. $\dfrac{A \rightarrow B, A}{\vdash\ B}$ 4. $\dfrac{A \rightarrow B, \neg B}{\vdash\ \neg A}$

5. $\dfrac{A \& B}{\vdash A}$ 6. $\dfrac{A}{\vdash A \lor B}$ 7. $\dfrac{\neg A}{\vdash\ A \rightarrow B}$ 8. $\dfrac{\neg\neg A}{\vdash\ A}$

5.3.2 LA-rule for the inference of *conjunction* (hypothetical)

$$\text{inf}_1\text{:}\quad \begin{bmatrix}\text{verb: } \alpha \\ \text{prn: } m\end{bmatrix} \begin{bmatrix}\text{verb: } \beta \\ \text{prn: } n\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{verb: } \alpha \\ \text{prn: } m \\ \text{cnj: } m \textit{ and } n\end{bmatrix} \begin{bmatrix}\text{verb: } \beta \\ \text{prn: } n \\ \text{cnj: } m \textit{ and } n\end{bmatrix}$$

5.3.3 *modus ponens* in Propositional Calculus

Premise 1:	If the sun is shining, Mary takes a walk.	$A \rightarrow B$
Premise 2:	The sun is shining.	$\underline{A \qquad}$
Conclusion:	Mary takes a walk.	$\vdash B$

5.3.4 *modus ponens* in Predicate Calculus

$$\frac{\forall x[\mathsf{f}(x) \rightarrow \mathsf{g}(x)],\ \exists x[\mathsf{f}(x)\ \&\ \mathsf{h}(x)]}{\vdash \exists x[\mathsf{g}(x)\ \&\ \mathsf{h}(x)]}$$

Premise 1:	For all x, if x is a dog, then x is an animal.	$\forall$x[dog(x) $\rightarrow$ animal(x)]
Premise 2:	There exists an x, x is a dog and x is tired.	$\exists$x[dog(x) & tired(x)]
Conclusion:	There exists an x, x is an animal and x is tired.	$\vdash \exists$x[animal(x)&tired(x)]

5.3.5 INFERENCE RULE INF$_2$ FOR RECONSTRUCTING *modus ponens*

$$\text{inf}_2\text{:} \begin{bmatrix}\text{verb: be}\\ \text{arg: } \alpha\\ \text{mdr: } \beta\\ \text{prn: } \textit{e-n}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha\\ \text{fnc: be}\\ \text{prn: } \textit{e-n}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta\\ \text{mdd: be}\\ \text{mdr:}\\ \text{prn: } \textit{e-n}\end{bmatrix} \begin{bmatrix}\text{verb: is-a}\\ \text{arg: } \delta\ \gamma\\ \text{prn: } \textit{a-m}\end{bmatrix} \begin{array}{l}\text{if } \alpha \text{ instantiates } \delta,\\ \text{replace } \alpha \text{ with } \gamma\\ \text{and replace } \textit{e-n} \text{ with } \textit{e-n'}\end{array} \quad \{\ \ldots\ \}$$

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5.3.6 Abstract Paraphrase

1. Absolute premise: noun type δ is-a noun type γ.
2. Episodic premise: noun token α happens to be adjective β.
3. Episodic conclusion: If noun token α instantiates noun type δ, then noun token γ happens to be adjective β.

5.3.7 Concrete example based on the abstract paraphrase

1. Absolut premise: *dog* type is-a(n) *animal* type.
2. Episodic premise: *dog* token happens to be *tired*.
3. Episodic conclusion: If *dog* token instantiates *dog* type, then *animal* token happens to be *tired*

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5.3.8 Applying inf$_2$ to the Word Bank 5.2.1

$$
\text{inf}_2\text{:}
\begin{bmatrix}\text{verb: be}\\ \text{arg: } \alpha\\ \text{mdr: } \beta\\ \text{prn: } e\text{-}n\end{bmatrix}
\begin{bmatrix}\text{noun: } \alpha\\ \text{fnc: be}\\ \text{prn: } e\text{-}n\end{bmatrix}
\begin{bmatrix}\text{adj: } \beta\\ \text{mdd: be}\\ \text{mdr:}\\ \text{prn: } e\text{-}n\end{bmatrix}
\begin{bmatrix}\text{verb: is-a}\\ \text{arg: } \delta\ \gamma\\ \text{prn: } a\text{-}m\end{bmatrix}
\begin{array}{l}\text{if } \alpha \text{ instantiates } \delta,\\ \text{replace } \alpha \text{ with } \gamma\\ \text{and replace } e\text{-}n \text{ with } e\text{-}n'\end{array}
\quad \{\ \dots\ \}
$$

$$
\begin{bmatrix}\text{verb: be}\\ \text{arg: dog}\\ \text{mdr: tired}\\ \text{prn: e-23}\end{bmatrix}
\begin{bmatrix}\text{noun: dog}\\ \text{fnc: be}\\ \text{mdr:}\\ \text{prn: e-23}\end{bmatrix}
\begin{bmatrix}\text{adj: tired}\\ \text{mdd: be}\\ \text{mdr:}\\ \text{prn: e-23}\end{bmatrix}
\begin{bmatrix}\text{verb: is-a}\\ \text{arg: dog animal}\\ \text{mdr:}\\ \text{prn: a-11}\end{bmatrix}
$$

5.3.9 Result of applying inf$_2$ to the Word Bank 5.2.1

$$
\begin{bmatrix}\text{verb: be}\\ \text{arg: animal}\\ \text{mdr: tired}\\ \text{prn: e-23'}\end{bmatrix}
\begin{bmatrix}\text{noun: animal}\\ \text{fnc: be}\\ \text{mdr:}\\ \text{prn: e-23'}\end{bmatrix}
\begin{bmatrix}\text{adj: tired}\\ \text{mdd: be}\\ \text{mdr:}\\ \text{prn: e-23'}\end{bmatrix}
$$

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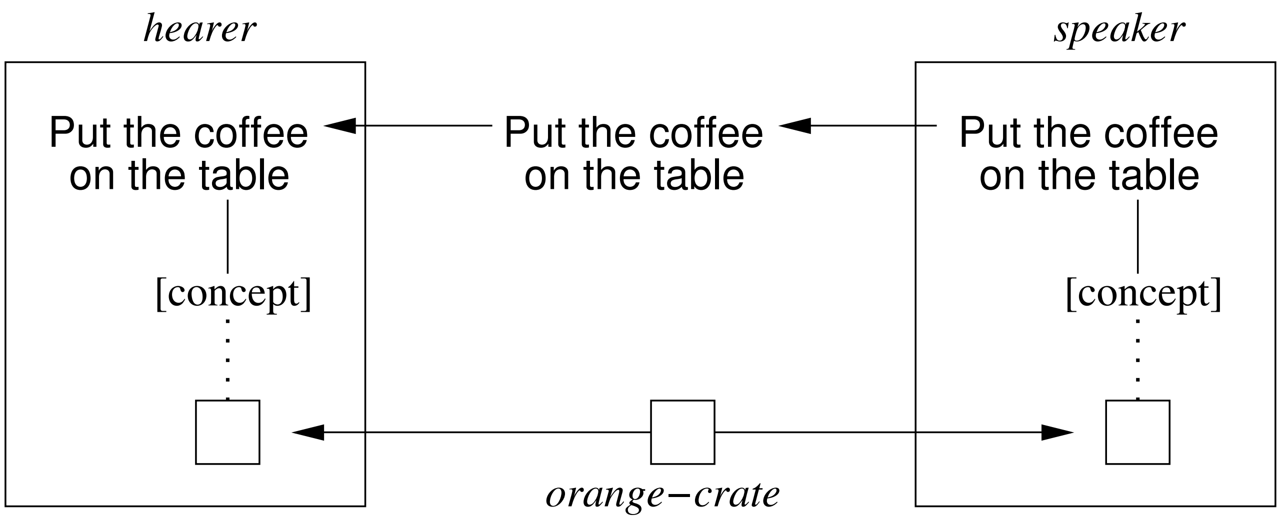
5.4 Indirect Uses of Language

5.4.1 NON-LITERAL USE OF THE WORD table



5.4.2 Grice's definition of meaning

Definiendum: U meant something by uttering x.

Definiens: For some audience A, U intends his utterance of x to produce in A some effect (response) E, by means of A's recognition of the intention.

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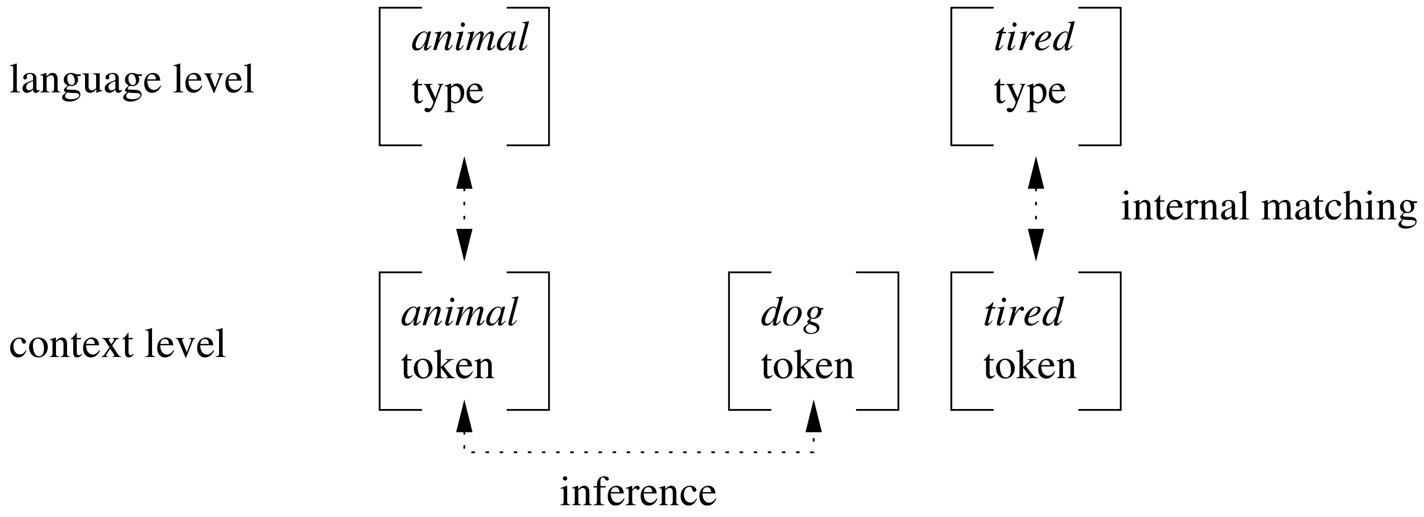
5.4.3 Contextual inference underlying a non-literal use



5.4.4 Advantages of handling indirect uses via inferences

1. Direct and indirect uses of language are based on the same method of strict internal matching (cf. 3.2.3), which greatly facilitates computational realization.
2. The inferencing underlying indirect uses is restricted to the level of context. Therefore, agents with and without language can use the same cognitive system.
3. Inferencing at the level of context is much more powerful and flexible than the traditional inferencing based on isolated signs of language.
4. Assuming that natural language directly reflects the contextual coding, the contextual inferences can be studied by analyzing their language reflections.

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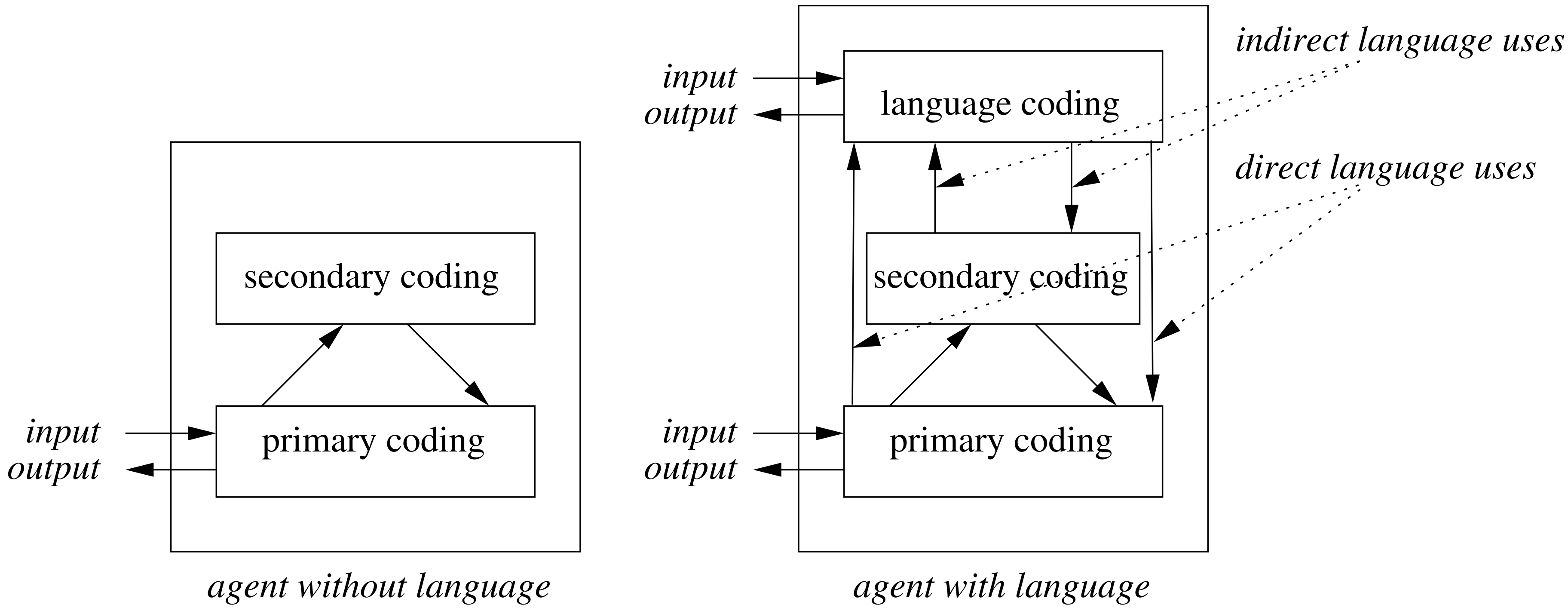
5.5 Secondary Coding as Perspective Taking

5.5.1 CODING LEVELS IN AGENTS WITH AND WITHOUT LANGUAGE



5.5.2 Functions of Coding Levels in Database Semantics

1. *Primary coding* at the context level
   Represents contextual recognition and action at a low level of abstraction in a simple standardized format in order to ensure veracity.
2. *Secondary coding* at the context level
   Consists of inferencing over the primary coding in order to obtain sufficient expressive power at varying levels of abstraction.
3. *Language coding*
   Represents primary and secondary context coding in a natural language.

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5.6 Shades of Meaning

5.6.1 Lexical lookup of the word dog

$$\begin{bmatrix} \text{sur: } \mathsf{dog} \\ \text{noun: } \textit{dog} \\ \text{fnc: } \\ \text{mdr: } \\ \text{prn: } \end{bmatrix}$$

5.6.2 Absolute part of the token line of *dog*

$$\begin{bmatrix} \text{noun: } \textit{dog} \end{bmatrix} \begin{bmatrix} \text{noun: dog} \\ \text{fnc: be} \\ \text{mdr: } \\ \text{prn: a-1} \end{bmatrix} \begin{bmatrix} \text{noun: dog} \\ \text{fnc: have} \\ \text{mdr: } \\ \text{prn: a-2} \end{bmatrix} \ldots$$

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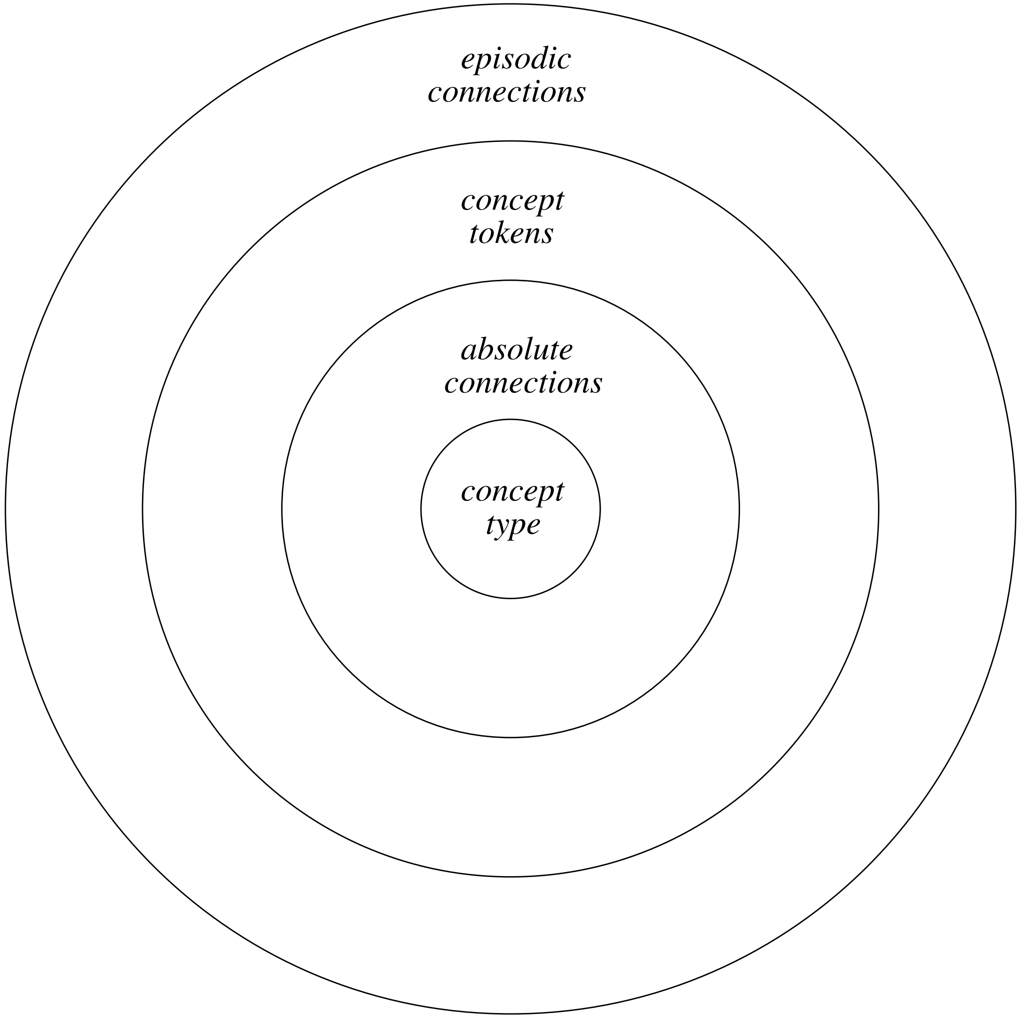
5.6.3 Complementation of a literal meaning$_1$ (concept type)



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Part II.
The Major Constraints of Natural Language

6. Intra-Propositional Functor-Argument Structure

6.1 Overview

6.1.1 Examples of intra-propositional functor-argument structure

1. Representing The man gave the child an apple (3-place verb)

$$\begin{bmatrix}\text{noun: apple}\\ \text{fnc: give}\\ \text{mdr:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: child}\\ \text{fnc: give}\\ \text{mdr:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{verb: give}\\ \text{arg: man child apple}\\ \text{mdr:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: man}\\ \text{fnc: give}\\ \text{mdr:}\\ \text{prn: 1}\end{bmatrix}$$

2. Representing The little black dog barked (adnominal adjectives)

$$\begin{bmatrix}\text{verb: bark}\\ \text{arg: dog}\\ \text{mdr:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{adj: black}\\ \text{mdd: dog}\\ \text{mdr:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{adj: little}\\ \text{mdd: dog}\\ \text{mdr:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: dog}\\ \text{fnc: bark}\\ \text{mdr: little black}\\ \text{prn: 2}\end{bmatrix}$$

3. Representing Julia has been sleeping deeply (adverbial adjective)

$$\begin{bmatrix}\text{adj: deep}\\ \text{mdd: sleep}\\ \text{mdr:}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{noun: Julia}\\ \text{fnc: sleep}\\ \text{mdr:}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{verb: sleep}\\ \text{arg: Julia}\\ \text{mdr: deep}\\ \text{prn: 3}\end{bmatrix}$$

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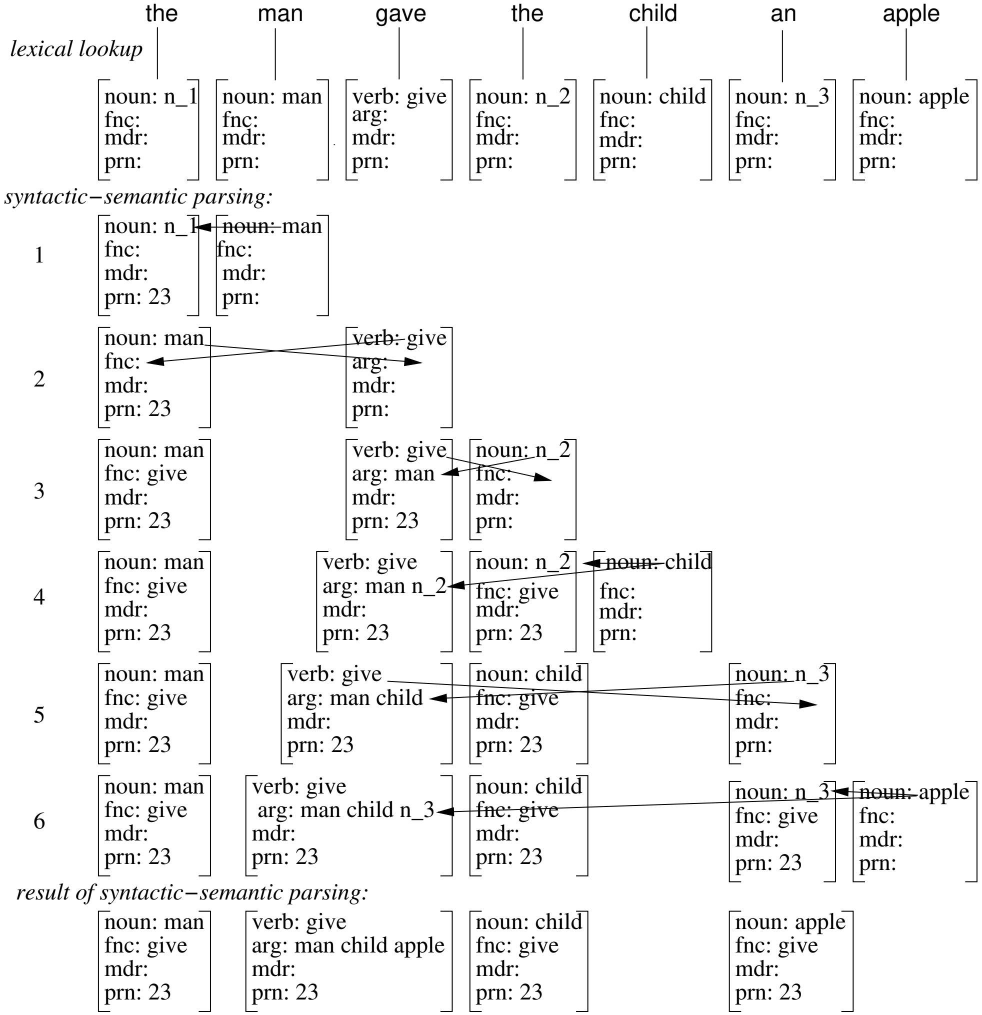
6.2 Determiners

6.2.1 3-PLACE PROPOSITION: The man gave the child an apple



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6.2.2 SCHEMATIC PRODUCTION FROM A 3-PLACE PROPOSITION

	activated sequence				*realization*
i					
	. . . V				
i.1		d			d
	V	N			
i.2		d nn			d nn
	V	N			
i.3	fv	d nn			d nn fv
	V	N			
i.4	fv	d nn	d		d nn fv d
	V	N	N		
i.5	fv	d nn	d nn		d nn fv d nn
	V	N	N		
i.6	v	d nn	d nn	d	d nn v d nn d
	V	N	N	N	
i.7	fv	d nn	d nn	d nn	d nn fv d nn d nn
	V	N	N	N	
i.8	fv p	d nn	d nn	d nn	d nn fv d nn d nn p
	V	N	N	N	

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6.2.3 Predicate Calculus analysis of All girls sleep

$\forall$x [girl(x) $\rightarrow$ sleep(x)]

6.2.4 Interpretation relative to a model

$\forall$x [girl(x) $\rightarrow$ sleep(x)]$^{@,g}$

6.2.5 Elimination of the outermost quantifier

[girl(x) $\rightarrow$ sleep(x)]$^{@,g'}$

6.2.6 Analyzing Every man loves a woman in Predicate Calculus

Reading 1: $\forall$x [man(x) $\rightarrow$ $\exists$y [woman(y) & love(x,y)]]
Reading 2: $\exists$y [woman(y) & $\forall$x [man(x) $\rightarrow$ love(x,y)]]

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6.2.7 Result of parsing Every man loves a woman in DBS

sur: noun: *man* cat: snp sem: pl exh mdr: fnc: love idy: 1 prn: 1	sur: verb: *love* cat: v sem: pres mdr: arg: man woman prn: 1	sur: noun: *woman* cat: snp sem: indef sg mdr: fnc: love idy: 2 prn: 1

6.2.8 The sem values of different determiner-noun combinations

a girl	[sem: indef sg]
some girls	[sem: indef pl sel]
all girls	[sem: pl exh]
the girl	[sem: def sg]
the girls	[sem: def pl]

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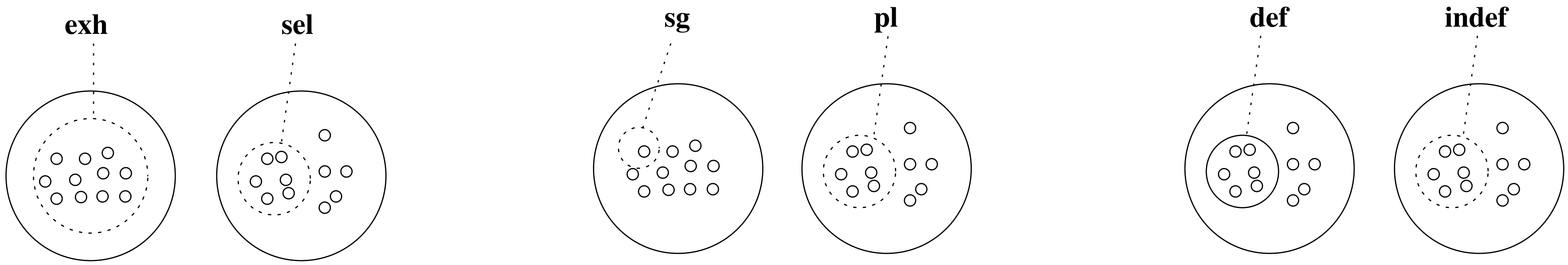
6.2.9 Set-theoretic interpretation of exh, sel, sg, pl, def, indef



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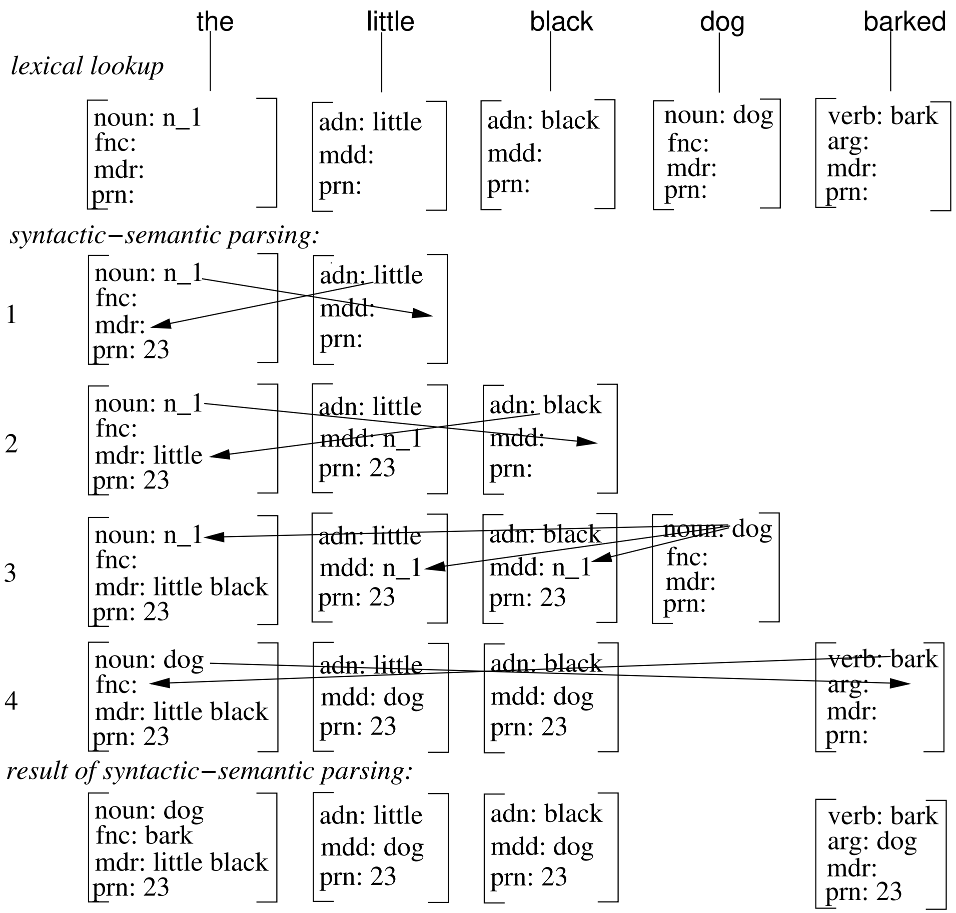
6.3 Adjectives

6.3.1 PARSING The little black dog barked IN THE HEARER-MODE



6.3.2 SCHEMATIC PRODUCTION OF THE The little black dog barked.

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```
      activated sequence          realization
i
          V
i.1           d                   d
          V   N
i.2           d   an              d an
          V   N   A
i.3           d   an  an          d an an
          V   N   A   A
i.4         d nn  an  an          d an an nn
          V   N   A   A
i.5   fv    d nn  an  an          d an an nn fv
          V   N   A   A
i.6  fv p   d nn  an  an          d an an nn fv p
          V   N   A   A
```


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6.3.3 Parsing Fido barked loudly in the hearer-mode

Fido	barked	loudly

lexical lookup

noun: Fido	verb: bark	adn: loud
fnc:	arg:	mdd:
mdr:	mdr:	prn:
prn:	prn:	

syntactic−semantic parsing:

1

noun: Fido	verb: bark
fnc:	arg:
mdr:	mdr:
prn: 17	prn:

2

noun: Fido	verb: bark	adn: loud
fnc: bark	arg: Fido	mdd:
mdr:	mdr:	prn:
prn: 17	prn: 17	

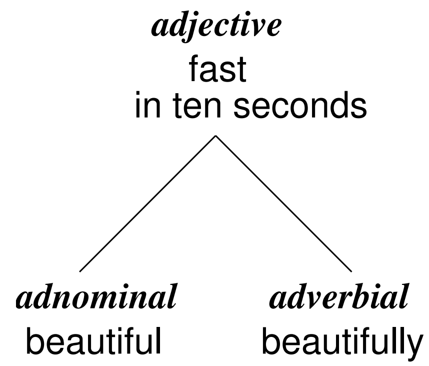
result of syntactic−semantic parsing:

noun: Fido	verb: bark	adn: loud
fnc: bark	arg: Fido	mdd: bark
mdr:	mdr: loud	prn: 17
prn: 17	prn: 17	

6.3.4 Schematic production of the Fido barked loudly.

	activated sequence			*realization*
i				
	V			
i.1		n		n
	V	N		
i.2	fv	n		n fv
	V	N		
i.3	fv	n	av	n fv av
	V	N	A	
i.4	fv p	n	av	n fv av p
	V	N	A	

6.3.5 Relation of the terms Adjective, Adnominal, and Adverbial in DBS



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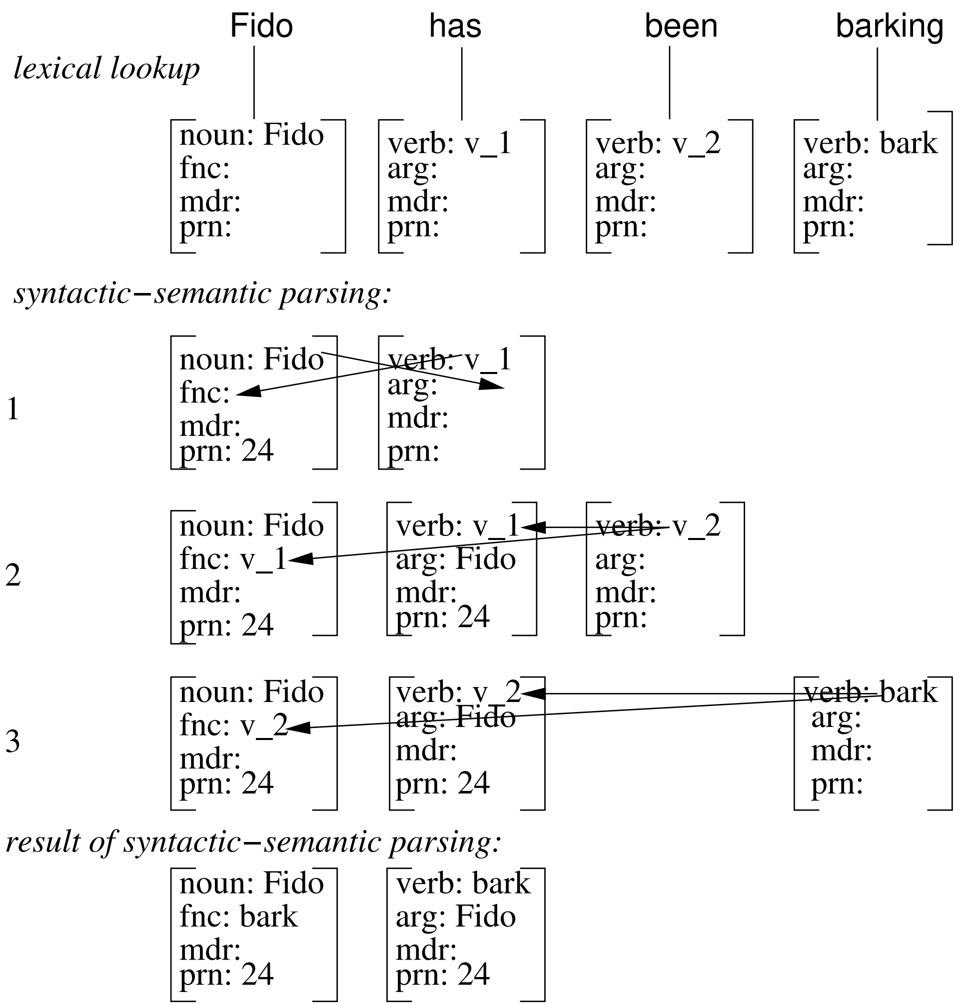
6.4 Auxiliaries

6.4.1 COMPLEX VERB PHRASE: Fido has been barking.



6.4.2 SCHEMATIC PRODUCTION OF Fido has been barking

	activated sequence		*realization*
i.			
	V		
i.1		n	n
	V	N	
i.2	ax	n	n ax
	V	N	
i.3	ax ax	n	n ax ax
	V	N	
i.4	ax ax nv	n	n ax ax nv
	V	N	
i.6	ax ax nv p	n	n ax ax nv p
	V	N	

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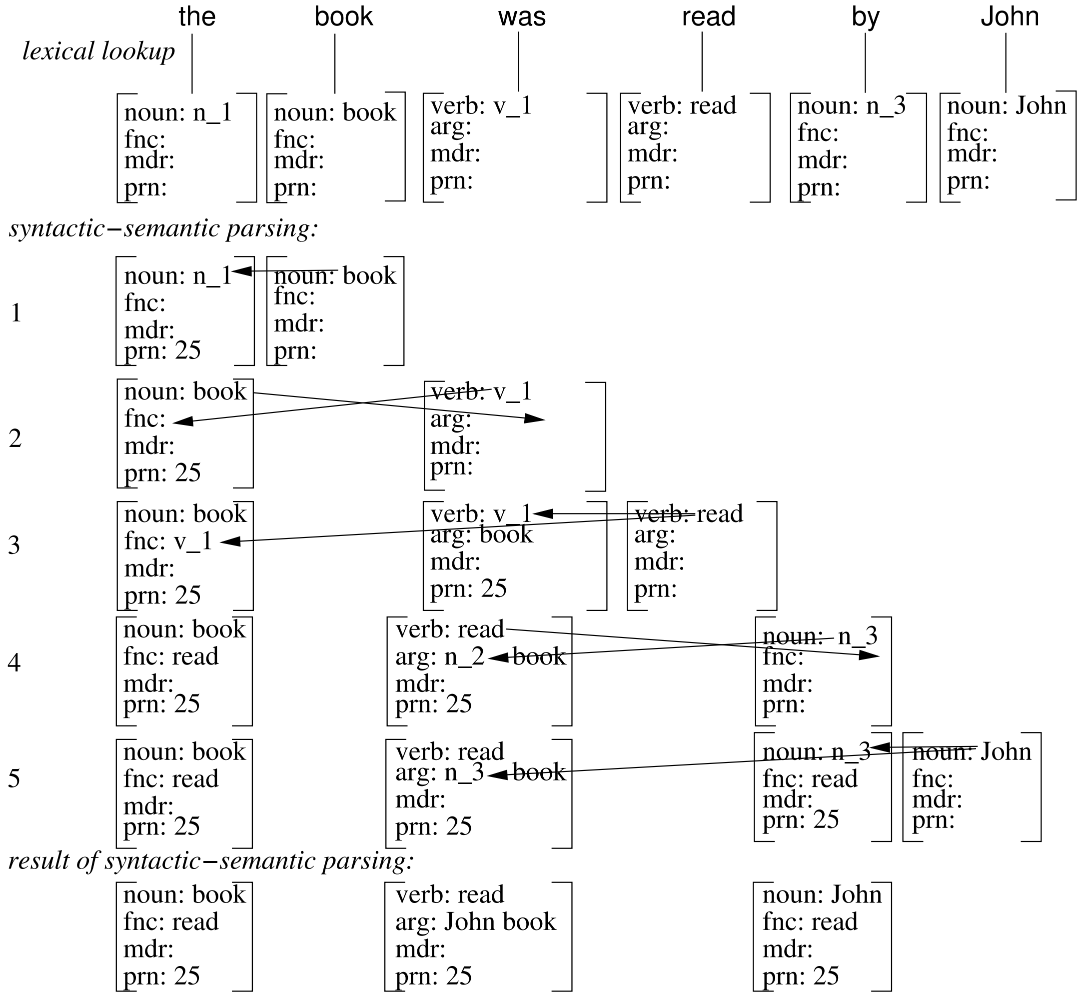
6.5 Passive

6.5.1 Interpretation of Passive: The book was read by John.



6.5.2 SCHEMATIC PRODUCTION OF The book was read by John.

	activated sequence			*realization*
i				
	V			
i.1			d	d
	V		N	
i.2			d nn	d nn
	V		N	
i.3	ax		d nn	d nn ax
	V		N	
i.4	ax nv		d nn	d nn ax nv
	V		N	
i.5	ax nv	by	d nn	d nn ax nv by
	V	N	N	
i.6	ax nv	by n	d nn	d nn ax nv by n
	V	N	N	
i.7	ax nv p	by n	d nn	d nn ax nv by n p
	V	N	N	

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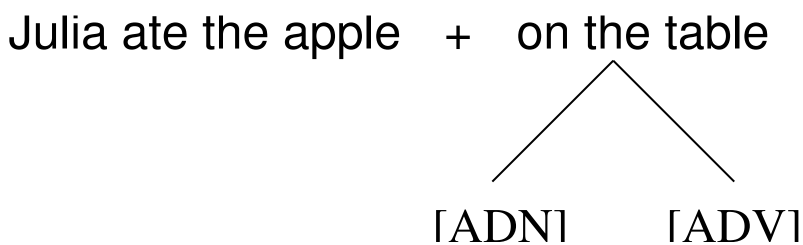
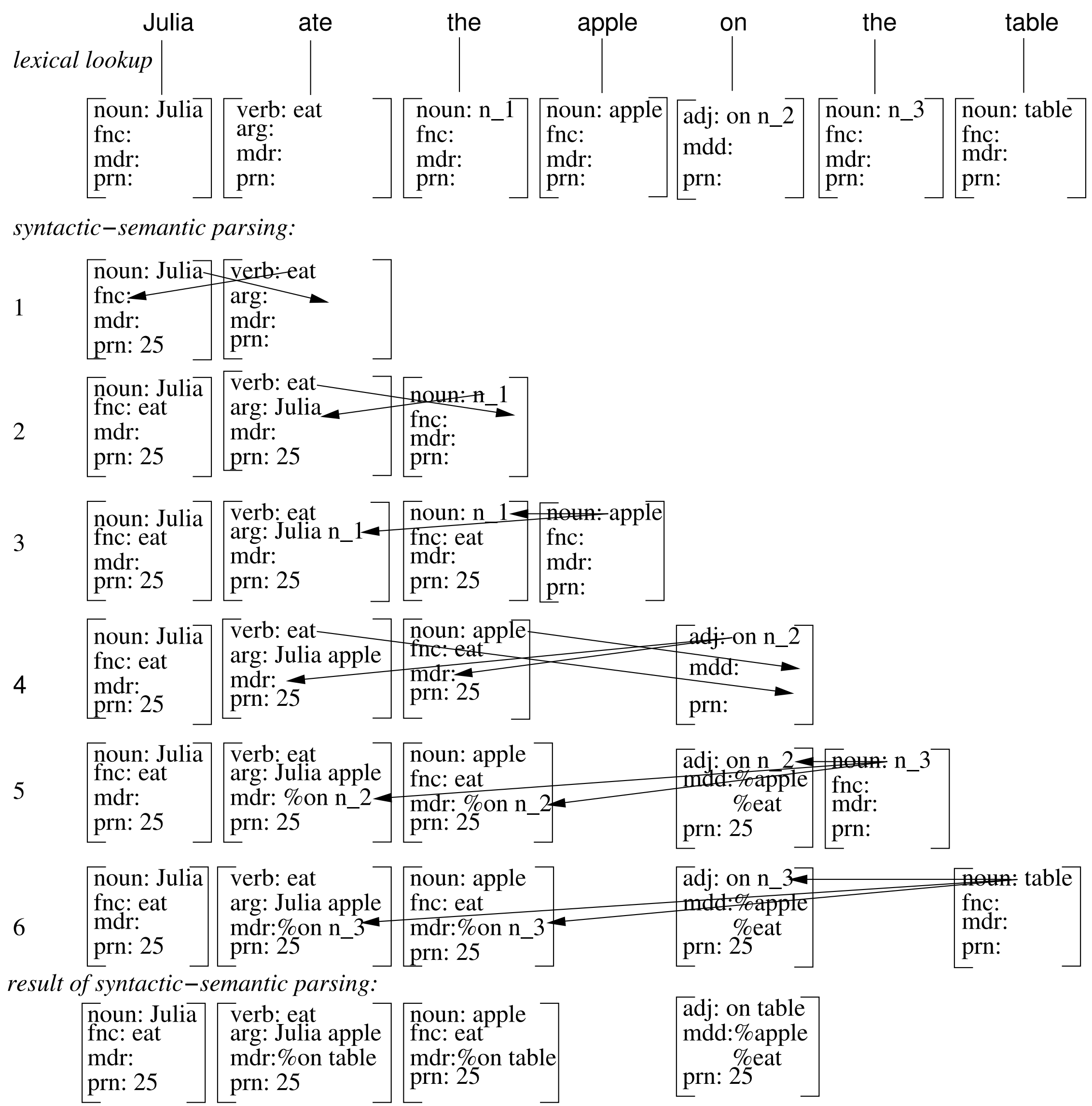
6.6 Prepositions

6.6.1 Semantic doubling of a prepositional phrase



6.6.2 ADJECTIVAL PHRASE: Julia ate the apple on the table.



6.6.3 RETRIEVAL DURING NAVIGATION

noun: Julia	verb: eat	noun: apple	adj: on table
fnc: eat	arg: Julia apple	fnc: eat	mdd: %apple
mdr:	mdr: %on table	mdr: %on table	%eat
prn: 25	prn: 25	prn: 25	prn: 25

6.6.4 PRODUCTION OF Julia ate the apple on the table.

	activated sequence				*realization*
i					
	V				
i.1		n			n
	V	N			
i.2	fv	n			n fv
	V	N			
i.3	fv	n	d		n fv d
	V	N	N		
i.4	fv	n	d n		n fv d n
	V	N	N		
i.5	fv	n	d n	pp	n fv d n pp
	V	N	N	A	
i.6	fv	n	d n	pp d	n fv d n pp d
	V	N	N	A	
i.7	fv	n	d n	pp d nn	n fv d n pp d nn
	V	N	N	A	
i.8	fv p	n	d n	pp d nn	n fv d n pp d nn p
	V	N	N	A	

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7. Extra-Propositional Functor-Argument Structure

7.1 Overview

7.1.1 Verb proplets of subordinate clauses

subject or object sentence	*adverbial sentence*	*adnominal sentence*
n/v: verb of the sub-clause	**a/v**: verb of the sub-clause	**a/v**: verb of the sub-clause
arg: noun(s) of the sub-clause	arg: noun(s) of the sub-clause	arg: noun(s) of the sub-clause
fnc: verb of the higher clause	**mdd: verb** of the higher clause	**mdd: noun** of the higher clause
prn: number of the sub-clause	prn: number of the sub-clause	prn: number of the sub-clause

7.1.2 Examples of extra-propositional functor-arg. structure

1. Representing That Fido barked amused Mary (subject sentence)

$$\begin{bmatrix} \text{n/v: that bark} \\ \text{arg: Fido} \\ \text{fnc: 28 amuse} \\ \text{prn: 27} \end{bmatrix} \begin{bmatrix} \text{noun: Fido} \\ \text{fnc: bark} \\ \text{mdr:} \\ \text{prn: 27} \end{bmatrix} \begin{bmatrix} \text{verb: amuse} \\ \text{arg: 27 bark} \quad \text{Mary} \\ \text{mdr:} \\ \text{prn: 28} \end{bmatrix} \begin{bmatrix} \text{noun: Mary} \\ \text{fnc: amuse} \\ \text{mdr:} \\ \text{prn: 28} \end{bmatrix}$$

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2. Representing John heard that Fido barked (object sentence)

noun: John	verb: hear	n/v: that bark	noun: Fido
fnc: hear	arg: John 31 bark	arg: Fido	fnc: bark
mdr:	mdr:	fnc: 30 hear	mdr:
prn: 30	prn: 30	prn: 31	prn: 31

3. Representing The dog which saw Mary barked (adnominal sent., subject gap)

noun: dog	a/v: see	noun: Mary	verb: bark
fnc: bark	arg: # Mary	fnc: see	arg: dog
mdr: 33 see	mdd:32 dog	mdr:	mdr:
prn: 32	prn: 33	prn: 33	prn: 32

4. Representing The dog which Mary saw barked (adnominal sent., object gap)

noun: dog	a/v: see	noun: Mary	verb: bark
fnc: bark	arg: Mary #	fnc: see	arg: dog
mdr: 35 see	mdd:34 dog	mdr:	mdr:
prn: 34	prn: 35	prn: 35	prn: 34

5. Representing When Fido barked Mary smiled (adverbial sentence)

a/v: when bark	noun: Fido	noun: Mary	verb: smile
arg: Fido	fnc: bark	fnc: smile	arg: Mary
mdd:37 smile	mdr:	mdr:	mdr: 36 bark
prn: 36	prn: 36	prn: 37	prn: 37

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7.1.3 Extra-Propositional Functor-Argument Structures

(i) sentential argument

(1) *subject:*

\# amused Mary

Fido barked

(2) *object:*

John heard #

Fido barked

(ii) sentential modifier, adnominal (relative clause)

(3) *subject*

the dog barked

\# saw Mary

(4) *object:*

the dog barked

Mary saw #

(iii) sentential modifier, adverbial

(5) Mary smiled

when Fido barked

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7.2 Sentential Argument as Subject

7.2.1 INTERPRETATION OF That Fido barked amused Mary.

	that	Fido	barked	amused	Mary
lexical lookup	n/v: that v_1 arg: fnc: prn:	noun: Fido fnc: mdr: prn:	verb: bark arg: mdr: prn:	verb: amuse arg: mdr: prn:	noun: Mary fnc: mdr: prn:

syntactic−semantic parsing

1	n/v: that v_1 arg: fnc: prn: 27	noun: Fido fnc: mdr: prn:			
2	n/v: that v_1 arg: Fido fnc: prn: 27	noun: Fido fnc: v_1 mdr: prn: 27	verb: bark arg: mdr: prn:		
3	n/v: that bark arg: Fido fnc: prn: 27	noun: Fido fnc: bark mdr: prn: 27		verb: amuse arg: mdr: prn:	
4	n/v: that bark arg: Fido fnc: 28 amuse prn: 27	noun: Fido fnc: bark mdr: prn: 27		verb: amuse arg: 27 bark mdr: prn: 28	noun: Mary fnc: mdr: prn:

result of syntactic−semantic parsing:

n/v: that bark arg: Fido fnc: 28 amuse prn: 27	noun: Fido fnc: bark mdr: prn: 27	verb: amuse arg: 27 bark Mary mdr: prn: 28	noun: Mary fnc: amuse mdr: prn: 28

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7.2.2 PRODUCTION OF That Fido barked amused Mary.

	activated sequence					*realization*
1						
	V					
1.1	sc					sc
	V	N				
1.2	sc	n				sc n
	V	N				
1.3	sc fv	n				sc n fv
	V	N				
2.1	sc fv	n	fv			sc n fv fv
	V	N	V			
2.2	sc fv	n	fv		n	sc n fv fv n
	V	N	V		N	
2.3	sc fv	n	fv	p	n	sc n fv fv n p
	V	N	V		N	

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7.3 Sentential Argument as Object

7.3.1 Interpretation of John heard that Fido barked.

John	heard	that	Fido	barked

lexical lookup

noun: John	verb: hear	n/v: that v_1	noun: Fido	verb: bark
fnc:	arg:	arg:	fnc:	arg:
mdr:	mdr:	fnc:	mdr:	mdr:
prn:	prn:	prn:	prn:	prn:

syntactic−semantic derivation

1

noun: John	verb: hear
fnc:	arg:
mdr:	mdr:
prn: 30	prn:

2

noun: John	verb: hear	n/v: that v_1
fnc: hear	arg: John	arg:
mdr:	mdr:	fnc:
prn: 30	prn: 30	prn:

3

noun: John	verb: hear	n/v: that v_1	noun: Fido
fnc: hear	arg: John 31 v_1	arg:	fnc:
mdr:	mdr:	fnc: 30 hear	mdr:
prn: 30	prn: 30	prn: 31	prn:

4

noun: John	verb: hear	n/v: that v_1	noun: Fido	verb: bark
fnc: hear	arg: John 31 v_1	arg: Fido	fnc: v_1	arg:
mdr:	mdr:	fnc: 30 hear	mdr:	mdr:
prn: 30	prn: 30	prn: 31	prn: 31	prn:

result of syntactic−semantic parsing:

noun: John	verb: hear	n/v: that bark	noun: Fido
fnc: hear	arg: John 31 bark	arg: Fido	fnc: bark
mdr:	mdr:	fnc: 30 hear	mdr:
prn: 30	prn: 30	prn: 31	prn: 31

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7.3.2 SCHEMATIC PRODUCTION OF John heard that Fido barked.

	activated sequence				*realization*
1					
	V				
1.1		n			n
	V	N			
1.2	fv	n			n fv
	V	N			
2.1	fv	n	sc		n fv sc
	V	N	V		
2.2	fv	n	sc	n	n fv sc n
	V	N	V	N	
2.3	fv	n	sc fv	n	n fv sc n fv
	V	N	V	N	
2.4	fv p	n	sc fv	n	n fv sc n fv p
	V	N	V	N	

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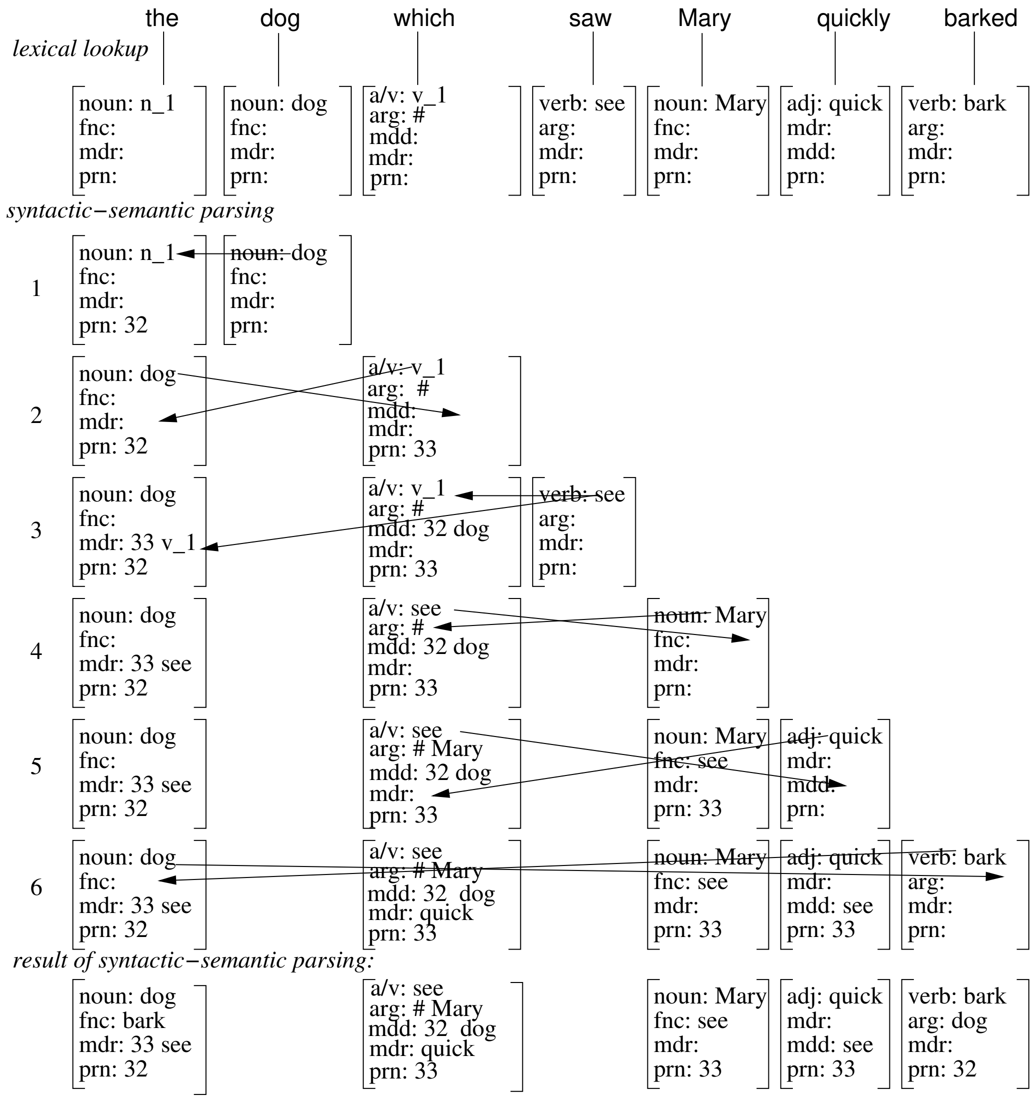
7.4 Adnominal Sentential Modifier with Subject Gap

7.4.1 INTERPRETATION OF The dog which saw Mary quickly barked



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7.4.2 SECOND READING OF 7.4.1, WITH quickly MODIFYING bark

noun: dog	a/v: see	noun: Mary	adj: quick	verb: bark
fnc: bark	arg: # Mary	fnc: see	mdd: bark	arg: dog
mdr: 33 see	mdd: 32 dog	mdr:	mdr:	mdr: quick
prn: 32	mdr:	prn: 33	prn: 32	prn: 32
	prn: 33			

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7.4.3 PRODUCTION OF The dog which saw Mary quickly barked

	activated sequence					*realization*
1						
	V					
1.1		d				d
	V	N				
1.2		d nn				d nn
	V	N	V			
2.1		d nn	wh			d nn wh
	V	N	V			
2.2		d nn	wh fv			d nn wh fv
	V	N	V			
2.3		d nn	wh fv	n		d nn wh fv n
	V	N	V	N		
1.3		d nn	wh fv	n	av	d nn wh fv n av
	V	N	V	N	A	
1.4	fv	d nn	wh fv	n	av	d nn wh fv n av fv
	V	N	V	N	A	
1.5	fv p	d nn	wh fv	n	av	d nn wh fv n av fv p
	V	N	V	N	A	

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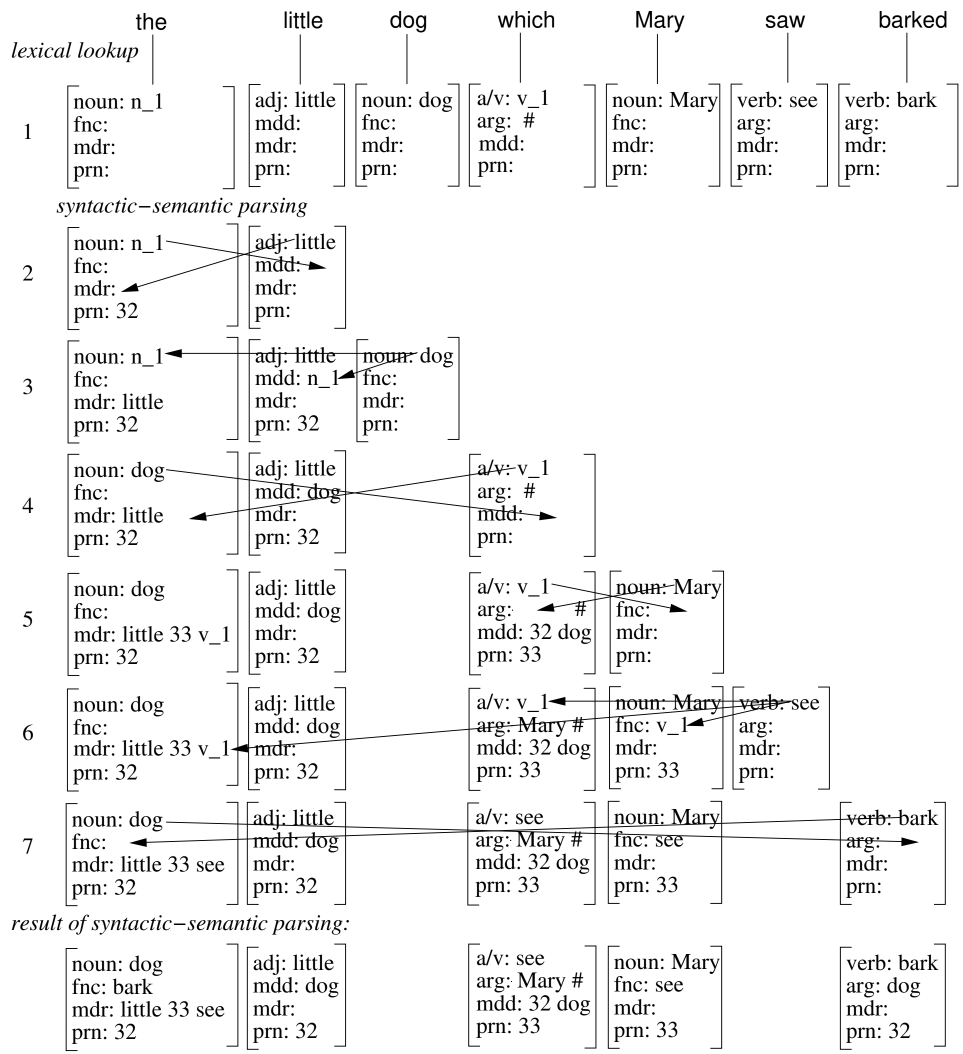
7.5 Adnominal Sentential Modifier with Object Gap

7.5.1 INTERPRETATION OF The little dog which Mary saw barked.



7.5.2 PRODUCTION OF The little dog which Mary saw barked.

	activated sequence					*realization*
1						
	V					
1.1		d				d
	V	N				
1.2		d	an			d an
	V	N	A			
1.3		d nn	an			d an nn
	V	N	A			
2.1		d nn	an	wh		d an nn wh
	V	N	A	V		
2.2		d nn	an	wh	n	d an nn wh n
	V	N	A	V	N	
2.3		d nn	an	wh fv	n	d an nn wh n fv
	V	N	A	V	N	
1.4	fv	d nn	an	wh fv	n	d an nn wh n fv fv
	V	N	A	V	N	
1.5	fv p	d nn	an	wh fv	n	d an nn wh n fv fv p
	V	N	A	V	N	

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7.6 Adverbial Sentential Modifier

7.6.1 INTERPRETATION OF When Fido barked Mary smiled.

	when	Fido	barked	Mary	smiled
lexical lookup	a/v: when v_1 arg: mdd: prn:	noun: Fido fnc: mdr: prn:	verb: bark arg: mdr: prn:	noun: Mary fnc: mdr: prn:	verb: smile arg: mdr: prn:

syntactic−semantic parsing

1	a/v: when v_1 arg: mdd prn: 27	noun: Fido fnc: mdr: prn:			
2	a/v: when v_1 arg: Fido mdd: prn: 27	noun: Fido fnc: v_1 mdr: prn: 27	verb: bark arg: mdr: prn:		
3	a/v: when bark arg: Fido mdd: prn: 27	noun: Fido fnc: bark mdr: prn: 27		noun: Mary fnc: mdr: prn:	
4	a/v: when bark arg: Fido mdd: prn: 27	noun: Fido fnc: bark mdr: prn: 27		noun: Mary fnc: mdr: prn:	verb: smile arg: mdr: prn: 28

result of syntactic−semantic parsing:

a/v: when bark arg: Fido mdd: 28 smile prn: 27	noun: Fido fnc: bark mdr: prn: 27	noun: Mary fnc: smile mdr: prn: 28	verb: smile arg: Mary mdr: 27 bark prn: 28

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7.6.2 PRODUCTION OF When Fido barked Mary smiled.

	activated sequence					*realization*
1						
	V					
1.1	sc					sc
	V	N				
1.2	sc	n				sc n
	V	N				
1.3	sc fv	n				sc n fv
	V	N				
2.1	sc fv	n			n	sc n fv n
	V	N	V		N	
2.2	sc fv	n	fv		n	sc n fv n fv
	V	N	V		N	
2.3	sc fv	n	fv	p	n	sc n fv n fv p
	V	N	V		N	

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8. Intra-Propositional Coordination

8.1 Overview

8.1.1 GRAMMATICAL RELATIONS OF the man, the woman, and the child

noun: man &	noun: woman	noun: child
fnc:	fnc:	fnc:
mdr:	mdr:	mdr:
nc: woman	nc: child	nc:
pc:	pc: man	pc: woman
prn: 26	prn: 26	prn: 26

8.1.2 GRAMMATICAL RELATIONS OF The man, the woman, and the child slept

noun: man &	noun: woman	noun: child	verb: sleep
fnc: sleep	fnc:	fnc:	arg: man &
mdr:	mdr:	mdr:	mdr:
nc: woman	nc: child	nc:	nc:
pc:	pc: man	pc: woman	pc:
prn: 26	prn: 26	prn: 26	prn: 26

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8.1.3 Different kinds of coordinations

1. *One simple noun coordination* (subject, cf. 8.2.1, 8.2.2)
   The man, the woman, and the child slept.
2. *One simple noun coordination* (object, 8.2.4, 8.2.5)
   John bought an apple, a pear, and a peach.
3. *Two simple noun coordinations* (subject object, cf. 8.2.3)
   The man, the woman, and the child bought an apple, a pear, and a peach.
4. *One simple verb coordination* (cf. 8.3.1, 8.3.2, 8.3.3)
   John bought, cooked, and ate the pizza.
5. *Three simple coordinations of noun, verb, and noun* (subject verb object)
   The man, the woman, and the child bought, cooked, and ate the steak, the potatoes, and the broccoli.
6. *One simple adjective coordination* (adnominal, cf. 8.3.4)
   John loves a smart, pretty, and rich girl.
7. *One simple adjective coordination* (adverbial, cf. 8.3.5)
   John talked gently, slowly, and seriously.

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8. *One simple noun coordination in a prepositional phrase*
   The company has offices in London, Paris, and New York.
9. *One simple noun coordination in a genitive construction*
   John visited the house of Julia, Susanne, and Mary.
10. *One complex verb-object coordination* (subject gapping, cf. 8.4.1, 8.4.5)
    Bob ate an apple, # walked his dog, and # read a paper.
11. *One complex subject-object coordination* (verb gapping, cf. 8.5.1, 8.5.4)
    Bob ate an apple, Jim # a pear, and Bill # a peach.
12. *One complex subject-verb coordination* (object gapping,
    Bob bought #, Jim peeled #, and Bill ate the peach.

8.1.4 Comparing simple and complex coordination

(i) *two simple coordinations*
Bob, Jim, and Bill bought, peeled, and ate the peach.

(ii) *one complex coordination*
Bob bought #, Jim peeled #, and Bill ate the peach.

8.2 Simple Coordination of Nouns in Subject and Object Position

8.2.1 NOUN COORDINAT. (SUBJECT): The man, the woman, and the child slept

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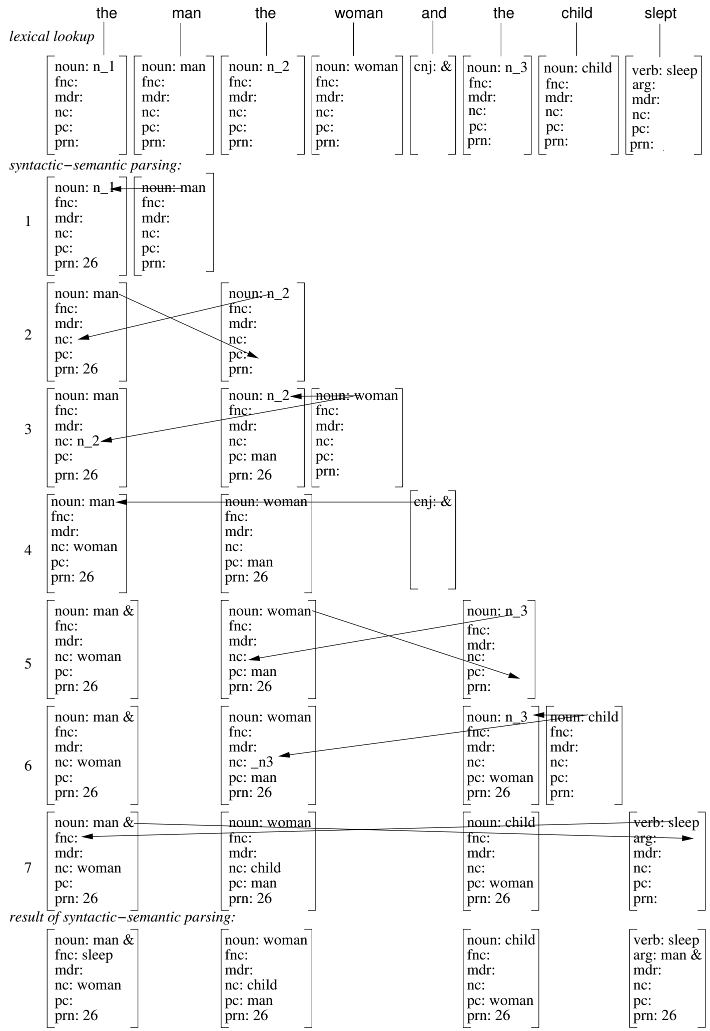

8.2.2 PRODUCTION OF The man the woman and the child slept.

activated sequence *realization*

i.					
	V				
i.1		d			d
	V	N			
i.2		d nn			d nn
	V	N			
i.3		d nn	d		d nn d
	V	N	N		
i.4		d nn	d nn		d nn d nn
	V	N	N		
i.5		d nn cc	d nn		d nn d nn cc
	V	N	N		
i.6		d nn cc	d nn	d	d nn d nn cc d
	V	N	N	N	
i.7		d nn cc	d nn	d nn	d nn d nn cc d nn
	V	N	N	N	
i.8	fv	d nn cc	d nn	d nn	d nn d nn cc d nn fv
	V	N	N	N	
i.9	fv p	d nn cc	d nn	d nn	d nn d nn cc d nn fv p
	V	N	N	N	

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8.2.3 Simple coordinations of subject and object nouns

noun: man &	noun: woman	noun: child	verb: buy	noun: apple &	noun: pear	noun: peach
fnc: buy	fnc:	fnc:	arg: man & apple &	fnc: buy	fnc:	fnc:
nc:	nc:	nc:		nc:	nc:	nc:
pc:	pc:	pc:		pc:	pc:	pc:

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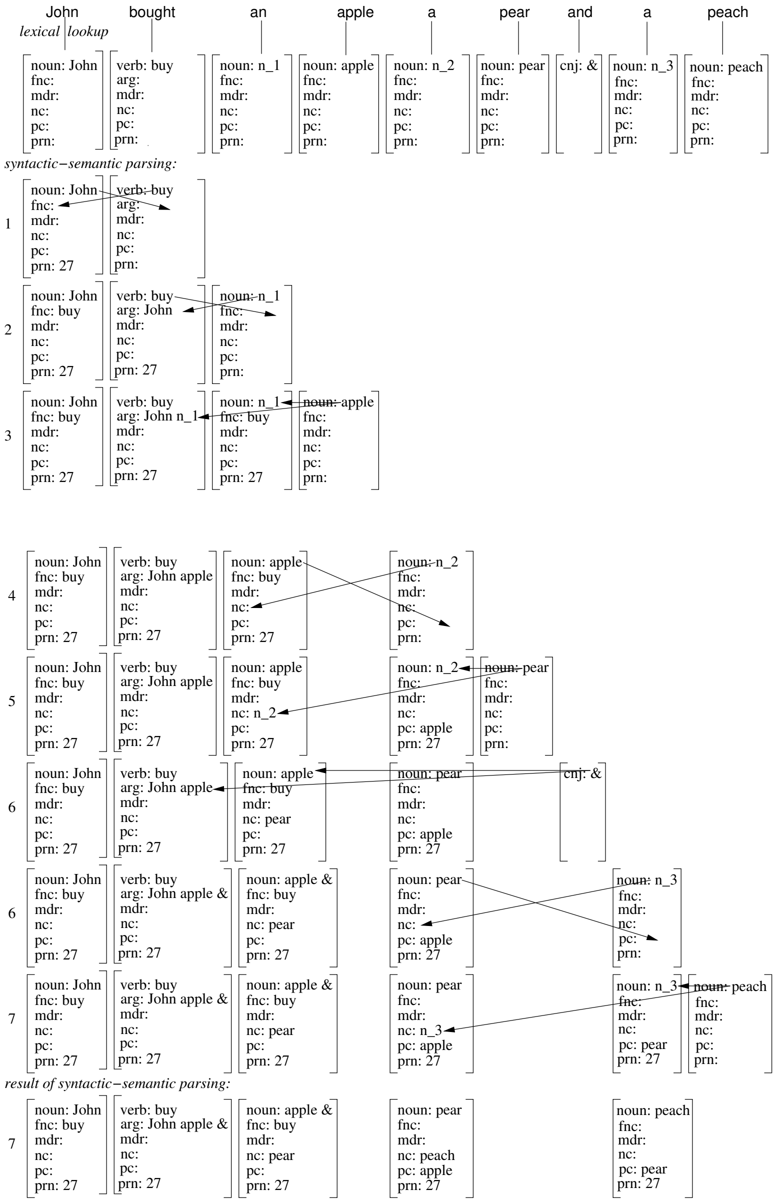
8.2.4 Noun coordination (object): John bought an apple, a pear, and a peach



8.2.5 PRODUCTION OF John bought an apple, a pear, and a peach.

	activated sequence					*realization*
i.						
	V					
i.1		n				n
	V	N				
i.2	fv	n				n fv
	V	N				
i.3	fv	n	d			n fv d
	V	N	N			
i.4	fv	n	d nn			n fv d nn
	V	N	N			
i.5	fv	n	d nn	d		n fv d nn d
	V	N	N			
i.6	fv	n	d nn	d nn		n fv d nn d nn
	V	N	N	N		
i.7	fv	n	d nn cc	d nn		n fv d nn d nn cc
	V	N	N	N		
i.8	fv	n	d nn cc	d nn	d	n fv d nn d nn cc d
	V	N	N	N	N	
i.9	fv	n	d nn cc	d nn	d nn	n fv d nn d nn cc d nn
	V	N	N	N	N	
i.10	fv p	n	d nn cc	d nn	d nn	n fv d nn d nn cc d nn p
	V	N	N	N	N	

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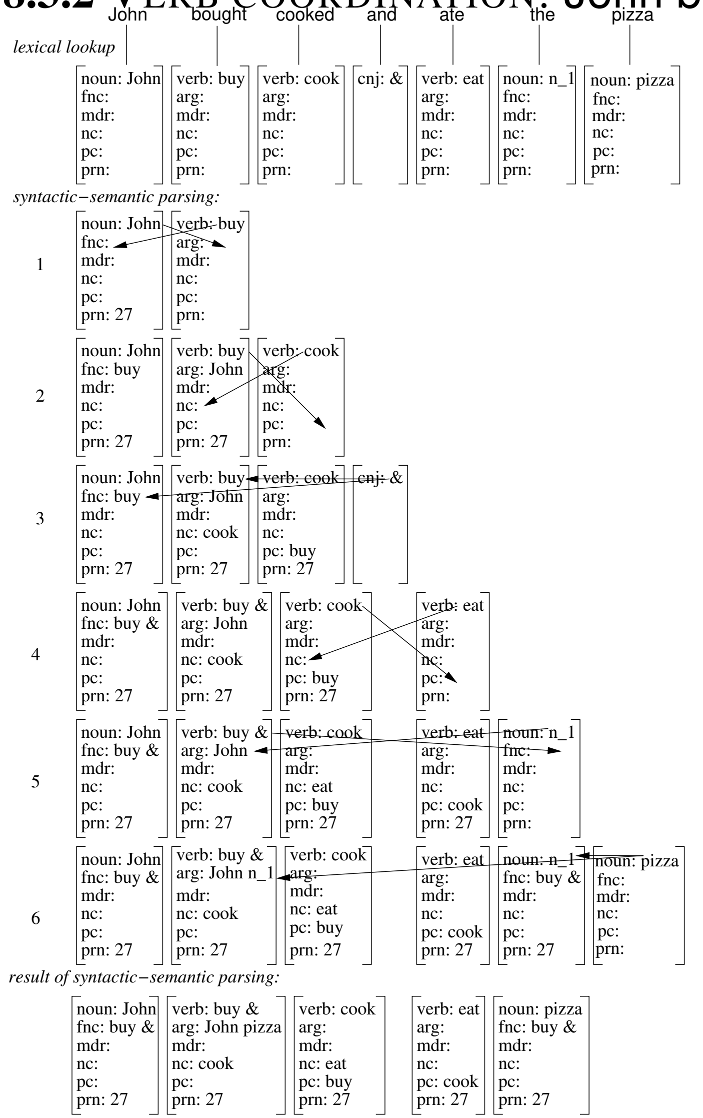
8.3 Simple Coordination of Verbs and of Adjectives

8.3.1 Coordination of two-place verbs

noun: John	verb: buy &	verb: cook	verb: eat	noun: pizza
fnc: buy &	arg: John pizza	arg:	arg:	fnc: buy &
nc:	nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:	pc:

8.3.2 VERB COORDINATION: John bought, cooked, and ate the pizza



8.3.3 PRODUCTION OF John bought, cooked, and ate the pizza.

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activated sequence						*realization*
i						
	V					
i.1		n				n
	V	N				
i.2	fv	n				n fv
	V	N				
i.3	fv	n	fv			n fv fv
	V	N	V			
i.4	fv cc	n	fv			n fv fv cc
	V	N	V			
i.5	fv cc	n	fv	fv		n fv fv cc fv
	V	N	V	V		
i.6	fv cc	n	fv	fv	d	n fv fv cc fv d
	V	N	V	V	N	
i.7	fv cc	n	fv	fv	d nn	n fv fv cc fv d nn
	V	N	V	V	N	
i.8	fv cc p	n	fv	fv	d nn	n fv fv cc fv d nn p
	V	N	V	V	N	

8.3.4 Adnominal coordination: John loves a smart, pretty, and rich girl

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noun: John	verb: love	noun: girl	adj: smart &	adj: pretty	adj: rich
fnc: love	arg: John girl	fnc: love	mdr: B	mdr: B	mdr: B
mdr:	mdr::	mdr: smart &	mdd: girl	mdd:	mdd:
nc:	nc:	nc:	nc: pretty	nc: rich	nc:
pc:	pc:	pc:	pc:	pc: smart	pc: pretty
prn: 21	prn: 21	prn: 21	prn: 21	prn: 21	prn: 21

8.3.5 Adverbial coordination: John talked slowly, gently, and seriously

noun: John	verb: talk	adj: slow &	adj: gentle	adj: serious
fnc: talk	arg: John	mdr: B	mdr: B	mdr: B
mdr:	mdr: slow &	mdd: talk	mdd:	mdd:
nc:	nc:	nc: gentle	nc: serious	nc:
pc:	pc:	pc:	pc: slow	pc: gentle
prn: 29	prn: 29	prn: 29	prn: 29	prn: 29

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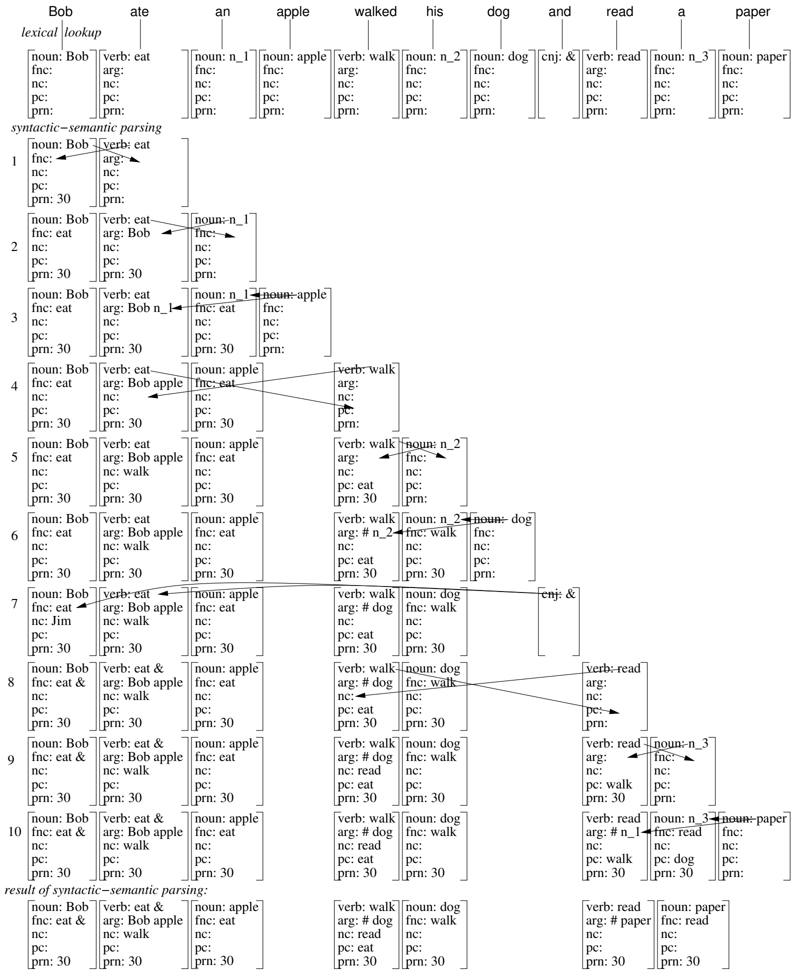
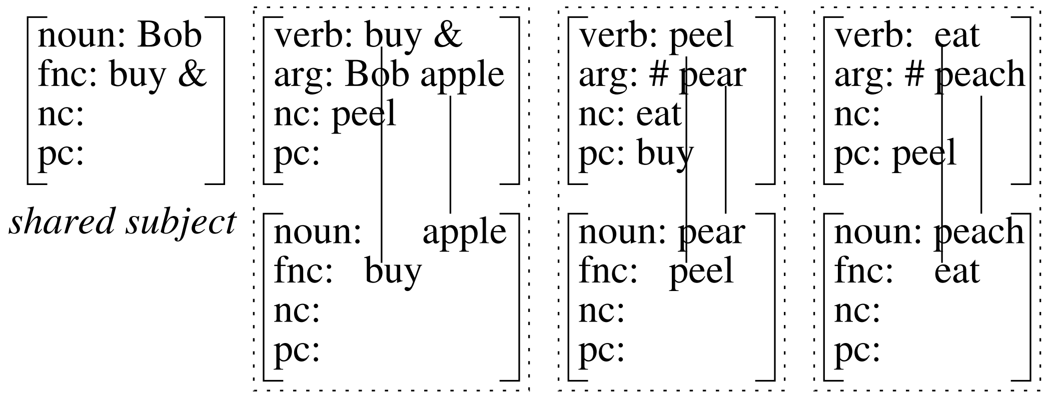
8.4 Complex Coordination of Verbs and Objects: Subject Gapping

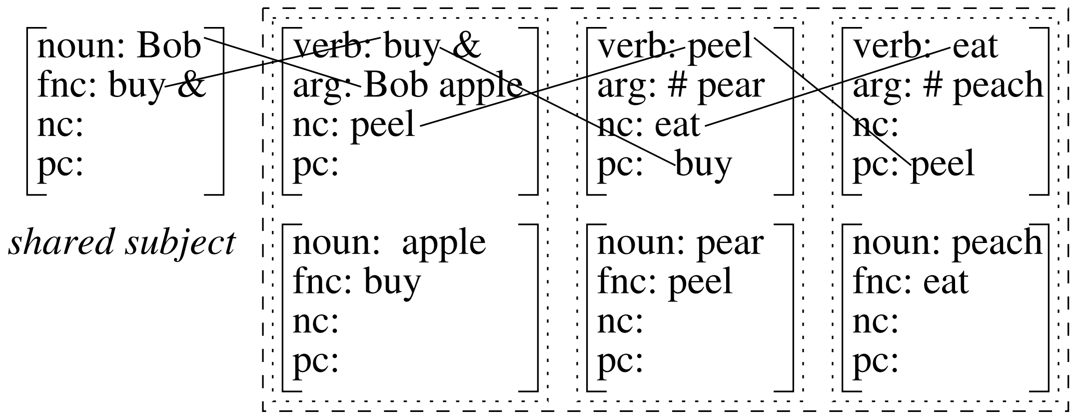
8.4.1 Bob ate an apple, # walked his dog, and # read a paper



8.4.2 Intra-conjunct relations of complex verb-object coordinat.



8.4.3 Extra-conjunct relations of complex verb-object coordinat.



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8.4.4 Corresponding simple verb and object coordinations

shared subject

noun: Bob	verb: buy &	verb: peel	verb: eat	noun: apple &	noun: pear	noun: peach
fnc: buy &	arg: Bob apple &	arg:	arg:	fnc: buy &	fnc:	fnc:
nc:	nc: peel	nc: eat	nc:	nc: pear	nc: peach	nc:
pc:	pc:	pc: buy	pc: peel	pc:	pc: apple	pc: pear

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8.4.5 PRODUCTION OF Bob ate an apple, walked his dog, and read a paper.

activated sequence								*realization*
i								
	V							
i.1		n						n
	V	N						
i.2	fv	n						n fv
	V	N						
i.3	fv	n	d					n fv d
	V	N	N					
i.4	fv	n	d nn					n fv d nn
	V	N	N					
i.5	fv	n	d nn	fv				n fv d nn fv
	V	N	N	V				
i.6	fv	n	d nn	fv	d			n fv d nn fv d
	V	N	N	V	N			
i.7	fv	n	d nn	fv	d nn			n fv d nn fv d nn
	V	N	N	V	N			
i.8	fv cc	n	d nn	fv	d nn			n fv d nn fv d nn cc
	V	N	N	V	N			
i.9	fv cc	n	d nn	fv	d nn	fv		n fv d nn fv d nn cc fv
	V	N	N	V	N	V		
i.10	fv cc	n	d nn	fv	d nn	fv	d	n fv d nn fv d nn cc fv d
	V	N	N	V	N	V	N	
i.11	fv cc	n	d nn	fv	d nn	fv	d nn	n fv d nn fv d nn cc fv d nn
	V	N	N	V	N	V	N	
i.12	fv cc p	n	d nn	fv	d nn	fv	d nn	n fv d nn fv d nn cc fv d nn p
	V	N	N	V	N	V	N	

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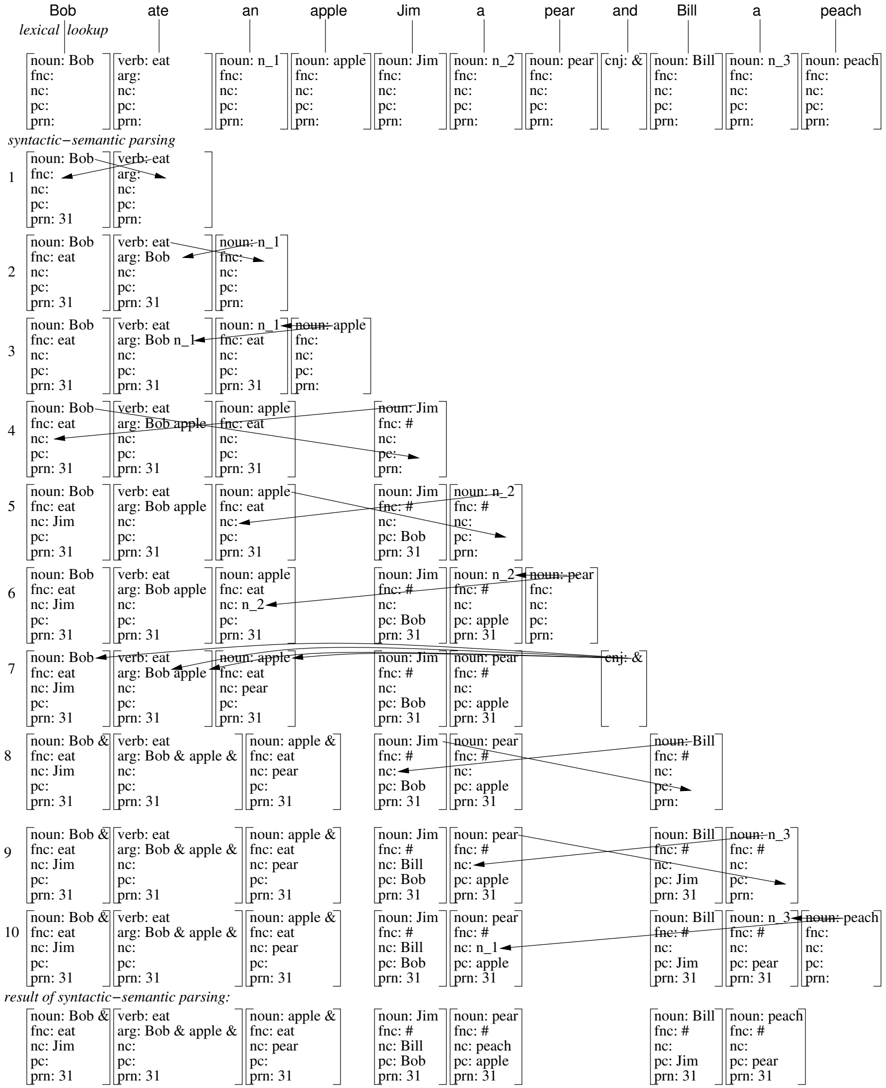
8.5 Complex Coordination of Subjects and Objects: Verb Gapping

8.5.1 Verb gapping: Bob ate an apple, Jim # a pear, and Bill # a peach



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8.5.2 Grammatical relations in complex subject-object coordinat.

	noun: Bob & fnc: eat nc: Jim pc: prn: 31	noun: Jim fnc: # nc: Bill pc: Bob prn: 31	noun: Bill fnc: # nc: pc: Jim prn: 31
verb: eat arg: Bob & apple & nc: pc: prn: 31 *shared vcrb*			
	noun: apple & fnc: eat nc: pear pc: prn: 31	noun: pear fnc: # nc: peach pc: apple prn: 31	noun: peach fnc: # nc: pc: pear prn: 31

8.5.3 Grammatical relations in simple subject and object coordinat.

noun: Bob & fnc: eat nc: Jim pc: prn: 31	noun: Jim fnc: nc: Bill pc: Bob prn: 31	noun: Bill fnc: nc: pc: Jim prn: 31	verb: eat arg: Bob & apple & nc: pc: prn: 31	noun: apple & fnc: eat nc: pear pc: prn: 31	noun: pear fnc: nc: peach pc: apple prn: 31	noun: peach fnc: nc: pc: pear prn: 31

8.5.4 PRODUCTION OF Bob ate an apple, Jim a pear, and Bill a peach.

activated sequence								*realization*
i								
	V							
i.1		n						n
	V	N						
i.2	fv	n						n fv
	V	N						
i.3	fv	n	d					n fv d
	V	N	N					
i.4	fv	n	d nn					n fv d nn
	V	N	N					
i.5	fv	n	d nn	n				n fv d nn n
	V	N	N	N				
i.6	fv	n	d nn	n	d			n fv d nn n d
	V	N	N	N	N			
i.7	fv	n	d nn	n	d nn			n fv d nn n d nn
	V	N	N	N	N			
i.8	fv cc	n	d nn	n	d nn			n fv d nn n d nn cc
	V	N	N	N	N			
i.9	fv cc	n	d nn	n	d nn	n		n fv d nn fv d nn cc n
	V	N	N	N	N	N		
i.10	fv cc	n	d nn	n	d nn	n	d	n fv d nn n d nn cc n d
	V	N	N	N	N	N	N	
i.11	fv cc	n	d nn	n	d nn	n	d nn	n fv d nn n d nn cc n d nn
	V	N	N	N	N	N	N	
i.12	fv cc p	n	d nn	n	d nn	n	d nn	n fv d nn n d nn cc n d nn p
	V	N	N	N	N	N	N	

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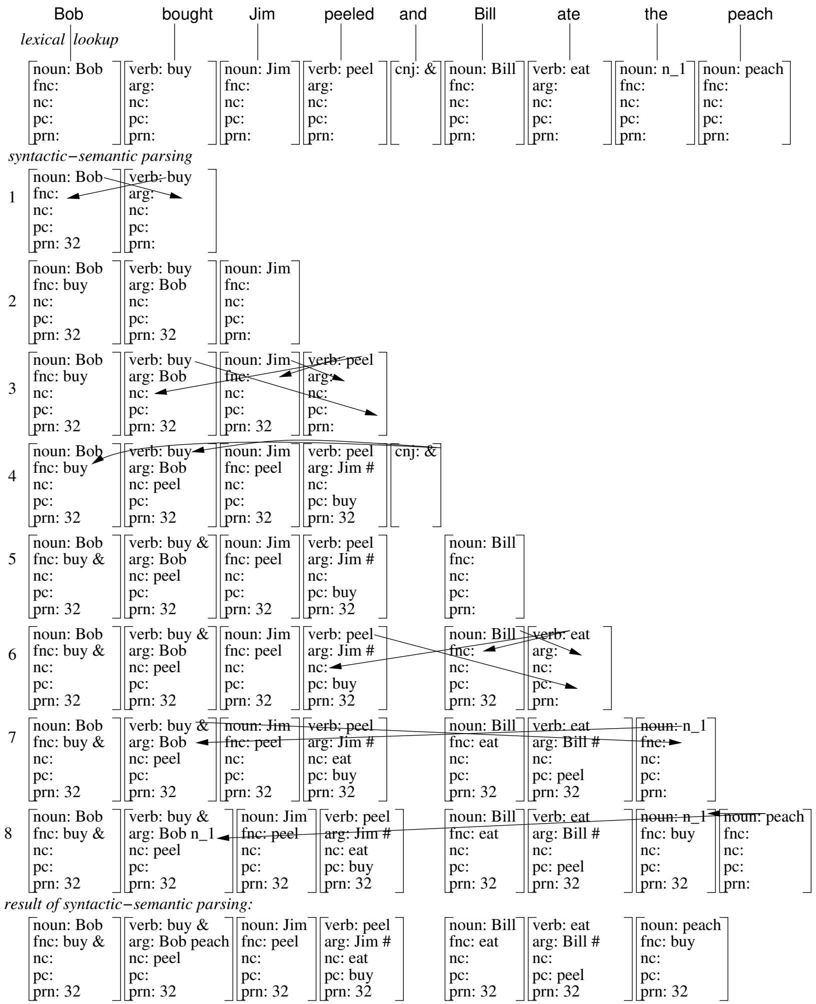
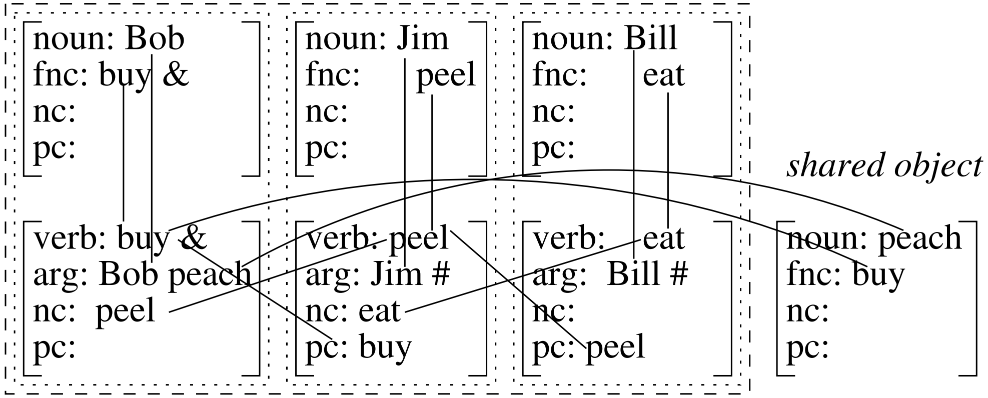
8.6 Complex Coordination of Subjects and Verbs: Object Gapping

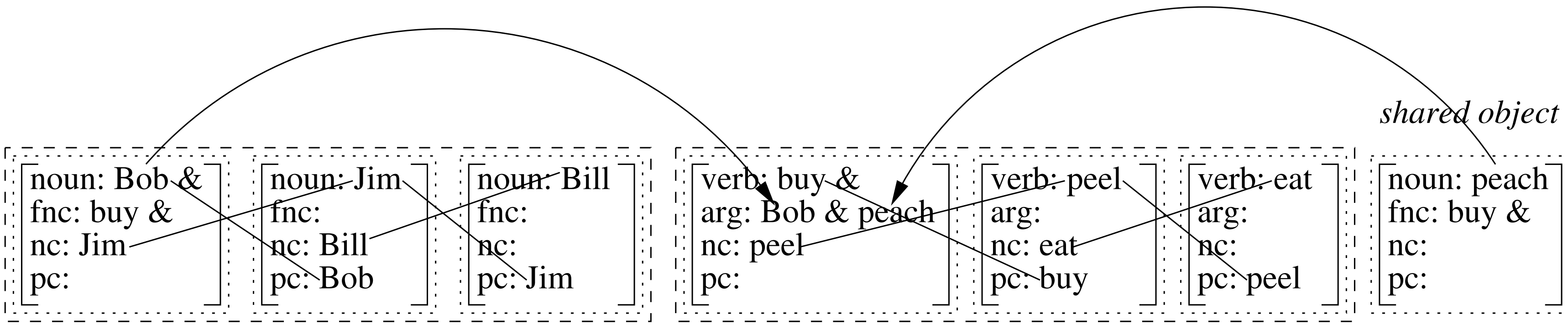
8.6.1 Object gapping: Bob bought #, Jim peeled #, and Bill ate the peach



8.6.2 Grammatical relations in complex subject-verb coordination



8.6.3 Relations in simple subject and verb coordinations



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8.6.4 PRODUCTION OF Bob bought, Jim peeled, and Bill ate the peach.

activated sequence								*realization*
i								
	V							
i.1		n						n
	V	N						
i.2	fv	n						n fv
	V	N						
i.3	fv	n		n				n fv n
	V	N	V	N				
i.4	fv	n	fv	n				n fv n fv
	V	N	V	N				
i.5	fv cc	n	fv	n				n fv n fv cc
	V	N	V	N				
i.6	fv cc	n	fv	n		n		n fv n fv cc n
	V	N	V	N	V	N		
i.7	fv cc	n	fv	n	fv	n		n fv n fv cc n fv
	V	N	V	N	V	N		
i.8	fv cc	n	fv	n	fv	n	d	n fv n fv cc n fv d
	V	N	V	N	V	N	N	
i.9	fv cc	n	fv	n	fv	n	d	n fv n fv cc n fv d nn
	V	N	V	N	V	N	N	
i.10	fv cc p	n	fv	n	fv	n	d nn	n fv n fv cc n fv d nn p
	V	N	V	N	V	N	N	

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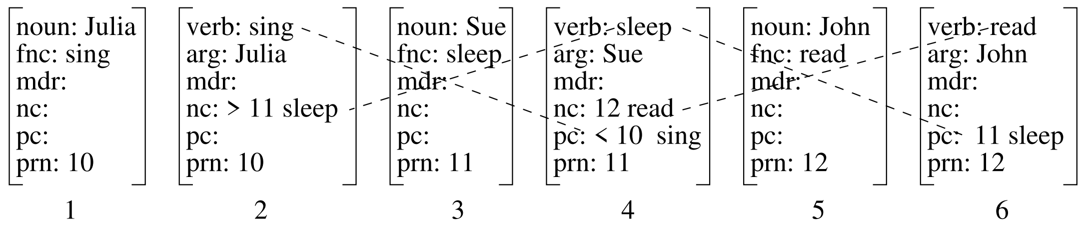
9. Extra-Propositional Coordination

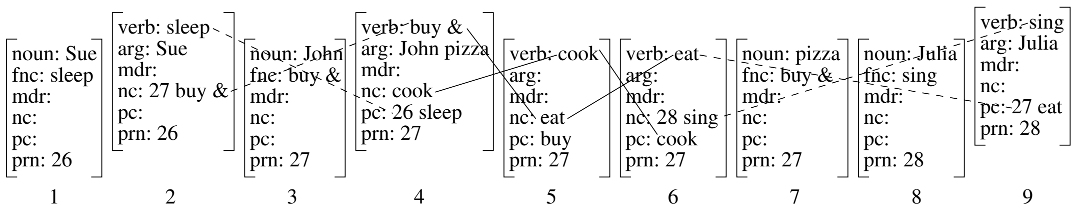
9.1 Overview

In Database Semantics, the coordination of propositions is coded in their verb proplets' nc and pc attributes. Consider the following set of proplets representing Julia sang. Then Sue slept. John read.:

9.1.1 Grammatical relations between concatenated propositions



9.1.2 Combining intra- and extra-propositional coordinations



The relations of extra-propositional coordination are indicated by dashed lines, while those of the intra-propositional coordination are indicated by solid lines.

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9.2 Interpretation and Production of Extra-Propositional Coordination

9.2.1 Derivation of Julia slept. John sang.

	Julia	slept	.	John	sang	.
lexical lookup	noun: Julia fnc: mdr: nc: pc: prn:	verb: sleep arg: mdr: nc: pc: prn:	pnc:.	noun: John fnc: mdr: nc: pc: prn:	verb: sing arg: mdr: nc: pc: prn:	pnc:.

syntactic−semantic parsing:

1	noun: Julia fnc: mdr: nc: pc: prn: 29	verb: sleep arg: mdr: nc: pc: prn:				
2	noun: Julia fnc: sleep mdr: nc: pc: prn: 29	verb: sleep arg: Julia mdr: nc: pc: prn: 29	pnc:.			
3	noun: Julia fnc: sleep mdr: nc: pc: prn: 29	verb: sleep arg: Julia mdr: nc: pc: prn: 29		noun: John fnc: mdr: nc: pc: prn:		
4	noun: Julia fnc: sleep mdr: nc: pc: prn: 29	verb: sleep arg: Julia mdr: nc: pc: prn: 29		noun: John fnc: mdr: nc: pc: prn: 30	verb: sing arg: mdr: nc: pc: prn:	
5	noun: Julia fnc: sleep mdr: nc: pc: prn: 29	verb: sleep arg: Julia mdr: nc: 30 sing pc: prn: 29		noun: John fnc: sing mdr: nc: pc: prn: 30	verb: sing arg: John mdr: nc: pc: 29 sleep prn: 30	pnc:.

result of syntactic−semantic parsing:

noun: Julia fnc: sleep mdr: nc: pc: prn: 29	verb: sleep arg: Julia mdr: nc: 30 sing pc: prn: 29	noun: John fnc: sing mdr: nc: pc: prn: 30	verb: sing arg: John mdr: nc: pc: 29 sleep prn: 30

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9.2.2 Production of Julia slept. John sang.

	activated sequence				*realization*
1					
	V				
1.1		n			n
	V	N			
1.2	fv	n			n fv
	V	N			
1.3	fv p	n			n fv p
	V	N			
2.1	fv p	n		n	n fv p n
	V	N	V	N	
2.2	fv p	n	fv	n	n fv p n fv
	V	N	V	N	
2.3	fv p	n	fv p	n	n fv p n fv p
	V	N	V	N	

After the initial LA-think navigation from V to N, LA-speak produces the abstract n fv p surface in lines 1.1 – 1.3. Thereby the sentence-final punctuation mark is lexicalized using the sentence mood specified in the verb proplet. Then LA-think traverses the second VN proplet sequence, from which LA-speak produces the second abstract n fv p surface in lines 2.1 – 2.3. The suspension shows up in line 2.1 in a way similar to example 7.6.2. See Chapters 11. and 12. for the explicitly defined LA-hear, LA-think, and LA-speak grammars handling extra-propositional coordination.

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9.3 Simple Coordinations as Sentential Arguments and Modifiers

9.3.1 Simple coordinations in sentential arguments 1

1. Noun coordination as the subject of a subject sentence:
   That the man, the woman, and the child slept surprised Mary.

$$
\begin{bmatrix}\text{n/v: that sleep}\\ \text{arg: man \&}\\ \text{fnc: 9 surprise}\\ \text{prn: 8}\end{bmatrix}
\begin{bmatrix}\text{noun: man \&}\\ \text{fnc: sleep}\\ \text{nc: woman}\\ \text{pc:}\\ \text{prn: 8}\end{bmatrix}
\begin{bmatrix}\text{noun: woman}\\ \text{fnc:}\\ \text{nc: child}\\ \text{pc: man}\\ \text{prn: 8}\end{bmatrix}
\begin{bmatrix}\text{noun: child}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: woman}\\ \text{prn: 8}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{verb: surprise}\\ \text{arg: 8 sleep Mary}\\ \text{prn: 9}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: surprise}\\ \text{prn: 9}\end{bmatrix}
$$

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2. Verb coordination in a subject sentence:

That the man bought, cooked, and ate the pizza surprised Mary.

$$\begin{bmatrix}\text{noun: man}\\ \text{fnc: buy \&}\\ \text{prn: 10}\end{bmatrix}\begin{bmatrix}\text{n/v: that buy \&}\\ \text{arg: man pizza}\\ \text{fnc: 11 surprise}\\ \text{nc: cook}\\ \text{pc:}\\ \text{prn: 10}\end{bmatrix}\begin{bmatrix}\text{verb: cook}\\ \text{arg:}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 10}\end{bmatrix}\begin{bmatrix}\text{verb: eat}\\ \text{arg:}\\ \text{nc:}\\ \text{pc: cook}\\ \text{prn: 10}\end{bmatrix}\begin{bmatrix}\text{noun: pizza}\\ \text{fnc: buy \&}\\ \text{prn: 10}\end{bmatrix}$$

$$\begin{bmatrix}\text{verb: surprise}\\ \text{arg: 10 buy \& Mary}\\ \text{prn: 11}\end{bmatrix}\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: surprise}\\ \text{prn: 11}\end{bmatrix}$$

3. Noun coordination as the object of a subject sentence:

That Bob ate an apple, a pear, and a peach, surprised Mary.

$$\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: eat}\\ \text{prn: 12}\end{bmatrix}\begin{bmatrix}\text{n/v: that eat}\\ \text{arg: Bob apple \&}\\ \text{fnc: 13 surprise}\\ \text{prn: 12}\end{bmatrix}\begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: eat}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 12}\end{bmatrix}\begin{bmatrix}\text{noun: pear}\\ \text{fnc:}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 12}\end{bmatrix}\begin{bmatrix}\text{noun: peach}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 12}\end{bmatrix}$$

$$\begin{bmatrix}\text{verb: surprise}\\ \text{arg: 12 eat Mary}\\ \text{prn: 13}\end{bmatrix}\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: surprise}\\ \text{prn: 13}\end{bmatrix}$$

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9.3.2 Simple coordinations in sentential arguments 2

The crucial difference between the following three examples and those in 9.3.1 above is that the sentential and non-sentential arg values of the higher verb proplets (*surprise*, *see*) are in inverse order: in 9.3.1(1) they are [arg: 8 sleep Mary] (subject sentence), while in 9.3.2(1) they are [arg: Mary 15 sleep] (object sentence); in 9.3.1(2) they are [arg: 10 buy & Mary] (subject sentence), while in 9.3.2(2) they are [arg: Mary 17 buy &] (object sentence); and in 9.3.1(3) they are [arg: 12 buy Mary] (subject sentence), while in 9.3.2(3) they are [arg: Mary 19 buy] (object sentence).

1. Noun coordination as the subject of an object sentence:
   Mary saw that the man, the woman and the child slept.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 14}\end{bmatrix} \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary 15 sleep}\\ \text{prn: 14}\end{bmatrix}$$

$$\begin{bmatrix}\text{n/v: that sleep}\\ \text{arg: man \&}\\ \text{fnc: 14 see}\\ \text{prn: 15}\end{bmatrix} \begin{bmatrix}\text{noun: man \&}\\ \text{fnc: sleep}\\ \text{nc: woman}\\ \text{pc:}\\ \text{prn: 15}\end{bmatrix} \begin{bmatrix}\text{noun: woman}\\ \text{fnc:}\\ \text{nc: child}\\ \text{pc: man}\\ \text{prn: 15}\end{bmatrix} \begin{bmatrix}\text{noun: child}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: woman}\\ \text{prn: 15}\end{bmatrix}$$

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2. Verb coordination in an object sentence:

   Mary saw that the man bought, cooked, and ate the pizza.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 16}\end{bmatrix} \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary 17 buy \&}\\ \text{prn: 16}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: man}\\ \text{fnc: buy \&}\\ \text{prn: 17}\end{bmatrix} \begin{bmatrix}\text{n/v: that buy \&}\\ \text{arg: man pizza}\\ \text{fnc: 16 see}\\ \text{nc: cook}\\ \text{pc:}\\ \text{prn: 17}\end{bmatrix} \begin{bmatrix}\text{verb: cook}\\ \text{arg:}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 17}\end{bmatrix} \begin{bmatrix}\text{verb: eat}\\ \text{arg:}\\ \text{nc:}\\ \text{pc: cook}\\ \text{prn: 17}\end{bmatrix} \begin{bmatrix}\text{noun: pizza}\\ \text{fnc: buy \&}\\ \text{prn: 17}\end{bmatrix}$$

3. Noun coordination as the object of an object sentence::

   Mary saw that Bob bought an apple, a pear, and a peach.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 18}\end{bmatrix} \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary 19 buy}\\ \text{prn: 18}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy}\\ \text{prn: 19}\end{bmatrix} \begin{bmatrix}\text{n/v: that buy}\\ \text{arg: Bob apple \&}\\ \text{fnc: 18 see}\\ \text{prn: 19}\end{bmatrix} \begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: buy}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 19}\end{bmatrix} \begin{bmatrix}\text{noun: pear}\\ \text{fnc:}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 19}\end{bmatrix} \begin{bmatrix}\text{noun: peach}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 19}\end{bmatrix}$$

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9.3.3 Simple coordinations in sentential modifiers 1

1. Noun coordination as the subject of an adnominal sentence with a subject gap:

   structurally excluded!

   A relative clause with a subject gap cannot have a subject coordination because the gap (represented in English by a relative pronoun) cannot be part of a noun coordination.

2. Verb coordination in an adnominal sentence with a subject gap:

   Mary saw the man who bought, cooked, and ate the pizza.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 20}\end{bmatrix}\ \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary man}\\ \text{prn: 20}\end{bmatrix}\ \begin{bmatrix}\text{noun: man}\\ \text{fnc: see}\\ \text{mdr: 21 buy \&}\\ \text{prn: 20}\end{bmatrix}$$

$$\begin{bmatrix}\text{a/v: buy \&}\\ \text{arg: \# pizza}\\ \text{mdd: 20 man}\\ \text{nc: cook}\\ \text{pc:}\\ \text{prn: 21}\end{bmatrix}\ \begin{bmatrix}\text{verb: cook}\\ \text{arg:}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 21}\end{bmatrix}\ \begin{bmatrix}\text{verb: eat}\\ \text{arg:}\\ \text{nc:}\\ \text{pc: cook}\\ \text{prn: 21}\end{bmatrix}\ \begin{bmatrix}\text{noun: pizza}\\ \text{fnc: buy \&}\\ \text{prn: 21}\end{bmatrix}$$

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3. Noun coordination as the object of an adnominal clause with a subject gap:
Mary saw the man who bought an apple, a pear, and a peach.

$$
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 22}\end{bmatrix}
\begin{bmatrix}\text{verb: see}\\ \text{arg: Mary man}\\ \text{prn: 22}\end{bmatrix}
\begin{bmatrix}\text{noun: man}\\ \text{fnc: see}\\ \text{mdr: 23 buy}\\ \text{prn: 22}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{a/v: buy}\\ \text{arg: \# apple \&}\\ \text{mdd: 22 man}\\ \text{prn: 23}\end{bmatrix}
\begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: buy}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 23}\end{bmatrix}
\begin{bmatrix}\text{noun: pear}\\ \text{fnc:}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 23}\end{bmatrix}
\begin{bmatrix}\text{noun: peach}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 23}\end{bmatrix}
$$

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9.3.4 Simple coordinations in sentential modifiers 2

1. Noun coordination as the subject of an adnominal clause with an object gap:
   Mary saw the pizza which Bob, Jim, and Bill ate.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 24}\end{bmatrix} \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary pizza}\\ \text{prn: 24}\end{bmatrix} \begin{bmatrix}\text{noun: pizza}\\ \text{fnc: see}\\ \text{mdr: 25 eat}\\ \text{prn: 24}\end{bmatrix}$$

$$\begin{bmatrix}\text{a/v: eat}\\ \text{arg: Bob \& \#}\\ \text{mdd: 24 pizza}\\ \text{prn: 25}\end{bmatrix} \begin{bmatrix}\text{noun: Bob \&}\\ \text{fnc: eat}\\ \text{nc: Jim}\\ \text{pc:}\\ \text{prn: 25}\end{bmatrix} \begin{bmatrix}\text{noun: Jim}\\ \text{fnc:}\\ \text{nc: Bill}\\ \text{pc: Bob}\\ \text{prn: 25}\end{bmatrix} \begin{bmatrix}\text{noun: Bill}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: Jim}\\ \text{prn: 25}\end{bmatrix}$$

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2. Verb coordination in an adnominal clause with an object gap:
   Mary saw the pizza which the man bought, cooked, and ate.

$$
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 26}\end{bmatrix}
\begin{bmatrix}\text{verb: see}\\ \text{arg: Mary pizza}\\ \text{prn: 26}\end{bmatrix}
\begin{bmatrix}\text{noun: pizza}\\ \text{fnc: see}\\ \text{mdr: 27 buy \&}\\ \text{prn: 26}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{noun: man}\\ \text{fnc: buy \&}\\ \text{prn: 27}\end{bmatrix}
\begin{bmatrix}\text{a/v: buy \&}\\ \text{arg: man \#}\\ \text{mdd: 26 pizza}\\ \text{nc: cook}\\ \text{pc:}\\ \text{prn: 27}\end{bmatrix}
\begin{bmatrix}\text{verb: cook}\\ \text{arg:}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 27}\end{bmatrix}
\begin{bmatrix}\text{verb: eat}\\ \text{arg:}\\ \text{nc:}\\ \text{pc: cook}\\ \text{prn: 27}\end{bmatrix}
$$

3. Noun coordination as the object of the adnominal clause with an object gap:
   structurally excluded!
   A relative clause with an object gap cannot have an object coordination because the gap (represented in English by a relative pronoun) cannot participate in a coordination.

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9.3.5 Simple coordinations in sentential modifiers 3

1. Noun coordination as the subject of an adverbial sentence:
   Mary arrived after Bob, Jim, and Bill had eaten a pizza.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 28}\end{bmatrix} \begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 29 eat}\\ \text{prn: 28}\end{bmatrix} \begin{bmatrix}\text{a/v: after eat}\\ \text{arg: Bob \& pizza}\\ \text{mdd: 28 arrive}\\ \text{prn: 29}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: Bob \&}\\ \text{fnc: eat}\\ \text{nc: Jim}\\ \text{pc:}\\ \text{prn: 29}\end{bmatrix} \begin{bmatrix}\text{noun: Jim}\\ \text{fnc:}\\ \text{nc: Bill}\\ \text{pc: Bob}\\ \text{prn: 29}\end{bmatrix} \begin{bmatrix}\text{noun: Bill}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: Jim}\\ \text{prn: 29}\end{bmatrix} \begin{bmatrix}\text{noun: pizza}\\ \text{fnc: eat}\\ \text{prn: 29}\end{bmatrix}$$

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2. Verb coordination in an adverbial sentence:

After Bob had bought, cooked, and eaten the pizza, Mary arrived.

$$\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy \&}\\ \text{prn: 30}\end{bmatrix} \begin{bmatrix}\text{a/v: after buy \&}\\ \text{arg: Bob pizza}\\ \text{mdd: 31 arrive}\\ \text{nc: cook}\\ \text{pc:}\\ \text{prn: 30}\end{bmatrix} \begin{bmatrix}\text{verb: cook}\\ \text{arg:}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 30}\end{bmatrix} \begin{bmatrix}\text{verb: eat}\\ \text{arg:}\\ \text{nc:}\\ \text{pc: cook}\\ \text{prn: 30}\end{bmatrix} \begin{bmatrix}\text{noun: pizza}\\ \text{fnc: buy \&}\\ \text{prn: 30}\end{bmatrix}$$

$$\begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 30 buy}\\ \text{prn: 31}\end{bmatrix} \begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 31}\end{bmatrix}$$

3. Noun coordination as the object of an adverbial sentence:

Mary arrived after Bob had eaten an apple, a pear, and a peach.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 32}\end{bmatrix} \begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 33 eat}\\ \text{prn: 32}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: eat}\\ \text{prn: 33}\end{bmatrix} \begin{bmatrix}\text{a/v: after eat}\\ \text{arg: Bob apple \&}\\ \text{mdd: 32 arrive}\\ \text{prn: 33}\end{bmatrix} \begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: eat}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 33}\end{bmatrix} \begin{bmatrix}\text{noun: pear}\\ \text{fnc:}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 33}\end{bmatrix} \begin{bmatrix}\text{noun: peach}\\ \text{fnc:}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 33}\end{bmatrix}$$

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9.4 Complex Coordinations as Sentential Arguments and Modifiers

Corresponding to the grammatical analysis of simple subject, verb, and object coordinations in extra-propositional functor-argument structures, we turn now to complex verb-object, subject-object, and subject-verb coordinations (i.e. subject, verb, and object gapping, respectively). As before, their grammatical function is investigated in a (i) subject sentence, (ii) an object sentence, (iii) an adnominal sentence with subject gap, (iv) an adnominal sentence with object gap, and (v) an adverbial sentence.

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9.4.1 Complex coordinations in sentential arguments 1

1. Verb-object coordination in a subject sentence:
   That Bob ate an apple, walked his dog, and read a paper, amused Mary.

$$
\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: eat \&}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{n/v: that eat \&}\\ \text{arg: Bob apple}\\ \text{fnc: 30 amuse}\\ \text{nc: walk}\\ \text{pc:}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{noun: apple}\\ \text{fnc: eat}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{verb: walk}\\ \text{arg: \# dog}\\ \text{nc: read}\\ \text{pc: eat}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{noun: dog}\\ \text{fnc: walk}\\ \text{prn: 29}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{verb: read}\\ \text{arg: \# paper}\\ \text{nc:}\\ \text{pc: walk}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{noun: paper}\\ \text{fnc: read}\\ \text{prn: 29}\end{bmatrix}
\begin{bmatrix}\text{verb: amuse}\\ \text{arg: 29 eat \& Mary}\\ \text{prn: 30}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: amuse}\\ \text{prn: 30}\end{bmatrix}
$$

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2. Subject-object coordination in a subject sentence:
   That Bob ate an apple, Jim a pear, and Bill a peach, amused Mary.

$$\begin{bmatrix}\text{n/v: that eat}\\ \text{arg: Bob \& apple \&}\\ \text{fnc: 32 amuse}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{noun: Bob \&}\\ \text{fnc: eat}\\ \text{nc: Jim}\\ \text{pc:}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: eat}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{noun: Jim}\\ \text{fnc: \#}\\ \text{nc: Bill}\\ \text{pc: Bob}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{noun: pear}\\ \text{fnc: \#}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 31}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: Bill}\\ \text{fnc: \#}\\ \text{nc:}\\ \text{pc: Jim}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{noun: peach}\\ \text{fnc: \#}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 31}\end{bmatrix}
\begin{bmatrix}\text{verb: amuse}\\ \text{arg: 31 eat Mary}\\ \text{prn: 32}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: amuse}\\ \text{prn: 32}\end{bmatrix}$$

3. Subject-verb coordination in a subject sentence:
   That Bob bought, Jim peeled, and Bill ate the peach, amused Mary.

$$\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy \&}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{n/v: that buy \&}\\ \text{arg: Bob peach}\\ \text{fnc: 34 amuse}\\ \text{nc: peel}\\ \text{pc:}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{noun: Jim}\\ \text{fnc: peel}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{verb: peel}\\ \text{arg: Jim \#}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{noun: Bill}\\ \text{fnc: eat}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{verb: eat}\\ \text{arg: Bill \#}\\ \text{nc:}\\ \text{pc: peel}\\ \text{prn: 33}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: peach}\\ \text{fnc: buy}\\ \text{prn: 33}\end{bmatrix}
\begin{bmatrix}\text{verb: amuse}\\ \text{arg: 33 buy \& Mary}\\ \text{prn: 34}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: amuse}\\ \text{prn: 34}\end{bmatrix}$$

9.4.2 Complex coordinations in sentential arguments 2

1. Verb-object coordination in an object sentence:
   Mary saw that Bob ate an apple, walked his dog, and read a paper.

$$
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 34}\end{bmatrix}
\begin{bmatrix}\text{verb: see}\\ \text{arg: Mary 35 eat \&}\\ \text{prn: 34}\end{bmatrix}
\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: eat \&}\\ \text{prn: 35}\end{bmatrix}
\begin{bmatrix}\text{n/v: that eat \&}\\ \text{arg: Bob apple}\\ \text{fnc: 34 see}\\ \text{nc: walk}\\ \text{pc:}\\ \text{prn: 35}\end{bmatrix}
\begin{bmatrix}\text{noun: apple}\\ \text{fnc: eat}\\ \text{prn: 35}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{verb: walk}\\ \text{arg: \# dog}\\ \text{nc: read}\\ \text{pc: eat}\\ \text{prn: 35}\end{bmatrix}
\begin{bmatrix}\text{noun: dog}\\ \text{fnc: walk}\\ \text{prn: 35}\end{bmatrix}
\begin{bmatrix}\text{verb: read}\\ \text{arg: \# paper}\\ \text{nc:}\\ \text{pc: walk}\\ \text{prn: 35}\end{bmatrix}
\begin{bmatrix}\text{noun: paper}\\ \text{fnc: read}\\ \text{prn: 35}\end{bmatrix}
$$

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2. Subject-object coordination (verb gapping, cf. 8.5) in an object sentence:
   Mary saw that Bob ate an apple, Jim a pear, and Bill a peach.

$$\begin{bmatrix} \text{noun: Mary} \\ \text{fnc: see} \\ \text{prn: 36} \end{bmatrix} \begin{bmatrix} \text{verb: see} \\ \text{arg: Mary 37 eat} \\ \text{prn: 36} \end{bmatrix} \begin{bmatrix} \text{noun: Bob \&} \\ \text{fnc: eat} \\ \text{nc: Jim} \\ \text{pc:} \\ \text{prn: 37} \end{bmatrix} \begin{bmatrix} \text{n/v: that eat} \\ \text{arg: Bob \& apple \&} \\ \text{fnc: 36 see} \\ \text{prn: 37} \end{bmatrix} \begin{bmatrix} \text{noun: apple \&} \\ \text{fnc: eat} \\ \text{nc: pear} \\ \text{pc:} \\ \text{prn: 37} \end{bmatrix}$$

$$\begin{bmatrix} \text{noun: Jim} \\ \text{fnc: \#} \\ \text{nc: Bill} \\ \text{pc: Bob} \\ \text{prn: 37} \end{bmatrix} \begin{bmatrix} \text{noun: pear} \\ \text{fnc: \#} \\ \text{nc: peach} \\ \text{pc: apple} \\ \text{prn: 37} \end{bmatrix} \begin{bmatrix} \text{noun: Bill} \\ \text{fnc: \#} \\ \text{nc:} \\ \text{pc: Jim} \\ \text{prn: 37} \end{bmatrix} \begin{bmatrix} \text{noun: peach} \\ \text{fnc: \#} \\ \text{nc:} \\ \text{pc: pear} \\ \text{prn: 37} \end{bmatrix}$$

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3. Subject-verb coordination (object gapping, cf. 8.6) in an object sentence:
   Mary saw that Bob bought, Jim peeled, and Bill ate the peach .

$$
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 38}\end{bmatrix}
\begin{bmatrix}\text{verb: see}\\ \text{arg: Mary 39 buy \&}\\ \text{prn: 38}\end{bmatrix}
\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy \&}\\ \text{prn: 39}\end{bmatrix}
\begin{bmatrix}\text{n/v: that buy \&}\\ \text{arg: Bob peach}\\ \text{fnc: 38 see}\\ \text{nc: peel}\\ \text{pc:}\\ \text{prn: 39}\end{bmatrix}
\begin{bmatrix}\text{noun: Jim}\\ \text{fnc: peel}\\ \text{prn: 39}\end{bmatrix}
\begin{bmatrix}\text{verb: peel}\\ \text{arg: Jim \#}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 39}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{noun: Bill}\\ \text{fnc: eat}\\ \text{prn: 39}\end{bmatrix}
\begin{bmatrix}\text{verb: eat}\\ \text{arg: Bill \#}\\ \text{nc:}\\ \text{pc: peel}\\ \text{prn: 39}\end{bmatrix}
\begin{bmatrix}\text{noun: peach}\\ \text{fnc: buy}\\ \text{prn: 39}\end{bmatrix}
$$

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9.4.3 Complex coordination in sentential modifiers 1

The following relative clause example(s) containing complex coordinations are analogous to those in 9.3.3, which contain simple coordinations. However, in relative clauses with complex coordinations two constructions are structurally excluded, in contrast to simple coordinations, which exclude only one.

1. Verb-object coordination (subject gapping) in an adnom. sent. with subject gap:
   The man who ate an apple, walked his dog, and read a paper loves Mary.

$$
\begin{bmatrix}\text{noun: man}\\ \text{fnc: love}\\ \text{mdr: 41 eat \&}\\ \text{prn: 40}\end{bmatrix}
\begin{bmatrix}\text{a/v: eat \&}\\ \text{arg: \# apple}\\ \text{mdd: 40 man}\\ \text{nc: walk}\\ \text{pc:}\\ \text{prn: 41}\end{bmatrix}
\begin{bmatrix}\text{noun: apple}\\ \text{fnc: eat}\\ \text{prn: 41}\end{bmatrix}
\begin{bmatrix}\text{verb: walk}\\ \text{arg: \# dog}\\ \text{nc: read}\\ \text{pc: eat}\\ \text{prn: 41}\end{bmatrix}
\begin{bmatrix}\text{noun: dog}\\ \text{verb: walk}\\ \text{prn: 41}\end{bmatrix}
\begin{bmatrix}\text{verb: read}\\ \text{arg: \# paper}\\ \text{nc:}\\ \text{pc: walk}\\ \text{prn: 41}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{noun: paper}\\ \text{verb: read}\\ \text{prn: 41}\end{bmatrix}
\begin{bmatrix}\text{verb: love}\\ \text{arg: man Mary}\\ \text{prn: 40}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: love}\\ \text{prn: 40}\end{bmatrix}
$$

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2. Subject-object coordination (verb gapping) in an adnom. sent. with subject gap: *structurally excluded!*

   A subject-object coordination as the subject of a relative clause with the head serving as the subject is excluded, because the subject position is taken by the gap (represented in English by a relative pronoun) – which cannot participate in a coordination.

3. Subject-verb coordination (object gapping) in a adnominal sent. with subject gap:
   structurally excluded!

   This construction is excluded for the same reason as the one above.

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9.4.4 Complex coordination in sentential modifiers 2

The following relative clause example(s) containing complex coordinations are analogous to those in 9.3.4, which contain simple coordinations. However, as in the subject-gap relative clauses 9.4.3 with complex coordinations, two constructions are excluded, in contrast to simple coordinations, which exclude only one.

1. Verb-object coordination (subject gapping) in a adnominal sent. with object gap:
   structurally excluded!

   A verb-object coordination as the object of a relative clause with the head serving as the object is excluded, because the object position is taken by the gap (represented in English by a relative pronoun) – which cannot participate in a coordination.

2. Subject-object coordination (verb gapping) in an adnominal sentence with object gap:
   structurally excluded!

   This construction is excluded for the same reason as the one above.

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3. Subject-verb coordination (object gapping) in an adnominal sent. with object gap:

Mary saw the peach which Bob bought, Jim peeled, and Bill ate.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: see}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{verb: see}\\ \text{arg: Mary peach}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{noun: peach}\\ \text{fnc: see}\\ \text{mdr: 43 buy \&}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{a/v: buy \&}\\ \text{arg: Bob \#}\\ \text{mdd: 42 peach}\\ \text{nc: peel}\\ \text{pc:}\\ \text{prn: 43}\end{bmatrix} \begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy}\\ \text{prn: 43}\end{bmatrix}$$

$$\begin{bmatrix}\text{verb: peel}\\ \text{arg: Jim \#}\\ \text{pc: buy}\\ \text{nc: eat}\\ \text{prn: 43}\end{bmatrix} \begin{bmatrix}\text{noun: Jim}\\ \text{fnc: peel}\\ \text{prn: 43}\end{bmatrix} \begin{bmatrix}\text{verb: eat}\\ \text{arg: Bill \#}\\ \text{nc:}\\ \text{pc: peel}\\ \text{prn: 43}\end{bmatrix} \begin{bmatrix}\text{noun: Bill}\\ \text{fnc: eat}\\ \text{prn: 43}\end{bmatrix}$$

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9.4.5 Complex coordinations in sentential modifiers 3

1. Verb-object coordination (subject gapping, cf. 8.4) in an adverbial sentence:
   Mary arrived after Bob had eaten an apple, walked his dog, and read a paper.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 44}\end{bmatrix} \begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 45 eat \&}\\ \text{prn: 44}\end{bmatrix} \begin{bmatrix}\text{a/v: after eat \&}\\ \text{arg: Bob apple}\\ \text{mdd: 44 arrive}\\ \text{nc: walk}\\ \text{pc:}\\ \text{prn: 45}\end{bmatrix} \begin{bmatrix}\text{noun: Bob}\\ \text{fnc: eat}\\ \text{prn: 45}\end{bmatrix} \begin{bmatrix}\text{noun: apple}\\ \text{fnc: eat}\\ \text{prn: 45}\end{bmatrix}$$

$$\begin{bmatrix}\text{verb: walk}\\ \text{arg: \# dog}\\ \text{nc: read}\\ \text{pc: eat}\\ \text{prn: 45}\end{bmatrix} \begin{bmatrix}\text{noun: dog}\\ \text{fnc: walk}\\ \text{prn: 45}\end{bmatrix} \begin{bmatrix}\text{verb: read}\\ \text{arg: \# paper}\\ \text{nc:}\\ \text{pc: walk}\\ \text{prn: 45}\end{bmatrix} \begin{bmatrix}\text{noun: paper}\\ \text{fnc: read}\\ \text{prn: 45}\end{bmatrix}$$

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2. Subject-object coordination (verb gapping, cf. 8.5) in an adverbial sentence:

After Bob had eaten an apple, Jim a pear, and Bill a peach, Mary arrived.

$$
\begin{bmatrix}\text{a/v: after eat}\\ \text{arg: Bob \& apple \&}\\ \text{mdd: 47 arrive}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: Bob \&}\\ \text{fnc: eat}\\ \text{nc: Jim}\\ \text{pc:}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: apple \&}\\ \text{fnc: eat}\\ \text{nc: pear}\\ \text{pc:}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: Jim}\\ \text{fnc: \#}\\ \text{nc: Bill}\\ \text{pc: Bob}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: pear}\\ \text{fnc: \#}\\ \text{nc: peach}\\ \text{pc: apple}\\ \text{prn: 46}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{noun: Bill}\\ \text{fnc: \#}\\ \text{nc:}\\ \text{pc: Jim}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: peach}\\ \text{fnc: \#}\\ \text{nc:}\\ \text{pc: pear}\\ \text{prn: 46}\end{bmatrix}
\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 47}\end{bmatrix}
\begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 46 eat}\\ \text{prn: 47}\end{bmatrix}
$$

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3. Subject-verb coordination (object gapping, cf. 8.6) in an adverbial sentence:
   Mary arrived after Bob had bought, Jim had peeled, and Bill had eaten the peach.

$$\begin{bmatrix}\text{noun: Mary}\\ \text{fnc: arrive}\\ \text{prn: 48}\end{bmatrix}
\begin{bmatrix}\text{verb: arrive}\\ \text{arg: Mary}\\ \text{mdr: 49 buy \&}\\ \text{prn: 48}\end{bmatrix}
\begin{bmatrix}\text{noun: Bob}\\ \text{fnc: buy \&}\\ \text{prn: 49}\end{bmatrix}
\begin{bmatrix}\text{a/v: after buy \&}\\ \text{arg: Bob peach}\\ \text{mdd: 48 arrive}\\ \text{nc: peel}\\ \text{pc:}\\ \text{prn: 49}\end{bmatrix}$$

$$\begin{bmatrix}\text{noun: Jim}\\ \text{fnc: peel}\\ \text{prn: 49}\end{bmatrix}
\begin{bmatrix}\text{verb: peel}\\ \text{arg: Jim \#}\\ \text{nc: eat}\\ \text{pc: buy}\\ \text{prn: 49}\end{bmatrix}
\begin{bmatrix}\text{noun: Bill}\\ \text{fnc: eat}\\ \text{prn: 49}\end{bmatrix}
\begin{bmatrix}\text{verb: eat}\\ \text{arg: Bill \#}\\ \text{nc:}\\ \text{pc: peel}\\ \text{prn: 49}\end{bmatrix}
\begin{bmatrix}\text{noun: peach}\\ \text{fnc: buy}\\ \text{prn: 49}\end{bmatrix}$$

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9.5 Turn-Taking in Questions and Answers

While in a text, the sequence of propositions is produced by the same agent, in a dialog the propositions, or even just parts of propositions, in the sequence are produced by different agents.

This difference is formally characterized by the STAR of the propositions (cf. 2.6.2).

9.5.1 Comparing coordination in a text and a dialog

1. *Coordination of two propositions in a text*
   Julia ate an apple.$^{\mathrm{STAR}}$ Susanne ate a pear.$^{(\mathrm{STAR})}$
2. *Coordination of two propositions in a dialog*
   Julia ate an apple.$^{\mathrm{STAR}}$ Susanne ate a pear.$^{\mathrm{STA}'\mathrm{R}'}$
3. *Coordination of a question and an answer in a dialog*
   Who is singing? $^{\mathrm{STAR}}$ Julia.$^{\mathrm{STA}'\mathrm{R}'}$

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9.5.2 Illustrating kinds of coordination as sets of proplets

1. Julia is singing.$^{\mathrm{STAR}}$ Susanne is dreaming.$^{\mathrm{(STAR)}}$

$$\begin{bmatrix}\text{noun: Julia}\\ \text{fnc: sing}\\ \text{nc:}\\ \text{pc:}\\ \text{STAR:}\\ \text{prn: 4}\end{bmatrix} \begin{bmatrix}\text{verb: sing}\\ \text{arg: Julia}\\ \text{nc: 5 dream}\\ \text{pc:}\\ \text{STAR: s t John Bill}\\ \text{prn: 4}\end{bmatrix} \begin{bmatrix}\text{noun: Susanne}\\ \text{fnc: dream}\\ \text{nc:}\\ \text{pc:}\\ \text{STAR:}\\ \text{prn: 5}\end{bmatrix} \begin{bmatrix}\text{verb: dream}\\ \text{arg: Susanne}\\ \text{nc:}\\ \text{pc: 4 sing}\\ \text{STAR:}\\ \text{prn: 5}\end{bmatrix}$$

2. Julia is singing.$^{\mathrm{STAR}}$ Susanne is dreaming.$^{\mathrm{STA'R'}}$

$$\begin{bmatrix}\text{noun: Julia}\\ \text{fnc: sing}\\ \text{nc:}\\ \text{pc:}\\ \text{STAR:}\\ \text{prn: 4}\end{bmatrix} \begin{bmatrix}\text{verb: sing}\\ \text{arg: Julia}\\ \text{nc: 5 dream}\\ \text{pc:}\\ \text{STAR: s t John Bill}\\ \text{prn: 4}\end{bmatrix} \begin{bmatrix}\text{noun: Susanne}\\ \text{fnc: dream}\\ \text{nc:}\\ \text{pc:}\\ \text{STAR:}\\ \text{prn: 5}\end{bmatrix} \begin{bmatrix}\text{verb: dream}\\ \text{arg: Susanne}\\ \text{nc:}\\ \text{pc: 4 sing}\\ \text{STAR: s t Bill John}\\ \text{prn: 5}\end{bmatrix}$$

3. Who is singing? $^{\mathrm{STAR}}$ Julia.$^{\mathrm{STA'R'}}$

$$\begin{bmatrix}\text{noun: q\_1}\\ \text{fnc: sing}\\ \text{nc: Julia}\\ \text{pc:}\\ \text{STAR:}\\ \text{prn: n}\end{bmatrix} \begin{bmatrix}\text{verb: sing}\\ \text{arg: q\_1}\\ \text{nc:}\\ \text{pc:}\\ \text{STAR: s t John Bill}\\ \text{prn: n}\end{bmatrix} \begin{bmatrix}\text{noun: Julia}\\ \text{fnc: sing}\\ \text{nc:}\\ \text{pc: q\_1}\\ \text{STAR: s t Bill John}\\ \text{prn: n}\end{bmatrix}$$

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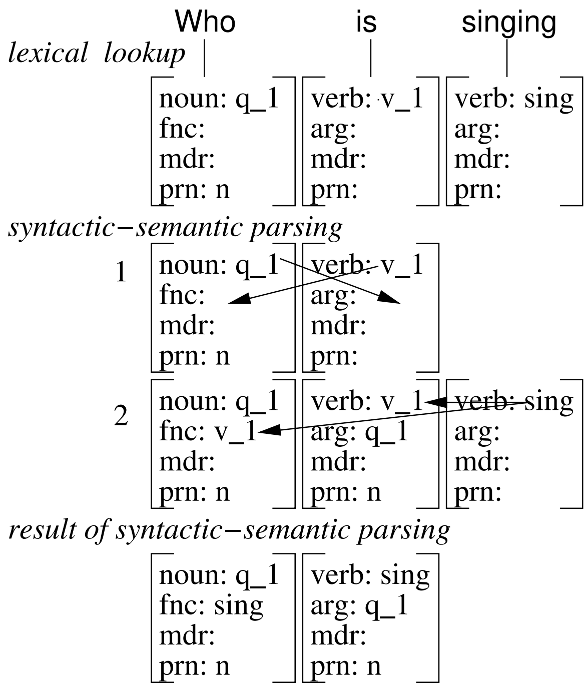
The interpretation and production of a question-answer pair may be experienced by an agent in the following constellations: (i) as the hearer of the question and the speaker of the answer, (ii) as the speaker of the question and the hearer of the answer, and (iii) as the hearer of the question and the answer (i.e. as an observer). These differences appear only in the STAR and the prn values, without affecting the grammatical analysis of the expressions used.

9.5.3 Derivation of a Wh-interrogative in the hearer-mode



The hearer's pragmatic use of this expression for querying consists in applying the verb proplet to the token line of *sing* (cf. Section 5.1):

9.5.4 Finding the answer

$$\begin{array}{lllllll}
 & & & & & \left[\begin{array}{l}\text{verb:}\textit{sing}\\ \text{arg: q_1}\\ \text{prn: n}\end{array}\right] & \textit{search pattern}\\
 & & & & & \quad\textit{matching?} & \\
\left[\text{verb: }\textit{sing}\right] & \left[\begin{array}{l}\text{verb: sing}\\ \text{arg: Bill}\\ \text{prn: 10}\end{array}\right] & \left[\begin{array}{l}\text{verb: sing}\\ \text{arg: Susanne}\\ \text{prn: 12}\end{array}\right] & \left[\begin{array}{l}\text{verb: sing}\\ \text{arg: Mary}\\ \text{prn: 15}\end{array}\right] & & \left[\begin{array}{l}\text{verb: sing}\\ \text{arg: Julia}\\ \text{prn: 19}\end{array}\right] & \textit{token line}
\end{array}$$

Given the present progressive tense of the question, the search pattern is matched with the last (and thus most recent) item in the token line of *sing*, thereby binding the variable q_1 to Julia and the variable *n* to 19. Thus the proplet underlying the answer to the question may be derived by navigating from *sing* to *Julia*, using the latter to produce the answer:

9.5.5 Derivation of the answer

$$\left[\begin{array}{l}\text{verb: sing}\\ \text{arg: Julia}\\ \text{prn: 19}\end{array}\right] \quad \left[\begin{array}{l}\text{noun: Julia}\\ \text{fnc: sing}\\ \text{prn: 19}\end{array}\right]$$

The interrogatives used in Wh-questions and yes/no-questions (cf. Section 5.1) may be arbitrarily complex, based on sentential arguments and modifiers. ‘Long distance dependencies’ are particularly interesting constructions in English:

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9.6 Complex Propositions as Thought Structures

9.6.1 Simple extra-propositional coordinat. of simple propositions

1. Extra-propositional forward navigation:
   Peter left the house. Then Peter crossed the street.

$$\begin{bmatrix}\text{noun: Peter}\\ \text{fnc: leave}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{verb: leave}\\ \text{arg: Peter house}\\ \text{nc: > 2 cross}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: house}\\ \text{fnc: leave}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: Peter}\\ \text{fnc: cross}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{verb: cross}\\ \text{arg: Peter street}\\ \text{nc:}\\ \text{pc: < 1 leave}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: street}\\ \text{fnc: cross}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 2}\end{bmatrix}$$

2. Extra-propositional backward navigation:
   Peter crossed the street. Before that Peter left the house.

$$\begin{bmatrix}\text{noun: Peter}\\ \text{fnc: cross}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{verb: cross}\\ \text{arg: Peter street}\\ \text{nc: < 1 leave}\\ \text{pc:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: street}\\ \text{fnc: cross}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: Peter}\\ \text{fnc: leave}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{verb: leave}\\ \text{arg: Peter house}\\ \text{nc: > 2 cross}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: house}\\ \text{fnc: leave}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}$$

The surfaces differ (i) in the order of the two sentences and (ii) in the realization of the coordinating conjunction, i.e. then (forward navigation) vs. before that (backward navigation). The distinction between forward and backward navigation arises also intra-propositionally, as shown by the alternative between active and passive (cf. Section 6.5).

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9.6.2 DIFFERENT EXTRA-PROPOSITIONAL FUNCTOR-ARGUMENT STRUCTURES

1. Adnominal sentence with subject gap:
   Peter, who had left the house, crossed the street.

$$\begin{bmatrix}\text{noun: Peter}\\ \text{fnc: cross}\\ \text{mdr: 2 leave}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{a/v: leave}\\ \text{arg: \# house}\\ \text{mdd: 1 Peter}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: house}\\ \text{fnc: leave}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{verb: cross}\\ \text{arg: Peter street}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: street}\\ \text{fnc: cross}\\ \text{prn: 1}\end{bmatrix}$$

2. Adverbial sentence:
   After Peter had left the house, he crossed the street.

$$\begin{bmatrix}\text{noun: Peter}\\ \text{fnc: leave}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{a/v: leave}\\ \text{arg: Peter house}\\ \text{mdd: > 2 cross}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: house}\\ \text{fnc: leave}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: Peter}\\ \text{fnc: cross}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{verb: cross}\\ \text{arg: Peter street}\\ \text{mdr: < 1 leave}\\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{noun: street}\\ \text{fnc: cross}\\ \text{prn: 2}\end{bmatrix}$$

These two representations are different from those in 9.6.1, and different from each other.

More specifically, as extra-propositional functor-argument structures, both examples in 9.6.2 background the content of proposition 2 (hypotaxis) – in contradistinction to the examples of extra-propositional coordination in 9.6.1 (parataxis). The two examples in 9.6.2 differ from each other, furthermore, in that they represent alternative perspectives on the content: the adnominal (or relative) clause attaches the background content to the noun *Peter* while the adverbial clause attaches it to the verb *cross*.

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Alternative (ii) has the disadvantage that it requires a transformation of a complex proposition (language level) into a simple coordination of simple propositions (context level) during language interpretation, and a transformation of a simple coordination of simple propositions (context level) into a complex proposition (language level) during language production. Moreover, the contents represented by simple coordinations of simple propositions and by the related special representations as complex propositions are not really the same, making the required transformations awkward and unnatural. The apparent advantage of this costly procedure, however, would be that inferencing at the context level would not have to deal with complex propositions.

Alternative (i) has the advantage that the language and the context level use the same coding, thus making any transformations unnecessary. Furthermore, the inferencing in LA-grammar (cf. Section 5.3) is sufficiently powerful to derive all the required conclusions from the simple as well as from the special representations. For example, both special representations in 9.6.2 support inferring the answer yes to the question Did Peter leave the house – just as both simple representations in 9.6.1.

Our choice of alternative (i) implies that the perspectives represented by extra-propositional functor-argument structure (cf. Chapter 7.), complex intra-propositional coordination (cf. Sections 8.4 –8.6) and their combination (cf. Section 9.4) are essentially thought structures. They are perspectives which arise already at the level of context and are merely reflected in language – just as the secondary coding underlying indirect (e.g. metaphoric) uses of language described in Sections 5.4 and 5.5.

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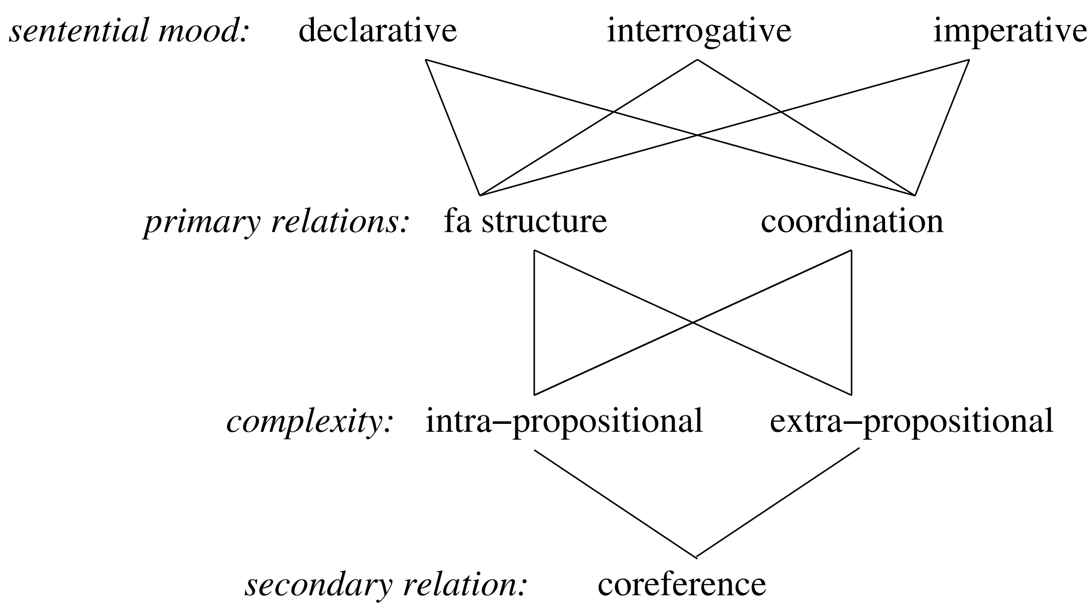
10. Intra- and Extra-Propositional Coreference

10.1 Overview

10.1.1 Correlating the major constructions



10.1.2 Different kinds of coreference

1. Name-based coreference in an extra-sentential coordination

   Julia ate an apple. Then Julia took a nap.

noun: Julia	verb: eat	noun: apple	noun: Julia	verb: take	noun: nap
fnc: eat	arg: Julia apple	fnc: eat	fnc: take	arg: Julia nap	fnc: take
mdr:	pc:	mdr:	mdr:	pc: < 36 eat	mdr:
idy: 1	nc: > 37 take	idy: 2	idy: 3 (=1)	nc:	idy: 4
prn: 36	prn: 36	prn: 36	prn: 37	prn: 37	prn: 37

2. Pronoun-based coreference in an extra-sentential coordination

   Julia ate an apple. Then she took a nap.

noun: Julia	verb: eat	noun: apple	noun: pro_1	verb: take	noun: nap
fnc: eat	arg: Julia apple	fnc: eat	fnc: take	arg: pro_1 nap	fnc: take
mdr:	pc:	mdr:	mdr:	pc: < 38 eat	mdr:
idy: 5	nc: > 39 take	idy: 6	idy: 7 (=5)	nc:	idy: 8
prn: 38	prn: 38	prn: 38	prn: 39	prn: 39	prn: 39

3. Blocked intra-propositional coreference between two equal names

   John shaved John.

noun: John	verb: shave	noun: John
fnc: shave	arg: John John	fnc: shave
idy: 9	mdr:	idy: 10
prn: 40	prn: 40	prn: 40

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4. Intra-propositional coreference between a name and a reflexive pronoun

%John shaved himself.

$$\begin{bmatrix}\text{noun: John}\\ \text{fnc: shave}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{verb: shave}\\ \text{arg: John rfl\_1}\\ \text{mdr:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: rfl\_1}\\ \text{fnc: shave}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}$$

5. Coreference between a nominal symbol and an intra-propositional coordination

The man washed his hands, clipped his nails, and shaved himself.

$$\begin{bmatrix}\text{noun: man}\\ \text{fnc: wash}\\ \text{mdr:}\\ \text{idy: 13}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{verb: wash \&}\\ \text{arg: man hand}\\ \text{nc: clip}\\ \text{pc:}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{noun: hand}\\ \text{fnc: wash}\\ \text{mdr:}\\ \text{idy: 14}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{verb: clip}\\ \text{arg: \# nail}\\ \text{nc: shave}\\ \text{pc: wash}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{noun: nail}\\ \text{fnc: clip}\\ \text{mdr:}\\ \text{idy: 15}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{verb: shave}\\ \text{arg: \# rfl\_2}\\ \text{nc:}\\ \text{pc: clip}\\ \text{prn: 42}\end{bmatrix} \begin{bmatrix}\text{noun: rfl\_2}\\ \text{fnc: shave}\\ \text{mdr:}\\ \text{idy: 16(=13)}\\ \text{prn: 42}\end{bmatrix}$$

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10.2 Intra-Propositional Coreference

10.2.1 Definition of **LA-think.pro-1**

$\text{ST}_S =_{def} \{\ (\ [\text{noun: RFL\_n}]\ \{\ \text{rfl-0 rfl-1}\})\ \}$

$$\text{rfl-0: } \begin{bmatrix}\text{noun: RFL\_n}\\ \text{cat: X'}\\ \text{idy: j}\\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: X}\\ \text{idy: i}\\ \text{prn: k}\end{bmatrix} \quad \begin{array}{l}\text{if X is not compatible with X'}\\ \text{set } nw = \text{preceding noun}\end{array} \quad \{\text{rfl-0, rfl-1}\}$$

$$\text{rfl-1: } \begin{bmatrix}\text{noun: RFL\_n}\\ \text{cat: X'}\\ \text{idy: j}\\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: X}\\ \text{idy: i}\\ \text{prn: k}\end{bmatrix} \quad \begin{array}{l}\text{if X is compatible with X'}\\ \text{set j = i}\end{array} \quad \{\}$$

$\text{ST}_F =_{def} \{(\ [\text{noun: }\alpha]\ \text{rp}_{\text{rfl}-1})\}$

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10.2.2 Applying the inference rule **rfl-1**

rule level rfl-1: $\begin{bmatrix}\text{noun: RFL\_n}\\ \text{cat: X'}\\ \text{idy: j}\\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: X}\\ \text{idy: i}\\ \text{prn: k}\end{bmatrix}$ if X is compatible with X' set j = i { }

language level $\begin{bmatrix}\text{noun: rfl\_1}\\ \text{fnc: shave}\\ \text{cat: m sg}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: John}\\ \text{fnc: shave}\\ \text{cat: m sg}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}$

10.2.3 Interpretation of John shaved himself after inference

$$\begin{bmatrix}\text{noun: John}\\ \text{cat: m sg}\\ \text{fnc: shave}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{verb: shave}\\ \text{arg: John, rfl\_1}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{noun: rfl\_1}\\ \text{cat: m sg}\\ \text{fnc: shave}\\ \text{idy: 2 (=1)}\\ \text{prn: 1}\end{bmatrix}$$

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10.3 Langacker-Ross Constraint for Sentential Arguments

10.3.1 LANGACKER-ROSS CONSTRAINT IN SENTENTIAL ARGUMENTS

1. **LH':** That *Mary* had found the answer pleased *her*.
2. **H'L:** %*She* knew that *Mary* had found the answer.
3. **L'H:** That *she* had found the answer pleased *Mary*.
4. **HL':** *Mary* knew that *she* had found the answer.

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10.3.2 LH': That *Mary* had found the answer pleased *her*. (n/v-cnn)

pattern level	n/v: sc β arg: X γ Y fnc: r α prn: q	noun: γ fnc: β idy: i prn: q			noun: PRO_n fnc: α idy: i prn: r
proplet level	n/v: that find arg: Mary answer fnc: 28 please prn: 27	noun: Mary fnc: find idy: 1 prn: 27	noun: answer fnc: find idy: 2 prn: 27	verb: please arg: 27 find pro_1 mdr: prn: 28	noun: pro_1 fnc: please idy: 3 prn: 28

10.3.3 H'L: %*She* knew that *Mary* had found the answer.

pattern level	noun: PRO_n fnc: α idy: i prn: r		n/v: sc β arg: X γ Y fnc: r α prn: q	noun: γ fnc: β idy: i prn: q	
proplet level	noun: pro_1 fnc: know idy: 1 prn: 27	verb: know arg: pro_1 28 find mdr: prn: 27	n/v: that find arg: Mary answer fnc: 27 know prn: 28	noun: Mary fnc: find idy: 2 prn: 28	noun: answer fnc: find idy: 3 prn: 28

10.3.4 L’H: That *she* had found the answer pleased *Mary*. (n/v-pro)

pattern level	n/v: sc α arg: X PRO_n Y fnc: r β prn: r	noun: PRO_n fnc: α idy: i prn: r			noun: γ fnc: β idy: i prn: q
proplet level	n/v: that find arg: pro_1 answer fnc: 28 please prn: 27	noun: pro_1 fnc: find idy: 3 prn: 27	noun: answer fnc: find idy: 2 prn: 27	verb: please arg: 27 find Mary mdr: prn: 28	noun: Mary fnc: please idy: 1 prn: 28

10.3.5 HL’: *Mary* knew that *she* had found the answer.(n/v-pro)

pattern level	noun: γ fnc: β idy: i prn: q		n/v: sc α arg: X PRO_n Y fnc: β prn: r	noun: PRO_n fnc: α idy: i prn: r	
proplet level	noun: Mary fnc: know idy: 1 prn: 27	verb: know arg: Mary 28 find mdr: prn: 27	n/v: that find arg: pro_1 answer fnc: 27 know prn: 28	noun: pro_1 fnc: find idy: 2 prn: 28	noun: answer fnc: find idy: 3 prn: 28

10.3.6 DEFINITION OF **LA-think.pro-2** (SENTENTIAL ARGUMENTS)

$\mathrm{ST}_S =_{def} \{ (\left[\text{noun: PRO\_n}\right] \{\text{n/v-cnn, n/v-pro}\}) \}$

$$\text{n/v-cnn: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{n/v: sc } \beta\\ \text{arg: X } \gamma \text{ Y}\\ \text{fnc: r } \alpha\\ \text{prn: q}\end{bmatrix} \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \quad \begin{array}{l}\text{if q and r are adjacent, q < r, and}\\ \text{PRO\_n and } \gamma \text{ are compatible, set i = j}\end{array} \quad \{\}$$

$$\text{n/v-pro: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{n/v: sc } \alpha\\ \text{arg: X PRO\_n Y}\\ \text{fnc: r } \beta\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \quad \begin{array}{l}\text{if q and r are adjacent and}\\ \text{PRO\_n and } \gamma \text{ are compatible, set i = j}\end{array} \quad \{\}$$

$\mathrm{ST}_F =_{def} \{(\left[\text{noun: } \alpha\right] \mathrm{rp}_{\mathrm{n/v-cnn}}), (\left[\text{noun: } \alpha\right] \mathrm{rp}_{\mathrm{n/v-pro}})\}$

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10.4 Langacker-Ross Constraint for Adnominal Sentential Modifiers

10.4.1 Langacker-Ross constraint in adnominal sub-clauses

1. **LH':** The man who loves *the woman* kissed *her*.
2. **H'L:** *%She* was kissed by the man who loves *the woman*.
3. **L'H:** The man who loves *her* kissed *the woman*.
4. **HL':** *The woman* was kissed by the man who loves *her*.

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10.4.2 LH': Every farmer who owns *a donkey* beats *it*. (adn-cnn)

pattern−level	noun: β fnc: α mdr: q γ idy: k prn: r		noun: δ fnc: γ mdr: idy: j prn: q		noun: PRO_n fnc: α mdr: idy: i prn: r
proplet level	noun: farmer fnc: beat mdr: 2 own idy: 1 prn: 1	a/v: own arg: # donkey mdd: 1 farmer prn: 2	noun: donkey fnc: own mdr: idy: 2 prn: 2	verb: beat arg: farmer pro−2 mdr: prn: 1	noun: pro_2 fnc: beat mdr: idy: 3 (=2) prn: 1
	Every farmer	who owns	a donkey	beats	it

10.4.3 H'L: *%She* was kissed by the man who loves *the woman*.

pattern−level	noun: PRO_n fnc: α mdr: idy: k prn: r		noun: β fnc: α mdr: q γ idy: i prn: r		noun: δ fnc: γ mdr: idy: j prn: q
proplet level	noun: pro_1 fnc: kiss mdr: idy: 1 prn: 1	verb: kiss arg: man pro_1 mdr: prn: 1	noun: man fnc: kiss mdr: 2 love idy: 2 prn: 1	a/v: love arg: # Mary mdd: 1 man prn: 2	noun: woman fnc: love mdr: idy: 3 prn: 2

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10.4.4 L'H: The man who loves *her* kissed *the woman*. (adn-pro)

pattern−level	noun: β fnc: γ mdr: r α idy: k prn: q	noun: PRO_n fnc: α mdr: idy: i prn: r	noun: δ fnc: γ mdr: idy: j prn: q

proplet level	noun: man fnc: kiss mdr: 2 love idy: 1 prn: 1	a/v: love arg: # pro_1 mdd: 1 man prn: 2	noun: pro_1 fnc: love mdr: idy: 2 prn: 2	verb: kiss arg: man woman mdr: prn: 1	noun: woman fnc: kiss mdr: idy: 3 prn: 1

10.4.5 HL': *The woman* was kissed by the man who loves *her*. (adn-pro)

pattern−level	noun: δ fnc: γ mdr: idy: k prn: q	noun: β fnc: γ mdr: r α idy: i prn: q	noun: PRO_n fnc: α mdr: idy: j prn: r

proplet level	noun: woman fnc: kiss mdr: idy: 1 prn: 1	verb: kiss arg: man woman mdr: prn: 1	noun: man fnc: kiss mdr: 2 love idy: 2 prn: 1	a/v: love arg: # pro_1 mdd: 1 man prn: 2	noun: pro_1 fnc: love mdr: idy: 3 prn: 2

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10.4.6 Definition of **LA-think.pro-3** (adnominal sentential modifiers)

$ST_S =_{def}$ { ([noun: PRO_n] {adn-cnn adn-pro}) }

adn-cnn: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: }\alpha\\ \text{mdr:}\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix}$ $\begin{bmatrix}\text{noun: }\beta\\ \text{fnc: }\alpha\\ \text{mdr: q }\gamma\\ \text{idy: k}\\ \text{prn: r}\end{bmatrix}$ $\begin{bmatrix}\text{noun: }\delta\\ \text{fnc: }\gamma\\ \text{mdr:}\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix}$ if q and r are adjacent, q < r, and PRO_n and α are compatible, set i = j {}

adn-pro: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: }\alpha\\ \text{mdr:}\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix}$ $\begin{bmatrix}\text{noun: }\beta\\ \text{fnc: }\gamma\\ \text{mdr: r }\alpha\\ \text{idy: k}\\ \text{prn: q}\end{bmatrix}$ $\begin{bmatrix}\text{noun: }\delta\\ \text{fnc: }\gamma\\ \text{mdr:}\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix}$ if q and r are adjacent and PRO_n and γ are compatible, set i = j {}

$ST_F =_{def}$ {([noun: α] $\text{rp}_{\text{adn-fnc}}$), ([noun: α] $\text{rp}_{\text{adn-mdr}}$)}

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10.5 Langacker-Ross Constraint for Adverbial Sentential Modifiers

10.5.1 LANGACKER-ROSS CONSTRAINT IN ADVERBIAL SUB-CLAUSES

1. **LH':** When *Mary* returned *she* kissed John.
2. **H'L:** %*She* kissed John when *Mary* returned.
3. **L'H:** When *she* returned *Mary* kissed John.
4. **HL':** *Mary* kissed John when *she* returned.

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10.5.2 LH’: When *Mary* returned *she* kissed John. (adv-cnn)

pattern level

noun: γ	a/v: sc β	noun: PRO_n
fnc: β	arg: X γ Y	fnc: α
idy: j	mdd: r α	idy: i
prn: q	prn: q	prn: r

proplet level

noun: Mary	a/v: when return	noun: pro_1	verb: kiss	noun: John
fnc: return	arg: Mary	fnc: kiss	arg: pro_1 John	fnc: kiss
idy: 1	mdd: 28 kiss	idy: 2	mdr: 27 return	idy: 3
prn: 27	prn: 27	prn: 28	prn: 28	prn: 28

10.5.3 H’L: %*She* kissed John when *Mary* returned.

pattern level

noun: PRO_n	noun: γ	a/v: sc β
fnc: α	fnc: β	arg: X γ Y
idy: i	idy: j	mdd: r α
prn: r	prn: q	prn: q

proplet level

noun: pro_1	verb: kiss	noun: John	noun: Mary	a/v: when return
fnc: kiss	arg: pro_1 John	fnc: kiss	fnc: return	arg: Mary
idy: 1	mdr: 28 return	idy: 2	idy: 3	mdd: 27 kiss
prn: 27	prn: 27	prn: 27	prn: 28	prn: 28

10.5.4 L'H: When *she* returned *Mary* kissed John. (adv-pro)

pattern level	noun: PRO_n	a/v: sc α	noun: γ		
	fnc: α	arg: X pro_n Y	fnc: β		
	idy: i	mdd: q β	idy: j		
	prn: r	prn: r	prn: q		
proplet level	noun: pro_1	a/v: when return	noun: Mary	verb: kiss	noun: John
	fnc: return	arg: pro_1	fnc: kiss	arg:Mary John	fnc: kiss
	idy: 1	mdd: 28 kiss	idy: 2	mdr: 27 return	idy: 3
	prn: 27	prn: 27	prn: 28	prn: 28	prn: 28

10.5.5 HL': *Mary* kissed John when *she* returned. (adv-pro)

pattern level	noun: γ			a/v: sc α	noun: PRO_n
	fnc: β			arg: X PRO_n Y	fnc: α
	idy: i			mdd: q β	idy: j
	prn: q			prn: r	prn: r
proplet level	noun: Mary	verb: kiss	noun: John	a/v: when return	noun: pro_1
	fnc: kiss	arg: Mary John	fnc: kiss	arg: pro_1	fnc: return
	idy: 1	mdr: 28 return	idy: 2	mdd: 27 kiss	idy: 3
	prn: 27	prn: 27	prn: 27	prn: 28	prn: 28

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10.5.6 DEFINITION OF **LA-think.pro-4** (ADVERBIAL SENTENTIAL MODIFIERS)

$ST_S =_{def} \{ (\begin{bmatrix}\text{noun: PRO\_n}\end{bmatrix} \{\text{adv-cnn adv-pro}\}) \}$

$$\text{adv-cnn: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{a/v: sc } \beta\\ \text{arg: X } \gamma \text{ Y}\\ \text{mdd: r } \alpha\\ \text{prn: q}\end{bmatrix} \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \quad \begin{array}{l}\text{if q and r are adjacent, q < r, and}\\ \text{PRO\_n and } \gamma \text{ are compatible, set i = j}\end{array} \quad \{\}$$

$$\text{adv-pro: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{a/v: sc } \alpha\\ \text{fnc: X PRO\_n Y}\\ \text{mdd: q } \beta\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \quad \begin{array}{l}\text{if q and r are adjacent and}\\ \text{PRO\_n and } \gamma \text{ are compatible, set i = j}\end{array} \quad \{\}$$

$ST_F =_{def} \{(\begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \text{rp}_{\text{adv-cnn}}), (\begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \text{rp}_{\text{adv-pro}})\}$

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10.5.7 Langacker-Ross constraint for oblique coreferents

1. **LH':** When *Mary* returned John kissed *her*.
2. **H'L:** %John kissed *her* when *Mary* returned.
3. **L'H:** When *she* returned John kissed *Mary*.
4. **HL':** John kissed *Mary* when *she* returned.

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10.5.8 LH’: When *Mary* returned John kissed *her*. (adv-cnn)

pattern level	noun: γ fnc: β idy: j prn: q	a/v: sc β arg: X γ *Y* mdd: r α prn: q			noun: PRO_n fnc: α idy: i prn: r
proplet level	noun: Mary fnc: return idy: 1 prn: 27	a/v: when return arg: Mary mdd: 28 kiss prn: 27	noun: John fnc: kiss idy: 3 prn: 28	verb: kiss arg: John pro_1 mdr: 27 return prn: 28	noun: pro_1 fnc: kiss idy: 2 prn: 28

10.5.9 H’L: %John kissed *her* when *Mary* returned.

pattern level			noun: PRO_n fnc: α idy: i prn: r	noun: γ fnc: β idy: j prn: q	a/v: sc β arg: X γ Y mdd: r α prn: q
proplet level	noun: John fnc: kiss idy: 2 prn: 27	verb: kiss arg: John pro_1 mdr: 28 return prn: 27	noun: pro_1 fnc: kiss idy: 1 prn: 27	noun: Mary fnc: return idy: 3 prn: 28	a/v: when return arg: Mary mdd: 27 kiss prn: 28

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10.5.10 L'H: When *she* returned John kissed *Mary* (adv-pro)

pattern level	noun: PRO_n fnc: α idy: i prn: r	a/v: sc α arg: X PRO_n Y mdd: q β prn: r			noun: γ fnc: β idy: j prn: q
proplet level	noun: pro_1 fnc: return idy: 1 prn: 27	a/v: when return arg: pro_1 mdd: 28 kiss prn: 27	noun: John fnc: kiss idy: 3 prn: 28	verb: kiss arg:John Mary mdr: 27 return prn: 28	noun: Mary fnc: kiss idy: 2 prn: 28

10.5.11 H'L: John kissed *Mary* when *she* returned (adv-pro)

pattern level			noun: γ fnc: β idy: i prn: q	noun: PRO_n fnc: α idy: j prn: r	a/v: sc α arg: X PRO_n Y mdd: q β prn: r
proplet level	noun: John fnc: kiss idy: 2 prn: 27	verb: kiss arg:John Mary mdr: 28 return prn: 27	noun: Mary fnc: kiss idy: 1 prn: 27	noun: pro_1 fnc: return idy: 3 prn: 28	a/v: when return arg: pro_1 mdd: 27 kiss prn: 28

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10.6 Handling Pronominal Coreference by means of Inference

10.6.1 Definition of **LA-think.pro**

$$ST_S =_{def} \{ ([\text{noun: PRO\_n}]\ \{\text{pro-0 rfl-1 n/v-cnn n/v-pro adn-cnn adn-pro adv-cnn adv-pro}\}) \}$$

pro-0: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{idy: j}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{idy: i}\\ \text{prn: q}\end{bmatrix}$ PRO_n and α are not compatible, set *nw* = preceding noun in the input sequence {pro-0 rfl-1 n/v-cnn n/v-PRO adn-cnn adn-PRO adv-cnn adv-PRO}

rfl-1: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{idy: j}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix}$ if PRO_n is a reflexive pronoun, and PRO_n and α are compatible, set j = i { }

n/v-cnn: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: }\alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{n/v: sc }\beta\\ \text{arg: X }\gamma\text{ Y}\\ \text{fnc: r }\alpha\\ \text{prn: q}\end{bmatrix} \begin{bmatrix}\text{noun: }\gamma\\ \text{fnc: }\beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix}$ if PRO_n is a non-reflexive personal pronoun, PRO_n and γ are compatible, q and r are adjacent, and q < r, set i = j { }

n/v-pro: $\begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: }\alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{n/v: sc }\alpha\\ \text{arg: X PRO\_n Y}\\ \text{fnc: r }\beta\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: }\gamma\\ \text{fnc: }\beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix}$ if PRO_n is a non-reflexive personal pronoun, PRO_n and γ are compatible, and q and r are adjacent, set i = j { }

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$$\text{adn-cnn: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{mdr:}\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: } \beta\\ \text{fnc: } \alpha\\ \text{mdr: q } \gamma\\ \text{idy: k}\\ \text{prn: r}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \delta\\ \text{fnc: } \gamma\\ \text{mdr:}\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \begin{matrix}\text{if PRO\_n is a non-reflexive personal pronoun,}\\ \text{PRO\_n and } \alpha \text{ are compatible,}\\ \text{q and r are adjacent, and q < r,}\\ \text{set i = j}\end{matrix} \quad \{\}$$

$$\text{adn-pro: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{mdr:}\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: } \beta\\ \text{fnc: } \gamma\\ \text{mdr: r } \alpha\\ \text{idy: k}\\ \text{prn: q}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \delta\\ \text{fnc: } \gamma\\ \text{mdr:}\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \begin{matrix}\text{if PRO\_n is a non-reflexive personal pronoun,}\\ \text{PRO\_n and } \gamma \text{ are compatible,}\\ \text{and q and r are adjacent,}\\ \text{set i = j}\end{matrix} \quad \{\}$$

$$\text{adv-cnn: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{a/v: sc } \beta\\ \text{arg: X } \gamma \text{ Y}\\ \text{mdd: r } \alpha\\ \text{prn: q}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \begin{matrix}\text{if PRO\_n is a non-reflexive personal pronoun,}\\ \text{PRO\_n and } \gamma \text{ are compatible,}\\ \text{q and r are adjacent, and q < r,}\\ \text{set i = j}\end{matrix} \quad \{\}$$

$$\text{adv-pro: } \begin{bmatrix}\text{noun: PRO\_n}\\ \text{fnc: } \alpha\\ \text{idy: i}\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{a/v: sc } \alpha\\ \text{fnc: X PRO\_n Y}\\ \text{mdd: q } \beta\\ \text{prn: r}\end{bmatrix} \begin{bmatrix}\text{noun: } \gamma\\ \text{fnc: } \beta\\ \text{idy: j}\\ \text{prn: q}\end{bmatrix} \begin{matrix}\text{if PRO\_n is a non-reflexive personal pronoun,}\\ \text{PRO\_n and } \gamma \text{ are compatible,}\\ \text{and q and r are adjacent,}\\ \text{set i = j}\end{matrix} \quad \{\}$$

$$\begin{aligned}\text{ST}_F =_{def} \{ & ([\text{noun: } \alpha] \ \text{rp}_{\text{rfl}-1}), ([\text{noun: } \alpha] \ \text{rp}_{\text{n/v}-\text{cnn}}), ([\text{noun: } \alpha] \ \text{rp}_{\text{n/v}-\text{pro}}),\\ & ([\text{noun: } \alpha] \ \text{rp}_{\text{adn}-\text{cnn}}), ([\text{noun: } \alpha] \ \text{rp}_{\text{adn}-\text{pro}}), ([\text{noun: } \alpha] \ \text{rp}_{\text{adv}-\text{cnn}})\\ & ([\text{noun: } \alpha] \ \text{rp}_{\text{adn}-\text{pro}})\}\end{aligned}$$

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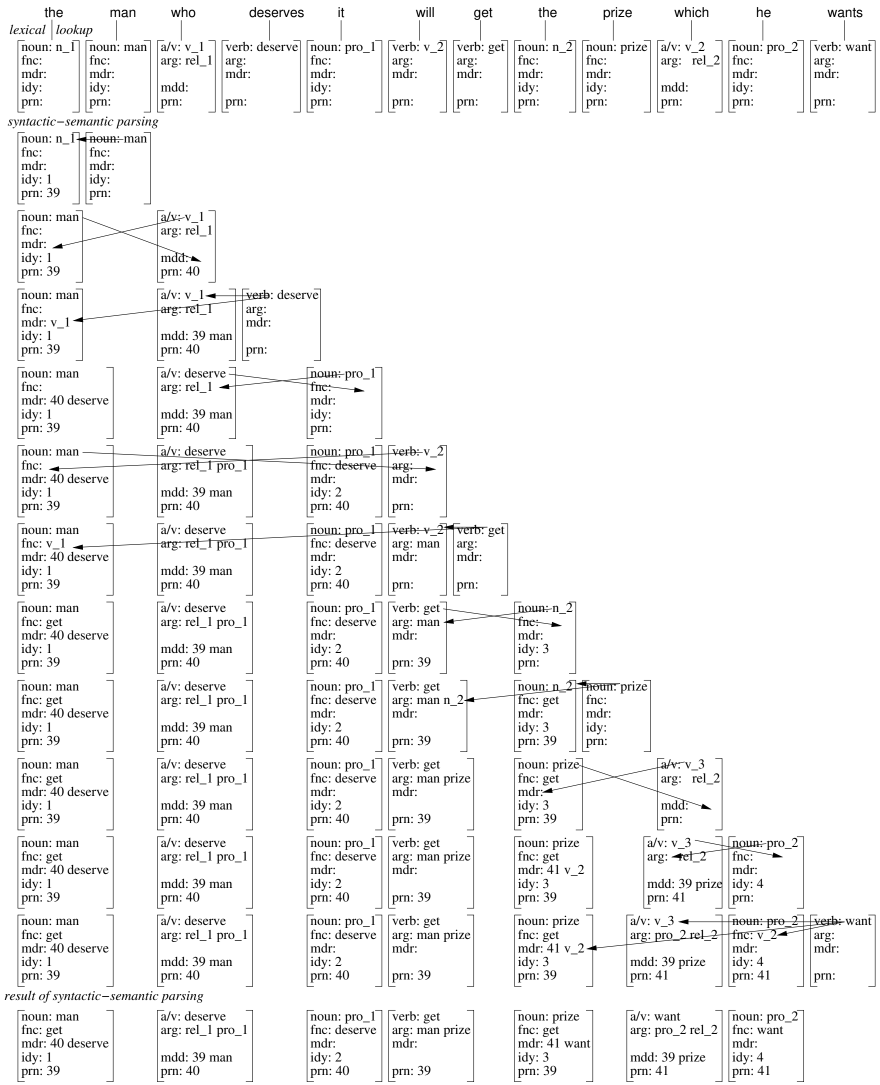
10.6.2 HEARER-MODE DERIVATION OF THE BACH-PETERS SENTENCE



10.6.3 The HL' constellation

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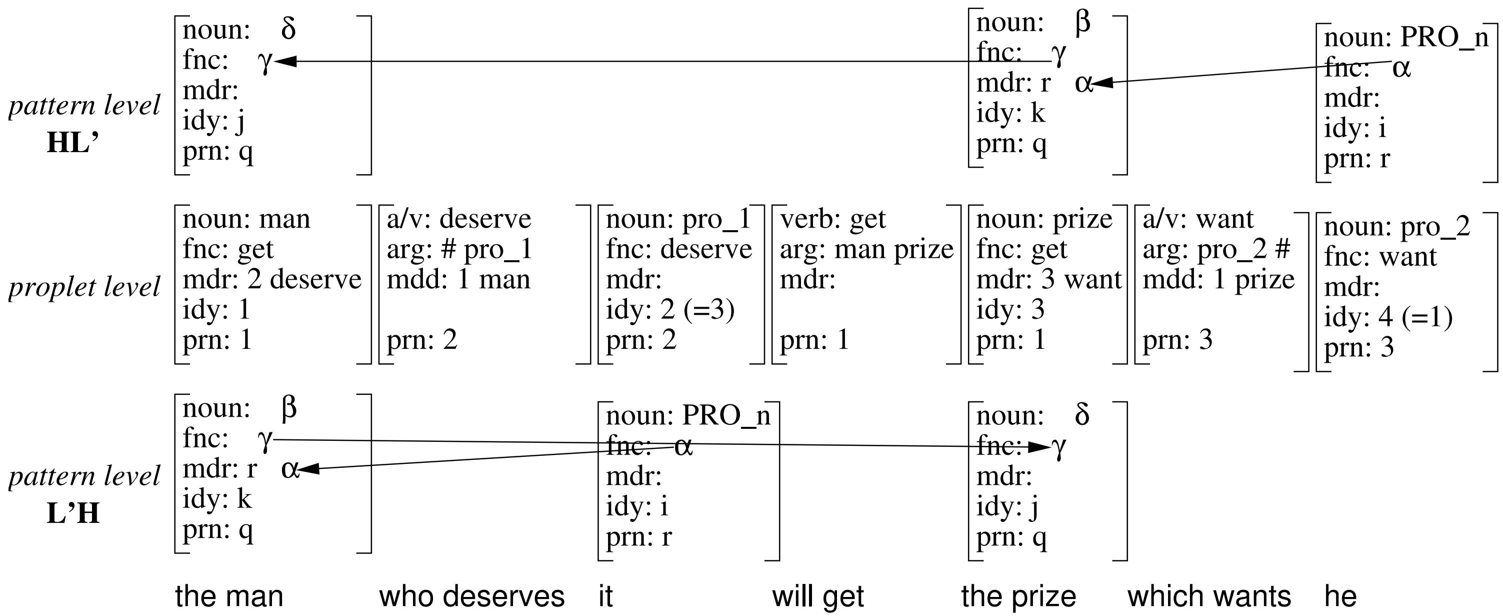
H: The *man* will get the prize
L': which *he* wants

10.6.4 The L'H constellation

The man **H:** will get the *prize*
L': who deserves *it*

10.6.5 THE COREFERENCE INFERENCES

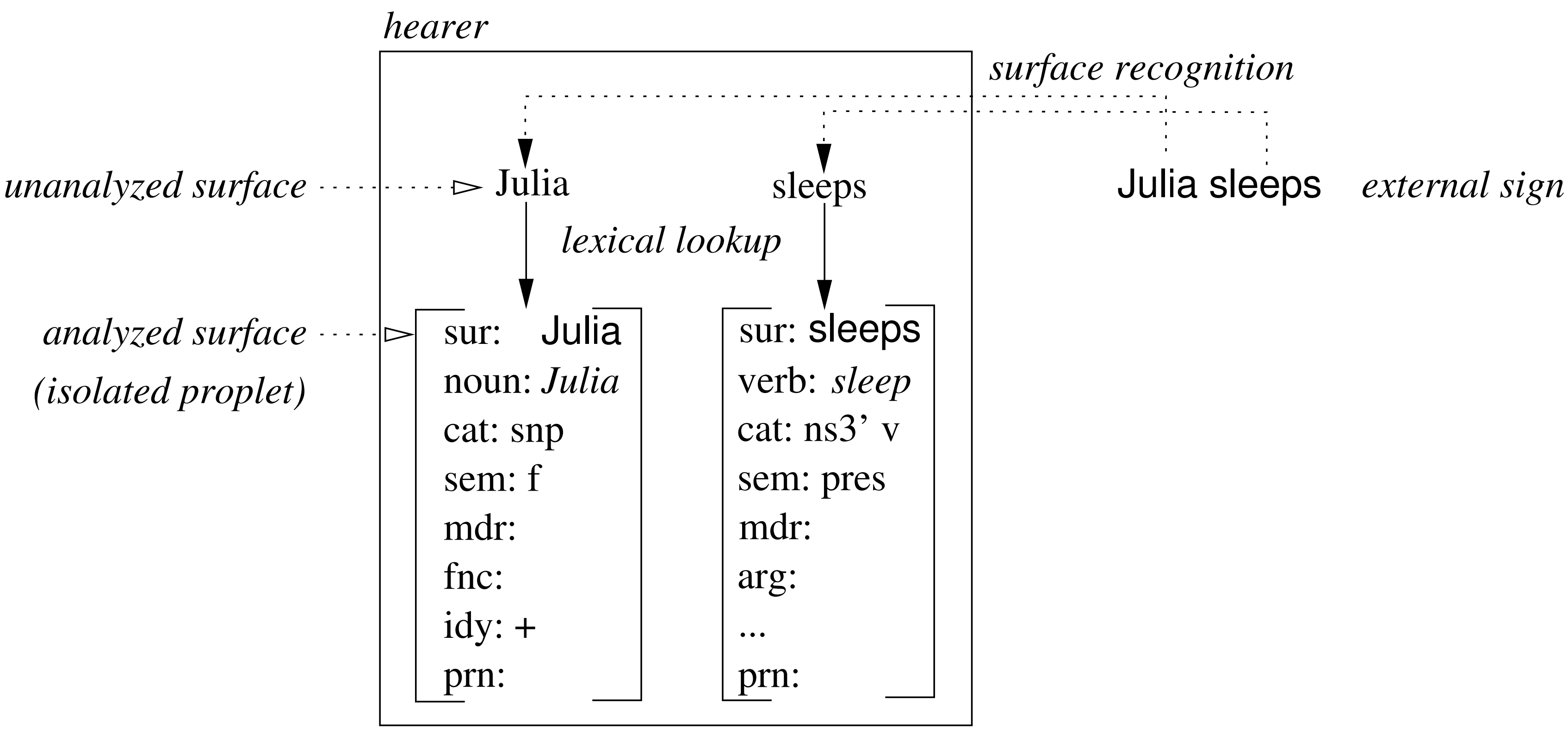


Part III.
The Declarative Specification of Formal Fragments

11. DBS.1: Hearer-Mode

11.1 Automatic Word Form Recognition

11.1.1 Surface recognition and lexical lookup



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11.2 Lexicon of LA-hear.1

11.2.1 The lexical entries of LA-hear.1

proper names:

$$
\begin{bmatrix} \text{sur: } \mathsf{Julia} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \mathsf{John} \\ \text{noun: } \textit{John} \\ \text{cat: nm} \\ \text{sem: m} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \mathsf{Susanne} \\ \text{noun: } \textit{Susanne} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
$$

$$
\begin{bmatrix} \text{sur: } \mathsf{sleeps} \\ \text{erb: } \textit{sleep} \\ \text{cat: ns3}' \text{ v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \mathsf{sings} \\ \text{verb: } \textit{sing} \\ \text{cat: ns3}' \text{ v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \mathsf{dreams} \\ \text{verb: } \textit{dream} \\ \text{cat: ns3}' \text{ v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}
$$

punctuation sign

$$
\begin{bmatrix} \text{sur: .} \\ \text{cat: v}' \text{ decl} \end{bmatrix}
$$

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11.2.2 Values of the cat attribute

decl	= declarative sentence
nm	= proper name
ns3′	= nominative third person singular valency position
v	= verb, unmarked for sentence mood
v′	= valency position for verb unmarked for sentence mood

11.2.3 Values of the sem attribute

f	= femininum
m	= masculinum
pres	= present tense

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11.2.4 Intra-propositional continuation attributes

arg: specifies the arguments of verbs (list)
fnc: specifies the functor of nouns (atom)
mdr: specifies the modifiers of nouns and verbs (list)
mdd: specifies the modified of adnominals and adverbials (atom)

11.2.5 Extra-propositional continuation attributes

idy: identity between nouns. Takes a number as value.
nc: next conjunct. Takes an optional conjunction, a proposition number, and a verb concept as value.
pc: previous conjunct. Takes values similar to nc.

11.2.6 Book-keeping attribute of LA-hear.1

prn: proposition number

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11.3 Preamble of LA-hear.1

11.3.1 List of binding variables

SM	= sentence mood
VT	= verb type filler
VT′	= verb type valency position
NP	= noun phrase filler
NP′	= noun phrase valency position
α, β, γ, etc.	= for individual concepts like *Julia, sleep, young,* etc.
i, j, k	= for number values of the prn and idy attributes

11.3.2 Restriction of binding variables

SM ϵ {decl}
VT ϵ {v}
VT′ ϵ {v′}
NP ϵ {nm}
NP′ ϵ {ns3′}

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11.3.3 Matching between a variable and a constant

$$\textit{rule level:} \begin{bmatrix} \text{cat: NP} \end{bmatrix}$$

matching?

$$\textit{language level:} \begin{bmatrix} \text{cat: nm} \end{bmatrix}$$

If variable X has the values a, b, or c, then the variable Y must have the values p or q.

11.3.4 Agreement conditions

if $\mathsf{VT} \in \{\mathsf{v}\}$, then $\mathsf{VT}' \in \{\mathsf{v}'\}$
if $\mathsf{NP} \in \{\mathsf{nm}\}$, then $\mathsf{NP}' \in \{\mathsf{ns3}'\}$

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11.4 Definition of LA-hear.1

11.4.1 Formal Definition of LA-hear.1

$\mathbf{ST}_S =_{def} \{ (\begin{bmatrix}\text{cat: X}\end{bmatrix} \{1 \text{ NOM+FV}\}) \}$

NOM+FV {2 S+IP}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: NP} \\ \text{fnc:} \\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:}\end{bmatrix}$$

delete NP′ nw.cat
acopy α nw.arg
ecopy β ss.fnc
ecopy PC nw.pc
acopy PCV nw.pc
set β NCV
copy$_{ss}$ copy$_{nw}$

S+IP {3 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix}$$

replace SM VT
set k PC
set α PCV
copy$_{ss}$

IP+START {1 NOM+FV}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: SM} \\ \text{nc:}\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{prn: k}\end{bmatrix}$$

increment nw.prn
ecopy k ss.nc
acopy ‘NCV’ ss.nc
copy$_{ss}$ copy$_{nw}$

$\mathbf{ST}_F =_{def} \{(\begin{bmatrix}\text{cat: decl}\end{bmatrix} \text{rp}_{\text{S+IP}})\}$

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11.4.2 Definitions of the operations

delete variable proplet-attr. =	delete the value corresponding to the variable in the corresponding attribute of the corresponding proplet at the level of language.
example:	delete NP$'$ nw.cat (in NOM+FV)
acopy variable proplet-attr. =	additively copy value(s) corresponding to the variable into the specified target slot; default position is at the end of the target slot.
examples:	acopy α nw.arg (in NOM+FV) acopy PCV nw.pc (in NOM+FV) acopy 'NCV' ss.nc (in IP+START)
ecopy variable proplet-attr. =	exclusively copy value(s) corresponding to the variable into the specified proplet attribute.
examples:	ecopy β ss.fnc (in NOM+FV) ecopy PC nw.pc (in NOM+FV) ecopy k ss.nc (in IP+START)
set value variable =	rule-based (rather than matching-based) binding of a variable to a value.
examples:	set β NCV (in NOM+FV) set k PC (in S+IP) set α PCV (in S+IP)
replace variable2 variable1 =	replace value of variable1 with value of variable2.
examples:	replace SM VT (in S+IP)
increment proplet-attr. =	increment numerical value of corresponding attribute by one.
example:	increment nw.prn (in IP+START)
copy$_{ss}$ =	include the proplets of the sentence start in the result.
examples:	NOM+FV, S+IP, IP+START
copy$_{nw}$ =	include the proplet of the next word in the result.
examples:	NOM+FV, IP+START

11.5 Interpreting a Sequence of Sentences

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11.5.1 Combining Julia and sleeps

NOM+FV {2 S+IP}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: NP} \\ \text{fnc:} \\ \text{prn: k}\end{bmatrix} \quad \begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:}\end{bmatrix} \qquad \begin{array}{l}\text{delete NP}' \text{ nw.cat} \\ \text{acopy } \alpha \text{ nw.arg} \\ \text{ecopy } \beta \text{ ss.fnc} \\ \text{ecopy PC nw.pc} \\ \text{acopy PCV nw.pc} \\ \text{set } \beta \text{ NCV} \\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur: 1.1 Julia} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: 1.2 sleeps} \\ \text{verb: } \textit{sleep} \\ \text{cat: ns3}' \text{ v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2$$

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11.5.2 Combining Julia sleeps and .

S+IP {3 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \quad \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix} \qquad \begin{array}{l}\text{replace SM VT} \\ \text{set k PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: v} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: 1.3 .} \\ \text{cat: v}' \text{ decl}\end{bmatrix}_3 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2$$

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11.5.3 Combining Julia sleeps. and John

3 IP+START {1 NOM+FV }

$$
\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: SM} \\ \text{nc:}\end{bmatrix}
\quad
\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{prn: k}\end{bmatrix}
\qquad
\begin{array}{l}\text{increment nw.prn} \\ \\ \text{ecopy k ss.nc} \\ \text{acopy `NCV' ss.nc} \\ \text{copy}_{ss}\ \text{copy}_{nw}\end{array}
$$

$$
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur: 2.1 John} \\ \text{noun: } \textit{John} \\ \text{cat: nm} \\ \text{sem: m} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_4
\Longrightarrow
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 NCV} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2
\quad
\begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{John} \\ \text{cat: nm} \\ \text{sem: m} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 2} \\ \text{prn: 2}\end{bmatrix}_4
$$

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11.5.4 Combining Julia sleeps. John and sings

1 NOM+FV {2 S+IP}

$$\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: NP}\\ \text{fnc:}\\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{verb: }\beta\\ \text{cat: NP}'\text{ X VT}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\end{bmatrix}$$

delete NP′ nw.cat
acopy α nw.arg
ecopy β ss.fnc
ecopy PC nw.pc
acopy PCV nw.pc
set β NCV
copy$_{ss}$ copy$_{nw}$

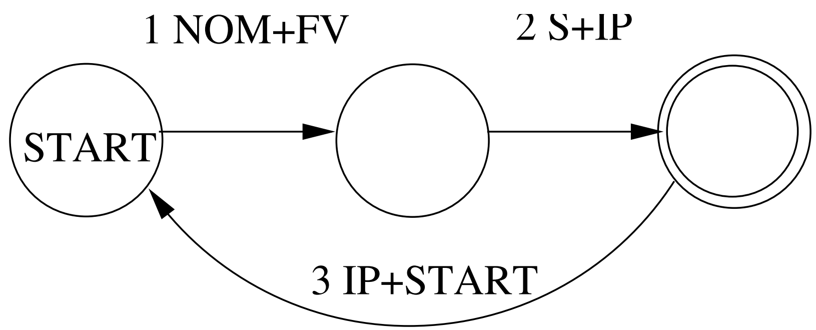
$$\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 NCV}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{John}\\ \text{cat: nm}\\ \text{sem: m}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 2}\\ \text{prn: 2}\end{bmatrix}_4 \begin{bmatrix}\text{sur: 2.2 sings}\\ \text{verb: }\textit{sing}\\ \text{cat: ns3}'\text{ v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2$$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{John}\\ \text{cat: nm}\\ \text{sem: m}\\ \text{mdr:}\\ \text{fnc: sing}\\ \text{idy: 2}\\ \text{prn: 2}\end{bmatrix}_4 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sing}\\ \text{cat: v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: John}\\ \text{nc:}\\ \text{pc: 1 sleep}\\ \text{prn: 2}\end{bmatrix}_5$$

11.5.5 Sequence of rule applications in deriving the sample of dbs-1

	1.1 Julia
1 NOM+FV	1.2 sleeps
2 S+IP	1.3 .
3 IP+START	2.1 John
1 NOM+FV	2.2 sings
2 S+IP	2.3 .
3 IP+START	3.1 Susanne
1 NOM+FV	3.2 dreams
2 S+IP	3.3 .

11.5.6 Finite state transition network of LA-hear.1



11.6 Storing the Output of LA-hear.1 in a Word Bank

11.6.1 Sorting an LA-hear derivation into a Word Bank

owner records (isolated proplets)	*member records* (connected proplets)
sur:	sur:
verb: *dream*	verb: *dream*
cat: n-s3’ v	cat: decl
sem: pres	sem: pres
mdr:	mdr:
arg:	arg: Susanne
nc:	nc:
pc:	pc: 2 sing
prn:	prn: 3
sur:	sur:
noun: *John*	noun: *John*
cat: nm	cat: nm
sem: m	sem: m
mdr:	mdr:
fnc:	fnc: sing
idy:	idy: 2
prn:	prn: 2

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owner records (isolated proplets)	*member records* (connected proplets)
sur:	sur:
noun: *Julia*	noun: *Julia*
cat: nm	cat: nm
sem: f	sem: f
mdr:	mdr:
fnc:	fnc: sleep
idy:	idy: 1
prn:	prn: 1

sur:	sur:
verb: *sing*	verb: *sing*
cat: n-s3’ v	cat: decl
sem: pres	sem: pres
mdr:	mdr:
arg:	arg: John
nc:	nc: 3 dream
pc:	pc: 1 sleep
prn:	prn: 2

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owner records (isolated proplets)	*member records* (connected proplets)
sur:	sur:
verb: *sleep*	verb: *sleep*
cat: n-s3’ v	cat: decl
sem: pres	sem: pres
mdr:	mdr:
arg:	arg: Julia
nc:	nc: 2 sing
pc:	pc:
prn:	prn: 1
sur:	sur:
noun: *Susanne*	noun: *Susanne*
cat: nm	cat: nm
sem: f	sem: f
mdr:	mdr:
fnc:	fnc: dream
idy:	idy: 3
prn:	prn: 3

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12. DBS.1: Speaker-Mode

12.1 Definition of LA-think.1

12.1.1 Formal Definition of LA-think.1

LX: proplet tokens in the Word Bank 11.6.1

ST$_S$ $=_{def}$ $\{$([verb: α] $\{$1 V_N_V$\}$)$\}$

V_N_V $\{$2 V_V_V$\}$

$\begin{bmatrix}\text{verb: } \alpha \\ \text{arg: } \beta \\ \text{prn: i}\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{fnc: } \alpha \\ \text{prn: i}\end{bmatrix}$ output position ss
switch to LA-speak.1 (optional, only in the speaker-mode)

V_V_V $\{$1 V_N_V$\}$

$\begin{bmatrix}\text{verb: } \alpha \\ \text{nc: j } \beta \\ \text{prn: i}\end{bmatrix}$ $\begin{bmatrix}\text{verb: } \beta \\ \text{pc: i } \alpha \\ \text{prn: j}\end{bmatrix}$ output position nw

ST$_F$ $=_{def}$ $\{$ ([verb: x] rp$_{\text{V_N_V}}$)$\}$

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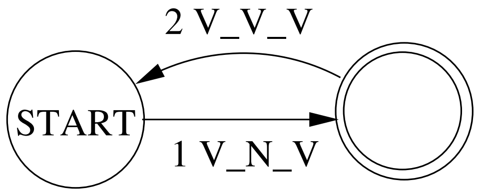
12.1.2 Finite State Transition Network of LA-think.1



12.1.3 Schematic description of LA-think.1 navigation:

rule name	*sample navigation*	*rule package*
V_N_V	sleep_Julia_sleep	{V_V_V}
V_V_V	sleep_dream_dream	{V_N_V}

12.1.4 Deriving a VNVNVN sequence

sleep Julia+ sing John+ dream Susanne
VN VN VN

rule name	*navigation steps*	*result sequence*
V_N_V	sleep_Julia_sleep	VN
V_V_V	sleep_sing_sing	VNV
V_N_V	sing_John_sing	VNVN
V_V_V	sing_dream_dream	VNVNV
V_N_V	dream_Susanne_dream	VNVNVN

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12.2 Navigating with LA-think.1

12.2.1 Providing an initial proplet for the navigation

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_1$$

12.2.2 Traversing the first proposition

1 V_N_V {2 V_V_V}

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{arg: } \beta \\ \text{prn: i} \end{bmatrix} \quad \begin{bmatrix} \text{noun: } \beta \\ \text{fnc: } \alpha \\ \text{prn: i} \end{bmatrix}$$

output position ss
switch to LA-speak.1

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$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_1$$

Activated sequence:

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_2$$

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12.2.3 Transition to the second proposition

2 V_V_V {1 V_N_V}

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{nc: j } \beta \\ \text{prn: i} \end{bmatrix} \quad \begin{bmatrix} \text{verb: } \beta \\ \text{pc: i } \alpha \\ \text{prn: j} \end{bmatrix} \qquad \text{output position nw}$$

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_1 \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sing} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: John} \\ \text{nc: 3 dream} \\ \text{pc: 1 sleep} \\ \text{prn: 2} \end{bmatrix}_3 \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sing} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: John} \\ \text{nc: 3 dream} \\ \text{pc: 1 sleep} \\ \text{prn: 2} \end{bmatrix}_3$$

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Activated sequence:

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sing}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: John}\\ \text{nc: 3 dream}\\ \text{pc: 1 sleep}\\ \text{prn: 2}\end{bmatrix}_3$$

12.2.4 Activated sequence at the end of the navigation

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sleep}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Julia}\\ \text{nc: 2 sing}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: sleep}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{sing}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: John}\\ \text{nc: 3 dream}\\ \text{pc: 1 sleep}\\ \text{prn: 2}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{John}\\ \text{cat: nm}\\ \text{sem: m}\\ \text{mdr:}\\ \text{fnc: sing}\\ \text{idy: 2}\\ \text{prn: 2}\end{bmatrix}_4 \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{dream}\\ \text{cat: decl}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg: Susanne}\\ \text{nc:}\\ \text{pc:2 sing}\\ \text{prn: 3}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{Susanne}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: dream}\\ \text{idy: 3}\\ \text{prn: 3}\end{bmatrix}_6$$

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12.3 Automatic Word Form Production

12.3.1 The function lex-n for the generation of proper names

If $\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: nm}\end{bmatrix}$ matches an activated N proplet, then lex-n [noun: α] = α'.

If α =	then α' =
John	John
Julia	Julia
Susanne	Susanne

12.3.2 The function lex-fv for the generation of verb forms

If $\begin{bmatrix}\text{verb: } \alpha \\ \text{arg: } \beta \text{ z} \\ \text{sem: pres}\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: nm}\end{bmatrix}$ match an activated VN sequence, then lex-fv [verb: α] = α'+s.

If α =	then α' =
dream	dream
sing	sing
sleep	sleep

12.3.3 The function lex-p for the generation of a full stop

If $\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{arg: } \beta\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{verb: } \alpha\end{bmatrix}$ match an activated VN sequence, then lex-p [verb: α] = . (full stop).

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12.4 Definition of LA-speak.1

12.4.1 Formal Definition of LA-speak.1

LX: proplet tokens in the activated sequence

$ST_S =_{def} \{(\begin{bmatrix}\text{verb: } \alpha\end{bmatrix} \{1 \text{ -NoP}\}) \}$

-NoP {2 -FVERB}

$$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: nm} \\ \text{prn: i}\end{bmatrix} \quad \text{lex-n} \begin{bmatrix}\text{noun: } \beta\end{bmatrix}$$

-FVERB {3 -STOP}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{arg: } \beta \\ \text{prn: i}\end{bmatrix} \quad \text{lex-fv} \begin{bmatrix}\text{verb: } \alpha\end{bmatrix}$$

-STOP {1 -NoP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: decl} \\ \text{arg: } \alpha \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-p} \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{switch to LA-think.1}\end{array}$$

ST$_F =_{def} \{(\begin{bmatrix}\text{cat:decl}\end{bmatrix} \text{rp}_{-\text{STOP}})\}$

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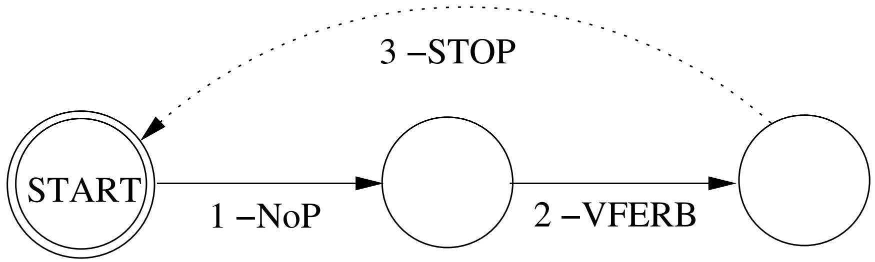
12.4.2 Finite State Transition Network of LA-speak.1



12.5 Producing a Sequence of Sentences

12.5.1 Realizing Julia of the first proposition

1 -NoP {2 -FVERB}

$$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: nm} \\ \text{prn: i}\end{bmatrix} \qquad \text{lex-n} \begin{bmatrix}\text{noun: } \beta\end{bmatrix}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{matrix}\text{sur:}\textbf{Julia} \Leftarrow! \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}\end{matrix}$$

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12.5.2 Realizing sleeps of the first proposition

2 -FVERB {3 -STOP}

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{arg: } \beta \\ \text{cat: decl} \\ \text{prn: i} \end{bmatrix} \qquad \text{lex-fv } \begin{bmatrix} \text{verb: } \alpha \end{bmatrix}$$

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix} \Longrightarrow \begin{array}{l} \text{sur: } \textbf{sleeps} \Leftarrow ! \\ \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \end{array} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}$$

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12.5.3 Realizing the punctuation sign of the first proposition

3 -STOP {1-NoP}

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{arg: } \beta \\ \text{prn: i} \end{bmatrix} \qquad \text{lex-p } [\text{verb: } \alpha] \quad \text{switch to LA-think.1}$$

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix} \Longrightarrow \begin{matrix} \text{sur: } \textbf{.} \Leftarrow ! \\ \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{sleep} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc: 2 sing} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \end{matrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: sleep} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}$$

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12.5.4 Realizing John of the second proposition

1 -NoP {2 -FVERB}

$$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: nm} \\ \text{prn: i}\end{bmatrix} \qquad \text{lex-n } \begin{bmatrix}\text{noun: } \beta\end{bmatrix}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sing} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: John} \\ \text{nc: 3 dream} \\ \text{pc: 1 sleep} \\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{John} \\ \text{cat: nm} \\ \text{sem: m} \\ \text{mdr:} \\ \text{fnc: sing} \\ \text{idy: 2} \\ \text{prn: 2}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{sing} \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{mdr:} \\ \text{arg: John} \\ \text{nc: 3 dream} \\ \text{pc: 1 sleep} \\ \text{prn: 2}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{John} \Leftarrow ! \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{John} \\ \text{cat: nm} \\ \text{sem: m} \\ \text{mdr:} \\ \text{fnc: sing} \\ \text{idy: 2} \\ \text{prn: 2}\end{bmatrix}\end{matrix}$$

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12.6 Summarizing the DBS.1 System

1. **Word form recognition** (Sections 11.1 and 11.2)
   takes unanalyzed surfaces of natural language as input, and produces corresponding analyzed lexical entries (types, isolated proplets) as output. For simplicity, it is based here on a lookup from a full-form lexicon.
2. **LA-hear.1** (Sections 11.3 and 11.4)
   takes the output of automatic word form recognition as input, and produces sets of connected proplets serving as the input sign's semantic representation.
3. **Word Bank** (Section 11.6)
   takes the output of LA-hear.1 as input, and stores it automatically by using the core values of the proplets as the key.
4. **LA-think.1** (Section 12.1)
   takes the proplets of the Word Bank as input, navigates autonomously through the content of the Word Bank, and activates the proplets traversed.
5. **LA-speak.1** (Section 12.3)
   matches the proplets activated by LA-think.1, and produces unanalyzed surfaces of natural language with the help of
6. **Word form production** (Section 12.3)
   which takes proplets as input and renders suitable surfaces as output. For simplicity it is based here on full-form patterns and lexicalization tables.

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13. DBS.2: Hearer Mode

13.1 Lexicon of LA-hear.2

13.1.1 Proper names as in LA-hear.1 (cf. Section 11.2)

13.1.2 personal pronouns

$$
\begin{bmatrix}\text{sur: I}\\ \text{noun: }\textit{I}\\ \text{cat: ns1}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: you}\\ \text{noun: }\textit{you}\\ \text{cat: pro2}\\ \text{sem:}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: he}\\ \text{noun: }\textit{he}\\ \text{cat: ns3}\\ \text{sem: sg m}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: she}\\ \text{noun: }\textit{he}\\ \text{cat: ns3}\\ \text{sem: sg f}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: it}\\ \text{noun: }\textit{he}\\ \text{cat: snp}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: we}\\ \text{noun: }\textit{I}\\ \text{cat: np-2}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{sur: they}\\ \text{noun: }\textit{he}\\ \text{cat: np-2}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: me}\\ \text{noun: }\textit{I}\\ \text{cat: obq}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: him}\\ \text{noun: }\textit{he}\\ \text{cat: obq}\\ \text{sem: sg m}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: her}\\ \text{noun: }\textit{he}\\ \text{cat: obq}\\ \text{sem: sg f}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: us}\\ \text{noun: }\textit{I}\\ \text{cat: obq}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: them}\\ \text{noun: }\textit{he}\\ \text{cat: obq}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
$$

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13.1.3 Determiners

$$
\begin{bmatrix} \text{sur: } \textsf{a} \\ \text{noun: n\_1} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \textsf{every} \\ \text{noun: n\_1} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: pl exh} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \textsf{some} \\ \text{noun: n\_1} \\ \text{cat: pn}' \text{ pnp} \\ \text{sem: pl sel} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \textsf{all} \\ \text{noun: n\_1} \\ \text{cat: pn}' \text{ pnp} \\ \text{sem: pl exh} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
\begin{bmatrix} \text{sur: } \textsf{the} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}
$$

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13.1.4 Nouns

$$
\begin{bmatrix}\text{sur: car}\\ \text{noun: }\textit{car}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: cars}\\ \text{noun: }\textit{car}\\ \text{cat: pn}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: driver}\\ \text{noun: }\textit{driver}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: drivers}\\ \text{noun: }\textit{driver}\\ \text{cat: pn}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: farmer}\\ \text{noun: }\textit{farmer}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: farmers}\\ \text{noun: }\textit{farmer}\\ \text{cat: pn}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{sur: lift}\\ \text{noun: }\textit{lift}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: lifts}\\ \text{noun: }\textit{lift}\\ \text{cat: pn}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: tree}\\ \text{noun: }\textit{tree}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: trees}\\ \text{noun: }\textit{tree}\\ \text{cat: pn}\\ \text{sem: pl}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}
$$

13.1.5 Main verbs, one place

1 *Third person singular present tense*: as in LA-hear.1 (cf. Section 11.2).

2 *Non-third-person singular present tense*

sur: sleep	sur: sing	sur: dream	sur: speed
verb: *sleep*	verb: *sing*	verb: *dream*	verb: *speed*
cat: n-s3′ v	cat: n-s3′ v	cat: n-s3′ v	cat: n-s3′ v
sem: pres	sem: pres	sem: pres	sem: pres
mdr:	mdr:	mdr:	mdr:
arg:	arg:	arg:	arg:
nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:
prn:	prn:	prn:	prn:

3 *Past tense – past participle*

sur: slept	sur: sang	sur: dreamt	sur: speeded
verb: *sleep*	verb: *sing*	verb: *dream*	verb: *speed*
cat: n′ v	cat: n′ v	cat: n′ v	cat: n′ v
sem: past/perf	sem: past	sem: past/perf	sem: past/perf
mdr:	mdr:	mdr:	mdr:
arg:	arg:	arg:	arg:
nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:
prn:	prn:	prn:	prn:

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4 *Separate past participle*

sur: sung
verb: *sing*
cat: hv
sem: perf
mdr:
arg:
nc:
pc:
prn:

5 *Present participle*

sur: sleeping	sur: singing	sur: dreaming	sur: speeding
verb: *sleep*	verb: *sing*	verb: *dream*	verb: *speed*
cat: be	cat: be	cat: be	cat: be
sem: prog	sem: prog	sem: prog	sem: prog
mdr:	mdr:	mdr:	mdr:
arg:	arg:	arg:	arg:
nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:
prn:	prn:	prn:	prn:

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13.1.6 Main verbs, two place

1 *Third person singular present tense*

$$\begin{bmatrix}\text{sur: hits}\\ \text{verb: } \textit{hit}\\ \text{cat: ns3}'\ \text{a}'\ \text{v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix} \begin{bmatrix}\text{sur: knows}\\ \text{verb: } \textit{know}\\ \text{cat: ns3}'\ \text{a}'\ \text{v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}$$

2 *Non-third person singular present tense*

$$\begin{bmatrix}\text{sur: hit}\\ \text{verb: } \textit{hit}\\ \text{cat: n-s3}'\ \text{a}'\ \text{v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix} \begin{bmatrix}\text{sur: know}\\ \text{verb: } \textit{know}\\ \text{cat: n-s3}'\ \text{a}'\ \text{v}\\ \text{sem: pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}$$

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3 *Past tense/past participle*

$$\begin{bmatrix} \text{sur: hit} \\ \text{verb: } \textit{hit} \\ \text{cat: } n'\ a'\ v \\ \text{sem: past/perf} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: knew} \\ \text{verb: } \textit{know} \\ \text{cat: } n'\ a'\ v \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}$$

4 *Separate past participle*

$$\begin{bmatrix} \text{sur: known} \\ \text{verb: } \textit{know} \\ \text{cat: } a'\ hv \\ \text{sem: perf} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}$$

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5 *Present participle*

$$\begin{bmatrix}\text{sur: hitting}\\ \text{verb: } \textit{hit}\\ \text{cat: a}' \text{ be}\\ \text{sem: prog}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix} \quad \begin{bmatrix}\text{sur: knowing}\\ \text{verb: } \textit{know}\\ \text{cat: a}' \text{ be}\\ \text{sem: prog}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}$$

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13.1.7 Forms of a three place main verb

sur: give	sur: gives	sur: gave	sur: given	sur: giving
verb: *give*	verb: *give*	verb: *give*	verb: *give*	verb: *give*
cat: n-s3′ d′ a′ v	cat: ns3′ d′ a′ v	cat: n′ d′ a′ v	cat: d′ a′ hv	cat: d′ a′ be
sem: pres	sem: pres	sem: past	sem: perf	sem: prog
mdr:	mdr:	mdr:	mdr:	mdr:
arg:	arg:	arg:	arg:	arg:
nc:	nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:	pc:
prn:	prn:	prn:	prn:	prn:

13.1.8 Forms of the auxiliary be

sur: am	sur: ain’t	sur: is	sur: isn’t
verb: v_1	verb: v_1	verb: v_1	verb: v_1
cat: ns1′ be′ v	cat: ns13′ be′ v	cat: ns3′ be′ v	cat: ns3′ be′ v
sem: be_pres	sem: be_pres neg	sem: be_pres	sem: be_pres neg
mdr:	mdr:	mdr:	mdr:
arg:	arg:	arg:	arg:
nc:	nc:	nc:	nc:
pc:	pc:	pc:	pc:
prn:	prn:	prn:	prn:

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$$
\begin{bmatrix}\text{sur: are}\\ \text{verb: v\_1}\\ \text{cat: n-s13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: aren't}\\ \text{verb: v\_1}\\ \text{cat: n-s13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_pres neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: was}\\ \text{verb: v\_1}\\ \text{cat: ns13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_past}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: wasn't}\\ \text{verb: v\_1}\\ \text{cat: ns13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_past neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{sur: were}\\ \text{verb: v\_1}\\ \text{cat: n-s13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_past}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: weren't}\\ \text{verb: v\_1}\\ \text{cat: n-s13}'\ \text{be}'\ \text{v}\\ \text{sem: be\_past neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: been}\\ \text{verb: v\_1}\\ \text{cat: be}'\ \text{hv}\\ \text{sem: be\_perf}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: being}\\ \text{verb: v\_1}\\ \text{cat: be}'\ \text{be}\\ \text{sem: be\_prog}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
$$

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13.1.9 Forms of the auxiliary have

$$
\begin{bmatrix}\text{sur: have}\\ \text{verb: v\_1}\\ \text{cat: n-s3}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: haven't}\\ \text{verb: v\_1}\\ \text{cat: n-s3}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_pres neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: has}\\ \text{verb: v\_1}\\ \text{cat: s3}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_pres}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: hasn't}\\ \text{verb: v\_1}\\ \text{cat: s3}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_pres neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
$$

$$
\begin{bmatrix}\text{sur: had}\\ \text{verb: v\_1}\\ \text{cat: n}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_past}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: hadn't}\\ \text{verb: v\_1}\\ \text{cat: n}'\ \text{hv}'\ \text{v}\\ \text{sem: hv\_past neg}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
\begin{bmatrix}\text{sur: having}\\ \text{verb: v\_1}\\ \text{cat: be}'\ \text{hv}\\ \text{sem: hv\_prog}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}
$$

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13.1.10 Forms of the auxiliary do

$$\begin{bmatrix} \text{sur: do} \\ \text{verb: v\_1} \\ \text{cat: n-s3}'\ \text{do}'\ \text{v} \\ \text{sem: do\_pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: don't} \\ \text{verb: v\_1} \\ \text{cat: n-s3}'\ \text{do}'\ \text{v} \\ \text{sem: do\_pres neg} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: does} \\ \text{verb: v\_1} \\ \text{cat: ns3}'\ \text{do}'\ \text{v} \\ \text{sem: do\_pres} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: doesn't} \\ \text{verb: v\_1} \\ \text{cat: ns3}'\ \text{do}'\ \text{v} \\ \text{sem: do\_pres neg} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}$$

$$\begin{bmatrix} \text{sur: did} \\ \text{verb: v\_1} \\ \text{cat: n}'\ \text{do}'\ \text{v} \\ \text{sem: do\_past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: didn't} \\ \text{verb: v\_1} \\ \text{cat: n}'\ \text{do}'\ \text{v} \\ \text{sem: do\_past neg} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: doing} \\ \text{verb: v\_1} \\ \text{cat: a}'\ \text{be} \\ \text{sem: do\_prog} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix} \begin{bmatrix} \text{sur: done} \\ \text{verb: v\_1} \\ \text{cat: a}'\ \text{hv} \\ \text{sem: do\_perf} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}$$

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13.1.11 Forms of adnominals

sur: beautiful	sur: heavy	sur: heavier	sur: heaviest	sur: old	sur: older	sur: oldest
adj: *beautiful*	adj: *heavy*	adj: *heavy*	adj: *heavy*	adj: *old*	adj: *old*	adj: *old*
cat: adn	cat: adn	cat: adn	cat: adn	cat: adn	cat: adn	cat: adn
sem:	sem:	sem: comp	sem: SUP	sem:	sem: comp	sem: sup
mdr: B	mdr: B	mdr: B	mdr: B	mdr: B	mdr: B	mdr: B
mdd:	mdd:	mdd:	mdd:	mdd:	mdd:	mdd:
idy: B	idy: B	idy: B	idy: B	idy: B	idy: B	idy: B
prn:	prn:	prn:	prn:	prn:	prn:	prn:

13.1.12 Forms of adverbials

sur: heavily	sur: beautifully
adj: *heavy*	adj: *beautiful*
cat: adv	cat: adv
sem:	sem:
mdr: B	mdr: B
mdd:	mdd:
idy: B	idy: B
prn:	prn:

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13.1.13 Lexical values of the cat attribute

decl = declarative sentence
v = verb, unmarked for sentence mood
ns1 = nominative singular first person filler
pro2= nominative and oblique second person singular and plural filler
ns3 = nominative singular third person filler
np-2= nominative plural minus second person filler (i.e. first and third plural)
obq = noun phrase filler in the oblique (non-nominative) case
snp = third person singular noun phrase filler unmarked for case
pnp = third person plural noun phrase filler unmarked for case
np = third person noun phrase filler unmarked for case and number
nm = proper name
sn = singular noun valency filler
pn = plural noun valency filler
nn = noun filler unmarked for number
be = valency filler indicating a present participle
hv = valency filler indicating a past participle
adn = adnominal

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v'	= valency position for verb unmarked for sentence mood
n'	= valency position for nominative of any person or number
$n\text{-}s3'$	= valency position for nominative minus singular third person
$ns1'$	= valency position for nominative singular first person
$ns3'$	= valency position for nominative singular third person
$ns13'$	= valency position for nominative singular first and third person
$n\text{-}s13'$	= valency position for nominative minus singular first and third person
a'	= accusative valency position for oblique noun phrase
d'	= dative valency position for oblique noun phrase
sn'	= valency position for third person singular noun
pn'	= valency position for third person plural noun
be'	= valency position for a present participle
hv'	= valency position for a past participle
do'	= valency position for an infinitive

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13.1.14 Lexical values of the sem attribute

f	= femininum
m	= masculinum
sg	= singular
pl	= plural
def	= definite
indef	= indefinite
sel	= selective
exh	= exhaustive
pres	= present tense
past	= past tense
perf	= past participle
prog	= progressive
be_pres	= present tense of auxiliary be
hv_pres	= present tense of auxiliary have
do_pres	= present tense of auxiliary do, including modals
be_past	= past tense of auxiliary be
hv_past	= past tense of auxiliary have
do_past	= past tense of auxiliary do, including modals
be_perf	= past participle of auxiliary be
hv_perf	= past participle of auxiliary have
do_perf	= past participle of auxiliary do
neg	= negated
comp	= comparative
sup	= superlative

13.2 Preamble and Definition of LA-hear.2

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13.2.1 List of variables

α, β, γ	= for a core value
SM	= sentence mood
VT	= verb type filler
VT$'$	= verb type valency position
NP	= noun phrase filler
NP$'$	= noun phrase valency position
OBQ	= oblique noun phrase filler
OBQ$'$	= oblique noun phrase valency position
N	= noun filler
N$'$	= noun valency position
AUX	= auxiliary filler
AUX$'$	= auxiliary valency position

X, Y, Z	= .?.?.?.? (arbitrary sequence up to length 4)
N_n	= simultaneous substitution variable for a noun
V_n	= simultaneous substitution variable for a verb

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13.2.2 Restrictions of variables

SM	ϵ {decl}
VT	ϵ {v}
VT′	ϵ {v′}
NP	ϵ {pro2, nm, ns1, ns3, np-2, snp, pnp, pn, np, obq}
NP′	ϵ {n′, n-s3′, ns1′, ns3′, ns13′, n-s13′, d′, a′}
OBQ	ϵ {snp, pnp, pn, obq}
OBQ′	ϵ {d′, a′}
N	ϵ {sn, pn}
N′	ϵ {nn′, sn′, pn′}
AUX	ϵ {do, hv, be}
AUX′	ϵ {do′, hv′, be′}
N_*n*	ϵ {n_1, n_2, n_3, . . . }
V_*n*	ϵ {v_1, v_2, v_3, . . . }

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13.2.3 Agreement conditions

if NP = ns1, then $NP' \in \{n', n\text{-}s3', ns1', ns13'\}$
if NP = pro2, then $NP' \in \{n', n\text{-}s3', n\text{-}s13', d', a'\}$
if NP = ns3, then $NP' \in \{n', ns3', ns13'\}$
if NP = np-2, then $NP' \in \{n', n\text{-}s3', n\text{-}s13'\}$
if $NP \in \{nm, snp\}$, then $NP' \in \{n', ns3', ns13', d', a'\}$
if NP = pnp, then $NP' \in \{n', n\text{-}s3', n\text{-}s13', d', a'\}$
if NP = np, then $NP' \in \{n', ns3', ns13', n\text{-}s3', n\text{-}s13', d', a'\}$
if NP = obq, then $NP' \in \{d', a'\}$
if $AUX' = do'$, then $AUX = n\text{-}s3'$
if $AUX' = hv'$, then $AUX \in \{hv, n'\}$
if $AUX' = be'$, then AUX = be
if $N' = nn'$, then $N \in \{nn, sn, pn\}$
if $N' = sn'$, then $N \in \{nn, sn\}$
if $N' = pn'$, then $N \in \{nn, pn\}$

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13.2.4 Formal definition of LA-hear.2

$$\mathbf{ST}_S =_{def} \{ (\begin{bmatrix}\text{cat: X}\end{bmatrix} \{1 \text{ DET+ADN}, 2 \text{ DET+NN}, 3 \text{ NOM+FV}\}) \}$$

DET+ADN {4 DET+ADN, 5 DET+NN}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}' \text{ X}\\ \text{mdr:}\\ \text{idy:}\end{bmatrix} \begin{bmatrix}\text{adj: } \alpha\\ \text{cat: adn}\\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{acopy } \alpha \text{ ss.mdr}\\ \text{ecopy ss.noun nw.mdd}\\ \text{acopy ss.idy nw.mdd}\\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}$$

DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}' \text{ X}\\ \text{sem: Y}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix} \quad \begin{array}{l}\text{delete N}' \text{ ss.cat}\\ \text{acopy nw.sem ss.sem}\\ \text{replace } \alpha \text{ N\_}n\\ \text{copy}_{ss}\end{array}$$

NOM+FV {9 FV+NP, 10 AUX+NFV, 11 S+IP}

$$\begin{bmatrix}\text{noun: } \alpha\\ \text{cat: NP}\\ \text{fnc:}\\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{verb: } \beta\\ \text{cat: NP}' \text{ X VT}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\end{bmatrix} \quad \begin{array}{l}\text{delete NP}' \text{ nw.cat}\\ \text{acopy } \alpha \text{ nw.arg}\\ \text{ecopy } \beta \text{ ss.fnc}\\ \text{ecopy PC nw.pc}\\ \text{acopy PCV nw.pc}\\ \text{set } \beta \text{ NCV}\\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}$$

FV+NP {12 DET+ADN, 13 DET+NN, 14 FV+NP, 15 S+IP}

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$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix} \begin{array}{l}\text{delete NP}' \text{ ss.cat} \\ \text{acopy } \alpha \text{ ss.arg} \\ \text{ecopy } \beta \text{ nw.fnc} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

AUX+NFV {16 AUX+NFV, 17 FV+NP 18 S+IP}

$$\begin{bmatrix}\text{verb: V\_}n \\ \text{cat: AUX}' \text{ V} \\ \text{sem: X}\end{bmatrix} \begin{bmatrix}\text{verb: } \alpha \\ \text{cat: Y AUX} \\ \text{sem: Z}\end{bmatrix} \begin{array}{l}\text{replace Y AUX}' \\ \text{acopy nw.sem ss.sem} \\ \text{replace } \alpha \text{ V\_}n \\ \text{copy}_{ss}\end{array}$$

S+IP { 19 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix} \begin{array}{l}\text{replace SM VT} \\ \text{set k ss.PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}$$

IP+START {1 DET+ADN, 2 DET+NN, 3 NOM+FV}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: SM} \\ \text{nc:}\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: X NP} \\ \text{prn: k}\end{bmatrix} \begin{array}{l}\text{increment nw.prn} \\ \text{ecopy k ss.nc} \\ \text{acopy `NCV' ss.nc} \\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}$$

$\textbf{ST}_F =_{def} \{ (\begin{bmatrix}\text{cat: decl}\end{bmatrix} \text{ rp }_{\text{S+IP}}) \}$

13.2.5 Finite state transition network of LA-hear.2

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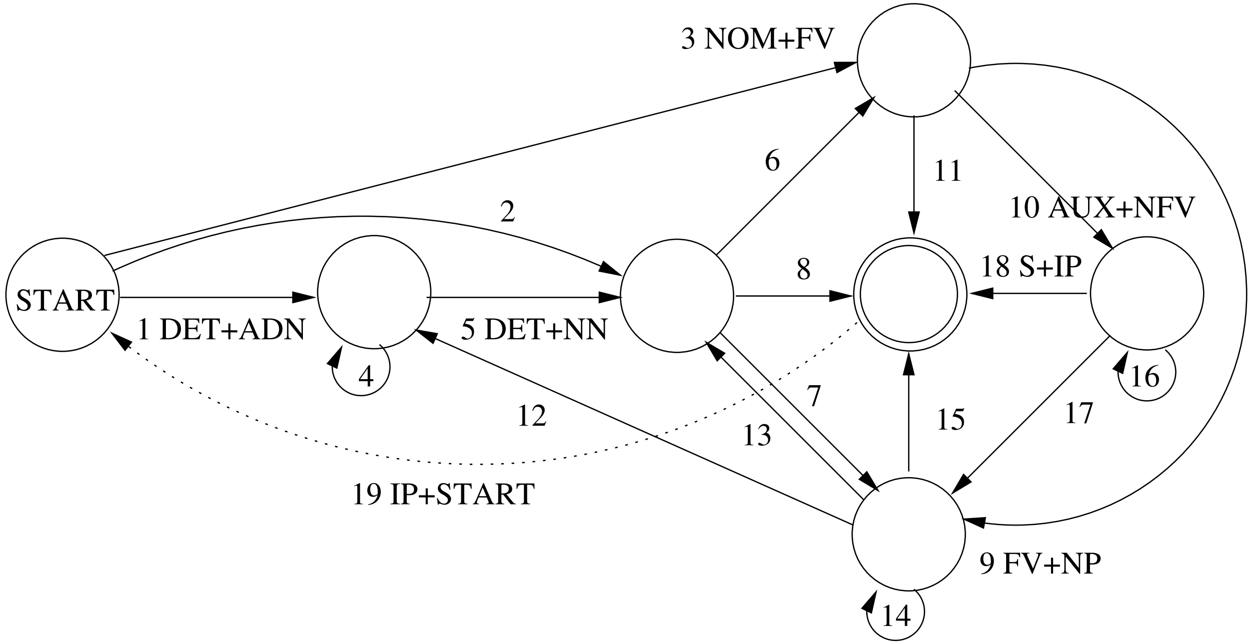
3 NOM+FV
6
11
10 AUX+NFV
2
8
18 S+IP
START
1 DET+ADN
5 DET+NN
4
16
7
12
13
15
17
19 IP+START
9 FV+NP
14

13.2.6 Sequence of rule applications in derivations 5.4, 5.5, and 5.6

	1.1 The
1 DET+ADN	1.2 heavy
4 DET+ADN	1.3 old
5 DET+NN	1.4 car
6 NOM+FV	1.5 hit
9 FV+NP	1.6 a
12 DET+ADN	1.7 beautiful
5 DET+NN	1.8 tree
8 S+IP	1.9 .
19 IP+START	2.1 The
2 DET+NN	2.2 car
6 NOM+FV	2.3 had
10 AUX+NFV	2.4 been
16 AUX+NFV	2.5 speeding
18 S+IP	2.6 .
19 IP+START	3.1 The
2 DET+NN	3.2 farmer
6 NOM+FV	3.3 gave
9 FV+NP	3.5 the
13 DET+NN	3.6 driver
7 FV+NP	3.7 a
13 DET+NN	3.8 lift
8 S+IP	3.4 .

13.3 Interpreting a Sentence with Complex Noun Phrases

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13.3.1 Combining The and heavy

1 DET+ADN {4 DET+ADN, 5 DET+NN}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\text{ X}\\ \text{mdr:}\\ \text{idy:}\end{bmatrix}\quad\begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adn}\\ \text{mdd:}\end{bmatrix}$$

acopy α ss.mdr
ecopy ss.noun nw.mdd
acopy ss.idy nw.mdd
copy$_{ss}$ copy$_{nw}$

$$\begin{bmatrix}\text{sur: 1.1 the}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_1\begin{bmatrix}\text{sur: 1.2 heavy}\\ \text{adj: }\textit{heavy}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_2\Longrightarrow\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr: heavy}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{heavy}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2$$

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13.3.2 Combining The heavy and old

4 DET+ADN {4 DET+ADN, 5 DET+NN}

$$
\begin{bmatrix} \text{noun: N\_}n \\ \text{cat: N}'\ \text{X} \\ \text{mdr:} \\ \text{idy:} \end{bmatrix}
\qquad
\begin{bmatrix} \text{adj: } \alpha \\ \text{cat: adn} \\ \text{mdd:} \end{bmatrix}
$$

acopy α ss.mdr
ecopy ss.noun nw.mdd
acopy ss.idy nw.mdd
copy$_{ss}$ copy$_{nw}$

$$
\begin{bmatrix} \text{sur:} \\ \text{noun: n\_1} \\ \text{cat: nn}'\ \text{np} \\ \text{sem: def} \\ \text{mdr: heavy} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{heavy} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr: B} \\ \text{mdd: n\_1 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_2
\begin{bmatrix} \text{sur: 1.3 old} \\ \text{adj: } \textit{old} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr: B} \\ \text{mdd:} \\ \text{idy: B} \\ \text{prn:} \end{bmatrix}_3
\Longrightarrow
\begin{bmatrix} \text{sur:} \\ \text{noun: n\_1} \\ \text{cat: nn}'\ \text{np} \\ \text{sem: def} \\ \text{mdr: heavy} \\ \quad \text{old} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{heavy} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr: B} \\ \text{mdd: n\_1 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_2
\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{old} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr: B} \\ \text{mdd: n\_1 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_3
$$

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13.3.3 Combining The heavy old and car

5 DET+NN { 6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\text{ X}\\ \text{sem: Y}\end{bmatrix} \qquad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr: heavy old}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{heavy}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{old}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur: 1.4 car}\\ \text{noun: }\textit{car}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_4 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{car}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: heavy old}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1$$

$$\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{heavy}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: car 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{old}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: car 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3$$

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13.3.4 Combining The heavy old car and hit

6 NOM+FV {9 FV+NP, 10 AUX+NFV, 11 S+IP}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: NP} \\ \text{fnc:} \\ \text{prn: k}\end{bmatrix} \quad \begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:}\end{bmatrix}$$

delete NP′ nw.cat
acopy α nw.arg
ecopy β ss.fnc
ecopy PC nw.pc
acopy PCV nw.pc
set β NCV
copy$_{ss}$ copy$_{nw}$

$$\begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: heavy old} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: 1.5 hit} \\ \text{verb: } \textit{hit} \\ \text{cat: n}' \text{ a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: heavy old} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5$$

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13.3.5 Combining The heavy old car hit **and** a

9 FV+NP {12 DET+ADN, 13 DET+NN, 14 FV+NP, 15 S+IP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix}$$

delete NP′ ss.cat
acopy α ss.arg
ecopy β nw.fnc
copy$_{ss}$copy$_{nw}$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5 \quad \begin{bmatrix}\text{sur: 1.6 a} \\ \text{noun: n\_2} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_6 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car n\_2} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:} \\ \text{noun: n\_2} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}_6$$

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13.3.6 **Combining** The heavy old car hit a **and** beautiful

12 DET+ADN {4 DET+ADN, 5 DET+NN}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{mdr:}\\ \text{idy:}\end{bmatrix} \quad \begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adn}\\ \text{mdd:}\end{bmatrix}$$

acopy α ss.mdr
ecopy ss.noun nw.mdd
acopy ss.idy nw.mdd
copy$_{ss}$ copy$_{nw}$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{hit}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: car n\_2}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_2}\\ \text{cat: sn}'\ \text{snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_6 \begin{bmatrix}\text{sur: 1.7 beautiful}\\ \text{adj: }\textit{beautiful}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_7 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{hit}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: car n\_2}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_2}\\ \text{cat: sn}'\ \text{snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_6 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{beautiful}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: n\_2 2}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_7$$

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13.3.7 Combining The heavy old car hit a beautiful **and** tree

5 DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\text{ X}\\ \text{sem: Y}\end{bmatrix} \quad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{hit}\\ \text{cat: sn}'\text{ v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: car n\_2}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_2}\\ \text{cat: sn}'\text{ snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_6 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{beautiful}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: n\_2 2}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_7 \begin{bmatrix}\text{sur: 1.8 tree}\\ \text{noun: }\textit{tree}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_8 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{hit}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: car tree}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_5$$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{tree}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_6 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{beautiful}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: tree 2}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_7$$

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13.3.8 Combining The heavy old car hit a beautiful tree and .

8 S+IP {19 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \quad \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix} \quad \begin{array}{l}\text{replace SM VT} \\ \text{set k PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: np} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}_6 \begin{bmatrix}\text{sur: 1.9 .} \\ \text{cat: v}' \text{ decl}\end{bmatrix}_8 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: np} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}_6$$

13.3.9 Result of parsing The heavy old car hit a beautiful tree.

$$
\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{car}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: heavy}\\ \quad\quad\text{old}\\ \text{fnc: hit}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{heavy}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: car 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{old}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: car 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3
\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{hit}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: car tree}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_5
\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{tree}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_6
\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{beautiful}\\ \text{cat: adn}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: tree 2}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_7
$$

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13.4 Interpreting a Sentence with a Complex Verb Phrase

13.4.1 Combining The heavy old car hit a beautiful tree. and The

19 IP+START {1 DET+ADN, 2 DET+NN, 3 NOM+FV}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: SM} \\ \text{nc:}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \beta \\ \text{cat: X NP} \\ \text{prn: k}\end{bmatrix}$$

increment nw.prn
ecopy k ss.nc
acopy 'NCV' ss.nc
copy_{ss} copy_{nw}

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_8 \begin{bmatrix}\text{sur: 2.1 the} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_1 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc: 2 NCV} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_8 \begin{bmatrix}\text{sur:} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix}_1$$

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13.4.2 Combining The and car

2 DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{sem: Y}\end{bmatrix}\quad\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\ \text{np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 3}\\ \text{prn: 2}\end{bmatrix}_1\begin{bmatrix}\text{sur: 2.2 car}\\ \text{noun: }\textit{car}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_2\Longrightarrow\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{car}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 3}\\ \text{prn: 2}\end{bmatrix}_1$$

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13.4.3 Combining The car and had

6 NOM+FV $\{$9 FV+NP, 10 AUX+NFV, 11 S+IP$\}$

$$
\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: NP} \\ \text{fnc:} \\ \text{prn: k}\end{bmatrix}
\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:}\end{bmatrix}
\quad
\begin{array}{l}\text{delete NP}' \text{ nw.cat} \\ \text{acopy } \alpha \text{ nw.arg} \\ \text{ecopy } \beta \text{ ss.fnc} \\ \text{ecopy PC nw.pc} \\ \text{acopy PCV nw.pc} \\ \text{set } \beta \text{ NCV} \\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}
$$

$$
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc: 2 NCV} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_8
\begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix}_1
\begin{bmatrix}\text{sur: 2.3 had} \\ \text{verb: v\_1} \\ \text{cat: n}' \text{ hv}' \text{ v} \\ \text{sem: hv\_past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:}\end{bmatrix}_3
\Longrightarrow
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: car tree} \\ \text{nc: 2 v\_1} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_8
\begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: v\_1} \\ \text{idy: 3} \\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:} \\ \text{verb: v\_1} \\ \text{cat: hv}' \text{ v} \\ \text{sem: hv\_past} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix}_3
$$

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13.4.4 Combining The car had **and** been

10 AUX+NFV {16 AUX+NFV, 17 FV+NP 18 S+IP}

$$\begin{bmatrix}\text{verb: V\_}n\\ \text{cat: AUX}'\text{ v}\\ \text{sem: X}\end{bmatrix} \begin{bmatrix}\text{verb: }\alpha\\ \text{cat: Y AUX}\\ \text{sem: Z}\end{bmatrix}$$

replace Y AUX$'$
acopy nw.sem ss.sem
replace α V_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } car\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: v\_1}\\ \text{idy: 3}\\ \text{prn: 2}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: v\_1}\\ \text{cat: hv}'\text{ v}\\ \text{sem: hv\_past}\\ \text{mdr:}\\ \text{arg: car}\\ \text{nc:}\\ \text{pc: 1 hit}\\ \text{prn: 2}\end{bmatrix}_3 \begin{bmatrix}\text{sur: 2.4 been}\\ \text{verb: v\_2}\\ \text{cat: be}'\text{ hv}\\ \text{sem: be\_perf}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}_4 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: } car\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: v\_2}\\ \text{idy: 3}\\ \text{prn: 2}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: v\_2}\\ \text{cat: be}'\text{ v}\\ \text{sem: hv\_past be\_perf}\\ \text{mdr:}\\ \text{arg: car}\\ \text{nc:}\\ \text{pc: 1 hit}\\ \text{prn: 2}\end{bmatrix}_3$$

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13.4.5 Combining The car had been and speeding

16 AUX+NFV {16 AUX+NFV, 17 FV+NP 18 S+IP}

$$
\begin{bmatrix} \text{verb: V\_}n \\ \text{cat: AUX}'\text{ v} \\ \text{sem: X} \end{bmatrix}
\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: Y AUX} \\ \text{sem: Z} \end{bmatrix}
\quad
\begin{array}{l} \text{replace Y AUX}' \\ \text{acopy nw.sem ss.sem} \\ \text{replace } \alpha \text{ V\_}n \\ \text{copy}_{ss} \end{array}
$$

$$
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: v\_2} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{verb: v\_2} \\ \text{cat: be}'\text{ v} \\ \text{sem: hv\_past} \\ \quad\text{be\_perf} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix}_3
\begin{bmatrix} \text{sur: 2.5 speeding} \\ \text{verb: } \textit{speed} \\ \text{cat: be} \\ \text{sem: prog} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}_5
\Longrightarrow
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{speed} \\ \text{cat: v} \\ \text{sem: hv\_past} \\ \text{be\_perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix}_3
$$

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13.4.6 Combining The car had been speeding **and .**

18 S+IP {19 IP+START}

$$
\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix}
\quad
\begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix}
\quad
\begin{array}{l}\text{replace SM VT} \\ \text{set k PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}
$$

$$
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{speed} \\ \text{cat: v} \\ \text{sem: hv\_past be\_perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix}_3
\begin{bmatrix}\text{sur: 2.6 .} \\ \text{cat: v}' \text{ decl}\end{bmatrix}_6
\Longrightarrow
\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past be\_perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix}_3
$$

13.4.7 Result of parsing The car had been speeding.

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{car}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: speed}\\ \text{idy: 3}\\ \text{prn: 2}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{speed}\\ \text{cat: decl}\\ \text{sem: hv\_past be\_perf prog}\\ \text{mdr:}\\ \text{arg: car}\\ \text{nc:}\\ \text{pc: 1 hit}\\ \text{prn: 2}\end{bmatrix}_3$$

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13.5 Interpreting a Sentence with a Three-Place Verb

13.5.1 Combining The car had been speeding. and A

19 IP+START { 1 DET+ADN, 2 DET+NN, 3 NOM+FV}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: SM} \\ \text{nc:}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \beta \\ \text{cat: X NP} \\ \text{prn: k}\end{bmatrix} \quad \begin{array}{l}\text{increment nw.prn} \\ \text{ecopy k ss.nc} \\ \text{acopy 'NCV' ss.nc} \\ \text{copy}_{ss}\ \text{copy}_{nw}\end{array}$$

$$\left[\begin{array}{l}\text{sur:} \\ \text{verb: } \textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc:} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{array}\right]_3 \left[\begin{array}{l}\text{sur: 3.1 A} \\ \text{noun: n\_1} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{array}\right]_1 \Longrightarrow \left[\begin{array}{l}\text{sur:} \\ \text{verb: } \textit{speed} \\ \text{cat: decl} \\ \text{sem: past perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc: 3 NCV} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{array}\right]_3 \left[\begin{array}{l}\text{sur:} \\ \text{noun: n\_1} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 4} \\ \text{prn: 3}\end{array}\right]_1$$

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13.5.2 Combining A and farmer

2 DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$
\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{sem: Y}\end{bmatrix}
\quad
\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{v sem: Z}\end{bmatrix}
\quad
\begin{array}{l}\text{delete N}'\ \text{ss.cat}\\ \text{acopy nw.sem ss.sem}\\ \text{replace }\alpha\ \text{N\_}n\\ \text{copy}_{ss}\end{array}
$$

$$
\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: sn}'\ \text{snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 4}\\ \text{prn: 3}\end{bmatrix}_1
\begin{bmatrix}\text{sur: 3.2 farmer}\\ \text{noun: }\textit{farmer}\\ \text{cat: sn}\\ \text{sem:}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_2
\Longrightarrow
\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{farmer}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 4}\\ \text{prn: 3}\end{bmatrix}_1
$$

13.5.3 Combining A farmer and gave

6 NOM+FV {9 FV+NP, 10 AUX+NFV, 11 S+IP}

$$
\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: NP}\\ \text{fnc:}\\ \text{prn: k}\end{bmatrix}
\quad
\begin{bmatrix}\text{verb: }\beta\\ \text{cat: NP}'\text{ X VT}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\end{bmatrix}
$$

delete NP$'$ nw.cat
acopy α nw.arg
ecopy β ss.fnc
ecopy PC nw.pc
acopy PCV nw.pc
set β NCV
copy$_{ss}$ copy$_{nw}$

$$
\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{speed}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{ perf prog}\\ \text{mdr:}\\ \text{arg: car}\\ \text{nc: 3 NCV}\\ \text{pc: 1 hit}\\ \text{prn: 2}\end{bmatrix}_3
\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{farmer}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy: 4}\\ \text{prn: 3}\end{bmatrix}_1
\begin{bmatrix}\text{sur: 3.3 gave}\\ \text{verb: }\textit{give}\\ \text{cat: n}'\text{ d}'\text{ a}'\text{ v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg:}\\ \text{nc:}\\ \text{pc:}\\ \text{prn:}\end{bmatrix}_3
\Longrightarrow
\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{speed}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{ perf prog}\\ \text{mdr:}\\ \text{arg: car}\\ \text{nc: 3 give}\\ \text{pc: 1 hit}\\ \text{prn: 2}\end{bmatrix}_3
\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{farmer}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 4}\\ \text{prn: 3}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{give}\\ \text{cat: d}'\text{ a}'\text{ v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: farmer}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}_3
$$

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13.5.4 Combining A farmer gave and the

9 FV+NP {12 DET+ADN, 13 DET+NN, 14 FV+NP, 15 S+IP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix}$$

delete NP′ ss.cat
acopy α ss.arg
ecopy β nw.fnc
copy$_{ss}$copy$_{nw}$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: d}' \text{ a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur: 3.4 the} \\ \text{noun: n\_2} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_4 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer n\_1} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:} \\ \text{noun: n\_2} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3}\end{bmatrix}_4$$

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13.5.5 **Combining** A farmer gave the **and** driver

13 DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\text{ X}\\ \text{sem: Y}\end{bmatrix}\quad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: a}'\text{ v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: farmer n\_2}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_2}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 5}\\ \text{prn: 3}\end{bmatrix}_4 \begin{bmatrix}\text{sur: 3.5 driver}\\ \text{noun: } \textit{driver}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: a}'\text{ v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: farmer driver}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{driver}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 5}\\ \text{prn: 3}\end{bmatrix}_4$$

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13.5.6 Combining A farmer gave the driver and a

7 FV+NP {12 DET+ADN, 13 DET+NN, 14 FV+NP, 15 S+IP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix} \quad \begin{array}{l}\text{delete NP}' \text{ ss.cat} \\ \text{acopy } \alpha \text{ ss.arg} \\ \text{ecopy } \beta \text{ nw.fnc} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer driver} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur: 3.6 a} \\ \text{noun: n\_3} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_6 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer driver n\_3} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:} \\ \text{noun: n\_3} \\ \text{cat: sn}' \text{ snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 6} \\ \text{prn: 3}\end{bmatrix}_6$$

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13.5.7 Combining A farmer gave the driver a **and** lift

13 DET+NN {6 NOM+FV, 7 FV+NP, 8 S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{sem: Y}\end{bmatrix} \quad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: farmer driver n\_3}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_3}\\ \text{cat: sn}'\ \text{snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}_6 \begin{bmatrix}\text{sur: 3.7 lift}\\ \text{noun: } \textit{lift}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_7 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: farmer driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}_6$$

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13.5.8 Combining A farmer gave the driver a lift and .

8 S+IP { 19 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \quad \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix} \quad \begin{array}{l}\text{replace SM VT} \\ \text{set k PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur: 3.8 .} \\ \text{cat: v}' \text{ decl}\end{bmatrix}_8 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}_3$$

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13.5.9 Result of parsing A farmer gave the driver a lift.

$$
\begin{bmatrix}
\text{sur:} \\
\text{noun: } \textit{farmer} \\
\text{cat: snp} \\
\text{sem: indef sg} \\
\text{mdr:} \\
\text{fnc: give} \\
\text{idy: 4} \\
\text{prn: 3}
\end{bmatrix}_2
\begin{bmatrix}
\text{sur:} \\
\text{verb: } \textit{give} \\
\text{cat: decl} \\
\text{sem: past} \\
\text{mdr:} \\
\text{arg: farmer driver lift} \\
\text{nc:} \\
\text{pc: 2 speed} \\
\text{prn: 3}
\end{bmatrix}_3
\begin{bmatrix}
\text{sur:} \\
\text{noun: } \textit{driver} \\
\text{cat: np} \\
\text{sem: def sg} \\
\text{mdr:} \\
\text{fnc: give} \\
\text{idy: 5} \\
\text{prn: 3}
\end{bmatrix}_4
\begin{bmatrix}
\text{sur:} \\
\text{noun: } \textit{lift} \\
\text{cat: snp} \\
\text{sem: indef sg} \\
\text{mdr:} \\
\text{fnc: give} \\
\text{idy: 6} \\
\text{prn: 3}
\end{bmatrix}_6
$$

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13.6 Storing the Output of LA-hear.2 in a Word Bank

13.6.1 Sorting proplets of LA-hear.2 sample into Word Bank

owner records (isolated proplets)	*member records* (connected proplets)		
sur: adj: *beautiful* cat: adn sem: mdr: B mdd: idy: B prn:	sur: beautiful adj: *beautiful* cat: adn sem: mdr: B mdd: tree 2 idy: B prn: 1		
sur: noun: *car* cat: sn sem: sg mdr: fnc: idy: prn:	sur: car noun: *car* cat: np sem: def sg mdr: heavy old fnc: hit idy: 1 prn: 1	sur: car noun: *car* cat: np sem: def sg mdr: fnc: speed idy: 3 prn: 2	
sur: noun: *driver* cat: sn sem: sg mdr: fnc: idy: prn:			sur: driver noun: *driver* cat: np sem: def sg mdr: fnc: give idy: 5 prn: 3

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owner records (isolated proplets)	*member records* (connected proplets)
sur:	sur: farmer
noun: *farmer*	noun: *farmer*
cat: sn	cat: snp
sem:	sem: indef sg
mdr:	mdr:
fnc:	fnc: give
idy:	idy: 4
prn:	prn: 3
sur:	sur: gave
verb: *give*	verb: *give*
cat: n-s3′ d′ a′ v	cat: decl
sem: pres	sem: past
mdr:	mdr:
arg:	arg: farmer driver lift
nc:	nc:
pc:	pc: 2 speed
prn:	prn: 3

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owner records (isolated proplets)	*member records* (connected proplets)
sur:	sur: heavy
adj: *heavy*	adj: *heavy*
cat: adn	cat: adn
sem:	sem:
mdr: B	mdr: B
mdd:	mdd: car 1
idy: B	idy: B
prn:	prn: 1

sur:	sur: hit
verb: *hit*	verb: *hit*
cat: n-s3′ a′ v	cat: decl
sem: PRES	sem: past
mdr:	mdr:
arg:	arg: car tree
nc:	nc: 2 speed
pc:	pc:
prn:	prn: 1

sur:	sur: old
adj: *old*	adj: *old*
cat: adn	cat: adn
sem:	sem:
mdr: B	mdr: B
mdd:	mdd: car 1
idy: B	idy: B
prn:	prn: 1

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owner records (isolated proplets)	*member records* (connected proplets)		
sur: verb: *speed* cat: n-s3′ v sem: pres mdr: arg: nc: pc: prn:		sur: speeding verb: *speed* cat: decl sem: hv_past be_perf prog mdr: arg: car nc: 3 give pc: 1 hit prn: 2	
sur: noun: *lift* cat: sn sem: sg mdr: fnc: idy: prn:			sur: lift noun: *lift* cat: snp sem: indef sg mdr: fnc: give idy: 6 prn: 3
sur: noun: *tree* cat: sn sem: sg mdr: fnc: idy: prn:	sur: tree noun: *tree* cat: np sem: indef sg mdr: beautiful fnc: hit idy: 2 prn: 1		

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isolated proplet	*connected proplets*	
sur: car	sur:	sur:
noun: *car*	noun: *car*	noun: *car*
cat: sn	cat: np	cat: np
sem: sg	sem: def sg	sem: def sg
mdr:	mdr: heavy old	mdr:
fnc:	fnc: hit	fnc: speed
idy:	idy: 1	idy: 3
prn:	prn: 1	prn: 2

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14. DBS.2: Speaker-Mode

14.1 Definition of LA-think.2

14.1.1 Formal definition of LA-think.2

LX: episodic proplets in the Word Bank 13.6.1

ST$_S$ $=_{def}$ {([verb: α] {1 V_N_V, 2 V_N_N })}

V_N_V {3 V_N_V, 4 V_N_N, 5 V_V_V}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X } \alpha \text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{fnc: } \beta \\ \text{mdr: NIL} \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{mark } \alpha \text{ in ss-arg} \\ \text{output position ss} \\ \text{activate LA-speak.2}\end{array}$$

V_N_N {6 N_A_N, 7 N_A_V}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X } \alpha \text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: } \gamma \text{ Z} \\ \text{fnc: } \beta \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{mark } \alpha \text{ in ss-arg} \\ \text{output position nw} \\ \text{activate LA-speak.2}\end{array}$$

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N_A_N {8 N_A_N, 9 N_A_V}

$$\begin{bmatrix}\text{noun:}\alpha\\ \text{mdr: !X } \beta \text{ Y}\\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta\\ \text{mdd: } \alpha\\ \text{prn: i}\end{bmatrix} \begin{array}{l}\text{mark } \beta \text{ in ss-mdr}\\ \text{output position ss}\\ \text{activate LA-speak.2}\end{array}$$

N_A_V {10 V_N_V, 11 V_N_N, 12 V_V_V}

$$\begin{bmatrix}\text{noun: } \alpha\\ \text{fnc: } \gamma\\ \text{mdr: !X } \beta\\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta\\ \text{mdd: } \alpha\\ \text{prn: i}\end{bmatrix} \begin{array}{l}\text{end-mark } \beta \text{ in ss-mdr}\\ \text{output position ss-fnc}\\ \text{activate LA-speak.2}\end{array}$$

V_V_V {1 V_N_V, 2 V_N_N}))}

$$\begin{bmatrix}\text{verb: } \alpha\\ \text{arg: !X}\\ \text{nc: j } \beta\\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{verb: } \beta\\ \text{arg: } \gamma\\ \text{pc: i } \alpha\\ \text{prn: m}\end{bmatrix} \text{ output position nw}$$

$$\textbf{ST}_F =_{def} \{([\text{verb: } \alpha] \text{ rp }_{\text{V\_N\_V}}), ([\text{verb: } \alpha] \text{ rp }_{\text{N\_A\_V}})\}$$

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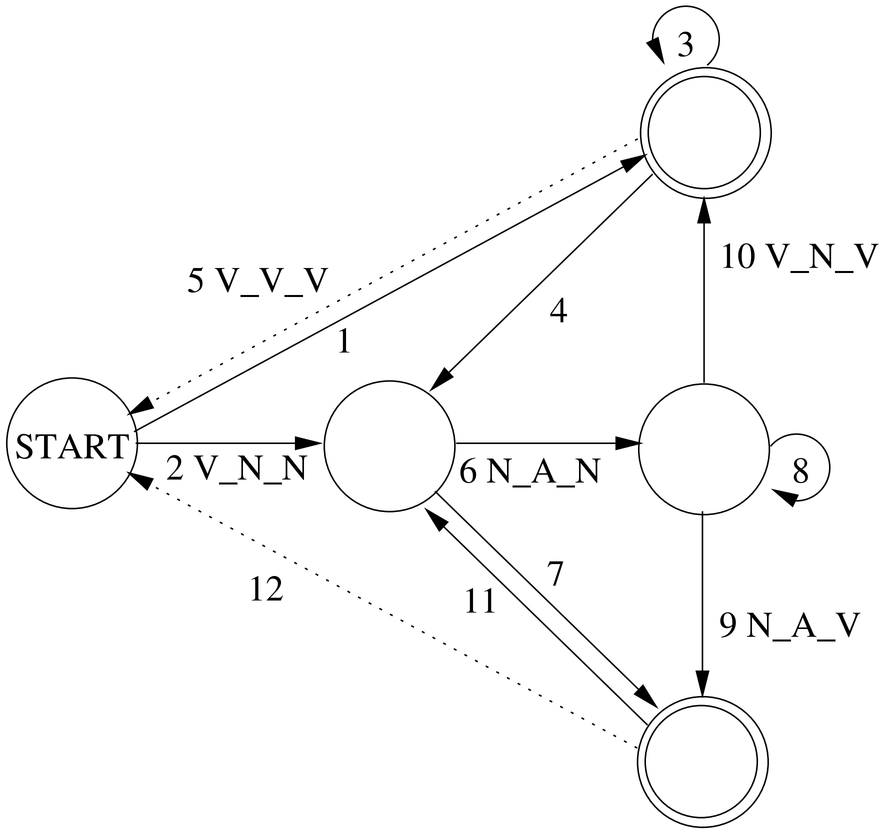
14.1.2 Finite State Transition Network of LA-think.2



14.1.3 Schematic description of LA-think.2:

rule name	*sample navigation*	*rule package*
V_N_V	give_girl_give	{V_N_V, V_N_N, V_V_V}
V_N_N	give_girl_girl	{N_A_N, N_A_V}
N_A_N	girl_beautiful_girl	{N_A_N, N_A_V}
N_A_V	girl_young_give	{V_N_V, V_N_N, V_V_V}
V_V_V	give_ read_read	{V_N_V, V_N_N}

14.1.4 Deriving a VNAANA VN VNNN sequence

rule name	*navigation steps*	*result sequence*
V_N_N	hit_car_car	VN
N_A_N	car_heavy_car	VNA
N_A_V	car_old_hit	VNAA
V_N_N	hit_tree_tree	VNAAN
N_A_V	tree_beautiful_hit	VNAANA
V_V_V	hit_speed_speed	VNAANA V
V_N_V	speed_car_speed	VNAANA VN
V_V_V	speed_give_give	VNAANA VN V
V_N_V	give_farmer_give	VNAANA VN VN
V_N_V	give_driver_give	VNAANA VN VNN
V_N_V	give_lift_give	VNAANA VN VNNN

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14.2 Definition of LA-speak.2

14.2.1 Formal Definition of LA-speak.2

$$\mathrm{ST}_S =_{def} \{(\begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \{1 \text{ -DET}, 2 \text{ -NoP}\})\}$$

-DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-d } \begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \\ \text{if X} \neq \text{NIL activate LA-think.2}\end{array}$$

-NoP {5 -FVERB, 6 -AUX, 7 -DET, 8 -NoP, 9 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X !}\alpha\text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{fnc: } \beta \\ \text{cat: nm} \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-n } \begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \\ \text{mark } \beta \text{ in [noun: } \alpha] \\ \text{if !X} \neq \text{NIL and Y} \neq \text{NIL activate LA-think.2}\end{array}$$

-ADN {10 -ADN, 11 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: !X } \beta\text{+ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta \\ \text{cat: adn} \\ \text{mdd: } \alpha \\ \text{prn: i}\end{bmatrix} \begin{array}{l}\text{where } \beta\text{+ = !}\beta \text{ or } \beta\text{+ = }\beta\text{!} \\ \text{lex-an } \begin{bmatrix}\text{adj: } \beta\end{bmatrix} \\ \text{if } \beta\text{+ = !}\beta\text{, activate LA-think.2} \\ \text{if } \beta\text{+ = }\beta\text{!, end-mark } \beta\text{+ again}\end{array}$$

-NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

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$\begin{bmatrix} \text{verb: } \beta \\ \text{arg: !X !}\alpha\text{ Y} \\ \text{prn: i} \end{bmatrix} \begin{bmatrix} \text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i} \end{bmatrix}$

where Z γ = NIL or γ = δ!!
lex-nn $[\text{noun: } \alpha]$
mark α in [noun: α]
if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

-FVERB {17 -DET, 18 -NoP, 19 -STOP}

$\begin{bmatrix} \text{verb: } \beta \\ \text{cat: decl} \\ \text{arg: !}\alpha\text{ X} \\ \text{prn: i} \end{bmatrix}$

lex-fv $[\text{verb: } \beta]$
mark decl in [verb: β]
if X $\neq$ NIL activate LA-think.2

-AUX {20 -AUX, 21 -NVERB}

$\begin{bmatrix} \text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X AUX Y} \\ \text{arg: !}\alpha\text{ Z} \\ \text{prn: i} \end{bmatrix}$

lex-ax $[\text{verb: } \beta]$
mark ax in $[\text{verb: } \beta]$

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-NVERB $\{22 \text{ -DET}, 23 \text{ -NoP}, 24 \text{ -STOP}\}$

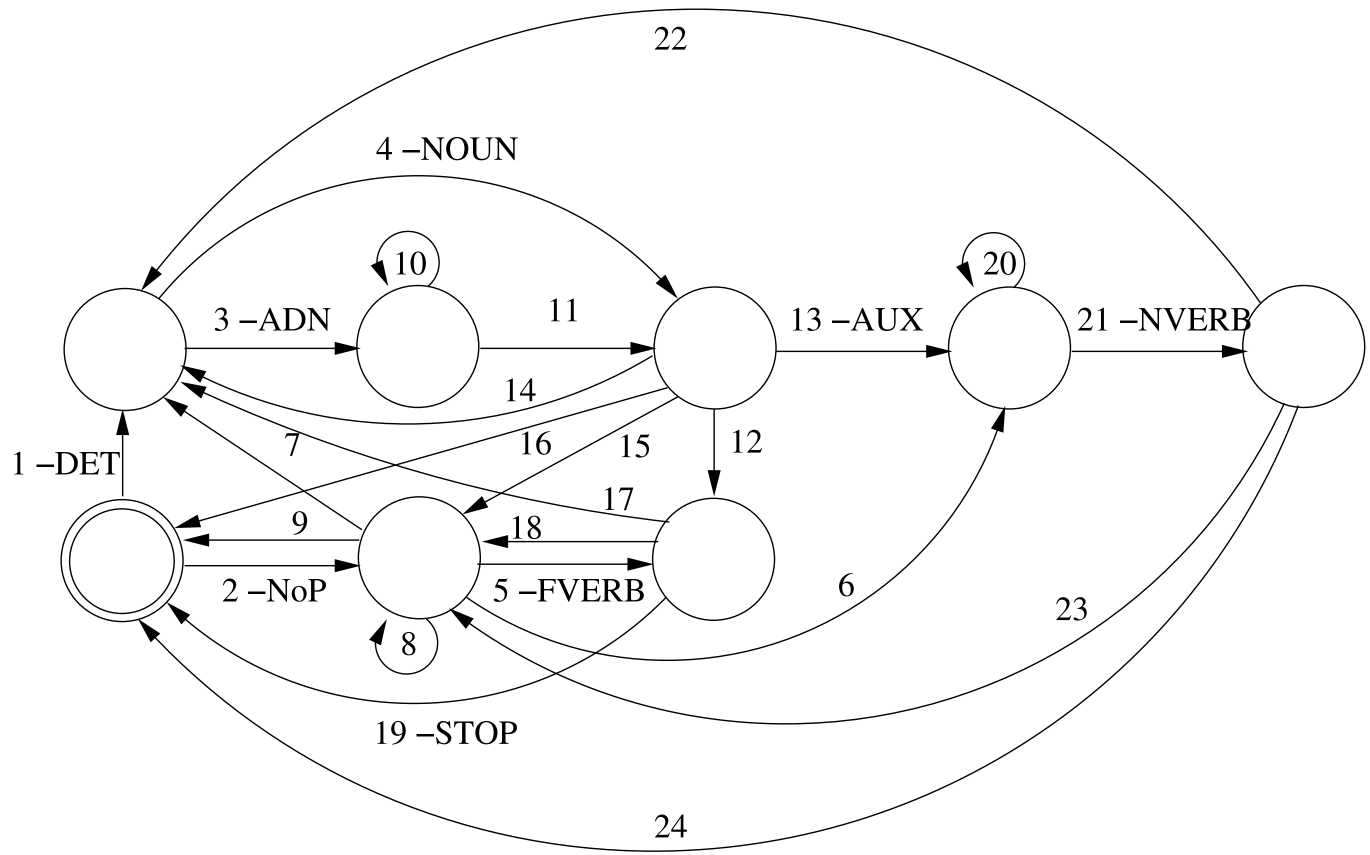
$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X Y} \\ \text{arg: !}\alpha \text{ Z} \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-nv } \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{mark decl in [verb: } \beta] \\ \text{Z} \neq \text{NIL activate LA-think.2}\end{array}$$

-STOP $\{1 \text{ -DET}, 2 \text{ N}\}$

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: !decl} \\ \text{arg: !X !}\alpha \\ \text{prn: i}\end{bmatrix} \quad \begin{bmatrix}\text{noun: !}\alpha \\ \text{fnc: } \beta \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-p } \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{activate LA-think.2}\end{array}$$

$\mathbf{ST}_F =_{def} \{(\begin{bmatrix}\text{cat:decl}\end{bmatrix} \text{ rp}_{-\text{STOP}})\}$

14.2.2 Finite State Transition Network of LA-speak.2



14.3 Automatic Word Form Production

14.3.1 The function lex-n for realizing names or pronouns

If $\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: nm}\end{bmatrix}$ matches an activated N proplet, then lex-n [noun: α] = α'.

If α =	then α' =
John	John
Julia	Julia
Susanne	Susanne

pattern	*surface*	*pattern*	*surface*
$\begin{bmatrix}\text{noun: } I \\ \text{cat: ns1}\end{bmatrix}$	I	$\begin{bmatrix}\text{noun:} you \\ \text{cat: pro2}\end{bmatrix}$	you
$\begin{bmatrix}\text{noun:} he \\ \text{cat: ns3} \\ \text{sem: sg m}\end{bmatrix}$	he	$\begin{bmatrix}\text{noun:} he \\ \text{cat: ns3} \\ \text{sem: sg f}\end{bmatrix}$	she
$\begin{bmatrix}\text{noun:} he \\ \text{cat: snp} \\ \text{sem: sg}\end{bmatrix}$	it	$\begin{bmatrix}\text{noun:} I \\ \text{cat: np1}\end{bmatrix}$	we
$\begin{bmatrix}\text{noun:} he \\ \text{cat: np3}\end{bmatrix}$	they	$\begin{bmatrix}\text{noun:} I \\ \text{cat: obq} \\ \text{sem: sg}\end{bmatrix}$	me

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$\begin{bmatrix}\text{noun:}\textit{he}\\ \text{cat: obq}\\ \text{sem: sg m}\end{bmatrix}$ him

$\begin{bmatrix}\text{noun:}\textit{he}\\ \text{cat: obq}\\ \text{sem: sg f}\end{bmatrix}$ her

$\begin{bmatrix}\text{noun:}\textit{I}\\ \text{cat: obq}\\ \text{sem: pl}\end{bmatrix}$ us

$\begin{bmatrix}\text{noun:}\textit{he}\\ \text{cat: obq}\\ \text{sem: pl}\end{bmatrix}$ them

14.3.2 The function lex-d for realizing determiners

pattern	*surface*
$\begin{bmatrix}\text{sem: indef sg}\end{bmatrix}$	a(n)
$\begin{bmatrix}\text{sem: sel}\end{bmatrix}$	some
$\begin{bmatrix}\text{sem: def}\end{bmatrix}$	

pattern	*surface*
$\begin{bmatrix}\text{cat: snp}\\ \text{sem: pl exh}\end{bmatrix}$	every
$\begin{bmatrix}\text{cat: pnp}\\ \text{sem: pl exh}\end{bmatrix}$	all

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14.3.3 The function lex-nn for realizing nouns

If $\begin{bmatrix}\text{noun: } \alpha \\ \text{sem: sg}\end{bmatrix}$ matches an activated N proplet, then lex-nn[noun: α] = α'.

If $\begin{bmatrix}\text{noun: } \alpha \\ \text{sem: pl}\end{bmatrix}$ matches an activated N proplet, then lex-nn[noun: α] = α'+s.

If	α = *car*	then α' =	car
	driver		driver
	farmer		farmer
	lift		lift

14.3.4 The function lex-fv for realizing finite verb forms

If $\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{arg: } \beta \text{ X}\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$ matches an activated sequence VN, where NP ϵ {ns3, snp}, then lex-fv[verb: α] = α'+s.

If $\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: pres} \\ \text{arg: } \beta \text{ X}\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$ matches an activated sequence VN, where NP ϵ {ns1, pro2, np-2, pnp}, then lex-fv[verb: α] = α'.

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If α = *dream* then α' =		dream
	give	give
	hit	hit
	know	know
	sing	sing
	sleep	sleep
	speed	speed

If $\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: TEMP} \\ \text{arg: } \beta \text{ x}\end{bmatrix}$ matches an activated sequence VN, where TEMP ϵ {past, past/perf}, then lex-fv[verb: α] = α'+ed or produces the associated surface.

If α = *speed* then the surface is =		sped
	dream	dreamt
	give	gave
	hit	hit
	know	knew
	sing	sang
	sleep	slept

If α = *learn* then α' =		learn
	...	...

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14.3.5 The function lex-ax for realizing auxiliaries

pattern	*surface*
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X} \\ \text{arg: } \beta\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: ns1} \\ \text{fnc: } \alpha\end{bmatrix}$	am
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X neg} \\ \text{arg: } \beta\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: ns1} \\ \text{fnc: } \alpha\end{bmatrix}$	ain't
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X} \\ \text{arg: } \beta\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	are, where NP ϵ {pro2, np-2, pnp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X neg} \\ \text{arg: } \beta\end{bmatrix}$ $\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	aren't, where NP ϵ {pro2, np-2, pnp}

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pattern		*surface*
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X} \\ \text{arg: } \beta\end{bmatrix}$	$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	is, where NP ϵ {np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_pres X neg} \\ \text{arg: } \beta\end{bmatrix}$	$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	isn't, where NP ϵ {np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_past X} \\ \text{arg: } \beta\end{bmatrix}$	$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	was, where NP ϵ {ns1, np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_past X neg} \\ \text{arg: } \beta\end{bmatrix}$	$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	wasn't, where NP ϵ {ns1, np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_past X} \\ \text{arg: } \beta\end{bmatrix}$	$\begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	were, where NP ϵ {pro2, np-2, pnp}

pattern	*surface*

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$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_past X neg} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix} \qquad \textsf{weren't}, \text{ where NP } \epsilon \ \{\text{pro2, np-2, pnp}\}$$

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: be\_perf X} \\ \text{arg: } \beta \end{bmatrix} \qquad \textsf{been}$$

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_pres X} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix} \qquad \textsf{have}, \text{ where NP } \epsilon \ \{\text{np1, pro2, np-2, pnp}\}$$

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_pres X neg} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix} \qquad \textsf{haven't}, \text{ where NP } \epsilon \ \{\text{np1, pro2, np-2, pnp}\}$$

$$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_pres X} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix} \qquad \textsf{has}, \text{ where NP } \epsilon \ \{\text{np3, nm, snp}\}$$

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pattern	*surface*
$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_pres X neg} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix}$	hasn't, where NP ϵ {np3, nm, snp}
$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_past X} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix}$	had, where NP ϵ {np1, pro2, np-2, nm, snp, pnp, np3}
$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: hv\_past X neg} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix}$	hadn't, where NP ϵ {np1, pro2, np-2, nm, snp, pnp, np3}
$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_pres X} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix}$	do, where NP ϵ {np1, pro2, np-2, pnp}
$\begin{bmatrix} \text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_pres X neg} \\ \text{arg: } \beta \end{bmatrix} \begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha \end{bmatrix}$	don't, where NP ϵ {np1, pro2, np-2, pnp}

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pattern	*surface*
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_pres X} \\ \text{arg: } \beta\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	does, where NP ϵ {np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_pres X neg} \\ \text{arg: } \beta\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	doesn't, where NP ϵ {np3, nm, snp}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_past X} \\ \text{arg: } \beta\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	did, where NP ϵ {np1, pro2, np-2, nm, snp, pnp, np3}
$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: decl} \\ \text{sem: do\_past X neg} \\ \text{arg: } \beta\end{bmatrix} \begin{bmatrix}\text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: } \alpha\end{bmatrix}$	didn't, where NP ϵ {np1, pro2, np-2, nm, snp, pnp, np3}

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14.3.6 The function lex-nv for realizing non-finite verb forms

If $\begin{bmatrix}\text{verb: }\alpha\\ \text{cat: decl}\\ \text{sem: prog}\end{bmatrix}$ matches an activated proplet V, then lex-nv[verb: α] = α'+ing, whereby α and α' are related as follows:

If α =	then α' =
dream	dream
give	giv
hit	hitt
know	know
sing	sing
sleep	sleep
speed	speed

If $\begin{bmatrix}\text{verb: }\alpha\\ \text{cat: decl}\\ \text{sem: perf}\end{bmatrix}$ matches an activated proplet V, then lex-fv[verb: α] produces the surface α':

α =	α' =
give	given
know	known
sing	sung

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14.3.7 The function lex-adn for realizing elementary adnominals

If $\begin{bmatrix} \text{adj: } \alpha \\ \text{cat: adn} \\ \text{sem: } \end{bmatrix}$ matches an activated proplet a, then lex-adn[adj: α] = α'.

If α =	then α' =
beautiful	beautiful
heavy	heavy
old	old

If $\begin{bmatrix} \text{adj: } \alpha \\ \text{cat: adn} \\ \text{sem: comp} \end{bmatrix}$ matches an activated proplet a, then lex-adn[adj: α] = α'+er.

If $\begin{bmatrix} \text{adj: } \alpha \\ \text{cat: adn} \\ \text{sem: sup} \end{bmatrix}$ matches an activated proplet a, then lex-adn[adj: α] = α'+est.

If α =	then α' =
heavy	heavy
old	old

14.3.8 The function lex-p for realizing a full stop

If $\begin{bmatrix} \text{cat: decl} \end{bmatrix}$ matches an activated V proplet, then lex-p applied to this proplet produces the surface . (full stop).

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14.4 Producing a Sentence with Complex Noun Phrases

14.4.1 LA-think and LA-speak rule applications with markings

14 -STOP

8 -FVERB mark V decl — 7 -NOUN mark N *car* — 13 -NOUN mark N *tree*

2 -DET — 4 -ADN — 6 -ADN end-mark N *old* — 10 -DET — 12 -ADN end-mark N *beautiful*

sur:	sur:	sur:	sur:	sur:	sur:
verb: *hit*	noun: *car*	adj: *heavy*	adj: *old*	noun: *tree*	adj: *beautiful*
cat: decl	cat: np	cat: adn	cat: adn	cat: snp	cat: adn
sem: past	sem: def sg	sem:	sem:	sem: indef sg	sem:
mdr:	mdr: heavy old	mdr:	mdr:	mdr: beautiful	mdr:
arg: car tree	fnc: hit	mdd: car 1	mdd: car 1	fnc: hit	mdd: tree 2
nc: 2 speed	idy: 1	idy:	idy:	idy: 2	idy:
pc:	prn: 1	prn: 1	prn: 1	prn: 1	prn: 1
prn: 1					

1 V_N_N mark V *car* — 3 N_A_N mark N *heavy* — 5 N_A_V end-mark N *old* — 9 V_N_N mark V *tree* — 11 N_A_V end-mark N *beautiful*

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14.4.2 Realizing The

1 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i}\end{bmatrix} \qquad \begin{array}{l}\text{lex-d } \begin{bmatrix}\text{noun: } \alpha\end{bmatrix} \\ \text{if X} \neq \text{NIL activate LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: heavy} \\ \quad\quad \text{old} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{array}{l}\text{sur:}\textbf{the} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: heavy} \\ \quad\quad \text{old} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}\end{array}$$

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14.4.3 Realizing heavy

3 -ADN {10 -ADN, 11 -NOUN}

$$\begin{bmatrix} \text{noun: } \alpha \\ \text{mdr: !X } \beta\text{+ Y} \\ \text{prn: i} \end{bmatrix} \begin{bmatrix} \text{adj: } \beta \\ \text{cat: adn} \\ \text{mdd: } \alpha \\ \text{prn: i} \end{bmatrix}$$

where β+ = !β or β+ = β!

lex-an $\begin{bmatrix} \text{adj: } \beta \end{bmatrix}$

if β+ = !β, activate LA-think.2

if β+ = β!, end-mark β+ again

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \text{old} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{heavy} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: 1 car} \\ \text{idy:} \\ \text{prn: 1} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \text{old} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix} \begin{matrix} \text{sur: } \textbf{heavy} \\ \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{heavy} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: 1 car} \\ \text{idy:} \\ \text{prn: 1} \end{bmatrix} \end{matrix}$$

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14.4.4 Realizing old

10 -ADN {10 -ADN, 11 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: !X } \beta\text{+ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta \\ \text{cat: adn} \\ \text{mdd: } \alpha \\ \text{prn: i}\end{bmatrix}$$

where β+ = !β or β+ = β!

lex-an $\begin{bmatrix}\text{adj: } \beta\end{bmatrix}$

if β+ = !β, activate LA-think.2

if β+ = β!, end-mark β+ again

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \text{old!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{old} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: 1 car} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \text{old!!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{old} \\ \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{old} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: car 1} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix}\end{array}$$

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14.4.5 Realizing car

11 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X !}\alpha\text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i}\end{bmatrix}$$

where Z γ = NIL or γ = δ!!

lex-nn $[\text{noun: } \alpha]$

mark α in [noun: α]

if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \quad\text{old!!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \overset{\text{sur: } \textbf{car}}{\begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \quad\text{old!!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}}$$

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14.4.6 Realizing hit

12 -FVERB {17 -DET, 18 -NoP, 19 -STOP}

$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: decl} \\ \text{arg: !}\alpha\text{ X} \\ \text{prn: i}\end{bmatrix}$

lex-fv [verb: β]
mark decl in [verb: β]
if X $\neq$ NIL activate LA-think.2

$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \quad\text{old!!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow$ sur: **hit** $\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: !heavy} \\ \quad\text{old!!} \\ \text{fnc: hit} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}$

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14.4.7 Realizing a

17 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i}\end{bmatrix} \qquad \text{lex-d} \begin{bmatrix}\text{noun: } \alpha\end{bmatrix}$$

if X $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car !tree} \\ \text{nc 2 speed:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car !tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{matrix}\text{sur: } \mathbf{a} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}\end{matrix}$$

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14.4.8 Realizing beautiful

3 -ADN {10 -ADN, 11 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: !X } \beta\text{+ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta \\ \text{cat: adn} \\ \text{mdd: } \alpha \\ \text{prn: i}\end{bmatrix}$$

where β+ = !β or β+ = β!

lex-an $\begin{bmatrix}\text{adj: } \beta\end{bmatrix}$
if β+ = !β, activate LA-think.2
if β+ = β!, end-mark β+ again

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car} \\ \quad\text{!tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful!} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{beautiful} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: tree 2} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car} \\ \quad\text{!tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful!!} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix} \begin{array}{c}\text{sur: } \textbf{beautiful} \\ \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{beautiful} \\ \text{cat: adn} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: tree 2} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix}\end{array}$$

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14.4.9 Realizing tree

11 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X !}\alpha \text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i}\end{bmatrix}$$

where Z γ = NIL or γ = δ!!
lex-nn [noun: α]
mark α in [noun: α]
if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car !tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful!} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{hit} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !car !tree} \\ \text{nc: 2 speed} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{tree} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{tree} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr: beautiful!!} \\ \text{fnc: hit} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}\end{matrix}$$

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14.4.10 Realizing . (full stop)

16 -STOP {1 -DET, 2 -NoP}

$$\begin{bmatrix}\text{verb: } \beta\\ \text{cat: !decl}\\ \text{arg: !X !}\alpha\\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: !}\alpha\\ \text{fnc: } \beta\\ \text{prn: i}\end{bmatrix} \qquad \begin{array}{l}\text{lex-p } \begin{bmatrix}\text{verb: } \beta\end{bmatrix}\\ \text{activate LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{hit}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !car !tree}\\ \text{nc: 2 speed}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{tree}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful!!}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix} \Longrightarrow \begin{array}{l}\text{sur: .}\\ \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{hit}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !car !tree}\\ \text{nc: 2 speed}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}\end{array} \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{tree}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr: beautiful!!}\\ \text{fnc: hit}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}$$

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14.5 Producing a Sentence with a Complex Verb Phrase

14.5.1 LA-think and LA-speak rule application with markings

7 -STOP

6 -NFVERB
mark V decl

5 -AUX
mark V be_past

4 -AUX
mark V hv_past

3 -NOUN
mark N *car*

2 -DET

$$\begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past be\_perf prog} \\ \text{mdr:} \\ \text{arg: car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \quad \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix}$$

1 V_N_V
mark V *car*

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14.5.2 Realizing The

1 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix} \text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i} \end{bmatrix} \qquad \begin{array}{l} \text{lex-d } [\text{noun: } \alpha] \\ \text{if X} \neq \text{NIL activate LA-think.2} \end{array}$$

$$\begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \begin{array}{l} \text{sur: } \textbf{the} \\ \begin{bmatrix} \text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix} \end{array}$$

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14.5.3 Realizing car

4 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X !}\alpha\text{ Y} \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i}\end{bmatrix}$$

where Z γ = NIL or $\gamma = \delta$!!

lex-nn $\begin{bmatrix}\text{noun: } \alpha\end{bmatrix}$

mark α in [noun: α]

if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{car} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix}\end{matrix}$$

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14.5.4 Realizing had

13 -AUX {20 -AUX, 21 -NVERB}

$$\begin{bmatrix} \text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X AUX Y} \\ \text{arg: !}\alpha\text{ Z} \\ \text{prn: i} \end{bmatrix} \qquad \begin{array}{l} \text{lex-ax } [\text{verb: } \beta] \\ \text{mark ax in } [\text{verb: } \beta] \end{array}$$

$$\begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix} \Longrightarrow \begin{array}{l} \text{sur: } \textbf{had} \\ \begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad \text{be\_perf} \\ \quad \text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \end{array} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix}$$

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14.5.5 Realizing been

20 -AUX {20 -AUX, 21 -NVERB}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X AUX Y} \\ \text{arg: !}\alpha\text{ Z} \\ \text{prn: i}\end{bmatrix} \qquad \begin{array}{l}\text{lex-ax } \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{mark ax in } \begin{bmatrix}\text{verb: } \beta\end{bmatrix}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad\text{be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix} \Longrightarrow \begin{array}{l}\text{sur: }\textbf{been} \\ \begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad\text{!be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix}\end{array} \begin{bmatrix}\text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix}$$

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14.5.6 Realizing speeding

21 -NVERB {22 -DET, 23 -NoP, 24 -STOP}

$$\begin{bmatrix} \text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X Y} \\ \text{arg: !}\alpha\text{ Z} \\ \text{prn: i} \end{bmatrix}$$

lex-nv [verb: β]
mark decl in [verb: β]
if Z $\neq$ NIL activate LA-think.2

$$\begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad\text{!be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix} \Longrightarrow \begin{matrix} \text{sur: }\textbf{speeding} \\ \begin{bmatrix} \text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: !decl} \\ \text{sem: !hv\_past} \\ \quad\text{!be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2} \end{bmatrix} \end{matrix} \begin{bmatrix} \text{sur:} \\ \text{noun: }\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2} \end{bmatrix}$$

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14.5.7 Realizing . (full stop)

24 -STOP {1 -DET, 2 -NoP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: !decl} \\ \text{arg: !X !}\alpha \\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{noun: !}\alpha \\ \text{fnc: } \beta \\ \text{prn: i}\end{bmatrix} \quad \begin{array}{l}\text{lex-p } \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{activate LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad\text{!be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix} \Longrightarrow \begin{array}{l}\text{sur: .} \\ \begin{bmatrix}\text{sur:} \\ \text{verb:}\textit{speed} \\ \text{cat: decl} \\ \text{sem: !hv\_past} \\ \quad\text{!be\_perf} \\ \quad\text{prog} \\ \text{mdr:} \\ \text{arg: !car} \\ \text{nc: 3 give} \\ \text{pc: 1 hit} \\ \text{prn: 2}\end{bmatrix}\end{array} \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{car} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: speed} \\ \text{idy: 3} \\ \text{prn: 2}\end{bmatrix}$$

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14.6 Producing a Sentence with a Three-Place Verb

14.6.1 LA-think and LA-speak rule applications with markings

11 -STOP

4 -FVERB mark V decl	3 -NOUN mark N *farmer* 2 -DET	7 -NOUN mark N *driver* 6 -DET	10 -NOUN mark N *lift* 9 -DET
sur: verb: *give* cat: decl sem: past mdr: arg: farmer driver lift nc: pc: 2 speed prn: 3	sur: noun: *farmer* cat: snp sem: indef sg mdr: fnc: give idy: 4 prn: 3	sur: noun: *driver* cat: np sem: def sg mdr: fnc: give idy: 5 prn: 3	sur: noun: *lift* cat: snp sem: indef sg mdr: fnc: give idy: 6 prn: 3

1 V_N_V
mark V *farmer*

5 V_N_V
mark V *driver*

8 V_N_V
mark V lift

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14.6.2 Realizing A

1 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i}\end{bmatrix} \qquad \text{lex-d } [\text{noun: } \alpha]$$

if X $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{the} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix}\end{matrix}$$

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14.6.3 Realizing farmer

4 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix} \text{verb: } \beta \\ \text{arg: !X !}\alpha \text{ Y} \\ \text{prn: i} \end{bmatrix} \quad \begin{bmatrix} \text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i} \end{bmatrix}$$

where Z γ = NIL or $\gamma = \delta$!!
lex-nn $[\text{noun: } \alpha]$
mark α in [noun: α]
if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{array}{l} \text{sur: } \textbf{farmer} \\ \begin{bmatrix} \text{sur:} \\ \text{noun: !}\textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3} \end{bmatrix} \end{array}$$

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14.6.4 Realizing gave

12 -FVERB {17 -DET, 18 -NoP, 19 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: decl} \\ \text{arg: } !\alpha\ X \\ \text{prn: i}\end{bmatrix}$$

lex-fv $\begin{bmatrix}\text{verb: } \beta\end{bmatrix}$
mark decl in [verb: β]
if X $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \overset{\text{sur: } \textbf{gave}}{\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix}} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix}$$

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14.6.5 Realizing the

17 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: X} \\ \text{prn: i}\end{bmatrix} \qquad \begin{array}{l}\text{lex-d } [\text{noun: } \alpha] \\ \text{if X} \neq \text{NIL activate LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{the} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3}\end{bmatrix}\end{array}$$

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14.6.6 Realizing driver

4 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix}\text{verb: } \beta\\ \text{arg: !X !}\alpha\text{ Y}\\ \text{prn: i}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \alpha\\ \text{mdr: Z } \gamma\\ \text{prn: i}\end{bmatrix}$$

where Z γ = NIL or γ = δ!!
lex-nn $[\text{noun: } \alpha]$
mark α in [noun: α]
if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{driver}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 5}\\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{driver}\\ \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{driver}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 5}\\ \text{prn: 3}\end{bmatrix}\end{matrix}$$

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14.6.7 Realizing a

14 -DET {3 -ADN, 4 -NOUN}

$$\begin{bmatrix}\text{noun: }\alpha\\ \text{mdr: X}\\ \text{prn: i}\end{bmatrix} \qquad \begin{array}{l}\text{lex-d }\begin{bmatrix}\text{noun: }\alpha\end{bmatrix}\\ \text{if X} \neq \text{NIL activate } \textbf{LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{a}\\ \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}\end{array}$$

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14.6.8 Realizing lift

4 -NOUN {12 -FVERB, 13 -AUX, 14 -DET, 15 -NoP, 16 -STOP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{arg: !X !}\alpha\text{ Y} \\ \text{prn: i}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \alpha \\ \text{mdr: Z } \gamma \\ \text{prn: i}\end{bmatrix}$$

where Z γ = NIL or $\gamma = \delta$!!
lex-nn $[\text{noun: } \alpha]$
mark α in [noun: α]
if !X $\neq$ NIL and Y $\neq$ NIL activate LA-think.2

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer !driver !lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{lift} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 6} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer !driver !lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{matrix}\text{sur:}\textbf{lift} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{lift} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 6} \\ \text{prn: 3}\end{bmatrix}\end{matrix}$$

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14.6.9 Realizing . (full stop)

16 -STOP {1 -DET, 2 -NoP}

$$\begin{bmatrix}\text{verb: }\beta\\ \text{cat: !decl}\\ \text{arg: !X !}\alpha\\ \text{prn: i}\end{bmatrix}\begin{bmatrix}\text{noun: !}\alpha\\ \text{fnc: }\beta\\ \text{prn: i}\end{bmatrix}\quad \begin{array}{l}\text{lex-p }\begin{bmatrix}\text{verb: }\beta\end{bmatrix}\\ \text{activate LA-think.2}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}\begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}\Longrightarrow \begin{array}{l}\text{sur: .}\\ \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}\end{array}\begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}$$

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15. DBS.3: Adnominal and Adverbial Modifiers

15.1 Interpreting Elementary and Complex Modifiers

15.1.1 Preposition, complex adjective, and elementary adjective

$$
\begin{array}{lll}
\text{on} & \text{on the big table} & \text{fast} \\
\left[\begin{array}{l}
\text{sur: on} \\
\text{adj: } \textit{on} \text{ n\_2} \\
\text{cat: adj} \\
\text{sem:} \\
\text{mdr:} \\
\text{mdd:} \\
\text{idy:} \\
\text{prn:}
\end{array}\right]
&
\left[\begin{array}{l}
\text{sur: on} \\
\text{adj: } \textit{on table} \\
\text{cat: adj} \\
\text{sem: def sg} \\
\text{mdr: big} \\
\text{mdd: apple 1} \\
\text{idy: 2} \\
\text{prn: 1}
\end{array}\right]
&
\left[\begin{array}{l}
\text{sur: fast} \\
\text{adj: } \textit{fast} \\
\text{cat: adj} \\
\text{sem:} \\
\text{mdr: B} \\
\text{mdd: car 4} \\
\text{idy: B} \\
\text{prn: 3}
\end{array}\right]
\end{array}
$$

15.1.2 Representing (eat) the apple on the table (adnominal)

$$
\left[\begin{array}{l}
\text{noun: apple} \\
\text{cat: np} \\
\text{sem: def sg} \\
\text{fnc: eat} \\
\text{mdr: on table} \\
\text{idy: 1} \\
\text{prn: 1}
\end{array}\right]
\quad
\left[\begin{array}{l}
\text{adj: on table} \\
\text{cat: adn} \\
\text{sem: def sg} \\
\text{mdr:} \\
\text{mdd: apple 1} \\
\text{idy: 2} \\
\text{prn: 1}
\end{array}\right]
$$

15.1.3 Representing eat (the apple) on the table (adverbial)

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sur: verb: *eat* cat: v sem: past mdr: on table arg: Julia apple nc: pc: prn: 1	adj: on table cat: adv sem: def sg mdr: mdd: eat idy: 2 prn: 1

15.1.4 Positions of elementary adnominals

(i)	The + *young* + girl ate an apple	(modifying the subject)
(ii)	Julia gave the + *young* + girl an apple	(modifying the indirect object)
(iii)	Julia gave the girl a + *red* + apple	(modifying the direct object)

15.1.5 Positions of complex adnominals (prepositional phrases)

(i)	the apple + *on the table* + pleased Julia	(modifying the subject)
(ii)	Julia ate the apple + *on the table*	(modifying the direct object)
(iii)	Julia gave John the apple + *on the table*	(modifying the direct object)

15.1.6 Positions of elementary adverbials

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(i) *quickly* + Julia ate the apple
(ii) Julia + *quickly* + ate the apple
(iii) Julia slept + *soundly*
(iv) Julia ate the apple + *quickly*

15.1.7 Positions of prepositional phrases used as adverbs

(i) *on the table* + Julia ate an apple
(ii) *Julia + *on the table* + ate the apple
(iii) Julia slept + *on the table*
(iv) Julia ate the apple + *on the table*

15.1.8 Positions of intensifiers

(i)	the + *very* big + table	(noun phrase)
(ii)	on the + *very* big + table	(prepositional phrase)
(iii)	*very* quickly + Julia ate an apple	(elementary adverbial)
(iv)	Julia + *very* quickly + ate an apple	(elementary adverbial)
(v)	Julia ate the apple + *very* quickly	(elementary adverbial)

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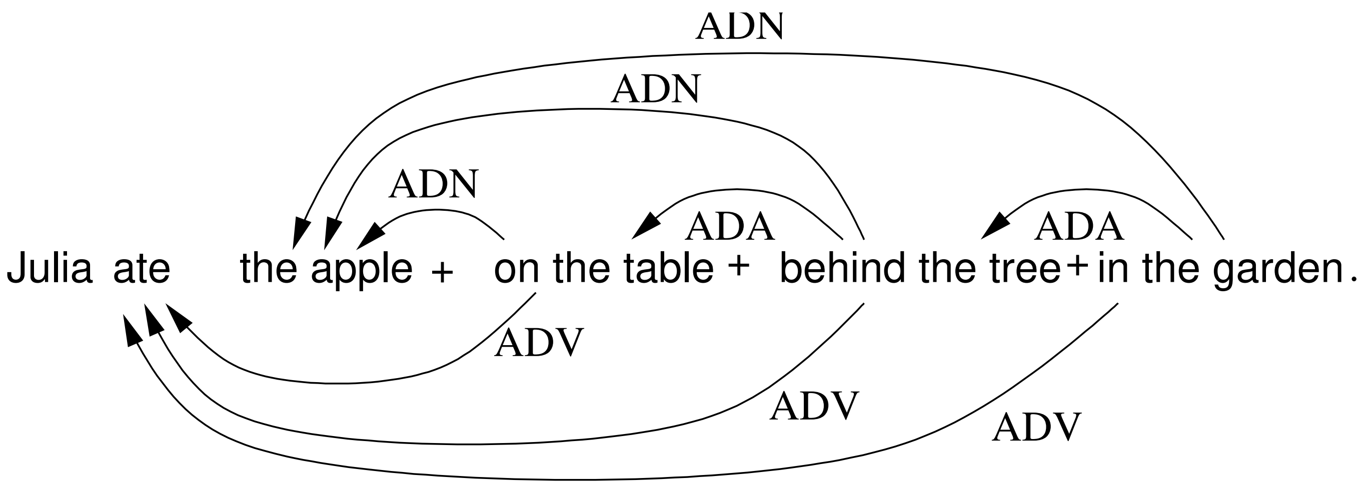
15.1.9 Interpretations of sequences of prepositional phrases

(i) the car + in the garage + with the broken window
(ii) Julia walked + into the garden + with John's shoes

15.1.10 Readings created by a sequence prepositional phrases



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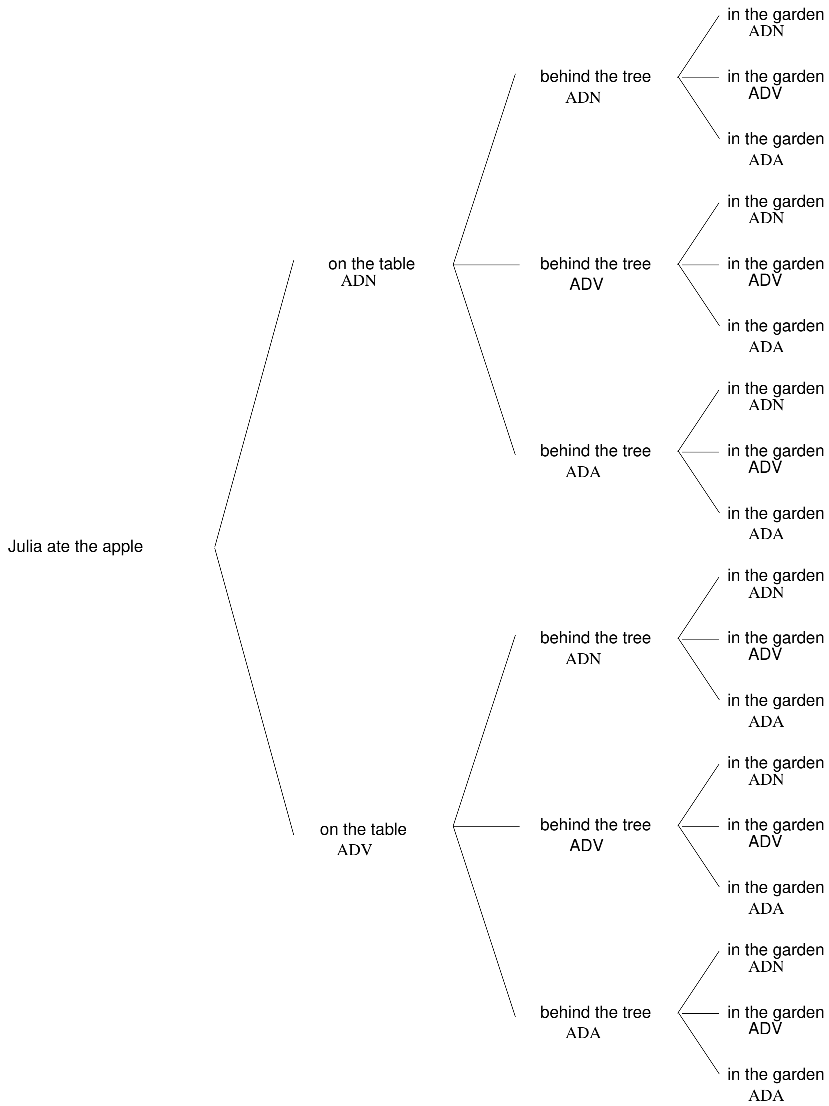
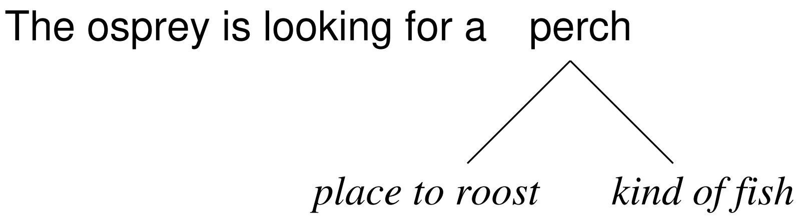
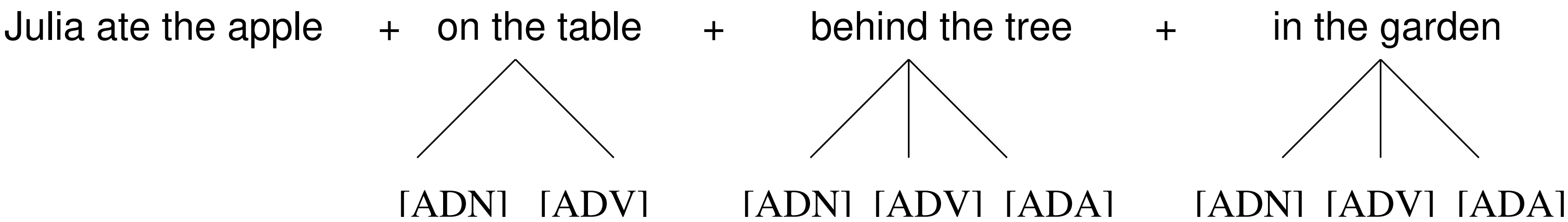
15.1.11 Nativist treatment of prepositional phrase ambiguities



15.1.12 Example of lexically-based semantic doubling



15.1.13 Prepositional phrase ambiguity as semantic doubling



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15.1.14 Formalizing semantic doubling in Database Semantics

$$\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: eat} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1 \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr: \%on table} \\ \quad \text{\%behind tree} \\ \quad \text{\%in garden} \\ \text{arg: Julia apple} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_2 \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{apple} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: \%on table} \\ \quad \text{\%behind tree} \\ \quad \text{\%in garden} \\ \text{fnc: eat} \\ \text{idy: 2} \\ \text{prn: 1} \end{bmatrix}_3$$

$$\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr: \%behind tree} \\ \text{mdd: \%apple 2} \\ \qquad \text{\%eat} \\ \text{idy: 3} \\ \text{prn: 1} \end{bmatrix}_5 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{behind tree} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr: \%in garden} \\ \text{mdd: \%apple 2} \\ \qquad \text{\%eat} \\ \qquad \text{\%on table 3} \\ \text{idy: 4} \\ \text{prn: 1} \end{bmatrix}_8 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{in garden} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{mdd: \%apple 2} \\ \qquad \text{\%eat} \\ \qquad \text{\%behind tree 4} \\ \text{idy: 5} \\ \text{prn: 1} \end{bmatrix}_{11}$$

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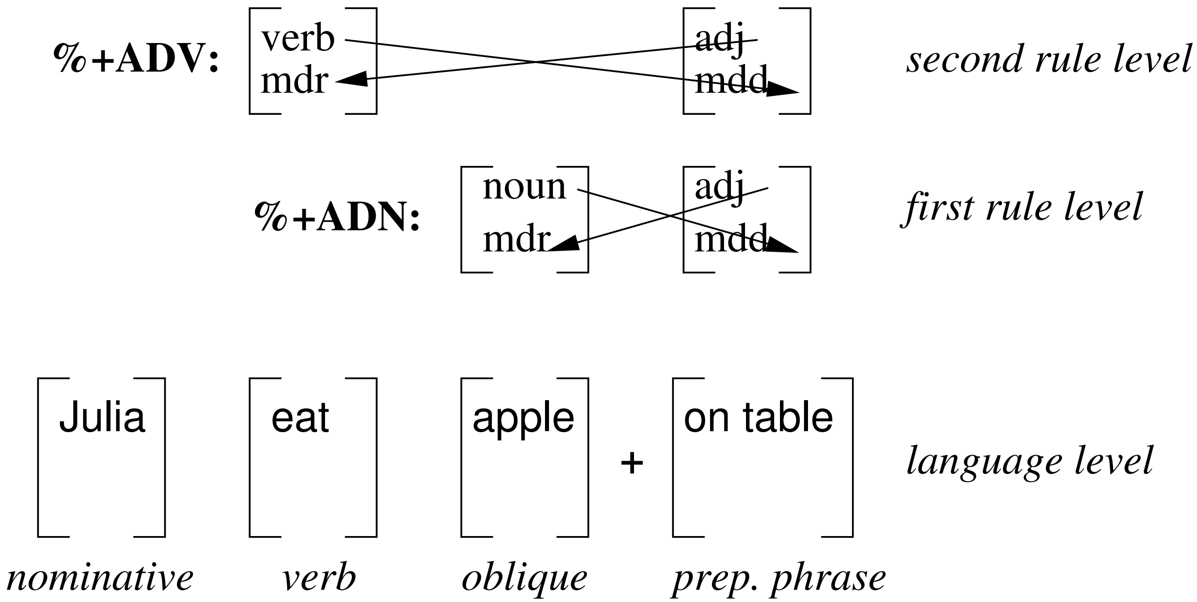
15.1.15 Adding preposition. phrase with adv and adn interpretation



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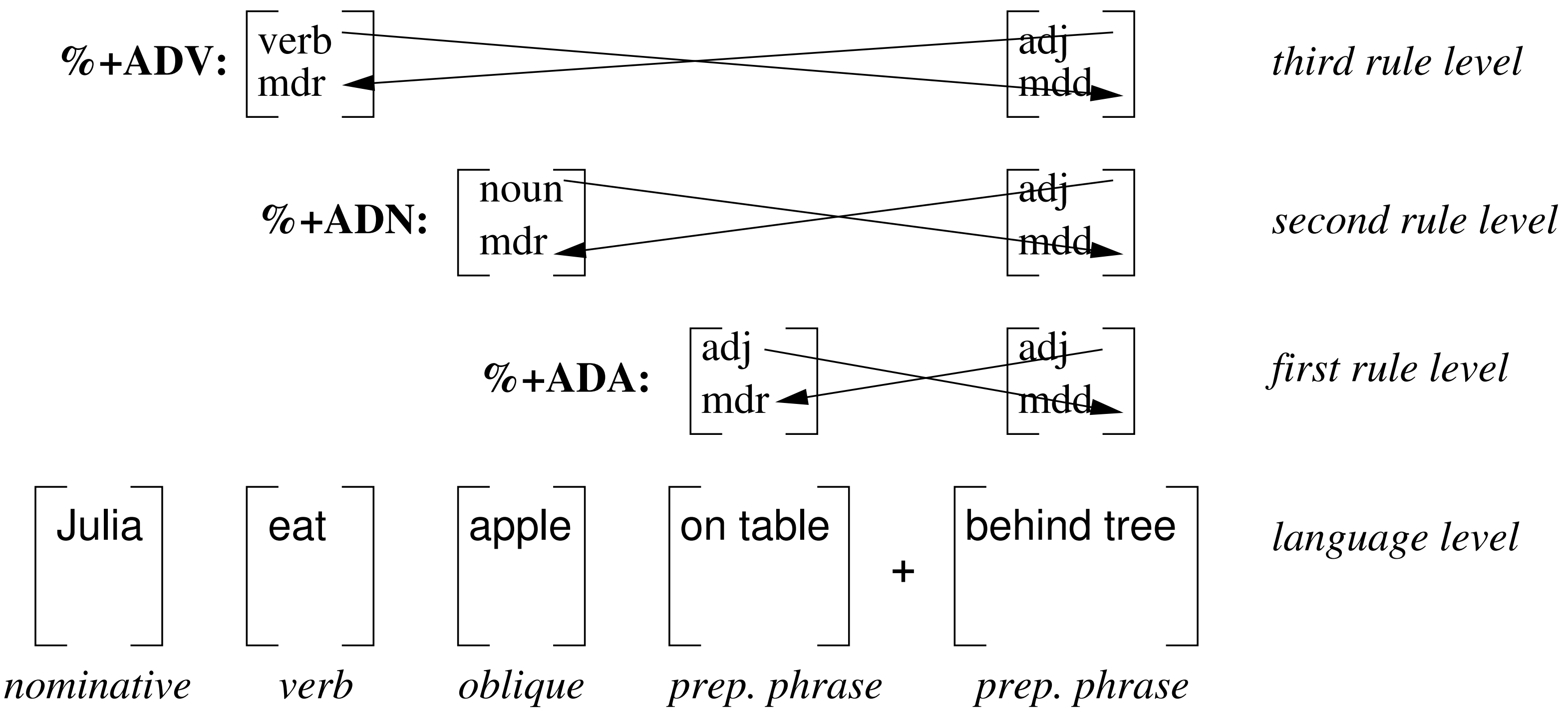
15.1.16 Prepositional phrase with adv, adn, and ada interpretation



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15.2 ADN and ADA Interpretations of Prepositional Phrases

15.2.1 Combining Julia and ate with NOM+FV

NOM+FV $\{$22 FV+NP, 23 AUX+NFV, 24 S+IP$\}$

$$
\begin{bmatrix} \text{noun: } \alpha \\ \text{cat: NP} \\ \text{fnc:} \\ \text{prn: k} \end{bmatrix}
\quad
\begin{bmatrix} \text{verb: } \beta \\ \text{cat: NP}'\text{ X VT} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \end{bmatrix}
\quad
\begin{array}{l} \text{delete NP}' \text{ nw.cat} \\ \text{acopy } \alpha \text{ nw.arg} \\ \text{ecopy } \beta \text{ ss.fnc} \\ \text{ecopy PC nw.pc} \\ \text{acopy PCV nw.pc} \\ \text{set } \beta \text{ NCV} \\ \text{copy}_{ss} \text{ copy}_{nw} \end{array}
$$

$$
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur: ate} \\ \text{verb: } \textit{eat} \\ \text{cat: n}'\text{ a}'\text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_2
\Longrightarrow
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: eat} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: a}'\text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_2
$$

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15.2.2 Combining Julia ate and the with FV+NP

FV+NP {DET+NN, DET+ADN, DET+INT, FV+NP, %NP+PREP, %V+ADV, V+INT, S+IP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix} \quad \begin{array}{l}\text{delete NP}' \text{ ss.cat} \\ \text{acopy } \alpha \text{ ss.arg} \\ \text{ecopy } \beta \text{ nw.fnc} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 2}\end{bmatrix}_1 \quad \begin{bmatrix}\text{sur: the} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_3 \quad \Longrightarrow \quad \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: Julia n\_1} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1}\end{bmatrix}_2 \quad \begin{bmatrix}\text{sur:} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc: eat} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}_3$$

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15.2.3 Combining Julia ate the and apple with DET+NN

DET+NN {NOM+FV, ADVNOM+FV, FV+NP, %NP+PREP, %V+ADV, V+INT, S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\text{ X}\\ \text{sem: Y}\end{bmatrix}\quad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}\qquad \begin{array}{l}\text{delete N}'\text{ ss.cat}\\ \text{acopy nw.sem ss.sem}\\ \text{replace }\alpha\text{ N\_}n\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: Julia n\_1}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur: apple}\\ \text{noun: }\textit{apple}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_4 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: }\textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 3}\end{bmatrix}_3$$

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15.2.4 Combining Julia ate the apple and on with %NP+PREP

%NP+PREP {PREP+NP}

$$\begin{bmatrix}\text{noun: } \alpha\\ \text{cat: N}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix} \quad \begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{\%ecopy nw.adj ss.mdr}\\ \text{\%ecopy } \alpha \text{ nw.mdd}\\ \text{acopy ss.idy nw.mdd}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur: on}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: \%on n\_2}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5$$

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15.2.5 Combining Julia ate the apple on and the with PREP+NP

PREP+NP {PREP+NN,PREP+ADN,PREP+INT,%NP+PREP,%V+ADV,%PREP+PREP,ADV+NOM,S+IP}

$$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{sem:}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: Y NP}\\ \text{sem: x}\end{bmatrix}$$

replace α N_n
acopy Y ss.cat:1
acopy nw.sem ss.sem
copy$_{ss}$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: \%on n\_2}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_2}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur: the}\\ \text{noun: n\_3}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_6 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: \%on n\_3}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_3}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr:}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5$$

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15.2.6 Combining Julia ate the apple on the and table with PREP+NN

PREP+NN {ADV+NOM, NOM+FV, FV+NP, %NP+PREP, %V+ADV, %PREPP+PREP, V+INT, S+IP}

$$\begin{bmatrix} \text{adj: PREP N\_}n \\ \text{cat: N}' \text{ adj} \\ \text{sem: Y} \end{bmatrix} \begin{bmatrix} \text{noun: } \alpha \\ \text{cat: N} \\ \text{sem: Z} \end{bmatrix} \quad \begin{array}{l} \text{delete N}' \text{ ss.cat} \\ \text{acopy nw.sem ss.sem} \\ \text{replace } \alpha \text{ N\_}n \\ \text{copy}_{ss} \end{array}$$

$$\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{apple} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: \%on n\_3} \\ \text{fnc: eat} \\ \text{idy: 2} \\ \text{prn: 1} \end{bmatrix}_3 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on} \text{ n\_3} \\ \text{cat: nn}' \text{ adj} \\ \text{sem: def} \\ \text{mdr:} \\ \text{mdd: \%apple 2} \\ \text{idy: 3} \\ \text{prn: 1} \end{bmatrix}_5 \begin{bmatrix} \text{sur: table} \\ \text{noun: } \textit{table} \\ \text{cat: sn} \\ \text{sem: sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}_6 \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{apple} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr: \%on table} \\ \text{fnc: eat} \\ \text{idy: 2} \\ \text{prn: 1} \end{bmatrix}_3 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{mdd: \%apple 2} \\ \text{idy: 3} \\ \text{prn: 1} \end{bmatrix}_5$$

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15.2.7 The ADN-interpretation of Julia ate the apple on the table

$$
\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: \%on table}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3
\begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on table}\\ \text{cat: adj}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5
$$

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15.2.8 Combining the apple on the table and behind with %PREPP+PREP

%PREPP+PREP {PREP+NP}

$$\begin{bmatrix}\text{adj: PREP } \alpha\\ \text{cat: adj}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix} \quad \begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{mdd:}\end{bmatrix}$$

%ecopy nw.adj ss.mdr
%ecopy ss.adj nw.mdd
acopy ss.idy nw.mdd
copy$_{ss}$copy$_{nw}$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: snp}\\ \text{sem: def sg}\\ \text{mdr: \%on table}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on table}\\ \text{cat: adj}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur: behind}\\ \text{adj: } \textit{behind} \text{ n\_4}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: snp}\\ \text{sem: def sg}\\ \text{mdr: \%on table}\\ \text{fnc:}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on table}\\ \text{cat: adj}\\ \text{sem: def sg}\\ \text{mdr: \%} \textit{behind} \text{ n\_4}\\ \text{mdd: \%apple 2}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5$$

$$\begin{bmatrix}\text{sur: behind}\\ \text{adj: } \textit{behind} \text{ n\_4}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd: \%on table}\\ \text{idy: 4}\\ \text{prn:}\end{bmatrix}_8$$

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15.3 ADV Interpretation of Prepositional Phrases

15.3.1 Combining Julia ate the apple and on with %V+ADV

%V+ADV {PREP+NP, %V+ADV, S+IP}

$$\begin{bmatrix}\text{verb: } \alpha\\ \text{cat: V}\\ \text{mdr:}\end{bmatrix} \quad \begin{bmatrix}\text{adj: } \beta \text{ X}\\ \text{cat: ADV}\\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{\%acopy nw.adj ss.mdr}\\ \text{\%ecopy } \alpha \text{ nw.mdd}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{mdd:}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur: on}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: \%on n\_2}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 3}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd \%:eat}\\ \text{idy: 3}\\ \text{prn:}\end{bmatrix}_5$$

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15.3.2 The ADV-interpretation of Julia ate the apple on the table

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: \%on table}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on table}\\ \text{cat: adj}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{mdd: \%eat}\\ \text{idy: 3}\\ \text{prn: 1}\end{bmatrix}_5$$

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15.3.3 Combining Julia ate the apple and fast with %V+ADV

%V+ADV {PREP+NP, %V+ADV, S+IP}

$$\begin{bmatrix}\text{verb: } \alpha\\ \text{cat: v}\\ \text{mdr:}\end{bmatrix} \quad \begin{bmatrix}\text{adj: } \beta\ \text{X}\\ \text{cat: ADV}\\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{\%acopy nw.adj ss.mdr}\\ \text{\%ecopy } \alpha \text{ nw.mdd}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: fast}\\ \text{adj: } \textit{fast}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: \%fast}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{fast}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd: \%eat}\\ \text{idy:}\\ \text{prn: 1}\end{bmatrix}_5$$

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15.3.4 Result of interpreting Julia ate the apple fast

$$
\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: \%fast}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{apple}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr:}\\ \text{fnc: eat}\\ \text{idy: 2}\\ \text{prn: 1}\end{bmatrix}_3
\begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{fast}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd: \%eat}\\ \text{idy:}\\ \text{prn: 1}\end{bmatrix}_5
$$

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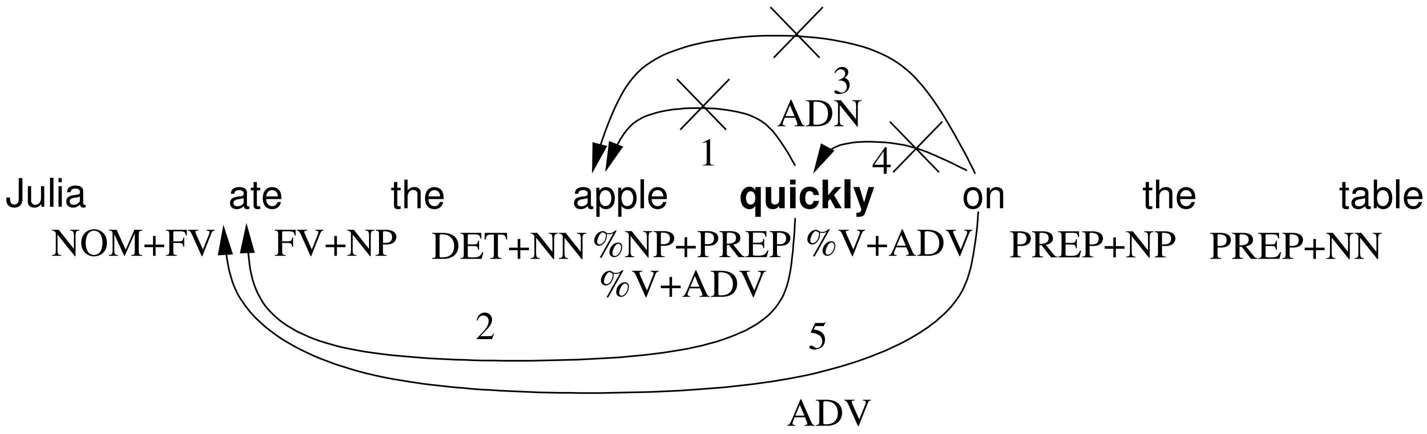
15.3.5 Interpretation of post-adverbial prepositional phrases



15.3.6 Result of interpreting Julia ate the apple quickly on the table

[
sur:
noun: *Julia*
cat: nm
sem: f
mdr:
fnc: eat
idy: 1
prn: 1
]$_1$

[
sur:
verb: *eat*
cat: v
sem: past
mdr: %quick
%on table
arg: Julia apple
nc:
pc:
prn: 1
]$_2$

[
sur:
noun: *apple*
cat: np
sem: def sg
mdr:
fnc: eat
idy: 2
prn: 1
]$_3$

[
sur:
adj: *quick*
cat: adj
sem:
mdr:
mdd: %eat
idy:
prn: 1
]$_6$

[
sur:
adj: *on table*
cat: adj
sem: def sg
mdr:
mdd: %eat
idy: 3
prn: 1
]$_5$

15.3.7 Combining Quickly and Julia with ADV+NOM

ADV+NOM {NOM+ADV, ADVNOM+FV, DET+NN, DET+ADN, DET+INT}

$$\begin{bmatrix}\text{adj: } \alpha \\ \text{cat: ADV} \\ \text{mdd:}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \beta \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix}$$

acopy v_n ss.mdd
ecopy v_n nw.fnc
replace adv ss.cat
copy$_{ss}$copy$_{nw}$

$$\begin{bmatrix}\text{sur: quickly} \\ \text{adj: } \textit{quick} \\ \text{cat: adv} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd:} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: Julia} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{quick} \\ \text{cat: adv} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: v\_1} \\ \text{idy:} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: v\_1} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_2$$

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15.3.8 Combining On the table and Julia with ADV+NOM

ADV+NOM {NOM+ADV, ADVNOM+FV, DET+NN, DET+ADN, DET+INT}

$$\begin{bmatrix}\text{adj: } \alpha \\ \text{cat: ADV} \\ \text{mdd:}\end{bmatrix} \quad \begin{bmatrix}\text{noun: } \beta \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix} \quad \begin{array}{l}\text{acopy v\_}n\text{ ss.mdd} \\ \text{ecopy v\_}n\text{ nw.fnc} \\ \text{replace adv ss.cat} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{mdd:} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: Julia} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adv} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{mdd: v\_1} \\ \text{idy: 1} \\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: v\_1} \\ \text{idy: 2} \\ \text{prn: 1}\end{bmatrix}_2$$

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15.3.9 Combining Julia and quickly with NOM+ADV

$$\textbf{NOM+ADV} \qquad \{\text{ADVNOM+FV}\}$$

$$\begin{bmatrix}\text{noun: } \beta\\ \text{cat: NP}\\ \text{fnc: }\end{bmatrix} \quad \begin{bmatrix}\text{adj: } \alpha\\ \text{cat: adv}\\ \text{mdd: }\end{bmatrix} \qquad \begin{array}{l}\text{acopy v\_1 nw.mdd}\\ \text{ecopy v\_1 ss.fnc}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur: }\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr: }\\ \text{fnc: }\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: quickly}\\ \text{adj: } \textit{quick}\\ \text{cat: adv}\\ \text{sem: }\\ \text{mdr: }\\ \text{mdd: }\\ \text{idy: }\\ \text{prn: 1}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur: }\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr: }\\ \text{fnc: v\_1}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: }\\ \text{adj: } \textit{quick}\\ \text{cat: adv}\\ \text{sem: }\\ \text{mdr: }\\ \text{mdd: v\_1}\\ \text{idy: }\\ \text{prn: 1}\end{bmatrix}_2$$

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15.3.10 Combining Quickly Julia and ate with ADVNOM+FV

ADVNOM+FV {FV+NP, AUX+NFV, %V+ADV, S+IP}

$$
\begin{bmatrix} \text{adj: } \alpha \\ \text{cat: adv} \\ \text{mdd: V\_}n \end{bmatrix}
\begin{bmatrix} \text{noun: } \beta \\ \text{cat: NP} \\ \text{fnc: V\_}n \end{bmatrix}
\begin{bmatrix} \text{verb: } \gamma \\ \text{cat: NP}' \text{ X VT} \\ \text{mdr:} \\ \text{arg:} \\ \text{pc:} \end{bmatrix}
\quad
\begin{array}{l} \text{delete NP}' \text{ nw.cat} \\ \text{acopy } \beta \text{ nw.arg} \\ \text{replace } \gamma \text{ V\_}n \\ \text{acopy } \alpha \text{ nw.mdr} \\ \text{ecopy PC nw.pc} \\ \text{acopy PCV nw.pc} \\ \text{set } \gamma \text{ NCV} \\ \text{copy}_{ss} \text{ copy}_{nw} \end{array}
$$

$$
\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{quick} \\ \text{cat: adv} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: v\_2} \\ \text{idy:} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: v\_2} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_2
\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: n}' \text{ a}' \text{ v} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg:} \\ \text{nc:} \\ \text{pc:} \\ \text{prn:} \end{bmatrix}_3
\Longrightarrow
\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{quick} \\ \text{cat: adv} \\ \text{sem:} \\ \text{mdr:} \\ \text{mdd: eat} \\ \text{idy:} \\ \text{prn: 1} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{Julia} \\ \text{cat: nm} \\ \text{sem: f} \\ \text{mdr:} \\ \text{fnc: eat} \\ \text{idy: 1} \\ \text{prn:} \end{bmatrix}_2
\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{eat} \\ \text{cat: a}' \text{ v} \\ \text{sem: past} \\ \text{mdr: quick} \\ \text{arg: Julia} \\ \text{nc:} \\ \text{pc:} \\ \text{prn: 1} \end{bmatrix}_3
$$

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15.3.11 **Result of parsing** On the table Julia quickly ate the apple

sur:	sur:	sur:	sur:	sur:
adj: *on table*	noun: *Julia*	adj: *quick*	verb: *eat*	noun: *apple*
cat: adj	cat: nm	cat: adv	cat: decl	cat: np
sem: def sg	sem: f	sem:	sem: past	sem: def sg
mdr:	mdr:	mdr:	mdr: on table quick	mdr:
mdd: eat	fnc: eat	mdd: eat	arg: Julia apple	fnc: eat
idy: 1	idy: 2	idy:	nc: pc:	idy: 3
prn: 1	prn: 1	prn: 1	prn: 1	prn: 1
1	4	5	6	7

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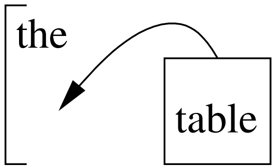
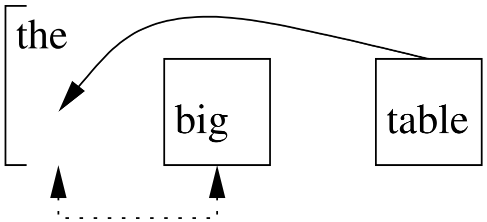
15.4 Intensifiers in Noun Phrases and Prepositional Phrases

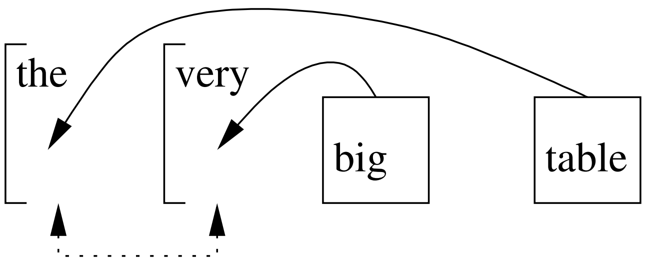
15.4.1 Wrappers in Noun Phrases



[noun: table
cat: np
sem: def sg
mdr:]



[noun: table
cat: np
sem: def sg
mdr: big] [adj: big
cat: adj
sem:
mdd: table]



[noun: table
cat: np
sem: def sg
mdr: big] [adj: big
cat: adj
sem: very
mdd: table]

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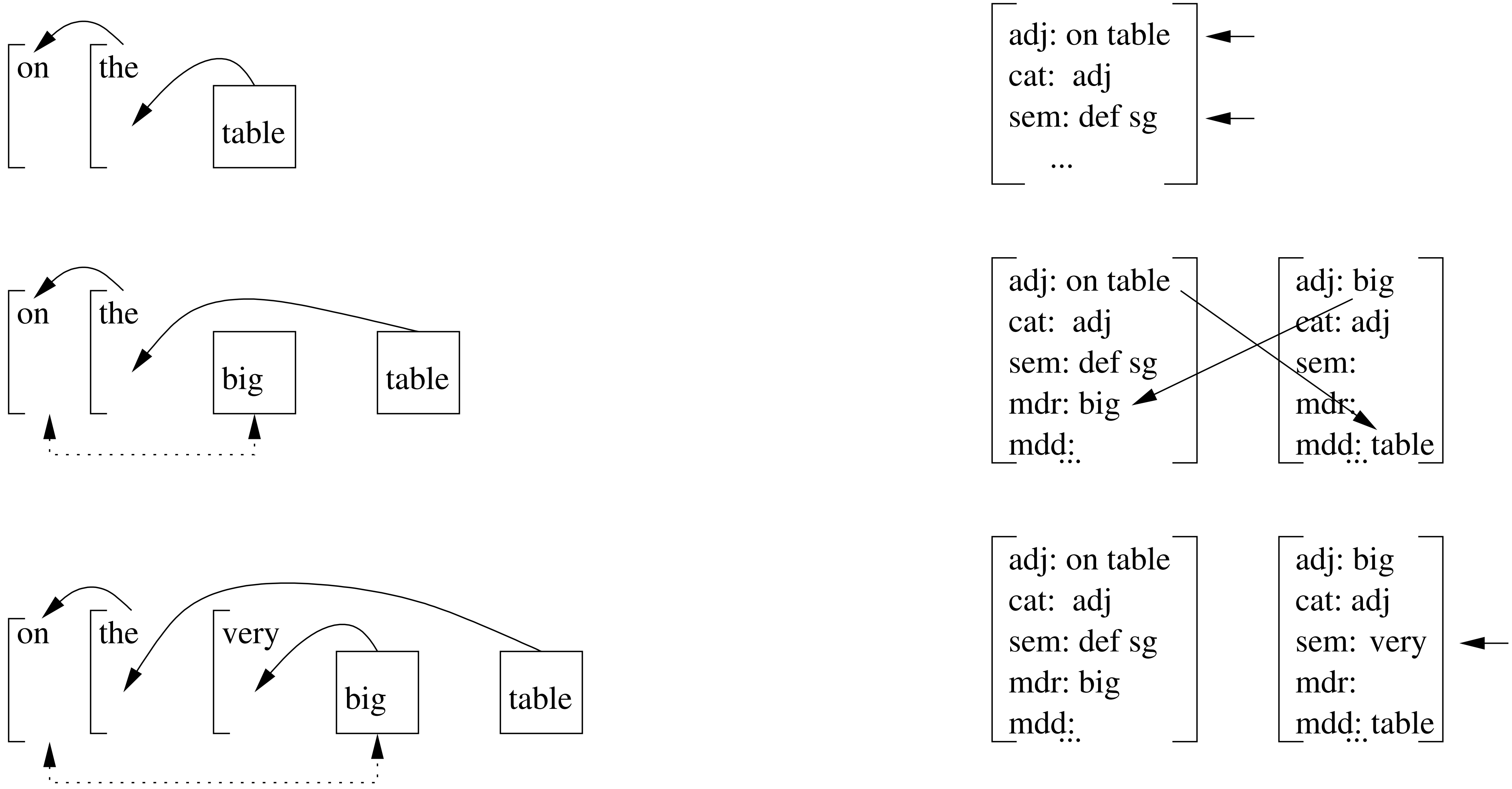
15.4.2 Wrappers in Prepositional Phrases



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15.4.3 Lexical Analysis of intensifier very and detensifier rather

$$\begin{bmatrix} \text{sur: very} \\ \text{adj: a\_1} \\ \text{cat: int} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd:} \\ \text{idy: B} \\ \text{prn:} \end{bmatrix} \qquad \begin{bmatrix} \text{sur: rather} \\ \text{adj: a\_1} \\ \text{cat: int} \\ \text{sem: rather} \\ \text{mdr: B} \\ \text{mdd:} \\ \text{idy: B} \\ \text{prn:} \end{bmatrix}$$

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15.4.4 Combining The and very with DET+INT

DET+INT {INT+ADJ}

$$
\begin{bmatrix} \text{noun: N\_}n \\ \text{cat: N}' \text{ X} \\ \text{mdr:} \\ \text{idy:} \end{bmatrix}
\begin{bmatrix} \text{adj: A\_}n \\ \text{mdd:} \\ \text{cat:} \end{bmatrix}
$$

acopy nw.adj ss.mdr
ecopy ss.noun nw.mdd
acopy ss.idy nw.mdd
replace adn nw.cat
copy_{ss} copy_{nw}

$$
\begin{bmatrix} \text{sur: the} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}_1
\begin{bmatrix} \text{sur: very} \\ \text{adj: a\_1} \\ \text{cat: adj} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd:} \\ \text{idy: B} \\ \text{prn:} \end{bmatrix}_3
\Longrightarrow
\begin{bmatrix} \text{sur:} \\ \text{noun: n\_1} \\ \text{cat: nn}' \text{ np} \\ \text{sem: def} \\ \text{mdr: a\_1} \\ \text{fnc:} \\ \text{idy: 1} \\ \text{prn:} \end{bmatrix}_1
\begin{bmatrix} \text{sur:} \\ \text{adj: a\_1} \\ \text{cat: adn} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: n\_1 1} \\ \text{idy: B} \\ \text{prn:} \end{bmatrix}_2
$$

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15.4.5 Combining The very and big with INT+ADJ

INT+ADJ {DET+NN,DET+ADN,DET+INT,ADV+NOM,ADVNOM+FV,%V+ADV,S+IP}

$$
\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix}
\quad
\begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix}
\quad
\begin{array}{l}\text{replace } \beta \text{ A\_}n\\ \text{copy}_{ss}\end{array}
$$

$$
\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr: a\_1}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{adj: a\_1}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_2
\begin{bmatrix}\text{sur: big}\\ \text{adj: }\textit{big}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_3
\Longrightarrow
\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\text{ np}\\ \text{sem: def}\\ \text{mdr: big}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1
\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{big}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2
$$

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15.4.6 Combining The very big and table with DET+NN

DET+NN {NOM+FV, ADJ+NOM, FV+NP, %NP+PREP, %V+ADV, V+INT, S+IP}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{sem: Y}\end{bmatrix} \qquad \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix} \qquad \begin{array}{l}\text{delete N}'\ \text{ss.cat}\\ \text{acopy nw.sem ss.sem}\\ \text{replace }\alpha\ \text{N\_}n\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: n\_1}\\ \text{cat: nn}'\ \text{np}\\ \text{sem: def}\\ \text{mdr: big}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{big}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: n\_1 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: table}\\ \text{noun: }\textit{table}\\ \text{cat: sn}\\ \text{sem: sg}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_4 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: }\textit{table}\\ \text{cat: np}\\ \text{sem: def sg}\\ \text{mdr: big}\\ \text{fnc:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{big}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: table 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2$$

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15.4.7 Combining the preposition on and the with PREP+NP

PREP+NP {PREP+NN,PREP+ADN,PREP+INT,%NP+PREP,%V+ADV,%PREPP+PREP,ADV+NOM,S+IP}

$$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{sem:}\end{bmatrix} \begin{bmatrix}\text{noun: }\alpha\\ \text{cat: Y NP}\\ \text{sem: X}\end{bmatrix} \quad \begin{array}{l}\text{replace } \alpha \text{ N\_}n\\ \text{acopy Y ss.cat:1}\\ \text{acopy nw.sem ss.sem}\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur: on}\\ \text{adj: } \textit{on} \text{ n\_1}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy:}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: the}\\ \text{noun: n\_2}\\ \text{cat: nn}' \text{ np}\\ \text{sem: def}\\ \text{mdr:}\\ \text{fnc:}\\ \text{idy:}\\ \text{prn:}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: nn}' \text{ adj}\\ \text{sem: def}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1$$

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15.4.8 Combining On the and big with PREP+ADN

PREP+ADN {PREP+ADN, PREP+NN, PREP+INT}

$$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: N}'\text{ ADJ}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix} \begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adn}\\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{acopy }\alpha\text{ ss.mdr}\\ \text{acopy ss.adj nw.mdd}\\ \text{ecopy ss.idy nw.mdd}\\ \text{copy}_{ss}\text{ copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: big}\\ \text{adj: }\textit{big}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_3 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr: big}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: big}\\ \text{adj: }\textit{big}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd: on n\_2 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3$$

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15.4.9 Result of parsing On the big table

$$\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr: big} \\ \text{mdd:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1 \begin{bmatrix} \text{sur: big} \\ \text{adj: } \textit{big} \\ \text{cat: adj} \\ \text{sem:} \\ \text{mdr: B} \\ \text{mdd: on table 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_3$$

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15.4.10 Combining On the and very with PREP+INT

PREP+INT {INT+ADJ}

$$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: N}'\text{ adj}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix}\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: adj}\\ \text{mdd:}\end{bmatrix}$$

acopy nw.adj ss.mdr
acopy ss.adj nw.mdd
ecopy ss.idy nw.mdd
replace adn nw.cat
copy$_{ss}$ copy$_{nw}$

$$\begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr:}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: very}\\ \text{adj: a\_1}\\ \text{cat: adj}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_3 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{adj: } \textit{on} \text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr: a\_1}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: a\_1}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: on n\_2 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3$$

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15.4.11 Combining On the very and big with INT+ADJ

INT+ADJ {DET+NN, DET+ADN, DET+INT, ADV+NOM, ADVNOM+FV, %V+ADV, S+IP}

$$\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix} \quad \begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix} \qquad \begin{array}{l}\text{replace }\beta\text{ A\_}n\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr: a\_1}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{adj: a\_1}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: on n\_2 1}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_2 \begin{bmatrix}\text{sur: big}\\ \text{adj: }\textit{big}\\ \text{cat: adj}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{on}\text{ n\_2}\\ \text{cat: nn}'\text{ adj}\\ \text{sem: def}\\ \text{mdr: big}\\ \text{mdd:}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_5 \begin{bmatrix}\text{sur:}\\ \text{adj: }\textit{big}\\ \text{cat: adn}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: on n\_2 1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_3$$

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15.4.12 Combining On the very big and table with PREP+NN

PREP+NN {ADV+NOM, NOM+FV, FV+NP, %NP+PREP, %V+ADV, %PREPP+PREP, S+IP}

$$\begin{bmatrix} \text{adj: PREP N\_}n \\ \text{cat: N}' \text{ adj} \\ \text{sem: Y} \end{bmatrix} \quad \begin{bmatrix} \text{noun: } \alpha \\ \text{cat: N} \\ \text{sem: Z} \end{bmatrix}$$

delete N′ ss.cat
acopy nw.sem ss.sem
replace α N_n
copy$_{ss}$

$$\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on} \text{ n\_2} \\ \text{cat: nn}' \text{ adj} \\ \text{sem: def} \\ \text{mdr: big} \\ \text{mdd:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{big} \\ \text{cat: adn} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: on n\_2 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_3 \begin{bmatrix} \text{sur: table} \\ \text{noun: } \textit{table} \\ \text{cat: sn} \\ \text{sem: sg} \\ \text{mdr:} \\ \text{fnc:} \\ \text{idy:} \\ \text{prn:} \end{bmatrix}_5 \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr: big} \\ \text{mdd:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_1 \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{big} \\ \text{cat: adn} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: on table 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_3$$

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15.4.13 Result of parsing On the very big table

$$\begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{on table} \\ \text{cat: adj} \\ \text{sem: def sg} \\ \text{mdr: big} \\ \text{mdd:} \\ \text{idy: 1} \\ \text{prn: 1} \end{bmatrix}_{1} \begin{bmatrix} \text{sur:} \\ \text{adj: } \textit{big} \\ \text{cat: adn} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: on table 1} \\ \text{idy: B} \\ \text{prn: 1} \end{bmatrix}_{3}$$

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15.5 Elementary Adverbs with Intensifiers

15.5.1 Combining Very and quickly with INT+ADJ

INT+ADJ {DET+NN, DET+ADN, DET+INT, ADV+NOM, ADVNOM+FV, %V+ADV, S+IP}

$$\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix} \quad \begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix} \qquad \begin{array}{l}\text{replace }\beta\text{ A\_}n\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur: very}\\ \text{adj: a\_1}\\ \text{cat: adj}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: quickly}\\ \text{adj: }\textit{quick}\\ \text{cat: adv}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{adj: quick}\\ \text{cat: adj}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_1$$

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15.5.2 Result of parsing Very quickly Julia ate the apple

$$
\begin{bmatrix}
\text{sur:} \\
\text{adj: quick} \\
\text{cat: adv} \\
\text{sem: very} \\
\text{mdr: B} \\
\text{mdd: eat} \\
\text{idy: B} \\
\text{prn: 1}
\end{bmatrix}_1
\begin{bmatrix}
\text{sur:} \\
\text{noun: } \textit{Julia} \\
\text{cat: nm} \\
\text{sem: f} \\
\text{mdr:} \\
\text{fnc: eat} \\
\text{idy: 1} \\
\text{prn: 1}
\end{bmatrix}_3
\begin{bmatrix}
\text{sur:} \\
\text{verb: } \textit{eat} \\
\text{cat: v} \\
\text{sem: past} \\
\text{mdr: quick} \\
\text{arg: Julia apple} \\
\text{nc:} \\
\text{pc:} \\
\text{prn: 1}
\end{bmatrix}_4
\begin{bmatrix}
\text{sur:} \\
\text{noun: } \textit{apple} \\
\text{cat: np} \\
\text{sem: def sg} \\
\text{mdr:} \\
\text{fnc: eat} \\
\text{idy: 2} \\
\text{prn: 1}
\end{bmatrix}_5
$$

15.5.3 Combining Julia and very with NOM+INT

NOM+INT {INT+ADJ}

$$\begin{bmatrix}\text{noun: } \beta\\ \text{cat: NP}\\ \text{fnc: }\end{bmatrix} \quad \begin{bmatrix}\text{adj: A\_}n\\ \text{cat: adj}\\ \text{mdd: }\end{bmatrix}$$

acopy v_1 nw.mdd
ecopy v_1 ss.fnc
replace adv nw.cat
$\text{copy}_{ss}\text{copy}_{nw}$

$$\begin{bmatrix}\text{sur: }\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr: }\\ \text{fnc: }\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: very}\\ \text{adj: a\_1}\\ \text{cat: adj}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: }\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2 \Longrightarrow \begin{bmatrix}\text{sur: }\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr: }\\ \text{fnc: v\_1}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur: }\\ \text{adj: a\_1}\\ \text{cat: adv}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: v\_1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2$$

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15.5.4 Combining Julia very and quickly with INT+ADJ

$$\textbf{INT+ADJ} \quad \{\text{DET+NN, DET+ADN, DET+INT, ADV+NOM, ADVNOM+FV, \%V+ADV, S+IP}\}$$

$$\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix} \quad \begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix} \qquad \begin{array}{l}\text{replace } \beta \text{ A\_}n\\ \text{copy}_{ss}\end{array}$$

$$\begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: v\_1}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: a\_1}\\ \text{cat: adv}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: v\_1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: quickly}\\ \text{adj: } \textit{quick}\\ \text{cat: adv}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_3 \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{Julia}\\ \text{cat: nm}\\ \text{sem: f}\\ \text{mdr:}\\ \text{fnc: v\_1}\\ \text{idy: 1}\\ \text{prn: 1}\end{bmatrix}_1 \begin{bmatrix}\text{sur:}\\ \text{adj: quick}\\ \text{cat: adv}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: v\_1}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_2$$

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15.5.5 Combining Julia ate the apple and very with V+INT

V+INT {INT+ADJ}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{mdr: }\end{bmatrix} \quad \begin{bmatrix}\text{adj: A\_}n \\ \text{cat: adj} \\ \text{mdd: }\end{bmatrix} \quad \begin{array}{l}\text{acopy } \alpha \text{ nw.mdd} \\ \text{acopy nw.adj ss.mdr} \\ \text{replace adv nw.cat} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$$\begin{bmatrix}\text{sur: } \\ \text{verb: } \textit{eat} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr: } \\ \text{arg: Julia apple} \\ \text{nc: } \\ \text{pc: } \\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: very} \\ \text{adj: a\_1} \\ \text{cat: adj} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: } \\ \text{idy: B} \\ \text{prn: 1}\end{bmatrix}_5 \Longrightarrow \begin{bmatrix}\text{sur: } \\ \text{verb: } \textit{eat} \\ \text{cat: v} \\ \text{sem: past} \\ \text{mdr: a\_1} \\ \text{arg: Julia apple} \\ \text{nc: } \\ \text{pc: } \\ \text{prn: 1}\end{bmatrix}_2 \begin{bmatrix}\text{sur: } \\ \text{adj: a\_1} \\ \text{cat: adv} \\ \text{sem: very} \\ \text{mdr: B} \\ \text{mdd: eat} \\ \text{idy: B} \\ \text{prn: 1}\end{bmatrix}_5$$

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15.5.6 Combining Julia ate the apple very **and** quickly **with INT+ADJ**

INT+ADJ {DET+NN, DET+ADN, DET+INT, ADV+NOM, ADVNOM+FV, %V+ADV, S+IP}

$$
\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix}
\quad
\begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix}
\qquad
\begin{array}{l}\text{replace } \beta \text{ A\_}n\\ \text{copy}_{ss}\end{array}
$$

$$
\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: a\_1}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur:}\\ \text{adj: a\_1}\\ \text{cat: adv}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: eat}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_5
\begin{bmatrix}\text{sur: quickly}\\ \text{adj: } \textit{quick}\\ \text{cat: adv}\\ \text{sem:}\\ \text{mdr: B}\\ \text{mdd:}\\ \text{idy: B}\\ \text{prn:}\end{bmatrix}_6
\Longrightarrow
\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{eat}\\ \text{cat: v}\\ \text{sem: past}\\ \text{mdr: quick}\\ \text{arg: Julia apple}\\ \text{nc:}\\ \text{pc:}\\ \text{prn: 1}\end{bmatrix}_2
\begin{bmatrix}\text{sur:}\\ \text{adj: quick}\\ \text{cat: adv}\\ \text{sem: very}\\ \text{mdr: B}\\ \text{mdd: eat}\\ \text{idy: B}\\ \text{prn: 1}\end{bmatrix}_5
$$

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15.6 Definition of LA-hear.3

15.6.1 Lexicon and preamble of LA-hear3

1. Lexicon of LA-hear.3:
   lexicon of LA-hear.1 and LA-hear.2 plus first entry of 15.1.1 and entries of 15.4.3.
2. Preamble of LA-hear3:
   variable definitions, restrictions, and agreement conditions of LA-hear.1 (cf. 11.2.2) and LA-hear.2 (cf. 13.2.1) plus

   PREP ϵ {*on, in, above, below, ...*}
   ADJ ϵ {adj, adn, adv}
   ADV ϵ {adj, adv}
   ADN ϵ {adj, adn}
   A_*n* = simultaneous substitution variable for an adjective

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15.6.2 Formal Definition of LA-hear.3

$\textbf{ST}_S =_{def}$ { ([cat: X] {1 DET+NN, 2 DET+ADN, 3 DET+INT, 4 NOM+ADV, 5 NOM+INT, 6 NOM+FV, 7 INT+ADJ, 8 PREP+NP, 9 ADV+NOM}) }

DET+NN {10 NOM+FV, 11 FV+NP, 12 S+IP, 13 %NP+PREP, 14 %V+ADV, 15 V+INT}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{sem: Y}\end{bmatrix}\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: N}\\ \text{sem: Z}\end{bmatrix}\quad\begin{array}{l}\text{delete N}'\ \text{ss.cat}\\ \text{acopy nw.sem ss.sem}\\ \text{replace }\alpha\text{ N\_}n\\ \text{copy}_{ss}\end{array}$$

DET+ADN {16 DET+NN, 17 DET+ADN, 18 DET+INT}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{mdr:}\\ \text{idy:}\end{bmatrix}\begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adn}\\ \text{mdd:}\end{bmatrix}\quad\begin{array}{l}\text{acopy }\alpha\text{ ss.mdr}\\ \text{ecopy ss.noun nw.mdd}\\ \text{acopy ss.idy nw.mdd}\\ \text{copy}_{ss}\text{ copy}_{nw}\end{array}$$

\$ **DET+INT** {19 INT+ADJ}

$$\begin{bmatrix}\text{noun: N\_}n\\ \text{cat: N}'\ \text{X}\\ \text{mdr:}\\ \text{idy:}\end{bmatrix}\begin{bmatrix}\text{adj: A\_}n\\ \text{mdd:}\end{bmatrix}\quad\begin{array}{l}\text{acopy nw.adj ss.mdr}\\ \text{ecopy ss.noun nw.mdd}\\ \text{acopy ss.idy nw.mdd}\\ \text{copy}_{ss}\text{ copy}_{nw}\end{array}$$

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$ **NOM+ADV** {20 ADVNOM+FV}

$$\begin{bmatrix}\text{noun: }\beta\\ \text{cat: NP}\\ \text{fnc: }\end{bmatrix}\begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adv}\\ \text{mdd: }\end{bmatrix}\begin{array}{l}\text{acopy v\_1 nw.mdd}\\ \text{acopy v\_1 ss.fnc}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$ **NOM+INT** {21 INT+ADJ}

$$\begin{bmatrix}\text{noun: }\beta\\ \text{cat: NP}\\ \text{fnc: }\end{bmatrix}\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: adj}\\ \text{mdd: }\end{bmatrix}\begin{array}{l}\text{acopy v\_1 nw.mdd}\\ \text{acopy v\_1 ss.fnc}\\ \text{replace adv nw.cat}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

NOM+FV {22 FV+NP, 23 AUX+NFV, 24 S+IP}

$$\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: NP}\\ \text{fnc: }\\ \text{prn: k}\end{bmatrix}\begin{bmatrix}\text{verb: }\beta\\ \text{cat: NP}'\text{ X VT}\\ \text{arg: }\\ \text{nc: }\\ \text{pc: }\end{bmatrix}\begin{array}{l}\text{delete NP}'\text{ nw.cat}\\ \text{acopy }\alpha\text{ nw.arg}\\ \text{ecopy }\beta\text{ ss.fnc}\\ \text{ecopy PC nw.pc}\\ \text{acopy PCV nw.pc}\\ \text{set }\beta\text{ NCV}\\ \text{copy}_{ss}\text{ copy}_{nw}\end{array}$$

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$ **INT+ADJ** {25 DET+NN, 26 DET+ADN, 27 DET+INT, 28 ADV+NOM, 29 ADVNOM+FV, 30 %V+ADV, 31 S+IP}

$$\begin{bmatrix}\text{adj: A\_}n\\ \text{cat: ADJ}\end{bmatrix}\begin{bmatrix}\text{adj: }\beta\\ \text{cat: ADJ}\end{bmatrix}\quad\begin{array}{l}\text{replace }\beta\text{ A\_}n\\ \text{copy}_{ss}\end{array}$$

$ **PREP+NP** {32 PREP+NN, 33 PREP+ADN, 34 PREP+INT, 35 %NP+PREP, 36 %V+ADV, 37 %PREPP+PREP, 38 ADV+NOM, 39 S+IP}

$$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{sem:}\end{bmatrix}\begin{bmatrix}\text{noun: }\alpha\\ \text{cat: Y NP}\\ \text{sem: X}\end{bmatrix}\quad\begin{array}{l}\text{replace }\alpha\text{ N\_}n\\ \text{acopy Y ss.cat:1}\\ \text{acopy nw.sem ss.sem}\\ \text{copy}_{ss}\end{array}$$

$ **ADV+NOM** {40 NOM+ADV, 41 ADVNOM+FV, 42 DET+NN, 43 DET+ADN, 44 DET+INT}

$$\begin{bmatrix}\text{adj: }\alpha\\ \text{cat: ADV}\\ \text{mdd:}\end{bmatrix}\begin{bmatrix}\text{noun: }\beta\\ \text{cat: Y NP}\\ \text{fnc:}\end{bmatrix}\quad\begin{array}{l}\text{acopy v\_}n\text{ ss.mdd}\\ \text{acopy v\_}n\text{ nw.fnc}\\ \text{replace adv ss.cat}\\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

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FV+NP {45 DET+NN, 46 DET+ADN, 47 DET+INT, 48 FV+NP, 49 %NP+PREP, 50 %V+ADV, 51 V+INT, 52 S+IP}

$$\begin{bmatrix}\text{verb: } \beta \\ \text{cat: NP}' \text{ X VT} \\ \text{arg:}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: Y NP} \\ \text{fnc:}\end{bmatrix} \quad \begin{array}{l}\text{delete NP}' \text{ ss.cat} \\ \text{acopy } \alpha \text{ ss.arg} \\ \text{ecopy } \beta \text{ nw.fnc} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

S+IP {53 IP+START}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: VT} \\ \text{prn: k}\end{bmatrix} \begin{bmatrix}\text{cat: VT}' \text{ SM}\end{bmatrix} \quad \begin{array}{l}\text{replace SM VT} \\ \text{set k PC} \\ \text{set } \alpha \text{ PCV} \\ \text{copy}_{ss}\end{array}$$

$ **%NP+PREP** {54 PREP+NP}

$$\begin{bmatrix}\text{noun: } \alpha \\ \text{cat: N} \\ \text{mdr:} \\ \text{idy: j}\end{bmatrix} \begin{bmatrix}\text{adj: PREP N\_}n \\ \text{cat: adj} \\ \text{mdd:}\end{bmatrix} \quad \begin{array}{l}\text{ecopy nw.adj ss.mdr} \\ \text{\%ecopy } \alpha \text{ nw.mdd} \\ \text{acopy ss.idy nw.mdd} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

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$ **%V+ADV** {55 PREP+NP, 56 %V+ADV, 57 S+IP}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{cat: v} \\ \text{mdr: }\end{bmatrix} \begin{bmatrix}\text{adj: } \beta \text{ X} \\ \text{cat: ADV} \\ \text{mdd: }\end{bmatrix} \begin{array}{l}\text{acopy nw.adj ss.mdr} \\ \text{ecopy } \alpha \text{ nw.mdd} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$ **V+INT** {58 INT+ADJ}

$$\begin{bmatrix}\text{verb: } \alpha \\ \text{mdr: }\end{bmatrix} \begin{bmatrix}\text{adj: A\_}n \\ \text{cat: adj} \\ \text{mdd: }\end{bmatrix} \begin{array}{l}\text{acopy } \alpha \text{ nw.mdd} \\ \text{acopy nw.adj ss.mdr} \\ \text{copy}_{ss}\text{copy}_{nw}\end{array}$$

$ **PREP+NN** {59 ADV+NOM, 60 NOM+FV, 62 FV+NP, 62 %NP+PREP,
63 %V+ADV, 64 % PREPP+PREP, 65 S+IP}

$$\begin{bmatrix}\text{adj: PREP N\_}n \\ \text{cat: N}' \text{ adj} \\ \text{sem: Y}\end{bmatrix} \begin{bmatrix}\text{noun: } \alpha \\ \text{cat: N} \\ \text{sem: Z}\end{bmatrix} \begin{array}{l}\text{delete N}' \text{ ss.cat} \\ \text{acopy nw.sem ss.sem} \\ \text{replace } \alpha \text{ N\_}n \\ \text{copy}_{ss}\end{array}$$

$ **PREP+ADN** {66 PREP+ADN, 67 PREP+NN, 68 PREP+INT}

$$\begin{bmatrix}\text{adj: PREP N\_}n \\ \text{cat: N}' \text{ ADJ} \\ \text{mdr: } \\ \text{idy: j}\end{bmatrix} \begin{bmatrix}\text{adj: } \alpha \\ \text{cat: adn} \\ \text{mdd: }\end{bmatrix} \begin{array}{l}\text{acopy } \alpha \text{ ss.mdr} \\ \text{acopy ss.adj nw.mdd} \\ \text{ecopy ss.idy nw.mdd} \\ \text{copy}_{ss} \text{ copy}_{nw}\end{array}$$

$ **PREP+INT** {69 INT+ADJ}

$\begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: N}'\text{ adj}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix} \begin{bmatrix}\text{adj: A\_}n\\ \text{cat: adj}\\ \text{mdd:}\end{bmatrix}$
acopy nw.adj ss.mdr
acopy ss.adj nw.mdd
ecopy ss.idy nw.mdd
replace adn nw.cat
copy$_{ss}$ copy$_{nw}$

$ **%PREPP+PREP** {70 PREP+NP}

$\begin{bmatrix}\text{adj: PREP }\alpha\\ \text{cat: adj}\\ \text{mdr:}\\ \text{idy: j}\end{bmatrix} \begin{bmatrix}\text{adj: PREP N\_}n\\ \text{cat: adj}\\ \text{mdd:}\end{bmatrix}$
%ecopy nw.adj ss.mdr
%ecopy ss.adj nw.mdd
acopy ss.idy nw.mdd
copy$_{ss}$copy$_{nw}$

$ **ADVNOM+FV** {71 FV+NP, 72 AUX+NFV, 73 %V+ADV, 74 S+IP}

$\begin{bmatrix}\text{adj: }\alpha\\ \text{cat: adv}\\ \text{mdd: V\_}n\end{bmatrix} \begin{bmatrix}\text{noun: }\beta\\ \text{cat: NP}\\ \text{fnc: V\_}n\end{bmatrix} \begin{bmatrix}\text{verb: }\gamma\\ \text{cat: NP}'\text{ X VT}\\ \text{mdr:}\\ \text{arg:}\\ \text{pc:}\end{bmatrix}$
delete NP$'$ nw.cat
acopy β nw.arg
replace γ V_n
acopy α nw.mdr
ecopy PC nw.pc
acopy PCV nw.pc
set γ NCV
copy$_{ss}$ copy$_{nw}$

AUX+NFV {75 AUX+NFV, 76 FV+NP, 77 S+IP}

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$$\begin{bmatrix}\text{verb: V\_}n\\ \text{cat: AUX}'\ \text{V}\\ \text{sem: X}\end{bmatrix}\ \begin{bmatrix}\text{verb: }\alpha\\ \text{cat: Y AUX}\\ \text{sem: Z}\end{bmatrix}$$

replace Y AUX$'$
acopy nw.sem ss.sem
replace α V_n
copy$_{ss}$

IP+START {1 DET+NN, 2 DET+ADN, 3 DET+INT, 4 NOM+ADV, 5 NOM+INT, 6 NOM+FV, 7 INT+ADJ, 8 PREP+NP, 9 ADV+NOM}

$$\begin{bmatrix}\text{verb: }\alpha\\ \text{cat: SM}\\ \text{nc:}\end{bmatrix}\ \begin{bmatrix}\text{noun: }\beta\\ \text{cat: NP}\\ \text{prn:}\end{bmatrix}$$

increment nw.prn
ecopy k ss.nc
acopy 'NCV' ss.nc
copy$_{ss}$ copy$_{nw}$

ST$_F$ $=_{def}$ { ([cat: decl] rp $_{\text{S+IP}}$)}

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15.6.3 Transitions handled by rule packages

rule name	*rule package*	*applications of rules in rule package*
IP+START:	DET+NN	The + table
(= ST_S)	DET+ADN	The + beautiful (table)
	DET+INT	The + very (beautiful table)
	NOM+ADV	Julia + quickly (ate an apple)
	NOM+INT	Julia + very (quickly ate an apple)
	NOM+FV	Julia + read (the book)
	INT+ADJ	Very + quickly (Julia ate an apple)
	PREP+NP	On + the (table)
	ADV+NOM	Quickly + Julia (ate an apple)
DET+NN:	NOM+FV	the book + pleased (Julia)
	FV+NP	Julia gave the man + a (book)
	S+IP	Julia read the book + .
	%NP+PREP	the book + on (the table pleased Julia)
	%V+ADV	Julia read the book + on (the table)
	V+INT	Julia ate the apple + very (quickly)
DET+ADN:	DET+NN	the big + table
	DET+ADN	the big + beautiful (table)
	DET+INT	the big + very (beautiful table)

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rule name	*rule package*	*applications of rules in rule package*
DET+INT:	INT+ADJ	the very + beautiful (table)
NOM+ADV:	ADVNOM+FV	Julia quickly + ate (an apple)
NOM+INT:	INT+ADJ	The young woman + very (quickly ate an apple)
NOM+FV:	FV+NP	Julia ate + the (apple)
	AUX+NFV	Julia has + eaten (an apple)
	S+IP	Julia slept + .
INT+ADJ:	DET+NN	the very beautiful + table
	DET+ADN	the very beautiful + big (table)
	DET+INT	the very beautiful + very (big table)
	ADV+NOM	very quickly + Julia
	ADVNOM+FV	Julia very quickly + ate (an apple)
	%V+ADV	Julia slept very soundly + on (the table)
	S+IP	Julia slept very soundly + .

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rule name	*rule package*	*applications of rules in rule package*
PREP+NP:	PREP+NN	on the + table
	PREP+ADN	on the + big (table)
	PREP+INT	on the + very (big table)
	%NP+PREP	the letter for Julia + on (the table)
	%V+ADV	John read the letter for Julia + quickly
	%PREPP+PREP	the letter for Julia + from Hamburg
	ADV+NOM	for Mary + John bought a book
	S+IP	John read the letter for Julia + .
ADV+NOM	NOM+ADV	On the table Julia + quickly (ate an apple)
	ADVNOM+FV	Quickly Julia + ate (an apple)
	DET+NN	Quickly the + girl (ate an apple)
	DET+ADN	Quickly the + pretty (girl ate an apple)
	DET+INT	Quickly the + very (pretty girl ate an apple)
FV+NP:	DET+NN	John saw the + table
	DET+ADN	John saw the + beautiful (table)
	DET+INT	John saw the + very (beautiful table)
	FV+NP	John gave Julia + the (book)
	%NP+PREP	John saw Julia + from (Hamburg)
	%V+ADV	John saw Julia + from (Hamburg)
	V+INT	John saw Julia + very (often).
	S+IP	John saw Julia + .

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rule name	*rule package*	*applications of rules in rule package*
S+IP:	IP+START	Julia was sleeping. + The (dog barked)
%NP+PREP:	PREP+NP	the book on + the (table)
%V+ADV:	PREP+NP	Julia ate the apple on + the (table)
	%V+ADV	Julia ate the apple quickly + on (the table)
	S+IP	Julia ate the apple quickly + .
V+INT:	INT+ADJ	Julia slept very + soundly
PREP+NN:	ADV+NOM	on the table + Julia (ate an apple)
	NOM+FV	the book on the table + pleased (Julia)
	FV+NP	Julia gave the man in the corner + a (book)
	%NP+PREP	Julia ate the apple on the table + behind (the tree)
	%V+ADV	Julia ate the apple on the table + behind (the tree)
	%PREPP+PREP	Julia ate the apple on the table + behind (the tree)
	S+IP	Julia ate the apple on the table + .
PREP+ADN	PREP+ADN	on the big + beautiful (table)
	PREP+NN	on the big + table
	PREP+INT	on the big + very (beautiful table)
PREP+INT	INT+ADJ	on the very + beautiful (table)

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rule name	*rule package*	*applications of rules in rule package*
%PREPP+PREP	PREP+NP	Julia ate the apple on the table + behind (the tree)
ADVNOM+FV:	FV+NP	Julia quickly ate + an (apple)
	AUX+NFV	In this bed Julia will + sleep
	%V+ADV	Quickly Julia slipped + under (the covers)
	S+IP	In this bed Julia slept + .
AUX+NFV:	AUX+NFV	the car had been + speeding
	FV+NP	Julia had read + the (book)
	S+IP	Julia was sleeping + .
IP+START:	DET+NN	The + table
	DET+ADN	The + beautiful (table)
	DET+INT	The + very (beautiful table)
	NOM+ADV	Julia + quickly (ate an apple)
	NOM+INT	Julia + very (quickly ate an apple)
	NOM+FV	Julia + read (the book)
	INT+ADJ	Very + quickly (Julia ate an apple)
	PREP+NP	On + the (table)
	ADV+NOM	Quickly + Julia (ate an apple)

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