Lecture 9–10
FROM ENGLISH TO DL COMPOSITIONALLY

1. Goal: Sample predictions

(1) Jim[1] came in. He$_1$ sat down. antecedent name
(1′) $\sigma \models_M [u_1|\ u_1 = jim,\ cm_{et}\ u_1];\ [sit_{et}\ u_1]$
iff $[\![jim]\!]^M \in {}^{\{\}}[\![cm_{et}]\!]^M\ \&\ [\![jim]\!]^M \in {}^{\{\}}[\![sit_{et}]\!]^M$

(2) Jim[1] has[2] a wife. She$_2$ is a doctor. antec. indefinite
(2′) $\sigma \models_M [u_1\ u_2|\ u_1 = jim°,\ u_2\ wife_{eet}\ u_1];\ [dr_{et}\ u_2]$
iff $\exists d(\langle d, [\![jim]\!]^M\rangle \in {}^{\{\}}[\![wife_{eet}]\!]^M\ \&\ d \in {}^{\{\}}[\![dr_{et}]\!]^M)$

(3) Jim[1] doesn't have[2] a wife. She$_2$ is a doctor. negated indef.
(3′) $\sigma \models_M [u_1|\ u_1 = jim°,\ \mathbf{not}[u_2|\ u_2\ wife_{eet}\ u_1]];\ [dr_{et}\ u_2]$
iff $\neg\exists d(\langle d, [\![jim]\!]^M\rangle \in {}^{\{\}}[\![wife_{eet}]\!]^M)\ \&\ \sigma_2 \in {}^{\{\}}[\![dr_{et}]\!]^M$

(4) (At least) one[1] student solved every[2] problem. quantifier scope:
(4′a) $\sigma \models_M\ [u_1|\ std_{et}\ u_1,\ [u_2|\ prb_{et}\ u_2] \Rightarrow [u_1\ slv_{eet}\ u_2]]$ SU > DO
iff $\exists c(c \in {}^{\{\}}[\![std_{et}]\!]^M\ \&\ \forall d(d \in {}^{\{\}}[\![prb_{et}]\!]^M \to \langle c, d\rangle \in {}^{\{\}}[\![slv_{eet}]\!]^M))$

(4′b) $\sigma \models_M [[u_2|\ prb_{et}\ u_2] \Rightarrow [u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ u_2]]$ SU < DO
iff $\forall d(d \in {}^{\{\}}[\![prb_{et}]\!]^M \to \exists c(c \in {}^{\{\}}[\![std_{et}]\!]^M\ \&\ \langle c, d\rangle \in {}^{\{\}}[\![slv_{eet}]\!]^M))$

(5) Every[1] student attempted but no[2] student solved one[3] problem. s/DO coordination
(5′) $\sigma \models_M [u_3|\ prb_{et}\ u_3,\ [u_1|\ std_{et}\ u_1] \Rightarrow [u_2|\ u_1\ att_{eet}\ u_3],\ \mathbf{not}[u_2|\ std_{et}\ u_2,\ u_2\ slv_{eet}\ u_3]]$
iff $\exists d(d \in {}^{\{\}}[\![prb_{et}]\!]\ \&\ \forall b(b \in {}^{\{\}}[\![std_{et}]\!]^M \to \langle b, d\rangle \in {}^{\{\}}[\![att_{eet}]\!]^M)$
$\&\ \neg\exists c(c \in {}^{\{\}}[\![std_{et}]\!]^M\ \&\ \langle b, d\rangle \in {}^{\{\}}[\![slv_{eet}]\!]^M))$

(6) Al[1] gave every[2] student her$_2$[3] homework. 'bnd. vbl.' ana.:
(6′) $\sigma \models_M\ [u_1|\ u_1 = al,\ [u_2|\ std_{et}\ u_2] \Rightarrow [u_3|\ u_3\ hw_{eet}\ u_2, u_1\ gvt_{eeet}\ u_3u_2]]$ DO > IO
iff $\forall d(d \in {}^{\{\}}[\![std_{et}]\!]^M \to \exists c(\langle c, d\rangle \in {}^{\{\}}[\![hw_{eet}]\!]^M\ \&\ \langle [\![al]\!]^M, c, d\rangle \in {}^{\{\}}[\![gvt_{eeet}]\!]^M)$

(7) Al[1] gave every[2] letter to its$_2$[3] addressee. 'bnd. vbl.' ana.:
(7′) $\sigma \models_M\ [u_1|\ u_1 = al,\ [u_2|\ ltr_{et}\ u_2] \Rightarrow [u_3|\ u_3\ adr_{eet}\ u_2, u_1\ gvt_{eeet}\ u_2u_3]]$ DO > PP
iff $\forall d(d \in {}^{\{\}}[\![ltr_{et}]\!]^M \to \exists c(\langle c, d\rangle \in {}^{\{\}}[\![adr_{eet}]\!]^M\ \&\ \langle [\![al]\!]^M, d, c\rangle \in {}^{\{\}}[\![gvt_{eeet}]\!]^M)$

(8) Al[1] gave every[2] man a[3] whiskey and every[4] woman a[5] cocktail. [DO IO] coord.
(8′) $\sigma \models_M [u_1|\ u_1 = al,\ [u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3, u_1\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5, u_1\ gvt_{eeet}\ u_5u_4]]$
iff $\forall d(d \in {}^{\{\}}[\![mn_{et}]\!]^M \to \exists c(c \in {}^{\{\}}[\![whs_{et}]\!]^M\ \&\ \langle [\![al]\!]^M, c, d\rangle \in {}^{\{\}}[\![gvt_{eeet}]\!]^M)$
$\&\ \forall d'(d' \in {}^{\{\}}[\![wm_{et}]\!]^M \to \exists c'(c' \in {}^{\{\}}[\![ckt_{et}]\!]^M\ \&\ \langle [\![al]\!]^M, c', d'\rangle \in {}^{\{\}}[\![gvt_{eeet}]\!]^M)$

(9a) Every[1] man who marries a[2] woman gives her$_2$ a[3] ring. donkey rel. clause
(9b) If a[1] man marries a[2] woman he$_1$ gives her$_2$ a[3] ring. donkey conditional
(9′) $\sigma \models_M [[u_1\ u_2|\ mn_{et}\ u_1,\ wm_{et}\ u_2, u_1\ mrr_{eet}\ u_2] \Rightarrow [u_3|\ rng_{et}\ u_3, u_1\ gvt_{eeet}\ u_3u_2]]$
iff $\forall b, c(b \in {}^{\{\}}[\![mn_{et}]\!]^M\ \&\ c \in {}^{\{\}}[\![wm_{et}]\!]^M\ \&\ \langle b, c\rangle \in {}^{\{\}}[\![mrr_{eet}]\!]^M$
$\to \exists d(d \in {}^{\{\}}[\![rng_{et}]\!]^M\ \&\ \langle b, d, c\rangle \in {}^{\{\}}[\![gvt_{eeet}]\!]^M))$

2. English fragment 2: CCG + DL

- UNIVERSAL RULES

(>) *Forward application*
X/Y: β_{ab} Y: α_a $\Rightarrow_>$ X: $\beta\alpha$

(<) *Backward application*
Y: α_a X\Y: β_{ab} $\Rightarrow_<$ X: $\beta\alpha$

(>**T**) *Forward type-raising*
X: α_a $\Rightarrow_{>\mathbf{T}}$ Y/(Y\X): $\lambda f_{ab}(f\alpha)$

(<**T**) *Backward type-raising*
X: α_a $\Rightarrow_{<\mathbf{T}}$ Y\(Y/X): $\lambda f_{ab}(f\alpha)$

(>**B**) *Forward composition*
X/Y: β_{ab} Y/Z: α_{ca} $\Rightarrow_{>\mathbf{B}}$ X/Z: $\lambda \upsilon_c(\beta\alpha\upsilon)$

(<**B**) *Backward composition*
Y\Z: α_{ca} X\Y: β_{ab} $\Rightarrow_{<\mathbf{B}}$ X\Z: $\lambda \upsilon_c(\beta\alpha\upsilon)$

- ENGLISH LEXICON

i. English categories:
AB-categories based on {s, np, n}, plus the following abbreviations:

n′	:=	n/np_{of}	vp	:=	s\np_N	
dp	:=	s/vp	vp_F	:=	s_F\np_N	for any feature F ∈ {*inf*, *sc*, *to*}[1]
prd	:=	s_{sc}\np_A	x/y/z	:=	(x/y)/z	
prd′	:=	prd/np_{of}	x\y/z	:=	(x\y)/z	

ii. Category-to-type correspondence, **tp**:
To any English category X, the function **tp** assigns a DL-type as follows:

tp(s)	=	T	**tp**(X/Y)	=	**tp**(Y)**tp**(X)
tp(np)	=	E	**tp**(X\Y)	=	**tp**(Y)**tp**(X)
tp(n)	=	(ET)			

iii.

Eng. item	|–	Category X: DL-translation of type **tp**(X)
came.in	|–	vp: $\lambda v[cm_{et}\ v]$
come.in	|–	vp_{inf}: $\lambda v[cm_{et}\ v]$
saw	|–	vp/np_A: $\lambda v'v[v\ see_{eet}\ v']$
see	|–	vp_{inf}/np_A: $\lambda v'v[v\ see_{eet}\ v']$
spoke	|–	vp/np_{to}: $\lambda v'v[v\ spk_{eet}\ v']$
speak	|–	vp_{inf}/np_{to}: $\lambda v'v[v\ spk_{eet}\ v']$
gave	|–	vp/dp/np_A: $\lambda v'Qv(Q\lambda v''[v\ gvt_{eeet}\ v''v'])$
		vp/dp_{to}/np_A: $\lambda v''Qv(Q\lambda v'[v\ gvt_{eeet}\ v''v'])$
give	|–	vp_{inf}/dp/np_A: $\lambda v'Qv(Q\lambda v''[v\ gvt_{eeet}\ v''v'])$
		vp_{inf}/dp_{to}/np_A: $\lambda v''Qv(Q\lambda v'[v\ gvt_{eeet}\ v''v'])$

[1] *inf* = (bare) infinitive, *sc* = small clause, *to* = *to*-infinitive

is, was	$\vert$–	vp/prd: $\lambda P(P)$
be	$\vert$–	vp_{inf}/prd: $\lambda P(P)$
has^n	$\vert$–	vp/prd′: $\lambda Rv([u_n]; Rvu_n)$
have^n	$\vert$–	vp_{inf}/prd′: $\lambda Rv([u_n]; Rvu_n)$
isn't, wasn't	$\vert$–	vp/prd: $\lambda Pv[\mathbf{not}\ Pv]$
didn't	$\vert$–	vp/vp_{inf}: $\lambda Pv[\mathbf{not}\ Pv]$
doesn't	$\vert$–	vp/vp_{inf}: $\lambda Pv[\mathbf{not}\ Pv]$
he$_n$	$\vert$–	np_N: u_n
him$_n$	$\vert$–	np_A: u_n
his$_m{}^n$	$\vert$–	s/vp/n′: $\lambda RP([u_n]; Ru_mu_n; Pu_n)$
		vp\(vp/np_A)/n′: $\lambda RR'v([u_n]; Ru_mu_n; R'u_nv)$
		⋮
Jim^n	$\vert$–	s/vp: $\lambda P([u_n \vert\ u_n = jim°]; Pu_n)$
		vp\(vp/np_A): $\lambda Rv([u_n \vert\ u_n = jim°]; Ru_nv)$
		⋮
doctor	$\vert$–	n: $\lambda v[dr_{et}\ v]$
wife	$\vert$–	n′: $\lambda v'v[v\ wife_{eet}\ v']$
who	$\vert$–	n\n/vp: $\lambda P'Pv(Pv; P'v)$
a	$\vert$–	prd/n: $\lambda P(P)$
		prd′/n′: $\lambda R(R)$
a^n, one^n	$\vert$–	s/vp/n: $\lambda PP'([u_n]; Pu_n; P'u_n)$
		s\(s/np_A)/n: $\lambda PP'([u_n]; Pu_n; P'u_n)$
		vp\(vp/np_A)/n: $\lambda PRv([u_n]; Pu_n; Ru_nv)$
		⋮
every^n	$\vert$–	s/vp/n: $\lambda PP'[[u_n]; Pu_n \Rightarrow P'u_n]$
		s\(s/np_A)/n: $\lambda PP'[[u_n]; Pu_n \Rightarrow P'u_n]$
		vp\(vp/np_A)/n: $\lambda PRv[[u_n]; Pu_n \Rightarrow Ru_nv]$
		⋮
no^n	$\vert$–	s/vp/n: $\lambda PP'[\mathbf{not}([u_n]; Pu_n; P'u_n)]$
		s\(s/np_A)/n: $\lambda PP'[\mathbf{not}([u_n]; Pu_n; P'u_n)]$
		vp\(vp/np_A)/n: $\lambda PRv[\mathbf{not}([u_n]; Pu_n; Ru_nv)]$
		⋮
to	$\vert$–	dp_{to}/dp: $\lambda Q(Q)$
if	$\vert$–	s/s/s: $\lambda pq[p \Rightarrow q]$
and, but	$\vert$–	s\s/s: $\lambda qp(p; q)$
		vp\vp/vp: $\lambda P'Pv(Pv; P'v)$
		(s/np_A)\(s/np_A)/(s/np_A): $\lambda P'Pv(Pv; P'v)$
		⋮
⋮		

3. Examples of semantic composition

All DL translations are reduced as much as possible by (valid) λ-conversion and/or merger.

DISCOURSE (1)

(1^1) Jim^1 came.in

s/vp: $\lambda P([u_1|\ u_1 = jim°];\ Pu_1)$ vp: $\lambda v[cm_{et}\ v]$

———————————— >

s: $[u_1|\ u_1 = jim°,\ cm_{et}\ u_1]$

(1^2) derivation 1

he_1 sat.down

np$_N$: u_1 s\np$_N$: $\lambda v[sit_{et}\ v]$

———————————— <

s: $[sit_{et}\ u_1]$

derivation 2

he_1 sat.down

np$_N$: u_1 s\np$_N$: $\lambda v[sit_{et}\ v]$

——— >**T**

s/(s\np$_N$): $\lambda P(Pu_1)$

———————————— >

s: $[sit_{et}\ u_1]$

DISCOURSE (2)

(2^1) Jim^1 has^2 a wife

s/vp: $\lambda P([u_1|\ u_1 = jim°];\ Pu_1)$ vp/prd′: $\lambda Rv([u_2];\ Rvu_2)$ prd′/n′: $\lambda R(R)$ n′: $\lambda v'v[v\ wife_{eet}\ v']$

———————— >

prd′: $\lambda v'v[v\ wife_{eet}\ v']$

———————————— >

vp: $\lambda v[u_2|\ u_2\ wife_{eet}\ v]$

———————————————— >

s: $[u_1\ u_2|\ u_1 = jim°,\ u_2\ wife_{eet}\ u_1]$

(2^2) she_2 is a doctor

np$_N$: u_2 s\np$_N$/prd: $\lambda P(P)$ prd/n: $\lambda P(P)$ n: $\lambda v[dr_{et}\ v]$

———————— >

prd: $\lambda v[dr_{et}\ v]$

———————————— >

s\np$_N$: $\lambda v[dr_{et}\ v]$

———————————————— <

s: $[dr_{et}\ u_2]$

SENTENCE (3^1)

• derivation 1

Jim[1]	doesn't	have[2]	a wife
s/vp:	vp/vp$_{inf}$:	vp$_{inf}$/prd′:	prd′:
$\lambda P([u_1 \mid u_1 = jim°]; Pu_1)$	$\lambda Pv[\mathbf{not}\ Pv]$	$\lambda Rv([u_2]; Rvu_2)$	$\lambda v'v[v\ wife_{eet}\ v']$

$>$ vp$_{inf}$: $\lambda v[u_2 \mid u_2\ wife_{eet}\ v]$

$>$ vp: $\lambda v[\mathbf{not}[u_2 \mid u_2\ wife_{eet}\ v]]$

[1] $>$ s: $[u_1 \mid u_1 = jim°, \mathbf{not}[u_2 \mid u_2\ wife_{eet}\ u_1]]$

1	$\lambda P([u_1 \mid u_1 = jim°]; Pu_1)\ \lambda v[\mathbf{not}[u_2 \mid u_2\ wife_{eet}\ v]]$	$>$
	$([u_1 \mid u_1 = jim°]; \lambda v[\mathbf{not}[u_2 \mid u_2\ wife_{eet}\ v]]u_1)$	λ-cnv
	$([u_1 \mid u_1 = jim°]; [\mathbf{not}[u_2 \mid u_2\ wife_{eet}\ u_1]])$	λ-cnv
	$[u_1 \mid u_1 = jim°, \mathbf{not}[u_2 \mid u_2\ wife_{eet}\ u_1]]$	F.mrg

• derivation 2

Jim[1]	doesn't	have[2]	a wife
s/vp:	vp/vp$_{inf}$:	vp$_{inf}$/prd′:	prd′:
$\lambda P([u_1 \mid u_1 = jim°]; Pu_1)$	$\lambda Pv[\mathbf{not}\ Pv]$	$\lambda Rv([u_2]; Rvu_2)$	$\lambda v'v[v\ wife_{eet}\ v']$

[1] $>\mathbf{B}$ vp/prd′: $\lambda Rv[\mathbf{not}([u_2]; Rvu_2)]$

[2] $>\mathbf{B}$ s/prd′: $\lambda R[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; Ru_1u_2)]$

[3] $>$ s: $[u_1 \mid u_1 = jim°, \mathbf{not}[u_2 \mid u_2\ wife_{eet}\ u_1]]$

1	$\lambda R(\lambda Pv[\mathbf{not}\ Pv]\ \lambda R'v'([u_2]; R'v'u_2)R)$	$>\mathbf{B}$
	$\lambda R(\lambda Pv[\mathbf{not}\ Pv]\ \lambda v'([u_2]; Rv'u_2))$	λ-cnv
	$\lambda R(\lambda v[\mathbf{not}\ \lambda v'([u_2]; Rv'u_2)v])$	λ-cnv
	$\lambda R(\lambda v[\mathbf{not}([u_2]; Rvu_2)])$	λ-cnv
	$\lambda Rv[\mathbf{not}([u_2]; Rvu_2)]$	abr.
2	$\lambda R(\lambda P([u_1 \mid u_1 = jim°]; Pu_1)\ \lambda R'v'[\mathbf{not}([u_2]; R'v'u_2)]R)$	$>\mathbf{B}$
	$\lambda R(\lambda P([u_1 \mid u_1 = jim°]; Pu_1)\ \lambda v'[\mathbf{not}([u_2]; Rv'u_2)])$	λ-cnv
	$\lambda R([u_1 \mid u_1 = jim°]; \lambda v'[\mathbf{not}([u_2]; Rv'u_2)]u_1)$	λ-cnv
	$\lambda R([u_1 \mid u_1 = jim°]; [\mathbf{not}([u_2]; Ru_1u_2)])$	λ-cnv
	$\lambda R[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; Ru_1u_2)]$	F.mrg
3	$\lambda R[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; Ru_1u_2)]\ \lambda v'v[v\ wife_{eet}\ v']$	$>$
	$[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; \lambda v'v[v\ wife_{eet}\ v']u_1u_2)]$	λ-cnv
	$[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; \lambda v[v\ wife_{eet}\ u_1]u_2)]$	λ-cnv
	$[u_1 \mid u_1 = jim°, \mathbf{not}([u_2]; [u_2\ wife_{eet}\ u_1])]$	λ-cnv
	$[u_1 \mid u_1 = jim°, \mathbf{not}[u_2 \mid u_2\ wife_{eet}\ u_1]]$	F.mrg

SENTENCE (4)

• reading SU > DO

one[1]	student	solved	every[2]	problem
s/vp/n: $\lambda PP'([u_1]; Pu_1; P'u_1)$	n: $\lambda v[std_{et}\ v]$	vp/np$_A$: $\lambda v'v[v\ slv_{eet}\ v']$	vp\(vp/np$_A$)/n: $\lambda PRv[[u_2]; Pu_2 \Rightarrow Ru_2v]$	n: $\lambda v[prb_{et}\ v]$

1 ———— >

s/vp: $\lambda P'([u_1|\ std_{et}\ u_1]; P'u_1)$

2 ———— >

vp\(vp/np$_A$): $\lambda Rv[[u_2|\ prb_{et}\ u_2] \Rightarrow Ru_2v]$

3 ———— <

vp: $\lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow [v\ slv_{eet}\ u_2]]$

4 ———— >

s: $[u_1|\ std_{et}\ u_1, [u_2|\ prb_{et}\ u_2] \Rightarrow [u_1\ slv_{eet}\ u_2]]$

1
$\lambda PP'([u_1]; Pu_1; P'u_1)\ \lambda v[std_{et}\ v]$ >
$\lambda P'([u_1]; \lambda v[std_{et}\ v]u_1; P'u_1)$ λ-cnv
$\lambda P'([u_1]; [std_{et}\ u_1]; P'u_1)$ λ-cnv
$\lambda P'([u_1|\ std_{et}\ u_1]; P'u_1)$ F.mrg

2
$\lambda PRv[[u_2]; Pu_2 \Rightarrow Ru_2v]\ \lambda v[prb_{et}\ v]$ >
$\lambda PRv[[u_2]; Pu_2 \Rightarrow Ru_2v]\ \lambda v'[prb_{et}\ v']$ a.v.
$\lambda Rv[[u_2]; \lambda v'[prb_{et}\ v']u_2 \Rightarrow Ru_2v]$ λ-cnv
$\lambda Rv[[u_2]; [prb_{et}\ u_2] \Rightarrow Ru_2v]$ λ-cnv
$\lambda Rv[[u_2|\ prb_{et}\ u_2] \Rightarrow Ru_2v]$ F.mrg

3
$\lambda Rv[[u_2|\ prb_{et}\ u_2] \Rightarrow Ru_2v]\ \lambda v'v[v\ slv_{eet}\ v']$ <
$\lambda Rv[[u_2|\ prb_{et}\ u_2] \Rightarrow Ru_2v]\ \lambda v'v''[v''\ slv_{eet}\ v']$ a.v.
$\lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow \lambda v'v''[v''\ slv_{eet}\ v']u_2v]$ λ-cnv
$\lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow \lambda v''[v''\ slv_{eet}\ u_2]v]$ λ-cnv
$\lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow [v\ slv_{eet}\ u_2]]$ λ-cnv

4
$\lambda P'([u_1|\ std_{et}\ u_1]; P'u_1)\ \lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow [v\ slv_{eet}\ u_2]]$ >
$([u_1|\ std_{et}\ u_1]; \lambda v[[u_2|\ prb_{et}\ u_2] \Rightarrow [v\ slv_{eet}\ u_2]]u_1)$ λ-cnv
$([u_1|\ std_{et}\ u_1]; [[u_2|\ prb_{et}\ u_2] \Rightarrow [u_1\ slv_{eet}\ u_2]])$ λ-cnv
$[u_1|\ std_{et}\ u_1, [u_2|\ prb_{et}\ u_2] \Rightarrow [u_1\ slv_{eet}\ u_2]]$ F.mrg

• reading DO > SU

one[1]	student	solved	every[2]	problem
s/vp/n: $\lambda PP'([u_1];\ Pu_1;\ P'u_1)$	n: $\lambda v[std_{et}\ v]$	vp/np$_A$: $\lambda v'v[v\ slv_{eet}\ v']$	s\(s/np$_A$)/n: $\lambda PP'[[u_2];\ Pu_2 \Rightarrow P'u_2]$	n: $\lambda v[prb_{et}\ v]$

1 ——— >

s/vp: $\lambda P'([u_1|\ std_{et}\ u_1];\ P'u_1)$

2 ——— >

s\(s/np$_A$): $\lambda P'[[u_2|\ prb_{et}\ u_2] \Rightarrow P'u_2]$

3 ——— >**B**

s/np$_A$: $\lambda v'[u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ v']$

4 ——— <

s: $[[u_2|\ prb_{et}\ u_2] \Rightarrow [u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ u_2]]$

1 $\lambda PP'([u_1];\ Pu_1;\ P'u_1)\ \lambda v[std_{et}\ v]$ >
$\lambda P'([u_1];\ \lambda v[std_{et}\ v]u_1;\ P'u_1)$ λ-cnv
$\lambda P'([u_1];\ [std_{et}\ u_1];\ P'u_1)$ λ-cnv
$\lambda P'([u_1|\ std_{et}\ u_1];\ P'u_1)$ F.mrg

2 $\lambda PP'[[u_2];\ Pu_2 \Rightarrow P'u_2]\ \lambda v[prb_{et}\ v]$ >
$\lambda P'[[u_2];\ \lambda v[prb_{et}\ v]u_2 \Rightarrow P'u_2]$ λ-cnv
$\lambda P'[[u_2];\ [prb_{et}\ u_2] \Rightarrow P'u_2]$ λ-cnv
$\lambda P'[[u_2|\ prb_{et}\ u_2] \Rightarrow P'u_2]$ F.mrg

3 $\lambda v'(\lambda P'([u_1|\ std_{et}\ u_1];\ P'u_1)\ \lambda v'v[v\ slv_{eet}\ v']v')$ >**B**
$\lambda v'(\lambda P'([u_1|\ std_{et}\ u_1];\ P'u_1)\ \lambda v''v[v\ slv_{eet}\ v'']v')$ a.v.
$\lambda v'(\lambda P'([u_1|\ std_{et}\ u_1];\ P'u_1)\ \lambda v[v\ slv_{eet}\ v'])$ λ-cnv
$\lambda v'([u_1|\ std_{et}\ u_1];\ \lambda v[v\ slv_{eet}\ v']u_1)$ λ-cnv
$\lambda v'([u_1|\ std_{et}\ u_1];\ [u_1\ slv_{eet}\ v'])$ λ-cnv
$\lambda v'[u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ v']$ F.mrg

4 $\lambda P'[[u_2|\ prb_{et}\ u_2] \Rightarrow P'u_2]\ \lambda v'[u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ v']$ <
$[[u_2|\ prb_{et}\ u_2] \Rightarrow \lambda v'[u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ v']u_2]$ λ-cnv
$[[u_2|\ prb_{et}\ u_2] \Rightarrow [u_1|\ std_{et}\ u_1,\ u_1\ slv_{eet}\ u_2]]$ λ-cnv

SENTENCE (5): s/np_A coordination

a. every[1] — student — attempted

every: $s/vp/n$: $\lambda PP'[[u_1]; Pu_1 \Rightarrow P'u_1]$

student: n: $\lambda v[std_{et}\, v]$

attempted: vp/np_A: $\lambda v'v[v\ att_{eet}\ v']$

$>$ s/vp: $\lambda P'[[u_1|\ std_{et}\, u_1] \Rightarrow P'u_1]$

$>\mathbf{B}$ s/np_A: $\lambda v'[[u_1|\ std_{et}\, u_1] \Rightarrow [u_1\ att_{eet}\ v']]$

b. no[2] — student — solved

no: $s/vp/n$: $\lambda PP'[\mathbf{not}([u_2]; Pu_2; P'u_2)]$

student: n: $\lambda v[std_{et}\, v]$

solved: vp/np_A: $\lambda v'v[v\ slv_{eet}\ v']$

$>$ s/vp: $\lambda P'[\mathbf{not}([u_2|\ std_{et}\, u_2]; P'u_2)]$

$>\mathbf{B}$ s/np_A: $\lambda v'[\mathbf{not}[u_2|\ std_{et}\, u_2,\ u_2\ slv_{eet}\ v']]$

c. one[3] — problem

one: $s\backslash(s/np_A)/n$: $\lambda PP'([u_3]; Pu_3; P'u_3)$

problem: n: $\lambda v[prb_{et}\, v]$

$>$ $s\backslash(s/np_A)$: $\lambda P'([u_3|\ prb_{et}\, u_3]; P'u_3)$

d. $x := s/np_A$

(a): x: $\lambda v'[[u_1|\ std_{et}\, u_1] \Rightarrow [u_1\ att_{eet}\ v']]$

but: $x\backslash x/x$: $\lambda P'Pv(Pv; P'v)$

(b): x: $\lambda v'[\mathbf{not}[u_2|\ std_{et}\, u_2,\ u_2\ slv_{eet}\ v']]$

one[3] problem: $s\backslash x$: $\lambda P'([u_3|\ prb_{et}\, u_3]; P'u_3)$

$>$ $x\backslash x$: $\lambda Pv(Pv; [\mathbf{not}[u_2|\ std_{et}\, u_2,\ u_2\ slv_{eet}\ v])$

$<$ x: $\lambda v[[u_1|\ std_{et}\, u_1] \Rightarrow [u_1\ att_{eet}\ v],\ \mathbf{not}[u_2|\ std_{et}\, u_2,\ u_2\ slv_{eet}\ v]]$

$<$ s: $[u_3|\ prb_{et}\, u_3,\ [u_1|\ std_{et}\, u_1] \Rightarrow [u_1\ att_{eet}\ u_3],\ \mathbf{not}[u_2|\ std_{et}\, u_2,\ u_2\ slv_{eet}\ u_3]]$

Homework 5

Use the lexicon of the English Fragment 2, and extend it with suitable lexical entries to derive the following translations of the English sentences (6)–(8). (Do NOT add any combinatory rules, i.e. use only >, <, >**T**, <**T**, >**B**, and/or <**B**):

(6) Al^1 gave every^2 student her$_2{}^3$ homework.

(6′) $[u_1|\ u_1 = al,\ [u_2|\ std_{et}\ u_2] \Rightarrow [u_3|\ u_1\ gvt_{eeet}\ u_3u_2,\ u_3\ hw_{eet}\ u_2]]$

(7) Al^1 gave every^2 letter to its$_2{}^3$ addressee.

(7′) $[u_1|\ u_1 = al,\ [u_2|\ ltr_{et}\ u_2] \Rightarrow [u_3|\ u_1\ gvt_{eeet}\ u_2u_3,\ u_3\ adr_{eet}\ u_2]]$

(8) Al^1 gave every^2 man a^3 whiskey and every^4 woman a^5 cocktail.

(8′) $[u_1|\ u_1 = al,\ [u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ u_1\ gvt_{eeet}\ u_3u_2,\ whs_{et}\ u_3],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ u_1\ gvt_{eeet}\ u_5u_4,\ ckt_{et}\ u_5]]$

Solution to homework 5

SENTENCE (6)

a. her$_2^3$ homework

dp/n′: $\lambda RP([u_3];\ Ru_2u_3;\ Pu_3)$ n′: $\lambda v'v[v\ hw_{eet}\ v]$

——— >

dp: $\lambda P([u_3|\ u_3\ hw_{eet}\ u_2];\ Pu_3)$

b. gave every^2 student her$_2^3$ homework

vp/dp/np$_A$: $\lambda v'Qv(Q\lambda v''[v\ gvt_{eeet}\ v''v'])$ (vp/dp)\(vp/dp/np$_A$)/n: $\lambda PTQv[[u_2];\ Pu_2 \Rightarrow Tu_2Qv]$ n: $\lambda v[std_{et}\ v]$ dp: $\lambda P([u_3|\ u_3\ hw_{eet}\ u_2];\ Pu_3)$

——— >

(vp/dp)\(vp/dp/np$_A$): $\lambda TQv[[u_2|\ std_{et}\ u_2] \Rightarrow Tu_2Qv]$

——— <

vp/dp: $\lambda Qv[[u_2|\ std_{et}\ u_2] \Rightarrow Q\lambda v''[v\ gvt_{eeet}\ v''u_2]]$

——— >

vp: $\lambda v[[u_2|\ std_{et}\ u_2] \Rightarrow [u_3|\ u_3\ hw_{eet}\ u_2,\ v\ gvt_{eeet}\ u_3u_2]]$

c. Al^1 gave every^2 student her$_2^3$ homework

s/vp: $\lambda P([u_1|\ u_1 = al°];\ Pu_1)$ vp: $\lambda v[[u_2|\ std_{et}\ u_2] \Rightarrow [u_3|\ u_3\ hw_{eet}\ u_2,\ v\ gvt_{eeet}\ u_3u_2]]$

——— >

s: $[u_1|\ u_1 = al°,\ [u_2|\ std_{et}\ u_2] \Rightarrow [u_3|\ u_3\ hw_{eet}\ u_2,\ u_1\ gvt_{eeet}\ u_3u_2]]$

SENTENCE (7)

a. to | its$_2{}^3$ | addressee

to — $\mathrm{dp}_{to}/\mathrm{dp}$: $\lambda Q(Q)$

its$_2{}^3$ — dp/n': $\lambda RP([u_3];\ Ru_2u_3;\ Pu_3)$

addressee — n': $\lambda v'v[v\ adr_{eet}\ v]$

its$_2{}^3$ addressee, combined by > : dp: $\lambda P([u_3|\ u_3\ adr_{eet}\ u_2];\ Pu_3)$

to its$_2{}^3$ addressee, combined by > : dp_{to}: $\lambda P([u_3|\ u_3\ adr_{eet}\ u_2];\ Pu_3)$

b. gave | every^2 | letter | to its$_2{}^3$ addressee

gave — $\mathrm{vp}/\mathrm{dp}_{to}/\mathrm{np}_{\mathrm{A}}$: $\lambda v''Qv(Q\lambda v'[v\ gvt_{eeet}\ v''v'])$

every^2 — $(\mathrm{vp}/\mathrm{dp}_{to})\backslash(\mathrm{vp}/\mathrm{dp}_{to}/\mathrm{np}_{\mathrm{A}})/\mathrm{n}$: $\lambda PTQv[[u_2];\ Pu_2 \Rightarrow Tu_2Qv]$

letter — n: $\lambda v[ltr_{et}\ v]$

to its$_2{}^3$ addressee (from a., >) — dp_{to}: $\lambda P([u_3|\ u_3\ adr_{eet}\ u_2];\ Pu_3)$

every^2 letter, combined by > : $(\mathrm{vp}/\mathrm{dp}_{to})\backslash(\mathrm{vp}/\mathrm{dp}_{to}/\mathrm{np}_{\mathrm{A}})$: $\lambda TQv[[u_2|\ ltr_{et}\ u_2] \Rightarrow Tu_2Qv]$

gave every^2 letter, combined by < : $\mathrm{vp}/\mathrm{dp}_{to}$: $\lambda Qv[[u_2|\ ltr_{et}\ u_2] \Rightarrow Q\lambda v'[v\ gvt_{eeet}\ u_2v']]$

gave every^2 letter to its$_2{}^3$ addressee, combined by > : vp: $\lambda v[[u_2|\ ltr_{et}\ u_2] \Rightarrow [u_3|\ u_3\ adr_{eet}\ u_2,\ v\ gvt_{eeet}\ u_2u_3]]$

c. Al^1 | gave every^2 letter to its$_2{}^3$ addressee

Al^1 — s/vp: $\lambda P([u_1|\ u_1 = al^{\circ}];\ Pu_1)$

gave every^2 letter to its$_2{}^3$ addressee (from b., >) — vp: $\lambda v[[u_2|\ ltr_{et}\ u_2] \Rightarrow [u_3|\ u_3\ adr_{eet}\ u_2,\ v\ gvt_{eeet}\ u_2u_3]]$

Al^1 gave every^2 letter to its$_2{}^3$ addressee, combined by > : s: $[u_1|\ u_1 = al^{\circ},\ [u_2|\ ltr_{et}\ u_2] \Rightarrow [u_3|\ u_3\ adr_{eet}\ u_2,\ u_1\ gvt_{eeet}\ u_2u_3]]$

SENTENCE (8): [DO IO]-coordination

a. every[2] man a[3] whiskey

every[2] — $(\mathrm{vp/dp})\backslash(\mathrm{vp/dp/np_A})/\mathrm{n}$: $\lambda PTQv[[u_2];\, Pu_2 \Rightarrow Tu_2Qv]$

man — n: $\lambda v[mn_{et}\, v]$

a[3] — dp/n: $\lambda PP'([u_3];\, Pu_3;\, P'u_3)$

whiskey — n: $\lambda v[whs_{et}\, v]$

every[2] man (>): $(\mathrm{vp/dp})\backslash(\mathrm{vp/dp/np_A})$: $\lambda TQv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2Qv]$

a[3] whiskey (>): dp: $\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3)$

(<T): $\mathrm{vp}\backslash(\mathrm{vp/dp})$: $\lambda F(F\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3))$

[1] (<B): $\mathrm{vp}\backslash(\mathrm{vp/dp/np_A})$: $\lambda Tv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3)v]$

1 $\lambda T(\lambda F(F\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3))\ \lambda T'Qv[[u_2|\, mn_{et}\, u_2] \Rightarrow T'u_2Qv]T)$
$\lambda T(\lambda F(F\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3))\ \lambda Qv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2Qv])$ λ-cnv
$\lambda T(\lambda Qv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2Qv]\ \lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3))$ λ-cnv
$\lambda T(\lambda v[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3)v])$ λ-cnv
$\lambda Tv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3)v]$ abr.

b. every[4] woman a[5] cocktail

every[4] — $(\mathrm{vp/dp})\backslash(\mathrm{vp/dp/np_A})/\mathrm{n}$: $\lambda PTQv[[u_4];\, Pu_4 \Rightarrow Tu_4Qv]$

woman — n: $\lambda v[wm_{et}\, v]$

a[5] — dp/n: $\lambda PP'([u_5];\, Pu_5;\, P'u_5)$

cocktail — n: $\lambda v[ckt_{et}\, v]$

every[4] woman (>): $(\mathrm{vp/dp})\backslash(\mathrm{vp/dp/np_A})$: $\lambda TQv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4Qv]$

a[5] cocktail (>): dp: $\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)$

(<T): $\mathrm{vp}\backslash(\mathrm{vp/dp})$: $\lambda F(F\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5))$

[2] (<B): $\mathrm{vp}\backslash(\mathrm{vp/dp/np_A})$: $\lambda Tv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v]$

2 $\lambda T(\lambda F(F\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5))\ \lambda T'Qv[[u_4|\, wm_{et}\, u_4] \Rightarrow T'u_4Qv]T)$
$\lambda T(\lambda F(F\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5))\ \lambda Qv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4Qv])$ λ-cnv
$\lambda T(\lambda Qv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4Qv]\ \lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5))$ λ-cnv
$\lambda T(\lambda v[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v])$ λ-cnv
$\lambda Tv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v]$ abr.

c. x := $\mathrm{vp}\backslash(\mathrm{vp/dp/np_A})$

every[2] man a[3] whiskey (<B) — x: $\lambda Tv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2\lambda P'([u_3|\, whs_{et}\, u_3];\, P'u_3)v]$

and — $\mathrm{x}\backslash\mathrm{x/x}$: $\lambda U'UTv(UTv;\, U'Tv)$

every[4] woman a[5] cocktail (<B) — x: $\lambda Tv[[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v]$

(>): $\mathrm{x}\backslash\mathrm{x}$: $\lambda UTv(UTv;\, [[u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v])$

(<): x: $\lambda Tv[[u_2|\, mn_{et}\, u_2] \Rightarrow Tu_2\lambda P([u_3|\, whs_{et}\, u_3];\, Pu_3)v,\, [u_4|\, wm_{et}\, u_4] \Rightarrow Tu_4\lambda P'([u_5|\, ckt_{et}\, u_5];\, P'u_5)v]$

d. Al[1] | gave | every[2] man a[3] whiskey and every[4] woman a[5] cocktail

s/vp: $\lambda P([u_1|\ u_1 = al^\circ];\ Pu_1)$

vp/dp/np$_A$: $\lambda v'Qv(Q\lambda v''[v\ gvt_{eeet}\ v''v'])$

vp\(vp/dp/np$_A$): $\lambda Tv[[u_2|\ mn_{et}\ u_2] \Rightarrow Tu_2\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow Tu_4\lambda P'([u_5|\ ckt_{et}\ u_5];\ P'u_5)v]$ <

1 ——— <

vp:
$\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ v\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ v\ gvt_{eeet}\ u_5u_4]]$

2 ——— >

s:
$[u_1|\ u_1 = al^\circ,\ [u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ v\ gvt_{eeet}\ u_3u_2],\ [u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ v\ gvt_{eeet}\ u_5u_4]]$

1.1 $\lambda Tv[[u_2|\ mn_{et}\ u_2] \Rightarrow Tu_2\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow Tu_4\lambda P'([u_5|\ ckt_{et}\ u_5];\ P'u_5)v]\ \lambda v'Qv(Q\lambda v''[v\ gvt_{eeet}\ v''v'])$ <

1.2 $\lambda Tv[[u_2|\ mn_{et}\ u_2] \Rightarrow Tu_2\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow Tu_4\lambda P'([u_5|\ ckt_{et}\ u_5];\ P'u_5)v]\ \lambda v'Qv'''(Q\lambda v''[v'''\ gvt_{eeet}\ v''v'])$ a.v.

1.3 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow \lambda v'Qv'''(Q\lambda v''[v'''\ gvt_{eeet}\ v''v'])u_2\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow \lambda v'Qv'''(Q\lambda v''[v'''\ gvt_{eeet}\ v''v'])u_4\lambda P'([u_5|\ ckt_{et}\ u_5];\ P'u_5)v]$ λ-cnv

1.4 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow \lambda Qv'''(Q\lambda v''[v'''\ gvt_{eeet}\ v''u_2])\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow \lambda Qv'''(Q\lambda v''[v'''\ gvt_{eeet}\ v''u_4])\lambda P'([u_5|\ ckt_{et}\ u_5];\ P'u_5)v]$ λ-cnv

1.5 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow \lambda v'''(\lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)\lambda v''[v'''\ gvt_{eeet}\ v''u_2])v,$
$[u_4|\ wm_{et}\ u_4] \Rightarrow \lambda v'''(\lambda P([u_5|\ ckt_{et}\ u_5];\ Pu_5)\lambda v''[v'''\ gvt_{eeet}\ v''u_4])v]$ λ-cnv

1.6 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow \lambda P([u_3|\ whs_{et}\ u_3];\ Pu_3)\lambda v''[v\ gvt_{eeet}\ v''u_2]),$
$[u_4|\ wm_{et}\ u_4] \Rightarrow \lambda P([u_5|\ ckt_{et}\ u_5];\ Pu_5)\lambda v''[v\ gvt_{eeet}\ v''u_4])]$ λ-cnv

1.7 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3];\ \lambda v''[v\ gvt_{eeet}\ v''u_2]u_3),$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5];\ \lambda v''[v\ gvt_{eeet}\ v''u_4]u_5)]$ λ-cnv

1.8 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3];\ [v\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5];\ [v\ gvt_{eeet}\ u_5u_4]]$ λ-cnv

1.9 $\lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ v\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ v\ gvt_{eeet}\ u_5u_4]]$ F.mrg

2.1 $\lambda P([u_1|\ u_1 = al^\circ];\ Pu_1)\ \lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ v\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ v\ gvt_{eeet}\ u_5u_4]]$ >

2.2 $([u_1|\ u_1 = al^\circ];\ \lambda v[[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ v\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ v\ gvt_{eeet}\ u_5u_4]]u_1)$ λ-cnv

2.3 $([u_1|\ u_1 = al^\circ];\ [[u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ u_1\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ u_1\ gvt_{eeet}\ u_5u_4]])$ λ-cnv

2.3 $[u_1|\ u_1 = al^\circ,\ [u_2|\ mn_{et}\ u_2] \Rightarrow [u_3|\ whs_{et}\ u_3,\ u_1\ gvt_{eeet}\ u_3u_2],$
$[u_4|\ wm_{et}\ u_4] \Rightarrow [u_5|\ ckt_{et}\ u_5,\ u_1\ gvt_{eeet}\ u_5u_4]]$ F.mrg