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

$\mathbf{ST}_S =_{def} \{([\text{verb: } \alpha]\ \{1\ \text{V\_N\_V},\ 2\ \text{V\_N\_N}\ \})\}$

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}

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

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}

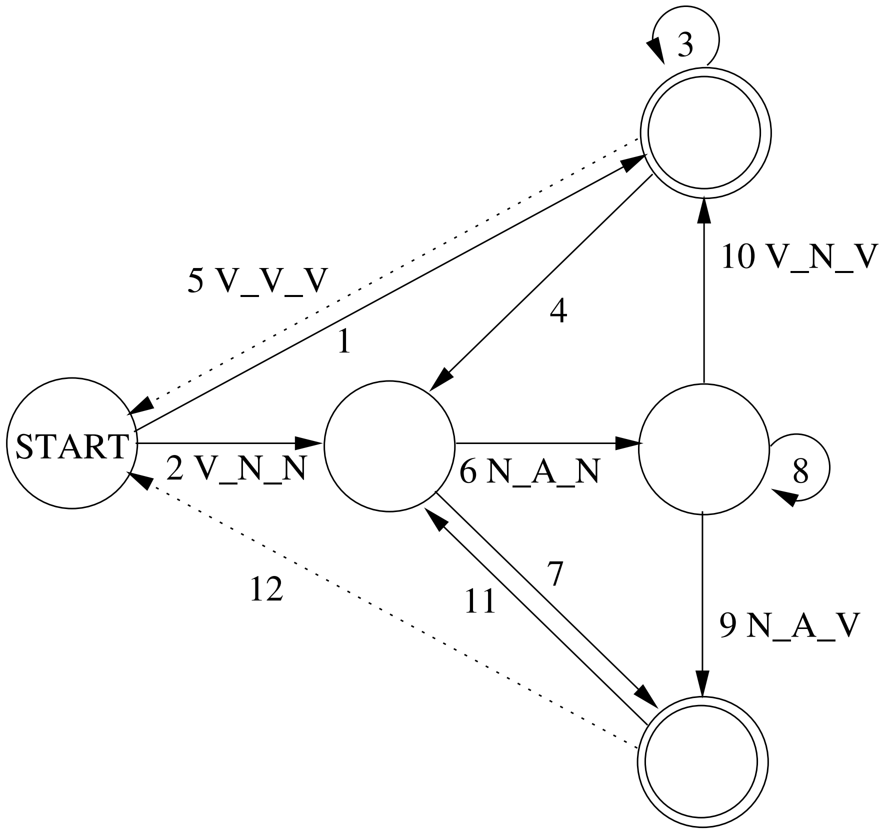
$$\begin{bmatrix}\text{noun: } \alpha\\ \text{fnc: } \gamma\\ \text{mdr: !X } \beta\\ \text{prn: i}\end{bmatrix} \begin{bmatrix}\text{adj: } \beta\\ \text{mdd: } \alpha\\ \text{prn: i}\end{bmatrix} \begin{array}{l}\text{end-mark } \beta \text{ in ss-mdr}\\ \text{output position ss-fnc}\\ \text{activate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

V_V_V {1 V_N_V, 2 V_N_N}))}

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

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

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

14.2 Definition of LA-speak.2

14.2.1 Formal Definition of LA-speak.2

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

-DET $\{3\ \text{-ADN, } 4\ \text{-NOUN}\}$

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

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

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

-ADN $\{10\ \text{-ADN, } 11\ \text{-NOUN}\}$

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

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

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

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

-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 $[\text{verb: } \beta]$

-NVERB {22 -DET, 23 -NoP, 24 -STOP}

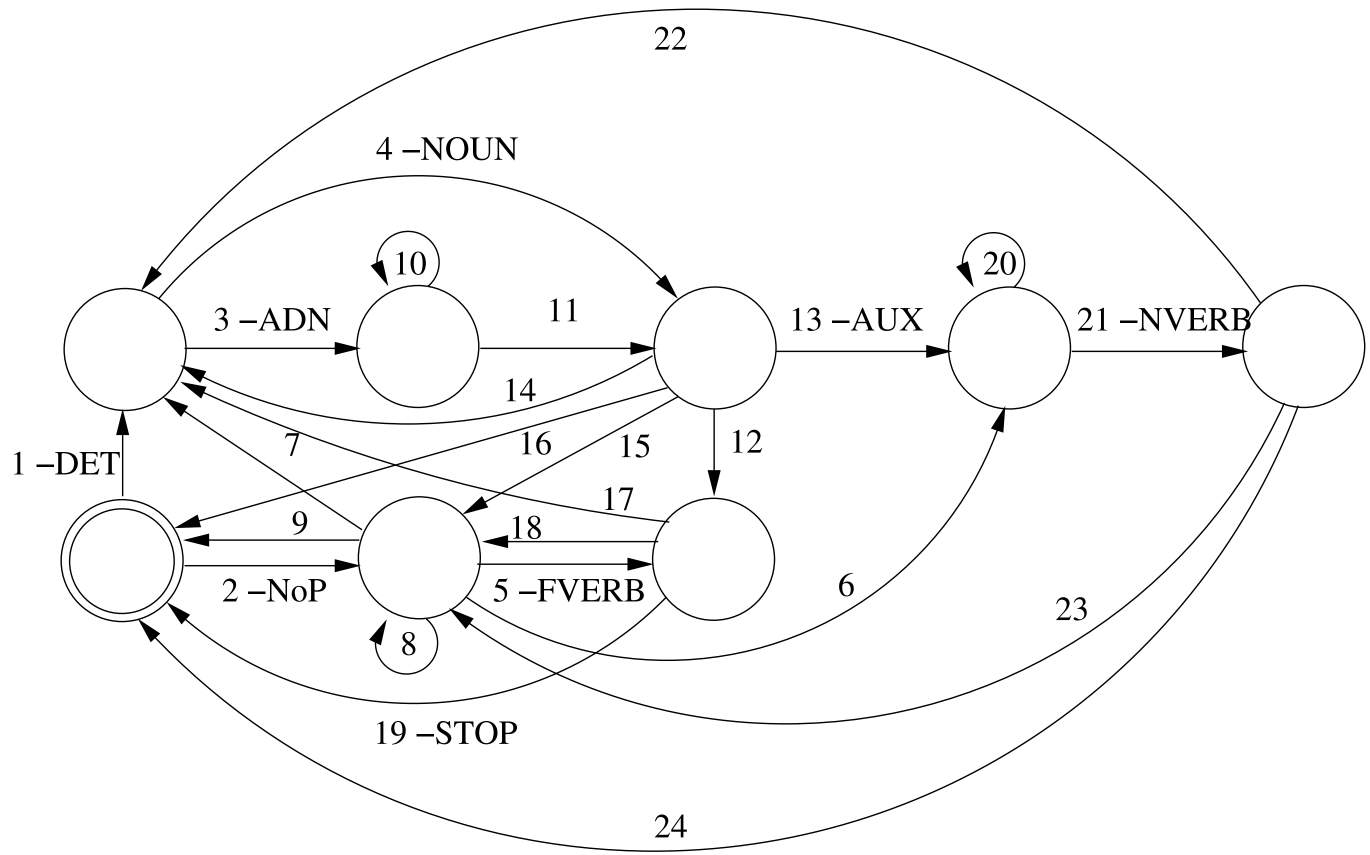
$$\begin{bmatrix} \text{verb: } \beta \\ \text{cat: decl} \\ \text{sem: !X Y} \\ \text{arg: !}\alpha\text{ Z} \\ \text{prn: i} \end{bmatrix} \quad \begin{array}{l} \text{lex-nv } \begin{bmatrix}\text{verb: } \beta\end{bmatrix} \\ \text{mark decl in [verb: } \beta] \\ \text{Z} \neq \text{NIL activate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

-STOP {1 -DET, 2 N}

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

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

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

$\begin{bmatrix}\text{noun:}\textit{he}\\ \text{cat: obq}\\ \text{sem: sg m}\end{bmatrix}$ 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*	*pattern*	*surface*
$\begin{bmatrix}\text{sem: indef sg}\end{bmatrix}$	a(n)	$\begin{bmatrix}\text{cat: snp}\\ \text{sem: pl exh}\end{bmatrix}$	every
$\begin{bmatrix}\text{sem: sel}\end{bmatrix}$	some	$\begin{bmatrix}\text{cat: pnp}\\ \text{sem: pl exh}\end{bmatrix}$	all
$\begin{bmatrix}\text{sem: def}\end{bmatrix}$			

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'.

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
	...		...

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}

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*

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

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

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

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

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

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}

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}

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

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).

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*

14.4.2 Realizing The

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

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

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

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

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

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

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

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 $\gamma = \delta$!!

lex-nn [noun: α]

mark α in [noun: α]

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

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

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

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

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

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

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

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

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 $\gamma = \delta$!!

lex-nn [noun: α]

mark α in [noun: α]

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

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

14.4.10 Realizing . (full stop)

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

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

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

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

sur: verb:*speed* cat: decl sem: hv_past be_perf prog mdr: arg: car nc: 3 give pc: 1 hit prn: 2	sur: noun: *car* cat: np sem: def sg mdr: fnc: speed idy: 3 prn: 2

1 V_N_V
mark V *car*

14.5.2 Realizing The

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

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

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

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 γ = δ!!

lex-nn [noun: α]

mark α in [noun: α]

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

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

14.5.4 Realizing had

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

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

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

14.5.5 Realizing been

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

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

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

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

sur: **speeding**

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

14.5.7 Realizing . (full stop)

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

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

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

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:	sur:	sur:	sur:
verb: *give*	noun: *farmer*	noun: *driver*	noun: *lift*
cat: decl	cat: snp	cat: np	cat: snp
sem: past	sem: indef sg	sem: def sg	sem: indef sg
mdr:	mdr:	mdr:	mdr:
arg: farmer driver lift	fnc: give	fnc: give	fnc: give
nc:	idy: 4	idy: 5	idy: 6
pc: 2 speed	prn: 3	prn: 3	prn: 3
prn: 3			

1 V_N_V
mark V *farmer*

5 V_N_V
mark V *driver*

8 V_N_V
mark V lift

14.6.2 Realizing A

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

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

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

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{the} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix}\end{array}$$

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

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{matrix}\text{sur: } \textbf{farmer} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: !}\textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3}\end{bmatrix}\end{matrix}$$

14.6.4 Realizing gave

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

sur: **gave**

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{farmer} \\ \text{cat: snp} \\ \text{sem: indef sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 4} \\ \text{prn: 3} \end{bmatrix}$$

14.6.5 Realizing the

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

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

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

$$\begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{the} \\ \begin{bmatrix}\text{sur:} \\ \text{noun: } \textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3}\end{bmatrix}\end{array}$$

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 $\gamma = \delta$!!

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

mark α in [noun: α]

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

$$\begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer !driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{bmatrix} \text{sur:} \\ \text{noun: } \textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3} \end{bmatrix} \Longrightarrow \begin{bmatrix} \text{sur:} \\ \text{verb: } \textit{give} \\ \text{cat: !decl} \\ \text{sem: past} \\ \text{mdr:} \\ \text{arg: !farmer !driver lift} \\ \text{nc:} \\ \text{pc: 2 speed} \\ \text{prn: 3} \end{bmatrix} \begin{array}{l} \text{sur: } \textbf{driver} \\ \begin{bmatrix} \text{sur:} \\ \text{noun: !}\textit{driver} \\ \text{cat: np} \\ \text{sem: def sg} \\ \text{mdr:} \\ \text{fnc: give} \\ \text{idy: 5} \\ \text{prn: 3} \end{bmatrix} \end{array}$$

14.6.7 Realizing a

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

$$\begin{bmatrix}\text{noun: } \alpha\\ \text{mdr: X}\\ \text{prn: i}\end{bmatrix}$$

lex-d $\begin{bmatrix}\text{noun: } \alpha\end{bmatrix}$
if X $\neq$ NIL activate **LA-think.2**

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer driver lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{array}{l}\text{sur: } \textbf{a}\\ \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}\end{array}$$

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

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: } \textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: !decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{matrix}\text{sur:}\textbf{lift}\\ \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}\end{matrix}$$

14.6.9 Realizing . (full stop)

16 -STOP $\{1 \text{ -DET}, 2 \text{ -NoP}\}$

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

$$\begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix} \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix} \Longrightarrow \begin{array}{l}\text{sur: .}\\ \begin{bmatrix}\text{sur:}\\ \text{verb: } \textit{give}\\ \text{cat: decl}\\ \text{sem: past}\\ \text{mdr:}\\ \text{arg: !farmer !driver !lift}\\ \text{nc:}\\ \text{pc: 2 speed}\\ \text{prn: 3}\end{bmatrix}\end{array} \begin{bmatrix}\text{sur:}\\ \text{noun: !}\textit{lift}\\ \text{cat: snp}\\ \text{sem: indef sg}\\ \text{mdr:}\\ \text{fnc: give}\\ \text{idy: 6}\\ \text{prn: 3}\end{bmatrix}$$