(Dynamic) Hamblin semantics

1 FROM ENGLISH QUESTIONS TO Ty2 (Hamblin 1973)

• TWO-SORTED TYPE THEORY (Ty2): Basic terms

$a \in Typ$	Var_a	Con_a	Name of objects
s	i, j		indices (worlds)
st	p, q		propositions (sets of worlds)
$(st)t$	Q		sets of propositions (p-sets)
e	x, y, z	$al, bill, \ldots$	entities
set		$man, sick, \ldots$	relations from worlds to entities
$seet$		$like, \ldots$	relations from worlds to pairs of entities
est	P		iv-denotations
$eest$	R		tv-denotations

• ASSERTION

(1) Al is_sick.

(1′) Hamblin 1973: Sec. 1: indicative ⇝ *proposition*

cat	phrase	Ty2-translation	type
pn	Al	al	e
iv	is_sick	$\lambda x \lambda i.\ sick(i, x)$	est
s	(1)	$\lambda i.\ sick(i, al)$	st

(1″) Hamblin 1973: Sec. 8: indicative ⇝ SG-*set of propositions*

cat	phrase	Ty2-translation		type
pn	Al	$\lambda x.\ x = al$	(=: pn′)	et
iv	is_sick	$\lambda P.\ P = \lambda x \lambda i.\ sick(i, x)$	(=: iv′)	$(est)t$
s	(1)	$\lambda p.\ \exists x \exists P(\text{pn}'(x) \wedge \text{iv}'(P) \wedge p = P(x))$		$(st)t$
		$= \lambda p.\ p = \lambda i.\ sick(i, al)$		

(2) Al likes Sue.

(2″)

cat	phrase	Ty2-translation		type
pn	Sue	$\lambda x.\ x = sue$	(=: pn′)	et
tv	likes	$\lambda R.\ R = \lambda y \lambda x \lambda i.\ like(i, x, y)$	(=: tv′)	$(eest)t$
iv	likes_S.	$\lambda P.\ \exists y \exists R(\text{pn}'(y) \wedge \text{tv}'(R) \wedge P = R(y))$		$(est)t$
		$= \lambda P.\ P = \lambda x \lambda i.\ like(i, x, sue)$		
pn	Al	$\lambda x.\ x = al$		et
s	(2)	$\lambda p.\ p = \lambda i.\ like(i, al, sue)$		

• YN QUESTION: Hamblin 1973: Sec. 8: yn que ⇝ DU-*set of propositions*

(3) Is_it_the_case_that (=: YN) Al is_sick?

(3″)

cat	phrase	Ty2-translation		type
pn	Al	$\lambda x.\ x = al$	(=: pn′)	et
iv	is_sick	$\lambda P.\ P = \lambda x \lambda i.\ sick(i, x)$	(=: iv′)	$(est)t$
s	(1)	$\lambda p.\ \exists x \exists P(\text{pn}'(x) \wedge \text{iv}'(P) \wedge p = P(x))$		$(st)t$
		$= \lambda p.\ p = \lambda i.\ sick(i, al)$		
s/s	YN	$\lambda Q \lambda p.\ \exists r(Q(r) \wedge (p = r \vee p = \lambda i.\ \neg r(i)))$		$((st)t)(st)t$
s	(3)	$\lambda p.\ p = \lambda i.\ sick(i, al)$ $\vee\ p = \lambda i.\ \neg sick(i, al)$		$(st)t$

• WH QUESTIONS: Hamblin 1973: Sec. 8: wh que ⇝ PL-*set of propositions*

(4) Who is sick?

(4″)

cat	phrase	Ty2-translation		type
pn	who	$\lambda x.\ person(i, x)$	(=: pn′)	et
iv	is_sick	$\lambda P.\ P = \lambda x \lambda j.\ sick(j, x)$	(=: iv′)	$(est)t$
s	(4)	$\lambda p.\ \exists x \exists P(\text{pn}'(x) \wedge \text{iv}'(P) \wedge p = P(x))$		$(st)t$
		$= \lambda p.\ \exists x(person(i, x) \wedge p = \lambda j.\ sick(j, x))$		

(5) Who does Al like?

(5″)

cat	phrase	Ty2-translation		type
pn	who	$\lambda x.\ person(i, x)$	(=: pn′)	et
tv	likes	$\lambda R.\ R = \lambda y \lambda x \lambda j.\ like(j, x, y)$	(=: tv′)	$(eest)t$
iv	likes_wh	$\lambda P.\ \exists y \exists R(\text{pn}'(y) \wedge \text{tv}'(R) \wedge P = R(y))$		$(est)t$
		$= \lambda P.\ \exists y(person(i, y) \wedge P = \lambda x \lambda j.\ like(j, x, y))$		
pn	Al	$\lambda x.\ x = al$		et
s	(5)	$\lambda p.\ \exists y(person(i, y) \wedge p = \lambda j.\ like(j, al, y))$		

(6) Who likes whom?

(6″)

cat	phrase	Ty2-translation		type
pn	whom	$\lambda x.\ person(i, x)$	(=: pn′)	et
tv	likes	$\lambda R.\ R = \lambda y \lambda x \lambda j.\ like(j, x, y)$	(=: tv′)	$(eest)t$
iv	likes wh	$\lambda P.\ \exists y(person(i, y) \wedge P = \lambda x \lambda j.\ like(j, x, y))$		$(est)t$
pn	who	$\lambda x.\ person(i, x)$		et
s	(6)	$\lambda p.\ \exists x \exists y(person(i, x) \wedge person(i, y)$ $\wedge\ p = \lambda j.\ like(j, x, y))$		$(st)t$

2 FROM ENGLISH QUESTIONS TO UC2

• TWO-SORTED UPDATE WITH CENTERING (UC2): Basic terms

$a \in Typ$	$^{\top}Var_a$	$^{\bot}Var_a$	Con_a	Name of objects
s		i, j		indices ($\top\bot$-lists)
st		I, J		infotention states
e	$\mathbf{x}$	y	$al, bill, \ldots$	entities
ω	$\mathbf{w}$	v		worlds
$\omega t := \Omega$	$\mathbf{p}$	q		propositions (sets of worlds)
Ωt	$\mathbf{Q}$	Q		sets of propositions
ωet			$man, sick, \ldots$	ωet-relations
ωeet			$like, \ldots$	ωeet-relations
se			$\mathbf{d}e_n$, de_n	e-projections
$s\omega$			$\mathbf{d}\omega_n$, $d\omega_n$	ω-projections
$s\Omega$			$\mathbf{d}\Omega_n$, $d\Omega_n$	Ω-projections

• DEFAULT CENTERING

$*\mathrm{p}_0 \;:=\; \{\langle\langle \mathrm{w}, \mathrm{p}_0\rangle, \langle\rangle\rangle: \mathrm{w} \in \mathrm{p}_0\}$

• ASSERTION

(1) Al — be.IND — sick — . (prosody)

UC2 $[\mathbf{x}|\ (\mathbf{x} = al)°];\ {}^{\mathrm{P}}[\mathbf{d}\omega \in \mathbf{d}\omega\{|\}];\ [sick\langle \mathbf{d}\omega, \mathbf{d}e\rangle];\ [\mathbf{p}];\ [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$

Ex1:

$\mathrm{p}_0 = \{\mathrm{w}_0,\ \mathrm{w}_1\} =:\ _{01}$

$\langle \mathrm{w}_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$

$\langle \mathrm{w}_1, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

$*(_{01})$

$\langle\langle \mathrm{w}_0,\ _{01}\rangle, \langle\rangle\rangle$

$\langle\langle \mathrm{w}_1,\ _{01}\rangle, \langle\rangle\rangle$

Al	be.IND	sick	. (prosody)
$[\mathbf{x}|\ (\mathbf{x} = al)°];$	${}^{\mathrm{P}}[\mathbf{d}\omega \in \mathbf{d}\omega\{|\}];$	$[sick\langle \mathbf{d}\omega, \mathbf{d}e\rangle];$	$[\mathbf{p}];\ [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$
c_1	c_1	c_2	$\mathrm{c}_3\ \ (_0 := \{\mathrm{w}_0\})$
$\langle\langle [\![al]\!], \mathrm{w}_0,\ _{01}\rangle, \langle\rangle\rangle$		$\langle\langle [\![al]\!], \mathrm{w}_0,\ _{01}\rangle, \langle\rangle\rangle$	$\langle\langle _0, [\![al]\!], \mathrm{w}_0,\ _{01}\rangle, \langle\rangle\rangle$
$\langle\langle [\![al]\!], \mathrm{w}_1,\ _{01}\rangle, \langle\rangle\rangle$			

(2) Al — like- — -IND — Sue

$[\mathbf{x}|\ (\mathbf{x} = al)°];\ [y|\ like\langle \mathbf{d}\omega, \mathbf{d}e, y\rangle];\ {}^{\mathrm{P}}[\mathbf{d}\omega \in \mathbf{d}\omega\{|\}];[(de = sue)°];$

. (prosody)

$[\mathbf{p}];\ [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$

• YN QUESTION

(3) be.IND Al sick

$^{P}[w|\ w \in \mathbf{d}\omega\{|\}];\ [\mathbf{x}|\ (\mathbf{x} = al)°];\ [sick\langle d\omega, \mathbf{d}e\rangle];$

? (prosody)

$[q];\ [d\Omega = d\omega\{|\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

<u>Ex1</u>:

$\mathtt{p}_0 = \{\mathtt{w}_0,\ \mathtt{w}_1\} =:\ _{01}$ $\langle \mathtt{w}_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$

$\langle \mathtt{w}_1, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

$*(_{01})$

$\langle\langle \mathtt{w}_0,\ _{01}\rangle, \langle\rangle\rangle$

$\langle\langle \mathtt{w}_1,\ _{01}\rangle, \langle\rangle\rangle$

be.IND	Al	sick
$^{P}[w\|\ w \in \mathbf{d}\omega\{\|\}];$	$[\mathbf{x}\|\ (\mathbf{x} = al)°];$	$[sick\langle d\omega, \mathbf{d}e\rangle];$
$\mathtt{c}_1$	$\mathtt{c}_2$	$\mathtt{c}_3$
$\langle\langle \mathtt{w}_0,\ _{01}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_0,\ _{01}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_0, \mathtt{p}_0\rangle, \langle \mathtt{w}_0\rangle\rangle$
$\langle\langle \mathtt{w}_0,\ _{01}\rangle, \langle \mathtt{w}_1\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_0,\ _{01}\rangle, \langle \mathtt{w}_1\rangle\rangle$	
$\langle\langle \mathtt{w}_1,\ _{01}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_1,\ _{01}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_1, \mathtt{p}_0\rangle, \langle \mathtt{w}_0\rangle\rangle$
$\langle\langle \mathtt{w}_1,\ _{01}\rangle, \langle \mathtt{w}_1\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_1,\ _{01}\rangle, \langle \mathtt{w}_1\rangle\rangle$	

? (prosody)

$[q];\ [d\Omega = d\omega\{\|\}];$	$[\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{\|\}]$
$\mathtt{c}_4\ \ (_0 := \{\mathtt{w}_0\})$	$\mathtt{c}_5$
$\langle\langle [\![al]\!], \mathtt{w}_0,\ _{01}\rangle, \langle _0, \mathtt{w}_0\rangle\rangle$	$\langle\langle \{_0\}, [\![al]\!], \mathtt{w}_0,\ _{01}\rangle, \langle _0, \mathtt{w}_0\rangle\rangle$
$\langle\langle [\![al]\!], \mathtt{w}_1,\ _{01}\rangle, \langle _0, \mathtt{w}_0\rangle\rangle$	$\langle\langle \{_0\}, [\![al]\!], \mathtt{w}_1,\ _{01}\rangle, \langle _0, \mathtt{w}_0\rangle\rangle$

• WH QUESTIONS

(4) who be.IND sick

$[\mathbf{x}|\ person\{\omega, \mathbf{x}\}];\ ^{P}[w|\ w \in \mathbf{d}\omega\{|\}];\ [sick\langle d\omega, \mathbf{d}e\rangle];$

? (prosody)

$[q];\ [d\Omega = d\omega\{|_{\mathbf{d}e}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

<u>Ex2</u>:

$\mathtt{p}_0 = \{\mathtt{w}_0,\ \mathtt{w}_1, \mathtt{w}_2, \mathtt{w}_3\}$

$=:\ _{0-3}$

$\langle \mathtt{w}_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_0, [\![sue]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
$\langle \mathtt{w}_1, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_1, [\![sue]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$
$\langle \mathtt{w}_2, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_2, [\![sue]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
$\langle \mathtt{w}_3, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_3, [\![sue]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

$\{\mathtt{d} \in D_e|\ \forall \mathtt{v} \in \mathtt{p}_0: \langle \mathtt{v}, \mathtt{d}\rangle \in {}^{\{\}}[\![person]\!]\}$

$= \{[\![al]\!], [\![sue]\!]\}$

$*({}_{0\text{-}3})$

$\langle\langle \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$

$\langle\langle \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$

$\langle\langle \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$

$\langle\langle \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$

who	be.IND	sick
$[\mathbf{x}\mid \mathit{person}\{\omega, \mathbf{x}\}];$	$^{\mathrm{P}}[w\mid w \in \mathbf{d}\omega\{\mid\}];$	$[\mathit{sick}\langle d\omega, \mathbf{d}e\rangle];$
$\mathtt{c}_1$	$\mathtt{c}_2$	$\mathtt{c}_3$
$\langle\langle [\![al]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![al]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_1\rangle\rangle$
	$\langle\langle [\![al]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![al]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![al]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_1\rangle\rangle$
	$\langle\langle [\![al]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![al]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![al]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_1\rangle\rangle$
	$\langle\langle [\![al]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![al]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![al]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![al]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_1\rangle\rangle$
	$\langle\langle [\![al]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![sue]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![sue]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_2\rangle\rangle$
	$\langle\langle [\![sue]\!], \mathtt{w}_0, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![sue]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![sue]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_2\rangle\rangle$
	$\langle\langle [\![sue]\!], \mathtt{w}_1, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![sue]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![sue]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_2\rangle\rangle$
	$\langle\langle [\![sue]\!], \mathtt{w}_2, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	
$\langle\langle [\![sue]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$	$\langle\langle [\![sue]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_0\rangle\rangle$
	$\vdots$	$\langle\langle [\![sue]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_2\rangle\rangle$
	$\langle\langle [\![sue]\!], \mathtt{w}_3, {}_{0\text{-}3}\rangle, \langle \mathtt{w}_3\rangle\rangle$	

? (prosody)

$[q]; [d\Omega = d\omega\{|_{\mathbf{d}e}\}];$	$[\mathbf{Q}]; [\mathbf{d}\Omega t = d\Omega\{|\}]$
$\mathtt{c}_4$	$\mathtt{c}_5$
$\langle\langle[\![al]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_1\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_1\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_1\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_1\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![al]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_1\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![al]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{01}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_2\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_0, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_2\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_1, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_2\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_2, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$
$\langle\langle[\![sue]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_2\rangle\rangle$	$\langle\langle\{{}_{01}, {}_{02}\}, [\![sue]\!], \mathtt{w}_3, {}_{0-3}\rangle, \langle{}_{02}, \mathtt{w}_0\rangle\rangle$

where ${}_{01} := \{\mathtt{w}_0, \mathtt{w}_1\} = \{\mathtt{v} \in \mathtt{p}_0 |\ \langle \mathtt{v}, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]\}$
${}_{02} := \{\mathtt{w}_0, \mathtt{w}_2\} = \{\mathtt{v} \in \mathtt{p}_0 |\ \langle \mathtt{v}, [\![sue]\!]\rangle \in {}^{\{\}}[\![sick]\!]\}$

(5) who(m) do.IND Al like
$[y|\ person\{\omega, y\}];\ {}^{P}[w|\ w \in \mathbf{d}\omega\{|\}];\ [\mathbf{x}|\ \mathbf{x} = al];\ [like\langle d\omega, \mathbf{d}e, de\rangle]$
? (prosody)
$[q];\ [d\Omega = d\omega\{|_{de}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

(6) who like- -IND
$[\mathbf{x}|\ person\{\omega, \mathbf{x}\}];\ [w\ y|\ like\langle w, \mathbf{d}e, y\rangle];\ {}^{P}[d\omega \in \mathbf{d}\omega\{|\}];$
who(m) **?** (prosody)
$[person\{\omega, de\}];\ [q];\ [d\Omega = d\omega\{|_{\mathbf{d}e,\, de}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

3 FROM ENGLISH QUESTIONS TO UC (cf. Bittner 2008)

• UPDATE WITH CENTERING (UC, 6-sorted): Basic terms

$a \in Typ$	$^{\top}Var_a$	$^{\perp}Var_a$	Con_a	Name of objects
s		i, j		indices (⊤⊥-lists)
st		I, J		infotention states
α	**a**	a	*john*	animate (entities)
β	**b**	b	*John*	inanimate (entities)
ε	**e**	e		events
σ	**s**	s		states (of entities)
τ	**t**	t		times
ω	**w**, **v**	w, v		worlds
$\omega\varepsilon$	$\underline{\mathbf{e}}$	$\underline{e}$		event concepts
$\omega t =: \Omega$	**p**, **q**	p, q		propositions (sets of worlds)
Ωt	**Q**	Q		sets of propositions
$\omega\alpha t$			*person*, …	$\omega\alpha$-relations
$\omega\sigma\alpha t$			*sick*, …	$\omega\sigma\alpha$-relations
$\omega\sigma\alpha\alpha t$			*like*, …	$\omega\sigma\alpha\alpha$-relations
$\varepsilon\alpha$			AGT	ε-dependent animates
$\varepsilon\sigma$			CON	ε-dependent states
$\sigma\varepsilon$			BEG, END	σ-dependent events
sa			$\mathbf{d}a_n$, da_n, …	a-projections ($a \in DTyp$)

• DEFAULT CENTERING

$*\langle p_0, e_0\rangle \;:=\; \{\langle\langle t, w, p_0, e_0\rangle, \langle \underline{e}\rangle\rangle|$
$\quad w \in {}^{\{\}}p_0 \wedge t = [\![\vartheta]\!](w, e_0) \wedge \underline{e} = \{\langle v, e_0\rangle | \; v \in {}^{\{\}}p_0\}$

$^{\top}w \in {}^{\top}p_0$ • $e_0 = \underline{e}_0(w)$: e_0-agt speaks up
| $[\![\vartheta]\!](w, e_0)$: e_0-instant

• ASSERTION

(1) Al be- -IND.

UC $[\mathbf{a}|\, (\mathbf{a} = al)°]$; $[s|\, (\text{EXP } s = \text{CTR } s)°]$; $^{P}[\mathbf{d}\omega \in \mathbf{d}\omega\{|\}]$;

.NPST

$^{P}[(\vartheta(\mathbf{d}\omega, \mathbf{d}\varepsilon) \leq \mathbf{d}\tau)°]$; $[\subset\langle \mathbf{d}\omega, d\sigma, \mathbf{d}\tau\rangle, (\text{CTR } d\sigma = \mathbf{d}\alpha)°]$;

sick . (prosody)

$[sick\langle \mathbf{d}\omega, d\sigma\text{: EXP}\rangle]$; $[\mathbf{p}]$; $[\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$

$^{\top}w \in {}^{\top}p_1 \subseteq p_0$ • $e_0 = \underline{e}_0(w)$: e_0-agt updates CG to $p_1 \subseteq p_0$
| $[\![\vartheta]\!](w, e_0)$: e_0-instant
——— s_1: Al is sick

(2) Al like- -IND.

UC $[\mathbf{a}|\ (\mathbf{a} = al)°];\ [s\ a|\ like\langle \mathbf{d}\omega, \text{EXP}, a\rangle, (\text{EXP}\ s = \text{CTR}\ s)°];\ {}^{\text{P}}[(\mathbf{d}\omega \in \mathbf{d}\Omega)°]$

.NPST

$;\ {}^{\text{P}}[(\vartheta(\mathbf{d}\omega, \mathbf{d}\varepsilon) \leq \mathbf{d}\tau)°];\ [\subset\langle \mathbf{d}\omega, d\sigma, \mathbf{d}\tau\rangle, (\text{CTR}\ d\sigma = \mathbf{d}\alpha)°];$

Sue **.** (prosody)

$[(d\alpha = sue)°];\ [\mathbf{p}];\ [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$

• YN QUESTION

(3) be- -IND.

UC $[s|\ (\text{EXP}\ s = \text{CTR}\ s)°];\ {}^{\text{P}}[w|\ w \in \mathbf{d}\omega\{|\}];$

.NPST

${}^{\text{P}}[(\vartheta(\mathbf{d}\omega, \mathbf{d}\varepsilon) \leq \mathbf{d}\tau)°];\ [\subset\langle d\omega, d\sigma, \mathbf{d}\tau\rangle];\ [\mathbf{a}|\ (\text{CTR}\ d\sigma = \mathbf{a})°];$

Al sick

$[(\mathbf{d}\alpha = al)°];\ [sick\langle d\omega, d\sigma\text{: EXP}\rangle];$

? (prosody)

$[q];\ [d\Omega = d\omega\{|\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

${}^{\top}\mathtt{w} \in {}^{\top}\mathtt{p}_0$	•	$\mathtt{e}_0 = \underline{\mathtt{e}}_0(\mathtt{w})$: $\mathtt{e}_0$-agt introduces ${}^{\top}\mathtt{Q}_1 = \{\mathtt{p}_1\}$ (asks for which $\mathtt{q} \in {}^{\top}\mathtt{Q}_1$, $\mathtt{w} \in \mathtt{q}$)
	|	$[\![\vartheta]\!](\mathtt{w}, \mathtt{e}_0)$: $\mathtt{e}_0$-instant

~~~~~~

$\mathtt{v} \in \mathtt{p}_1$		yes-answer to $\mathtt{e}_0$-question ${}^{\top}\mathtt{Q}_1$
	———	$\mathtt{s}_1$: Al is sick

• WH QUESTION

(4) who be- -IND.

UC $[\mathbf{a}|\ person\{\omega, \mathbf{a}\}];\ [s|\ (\text{EXP}\ s = \text{CTR}\ s)°];\ {}^{\text{P}}[w|\ w \in \mathbf{d}\omega\{|\}];$

.NPST

${}^{\text{P}}[(\vartheta(\mathbf{d}\omega, \mathbf{d}\varepsilon) \leq \mathbf{d}\tau)°];\ [\subset\langle d\omega, d\sigma, \mathbf{d}\tau\rangle];\ [(\text{CTR}\ d\sigma = \mathbf{d}\alpha)°];$

sick **?** (prosody)

$[sick\langle d\omega, d\sigma\text{: EXP}\rangle];\ [q];\ [d\Omega = d\omega\{|_{\mathbf{d}\alpha}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$

(6) who

UC $[\mathbf{a}|\ person\{\omega, \mathbf{a}\}];$

like- -IND.

$[s\ w\ a|\ like\langle w, \text{CTR}, a\rangle\ (\text{EXP}\ s = \text{CTR}\ s)°];\ {}^{\text{P}}[(d\omega \in \mathbf{d}\Omega)°];$

.NPST

${}^{\text{P}}[(\vartheta(\mathbf{d}\omega, \mathbf{d}\varepsilon) \leq \mathbf{d}\tau)°];\ [\subset\langle d\omega, d\sigma, \mathbf{d}\tau\rangle, (\text{CTR}\ d\sigma = \mathbf{d}\alpha)°];$

who(m) **?** (prosody)

$[person\{\omega, d\alpha\rangle];\ [q];\ [d\Omega = d\omega\{|_{\mathbf{d}\alpha,\, d\alpha}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$
~~~~~~

4 FROM KALAALLISUT QUESTIONS TO UC (Bittner 2008)

• ASSERTION

(1K) *Ole naparsima-pu-q.*
Ole sick-DEC.IV-3SG
Ole is sick.

Ole sick-
UC [**a**| (**a** = *ole*)°]; [*s*| *sick*⟨**d**ω, *s*: EXP⟩, (EXP *s* = CTR *s*)°];
.DEC.IV-3SG
P[*d*ωε =$_{\omega}$ **d**ε]; [⊂⟨**d**ω, *d*σ, **d**τ⟩]; [BEG *d*σ ≤$_{\vartheta\mathbf{d}\omega}$ *d*ωε, (CTR *d*σ = **d**α)°];
[**p**]; [**d**Ω = **d**ω{|}]

$^{\top}$w ∈ $^{\top}$p$_1$ ⊆ p$_0$ • e$_0$ = e$_0$(w): e$_0$-agt updates CG to p$_1$ ⊆ p$_0$
| ⟦ϑ⟧(w, e$_0$): e$_0$-instant
———— s$_1$: Ole is sick

(2K) *Siut-nngu-pu-nga.*
ear-ache-DEC.IV-1SG
I have an earache.

ear- -ache
UC [*b*| *ear*⟨**d**ω, *b*⟩]; [*s*| *feel.pain.in*⟨**d**ω, *s*: EXP: *d*β⟩ (EXP *s* = CTR *s*)°];
.DEC.IV-1SG
P[*d*ωε =$_{\omega}$ **d**ε]; [⊂⟨**d**ω, *d*σ, **d**τ⟩]; [BEG *d*σ ≤$_{\vartheta\mathbf{d}\omega}$ *d*ωε, (CTR *d*σ = AGT **d**ε)°]
; [**p**]; [**d**Ω = **d**ω{|}]

• YN QUESTION

(3K) *Ole naparsima-pi-a*?
Ole sick-QUE-3SG
Is Ole sick?

Ole sick-
UC [**a**| (**a** = *ole*)°]; [*s w*| *sick*⟨*w*, *s*: EXP⟩, (EXP *s* = CTR *s*)°];
-QUE-3SG
P[*d*ωε =$_{\omega}$ **d**ε]; [⊂⟨*d*ω, *d*σ, **d**τ⟩]; [BEG *d*σ ≤$_{\vartheta d\omega}$ *d*ωε, (CTR *d*σ = **d**α)°];
[*q*]; [*d*Ω = *d*ω{|}]; [**Q**]; [**d**Ω*t* = *d*Ω{|}]; [*ask*⟨ω, *d*ωε: AGT: **d**Ω*t*⟩]

$^{\top}$w ∈ $^{\top}$p$_0$ • e$_0$ = e$_0$(w): e$_0$-agt asks question $^{\top}$\{p$_1$\}
| ⟦ϑ⟧(w, e$_0$): e$_0$-instant
~~~~~~
v ∈ p$_1$ yes-answer to e$_0$-question $^{\top}$\{p$_1$\}
———— s$_1$: Ole is sick
~~~~~~

• WH QUESTIONS

(4K) *Kina* *naparsimava*?
kina *naparsima-pi-a*
who.SG sick-QUE-3SG
Who is sick?

who.SG sick-
UC [**a**| *person*{ω, **a**}]; [*s w*| *sick*⟨*w*, *s*: EXP⟩, (EXP *s* = CTR *s*)°];
-QUE-3SG
^{P}[*d*ωε $=_{ω}$ **d**ε]; [⊂⟨*d*ω, *d*σ, **d**τ⟩]; [BEG *d*σ $\leq_{\vartheta d_{\omega}}$ *d*ωε, (CTR *d*σ = **d**α)°];
[*q*]; [*d*Ω = *d*ω{$|_{\mathbf{d}\alpha}$}]; [**Q**]; [**d**Ω*t* = *d*Ω{|}]; [*ask*⟨ω, *d*ωε: AGT: **d**Ω*t*⟩]

(5K) *Ole* *sunnguva*?
Ole *su-nngu-pi-a*
Ole what-ache-QUE-3SG
Where is Ole hurting?

Ole
UC [**a**| (**a** = *ole*)°];
what- -ache
[*b*]; [*s w*| *feel.pain.in*⟨*w*, *s*: EXP: *d*β⟩, (EXP *s* = CTR *s*)°];
-QUE-3SG
^{P}[*d*ωε $=_{ω}$ **d**ε]; [⊂⟨*d*ω, *d*σ, **d**τ⟩]; [BEG *d*σ $\leq_{\vartheta d_{\omega}}$ *d*ωε, (CTR *d*σ = **d**α)°];
[*q*]; [*d*Ω = *d*ω{$|_{d\beta}$}]; [**Q**]; [**d**Ω*t* = *d*Ω{|}]; [*ask*⟨ω, *d*ωε: AGT: **d**Ω*t*⟩]

(6K) *Kina* *sunnguva*?
kina *su-nngu-pi-a*
who.SG what-ache-QUE-3SG
Who is hurting where?

who.SG
UC [**a**| *person*{ω, **a**}];
what- -ache
[*b*]; [*s w*| *feel.pain.in*⟨*w*, *s*: EXP: *d*β⟩, (EXP *s* = CTR *s*)°];
-QUE-3SG
^{P}[*d*ωε $=_{ω}$ **d**ε]; [⊂⟨*d*ω, *d*σ, **d**τ⟩]; [BEG *d*σ $\leq_{\vartheta d_{\omega}}$ *d*ωε, (CTR *d*σ = **d**α)°];
[*q*]; [*d*Ω = *d*ω{$|_{\mathbf{d}\alpha,\, d\beta}$}]; [**Q**]; [**d**Ω*t* = *d*Ω{|}]; [*ask*⟨ω, *d*ωε: AGT: **d**Ω*t*⟩]

(7) i. *Ole aniva*?
Ole ani-pi-a
Ole go.out-QUE-3SG
Has Ole gone out?

ii. *Qanga aniva*?
qanga ani-pi-a
$^{<}$when go.out-QUE-3SG
When did he go out?

(7i) Ole go.out-
UC $[\mathbf{a}|\ (\mathbf{a} = ole)^{o}]$; $[e\ w|\ go.out\langle w, e\text{: AGT}\rangle]$;
-QUE.3SG
$^{P}[d\omega\varepsilon =_{\omega} \mathbf{d}\varepsilon]$; $[\subset\{d\omega\text{: } d\varepsilon, \mathbf{d}\tau\}]$; $[d\varepsilon <_{\vartheta d_\omega} d\omega\varepsilon, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^{o}]$;
$[q]$; $[d\Omega = d\omega\{|\}]$; $[\mathbf{Q}]$; $[\mathbf{d}\Omega t = d\Omega\{|\}]$; $[ask\langle\omega, d\omega\varepsilon\text{: AGT: } \mathbf{d}\Omega t\rangle]$

$w \in {}^{\top}p_0$ • $e_0 =_0(w)$: e_0-agt asks $^{\top}\{p_1\}$
(i.e. whether w is a p_1-world)
| $[\![\vartheta]\!](w, e_0)$: e_0-instant

~~~~~~

$v \in p_1$ yes-answer to e_0-question $^{\top}\{p_1\}$
•———— e_1, $[\![\text{CON}|(e_1)$: Ole goes out, is out

(7ii) $^{<}$when go.out-
UC $[\mathbf{t}|\ \mathbf{t} <_{\forall \mathbf{d}\Omega} \vartheta(\omega\text{: } \mathbf{d}\varepsilon)]$; $[go.out\langle d\omega, d\varepsilon\text{: AGT}\rangle]$;
-QUE.3SG
$^{P}[d\omega\varepsilon =_{\omega} \mathbf{d}\varepsilon]$; $[\subset\{d\omega\text{: } d\varepsilon, \mathbf{d}\tau\}]$; $[d\varepsilon <_{\vartheta d_\omega} d\omega\varepsilon, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^{o}]$;
$[p]$; $[d\Omega = d\omega\{|_{\mathbf{d}\tau}\}]$; $[\mathbf{Q}]$; $[\mathbf{d}\Omega t = d\Omega\{|\}]$; $[ask\langle\omega, d\omega\varepsilon\text{: AGT: } \mathbf{d}\Omega t\rangle]$

$w \in {}^{\top}p_0$ • $e_0 = \underline{e}_0(w)$: e_0-agt asks $\{p_1\}$ & $^{\top}Q_2 = \{p_{21},\ldots\}$
(i.e. whether w is a p_1-world
& if so, for which $p_{2n} \subseteq p_1$, $w \in p_{2n}$)
$w \in q$ (i.e. whether w is a p_1-world)
| $[\![\vartheta]\!](w, e_0)$: e_0-instant

~~~~~~

$v \in p_1$ yes-answer to e_0-question $^{(\top)}\{p_1\}$
•———— e_1, $[\![\text{CON}|(e_1)$: Ole goes out, is out

~~~~~~

$v \in p_{2n} \subseteq p_1$ t_{2n}-answer to e_0-question $^{\top}Q_2 = \{\ldots p_{2n},\ldots\}$
|| $^{\top}t_{2n} < [\![\vartheta]\!](w, e_0)$: topical e_0-past
•———— e_1, $[\![\text{CON}|(e_1)$: Ole goes out, is out
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Questions: Partitions, answer sets, or both?

1 QUESTIONS AS PARTITIONS (GS 1982, 1984)

• INFERENCES FROM EMBEDDED QUESTIONS

(I) Ed knows whether Al is sick. (factive) iv/s̲ + YN-s̲
Al is sick.
Ed knows that Al is sick.

(II) Ed knows whether Al is sick.
Al is not sick.
Ed knows that Al is not sick.

(III) Ed told Bill whether Al is sick. (non-factive) iv\s̲ + YN-s̲
Al is sick.
Ed told Bill that Al is sick.

(IV) Ed told Bill whether Al is sick.
Al is not sick.
Ed told Bill that Al is not sick.

(V) Ed knows who is sick. iv\s̲ + WH-s̲
(Only) Al is sick.
Ed knows that (only) Al is sick.

(VII) Ed knows who likes whom.
Bill likes Al (and that's the full answer).
Ed knows that Bill likes Al (and that's the full answer).

• BASIC IDEA: To know *p* is to know any entailment of *p* (ditto for other attitude and speech reports.) In any world, an (embedded) question denotes the *exhaustive answer*, which entails all of the related *that*-complements.

• TWO-SORTED TYPE THEORY (Ty2): Basic terms

$a \in Typ$	Var_a	Con_a	Name of objects
s	*i*, *j*, *k*		indices (worlds)
st	*p*, *q*		propositions (sets of worlds)
(*st*)*t*	*Q*		sets of propositions (*p*-sets)
e	*x*, *y*, *z*	*al*, *bill*, *ed*,…	entities
set		*man*, *sick*, …	relations from worlds to entities
seet		*like*, …	relations from worlds to pairs of entities

• (EMBEDDED) QUESTIONS AS PARTITIONS (minus inessential complexities)[1]

cat	phrase	Ty2-translation	type
s	that Al is sick	$\lambda i[sick(i, al)]$	*st*
s	whether Al is sick	$\lambda j[sick(j, al) = sick(i, al)]$	*st*
s	who is sick	$\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, x)]$	*st*

Terminology
A *partition* of a set A is a family B of non-empty pairwise disjoint subsets of A such that $\cup B = A$.

Ex1:

$D_e = \{[\![al]\!], [\![ed]\!]\}$	$\langle w_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle w_0, [\![ed]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
$D_s = \{w_0, w_1, w_2, w_3\}$	$\langle w_1, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle w_1, [\![ed]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$
	$\langle w_2, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle w_2, [\![ed]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
	$\langle w_3, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle w_3, [\![ed]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

• $[\![\lambda i.\ sick(i, al)]\!]^g \qquad = {}^{\chi}\{w_0, w_1\}$

• $[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/w0]}$
$= {}^{\chi}\{v \in D_s |\ [\![sick]\!](v, [\![al]\!]) = [\![sick]\!](w_0, [\![al]\!])\}$
$= [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/w1]} \qquad = {}^{\chi}\{w_0, w_1\}$

$[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/w2]}$
$= [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/w3]} \qquad = {}^{\chi}\{w_2, w_3\}$

• $[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w0]}$
$= {}^{\chi}\{v \in D_s |\ \{d |\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{d |\ \langle w_0, d\rangle \in {}^{\{\}}[\![sick]\!]\}\} = {}^{\chi}\{w_0\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w1]}$
$= {}^{\chi}\{v \in D_s |\ \{d |\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{d |\ \langle w_1, d\rangle \in {}^{\{\}}[\![sick]\!]\}\} = {}^{\chi}\{w_1\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w2]}$
$= {}^{\chi}\{v \in D_s |\ \{d |\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{d |\ \langle w_2, d\rangle \in {}^{\{\}}[\![sick]\!]\}\} = {}^{\chi}\{w_2\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w3]}$
$= {}^{\chi}\{v \in D_s |\ \{d |\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{d |\ \langle w_3, d\rangle \in {}^{\{\}}[\![sick]\!]\}\} = {}^{\chi}\{w_3\}$

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[1] Following Montague 1973, GS '82 assume cat-to-type correspondence, so all phrases of a given category translate into the highest type instantiated for that category, e.g. 'know' is first translated into *know′* of type *s*(*sst*)(*se*)*t* (*sst* needed for 'wonder', *se* for 'is rising') and then simplified to $know'_*$ of type *s*(*st*)*et* by a meaning postulate. Based on cross-linguistic evidence, I give up cat-to-type correspondence and build meaning postulates into the basic meaning assignment—e.g. my *know* corresponds to GS $know'_*$.

2 FROM PARTITIONS TO EXHAUSTIVITY INFERENCES

• YN-COMPLEMENTS

(I) Ed knows whether Al is sick.
Al is sick.
Ed knows that Al is sick.

Ty2 $know(i, ed, \lambda j[sick(j, al) = sick(i, al)])$
$sick(i, al)$
$know(i, ed, \lambda j[sick(j, al)])$

PROOF. If (1) & (2), then (7).

1. $[\![know(i, ed, \lambda j[sick(j, al) = sick(i, al)])]\!]^g = 1$	premise 1
2. $[\![sick(i, al)]\!]^g = 1$	premise 2
3. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g) = 1$	(1), Ty2
4. $[\![sick]\!](g(i), [\![al]\!]) = 1$	(2), Ty2
5. $[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g$	
$= {}^{\chi}\{v \in D_s \mid [\![sick]\!](v, [\![al]\!]) = 1\}$	(4), Ty2
$= [\![\lambda j[sick(j, al)]]\!]^g$	Ty2
6. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[sick(j, al)]]\!]^g) = 1$	(3), (5)
7. $[\![know(i, ed, \lambda j[sick(j, al)])]\!]^g = 1$	Ty2

(II) Ed knows whether Al is sick.
Al is not sick.
Ed knows that Al is not sick.

Ty2 $know(i, ed, \lambda j[sick(j, al) = sick(i, al)])$
$\neg sick(i, al)$
$know(i, ed, \lambda j[\neg sick(j, al)])$

PROOF. If (1) & (2), then (7).

1. $[\![know(i, ed, \lambda j[sick(j, al) = sick(i, al)])]\!]^g = 1$	premise 1
2. $[\![\neg sick(i, al)]\!]^g = 1$	premise 2
3. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g) = 1$	(1), Ty2
4. $[\![sick]\!](g(i), [\![al]\!]) = 0$	(2), Ty2
5. $[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g$	
$= {}^{\chi}\{v \in D_s \mid [\![sick]\!](v, [\![al]\!]) = 0\}$	(4), Ty2
$= [\![\lambda j[\neg sick(j, al)]]\!]^g$	Ty2
6. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[\neg sick(j, al)]]\!]^g) = 1$	(3), (5)
7. $[\![know(i, ed, \lambda j[\neg sick(j, al)))]\!]^g = 1$	Ty2

(III) Ed told Bill whether Al is sick.
Al is sick.
Ed told Bill that Al is sick.

Ty2 $tell(i, ed, bill, \lambda j[sick(j, al) = sick(i, al)])$
$\underline{sick(i, al)}$
$tell(i, ed, bill, \lambda j[sick(j, al)])$

PROOF (as for (**I**)) If (1) & (2), then (7).

1. $[\![tell(i, ed, bill, \lambda j[sick(j, al) = sick(i, al)])]\!]^g = 1$	premise 1
2. $[\![sick(i, al)]\!]^g = 1$	premise 2
3. $[\![tell]\!](g(i), [\![ed]\!], [\![bill]\!], [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g) = 1$	(1), Ty2
4. $[\![sick]\!](g(i), [\![al]\!]) = 1$	(2), Ty2
5. $[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^g$	
$= {}^{\chi}\{v \in D_s \mid [\![sick]\!](v, [\![al]\!]) = 1\}$	(4), Ty2
$= [\![\lambda j[sick(j, al)]]\!]^g$	Ty2
6. $[\![tell]\!](g(i), [\![ed]\!], [\![bill]\!], [\![\lambda j[sick(j, al)]]\!]^g) = 1$	(3), (5)
7. $[\![tell(i, ed, bill, \lambda j[sick(j, al)])]\!]^g = 1$	Ty2

(IV) Ed told Bill whether Al is sick.
Al is not sick.
Ed told Bill that Al is not sick.

Ty2 $tell(i, ed, bill, \lambda j[sick(j, al) = sick(i, al)])$
$\underline{\neg sick(i, al)}$
$tell(i, ed, bill, \lambda j[\neg sick(j, al)])$

PROOF (as for **(II)**) Exercise.

REMARK.
In the proofs of **(I)–(IV)** the (non-)factivity of the main verb is irrelevant. If desired, factivity can be made explicit by means of meaning postulates e.g.:

MP_{fct}. $know(i, x, p) \leftrightarrow (p(i) \wedge believe(i, x, p))$

• WH-COMPLEMENTS

(V) Ed knows who is sick. (*strong* inf.)
Only Al is sick.
Ed knows that only Al is sick.

Ty2 $know(i, ed, \lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)])$
$\forall x(sick(i, x) \leftrightarrow x = al)$
$know(i, ed, \lambda j[\forall x(sick(j, x) \leftrightarrow x = al)])$

PROOF. If (1) & (2), then (7):
1. $[\![know(i, ed, \lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)])]\!]^g = 1$ prem. 1
2. $[\![\forall x(sick(i, x) \leftrightarrow x = al)]\!]^g = 1$ prem. 2
3. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)]]\!]^g) = 1$ (1), Ty2
4. $\{\mathrm{d}|\ \langle g(i), \mathrm{d}\rangle \in {}^{\{\}}[\![sick]\!]\} = \{[\![al]\!]\}$ (2), Ty2
5. $[\![\lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)]]\!]^g$
   $= {}^{\chi}\{\mathrm{w}|\ \{\mathrm{d}|\ \langle \mathrm{w}, \mathrm{d}\rangle \in {}^{\{\}}[\![sick]\!]\} = \{[\![al]\!]\}\}$ (4), Ty2
   $= [\![\lambda j[\forall x(sick(j, x) \leftrightarrow x = al)]]\!]^g$ Ty2
6. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[\forall x(sick(j, x) \leftrightarrow x = al)]]\!]^g) = 1$ (3), (5)
7. $[\![know(i, ed, \lambda j[\forall x(sick(j, x) \leftrightarrow x = al)])]\!]^g = 1$ Ty2

(VII) Ed knows who likes whom. (*strong* inf.)
Bill likes Al and that's the full answer.
Ed knows that [Bill likes Al and that's the full answer].

Ty2 $know(i, ed, \lambda j[\lambda xy.like(j, x, y) = \lambda xy.like(i, x, y)])$
$\forall xy(like(i, x, y) \leftrightarrow x = bill \wedge y = al)$
$know(i, ed, \lambda j[\forall xy(like(i, x, y) \leftrightarrow x = bill \wedge y = al)])$

PROOF. If (1) & (2), then (7):
1. $[\![know(i)(ed, \lambda j[\lambda xy.like(j, x, y) = \lambda xy.like(i, x, y)])]\!]^g = 1$ prem. 1
2. $[\![\forall xy(like(i, x, y) \leftrightarrow x = bill \wedge y = al)]\!]^g = 1$ prem. 2
3. $[\![know]\!](g(i), [\![ed]\!],$ (1), Ty2
   $[\![\lambda j[\lambda xy.like(j, x, y) = \lambda xy.like(i, x, y)]]\!]^g) = 1$
4. $\{\langle \mathrm{d}, \mathrm{d}'\rangle|\ \langle g(i), \mathrm{d}, \mathrm{d}'\rangle \in {}^{\{\}}[\![like]\!]\} = \{\langle [\![bill]\!], [\![al]\!]\rangle\}$ (2), Ty2
5. $[\![\lambda j[\lambda xy.like(j, x, y) = \lambda xy.like(i, x, y)]]\!]^g$
   $= {}^{\chi}\{\mathrm{w}|\ \{\langle \mathrm{d}, \mathrm{d}'\rangle|\ \langle \mathrm{w}, \mathrm{d}, \mathrm{d}'\rangle \in {}^{\{\}}[\![like]\!]\} = \{\langle [\![bill]\!], [\![al]\!]\rangle\}\}$ (4), Ty2
   $= [\![\lambda j[\forall xy(like(j, x, y) \leftrightarrow x = bill \wedge y = al)]]\!]^g$ Ty2
6. $[\![know]\!](g(i), [\![ed]\!],$
   $[\![\lambda j[\forall xy(like(j, x, y) \leftrightarrow x = bill \wedge y = al)]]\!]^g) = 1$ (3), (5)
7. $[\![know(i, ed, \lambda j[\forall xy(like(j, x, y) \leftrightarrow x = bill \wedge y = al)])]\!]^g = 1$ Ty2

($V_\subseteq$) Ed knows who is sick.
<u>Al is sick.</u>
Ed knows that Al is sick. (*weak* inf.)

Ty2 $know(i, ed, \lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)])$
$\underline{sick(i, al)}$
$know(i, ed, \lambda j[sick(j, al)])$

$MP_\subseteq$[2] $know(i, x, p) \wedge p \subseteq q \rightarrow know(i, x, q)$

PROOF of ($\mathbf{V}_\subseteq$): Assuming $MP_\subseteq$, if (1) & (2), then (8):

1. $[\![know(i, ed, \lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)])]\!]^g = 1$ prem. 1
2. $[\![sick(i, al)]\!]^g = 1$ prem. 2
3. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)]]\!]^g) = 1$ (1), Ty2
4. $[\![sick]\!](g(i), [\![al]\!]) = 1$ (2), Ty2
5. $[\![al]\!] \in \{\mathtt{d} | \langle g(i), \mathtt{d}\rangle \in {}^{\{\}}[\![sick]\!]\}$ {–|–}
6. $[\![\lambda j[\lambda x.sick(j, x) = \lambda x.sick(i, x)]]\!]^g$
   $= {}^{\chi}\{\mathtt{w} | \{\mathtt{d} | \langle \mathtt{w}, \mathtt{d}\rangle \in {}^{\{\}}[\![sick]\!]\} = \{\mathtt{d} | \langle g(i), \mathtt{d}\rangle \in {}^{\{\}}[\![sick]\!]\}\}$ Ty2
   $\subseteq {}^{\chi}\{\mathtt{w} | [\![al]\!] \in \{\mathtt{d} | \langle \mathtt{w}, \mathtt{d}\rangle \in {}^{\{\}}[\![sick]\!]\}\}$ (5), {–|–}
   $= {}^{\chi}\{\mathtt{w} | \langle \mathtt{w}, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]\}$ {–|–}
   $= [\![\lambda j[sick(j, al)]]\!]^g$ Ty2
7. $[\![know]\!](g(i), [\![ed]\!], [\![\lambda j[sick(j, al)]]\!]^g) = 1$ (3), (5), $MP_\subseteq$
8. $[\![know(i, ed, \lambda j[sick(j, al)])]\!]^g = 1$ Ty2

[2] $p \subseteq q := \forall j(p(j) \rightarrow q(j))$

3 FROM ANSWER SETS TO PARTITIONS

• FROM RANKING SETS TO ORDERING RELATIONS (Lewis 1981)

Given a set $\mathtt{Q}$ of propositions:

i$_<$. world $\mathtt{v}$ is $\mathtt{Q}$-better than world $\mathtt{w}$,

$\mathtt{v} <_{\mathtt{Q}} \mathtt{w}$ iff $\{\mathtt{q} | \mathtt{q} \in \mathtt{Q} \wedge \mathtt{w} \in \mathtt{q}\} \subset \{\mathtt{q} | \mathtt{q} \in \mathtt{Q} \wedge \mathtt{v} \in \mathtt{q}\}$

ii$_<$. the set of $\mathtt{Q}$-best $\mathtt{p}$-worlds,

$\text{MIN}_{\mathtt{Q}}(\mathtt{p}) := \{\mathtt{w} | \mathtt{w} \in \mathtt{p} \wedge \neg\exists \mathtt{v}(\mathtt{v} \in \mathtt{p} \wedge \mathtt{v} <_{\mathtt{Q}} \mathtt{w})\}$

Terminology: For any relation R on a non-empty set A,

- R is a (*weak*) *partial order* (on A) iff R is transitive ($xRy \wedge yRz \to xRz$), reflexive (xRx, for all $x \in A$) & antisymmetric ($xRy \wedge yRx \to x = y$)
- R is a *strict* (*partial*) *order* (on A) iff
  R is transitive & irreflexive ($\neg xRx$, for all $x \in A$)

• FROM ANSWER SETS TO EQUIVALENCE RELATIONS

Given a set $\mathtt{Q}$ of propositions:

i$_\equiv$. world $\mathtt{v}$ is $\mathtt{Q}$-equivalent to world $\mathtt{w}$,

$\mathtt{v} \equiv_{\mathtt{Q}} \mathtt{w}$ iff $\{\mathtt{q} | \mathtt{q} \in \mathtt{Q} \wedge \mathtt{w} \in \mathtt{q}\} = \{\mathtt{q} | \mathtt{q} \in \mathtt{Q} \wedge \mathtt{v} \in \mathtt{q}\}$

ii$_\equiv$. the $\mathtt{Q}$-equvalence class of $\mathtt{v}$,

$\text{EQU}_{\mathtt{Q}}(\mathtt{v}) := \{\mathtt{w} | \mathtt{v} \equiv_{\mathtt{Q}} \mathtt{w}\}$

Terminology:

- $R \subseteq A \times A$ is an *equivalence relation* on A iff
  Dom $R = A$ and R is transitive, reflexive & symmetric ($xRy \to yRx$)
- $[x]_R := \{y \in A | xRy\}$ is the *(R-)equivalence class* of x, for all $x \in A$.
- $A/R := \{[x]_R | x \in A\}$ is called *A modulo R*.

FACT: If R is an equivalence relation on A, then A/R is a partition of A.

PROOF (outline):

(a) For all $x \in A$, xRx (by reflexivity). Hence $x \in [x]_R$, and so $[x]_R \neq \emptyset$.

(b) $\cup(A/R) = \cup\{\{y \in A | xRy\} | x \in A\} = A$, given (a) & Dom $R = A$.

(c) $xRy \to [x]_R = [y]_R$.

- ($\subseteq$). Suppose $z \in [x]_R$. Then xRz (df. $[x]_R$) and so zRx (symm.). Hence zRy (by tr., given xRy), and so yRz (symm.). Therefore, $z \in [y]_R$.
- ($\supseteq$). Analogous reasoning.

(d) $\neg xRy \to [x]_R \cap [y]_R = \emptyset$.

Suppose $z \in [x]_R$ & $z \in [y]_R$. Then xRz & yRz. Hence zRy (symm.), xRy (tr.), and $[x]_R = [y]_R$ (by (c)). But then $[x]_R \cap [y]_R = [x]_R \neq \emptyset$ (by (a)).

• PARTITIONS ON DEMAND

Ex1:

$D_e = \{[\![al]\!], [\![ed]\!]\}$	$\langle \mathtt{w}_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_0, [\![ed]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
$D_s = \{\mathtt{w}_0, \mathtt{w}_1, \mathtt{w}_2, \mathtt{w}_3\}$	$\langle \mathtt{w}_1, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_1, [\![ed]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$
	$\langle \mathtt{w}_2, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_2, [\![ed]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
	$\langle \mathtt{w}_3, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$	$\langle \mathtt{w}_3, [\![ed]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

cat	phrase	Ty2-translation
s	whether Al is sick	$\lambda j[sick(j, al) = sick(i, al)]$
	(Q = B(ittner) set)	$= \lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al)] \wedge j \equiv_Q i)]$
	(Q = H(amblin) set)	$= \lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al) \vee p = \lambda k.\neg sick(k, al)] \wedge j \equiv_Q i)]$

• GS partition

$[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/\mathtt{w}0]}$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ [\![sick]\!](\mathtt{v}, [\![al]\!]) = [\![sick]\!](\mathtt{w}_0, [\![al]\!])\}$

$= [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/\mathtt{w}1]}$ $\qquad = {}^{\chi}\{\mathbf{w_0}, \mathbf{w_1}\}$

$[\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/\mathtt{w}2]}$

$= [\![\lambda j[sick(j, al) = sick(i, al)]]\!]^{g[i/\mathtt{w}3]}$ $\qquad = {}^{\chi}\{\mathbf{w_2}, \mathbf{w_3}\}$

• B answer-set induced partition

$[\![\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al)] \wedge j \equiv_Q i)]]\!]^{g[i/\mathtt{w}0]}$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \exists \mathtt{Q}(\mathtt{Q} = \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \equiv_{\mathtt{Q}} \mathtt{w}_0)\}$ $\qquad$ Ty2

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \in {}^{\{\}}\mathtt{q}\}$

$\qquad = \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{w}_0 \in {}^{\{\}}\mathtt{q}\}\}$ $\qquad \equiv_{\mathtt{Q}}$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \in {}^{\{\}}\mathtt{q}\}$

$\qquad = \{[\![\lambda k[sick(k, al)]]\!]^g\}\}$ $\qquad \mathtt{w}_0$

$= [\![\lambda k[sick(k, al)]]\!]^g$ $\qquad$ Ty2

$= [\![\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al)] \wedge j \equiv_Q i)]]\!]^{g[i/\mathtt{w}1]}$ $\qquad = {}^{\chi}\{\mathbf{w_0}, \mathbf{w_1}\}$

$[\![\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al)] \wedge j \equiv_Q i)]]\!]^{g[i/\mathtt{w}2]}$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \exists \mathtt{Q}(\mathtt{Q} = \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \equiv_{\mathtt{Q}} \mathtt{w}_2)\}$ $\qquad$ Ty2

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \in {}^{\{\}}\mathtt{q}\}$

$\qquad = \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{w}_2 \in {}^{\{\}}\mathtt{q}\}\}$ $\qquad \equiv_{\mathtt{Q}}$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \{\mathtt{q} |\ \mathtt{q} \in \{[\![\lambda k[sick(k, al)]]\!]^g\} \wedge \mathtt{v} \in {}^{\{\}}\mathtt{q}\}$

$\qquad = \{\}\}$ $\qquad \mathtt{w}_2$

$= {}^{\chi}\{\mathtt{v} \in D_s |\ \mathtt{v} \notin {}^{\{\}}[\![\lambda k[sick(k, al)]]\!]^g\}$ $\qquad \{-|-\}$

$= [\![\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al)] \wedge j \equiv_Q i)]]\!]^{g[i/\mathtt{w}3]}$ $\qquad = {}^{\chi}\{\mathbf{w_0}, \mathbf{w_1}\}$

H answer-set induced partition

$⟦\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al) \lor p = \lambda k.\neg sick(k, al)]$
$\quad \land j \equiv_Q i)]⟧^{g[i/w0]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \equiv_Q w_0)\}$ Ty2
$= {}^{\chi}\{v \in D_s |\ \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \in {}^{\{\}}q\}$
$\quad = \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land w_0 \in {}^{\{\}}q\}\}$ $\equiv_Q$
$= {}^{\chi}\{v \in D_s |\ \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \in {}^{\{\}}q\}$
$\quad = \{⟦\lambda k[sick(k, al)]⟧^g\}\}$ w_0
$= {}^{\chi}\{v \in D_s |\ v \in {}^{\{\}}⟦\lambda k[sick(k, al)]⟧^g \land v \notin ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$= ⟦\lambda k[sick(k, al)]⟧^g$ Ty2
$= ⟦\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al) \lor p = \lambda k.\neg sick(k, al)]$
$\quad \land j \equiv_Q i)]⟧^{g[i/w1]}$ $= {}^{\chi}\{\mathbf{w_0, w_1}\}$

$⟦\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al) \lor p = \lambda k.\neg sick(k, al)]$
$\quad \land j \equiv_Q i)]⟧^{g[i/w2]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \equiv_Q w_2)\}$ Ty2
$= {}^{\chi}\{v \in D_s |\ \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \in {}^{\{\}}q\}$
$\quad = \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land w_0 \in {}^{\{\}}q\}\}$ $\equiv_Q$
$= {}^{\chi}\{v \in D_s |\ \{q |\ q \in \{⟦\lambda k[sick(k, al)]⟧^g, ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$\quad \land v \in {}^{\{\}}q\}$
$\quad = \{⟦\lambda k[\neg sick(k, al)]⟧^g\}\}$ w_2
$= {}^{\chi}\{v \in D_s |\ v \notin {}^{\{\}}⟦\lambda k[sick(k, al)]⟧^g \land v \in ⟦\lambda k[\neg sick(k, al)]⟧^g\}$
$= ⟦\lambda k[\neg sick(k, al)]⟧^g$ Ty2
$= ⟦\lambda j[\exists Q(Q = \lambda p[p = \lambda k.sick(k, al) \lor p = \lambda k.\neg sick(k, al)]$
$\quad \land j \equiv_Q i)]⟧^{g[i/w3]}$ $= {}^{\chi}\{\mathbf{w_2, w_3}\}$

cat	phrase	Ty2-translation
s	who is sick	$\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, x)]$
		$= \lambda j[\exists Q(Q = \lambda p[\exists x(p = \lambda k.sick(k, x))] \land j \equiv_Q i)]$

- <u>GS partition</u>

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w0]}$
$= {}^{\chi}\{v \in D_s |\ \{d|\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\}$
$\quad = \{d|\ \langle w_0, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{[\![al]\!], [\![ed]\!]\}\} \quad = {}^{\chi}\{\mathbf{w_0}\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w1]}$
$= {}^{\chi}\{v \in D_s |\ \{d|\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\}$
$\quad = \{d|\ \langle w_1, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{[\![al]\!]\}\} \quad = {}^{\chi}\{\mathbf{w_1}\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w2]}$
$= {}^{\chi}\{v \in D_s |\ \{d|\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\}$
$\quad = \{d|\ \langle w_2, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{[\![ed]\!]\}\} \quad = {}^{\chi}\{\mathbf{w_2}\}$

$[\![\lambda j[\lambda x.\ sick(j, x) = \lambda x.\ sick(i, al)]]\!]^{g[i/w3]}$
$= {}^{\chi}\{v \in D_s |\ \{d|\ \langle v, d\rangle \in {}^{\{\}}[\![sick]\!]\}$
$\quad = \{d|\ \langle w_3, d\rangle \in {}^{\{\}}[\![sick]\!]\} = \{\}\} \quad = {}^{\chi}\{\mathbf{w_3}\}$

- <u>Answer-set induced partition</u>

$[\![\lambda j[\exists Q(Q = \lambda p[\exists x(p = \lambda k.sick(k, x))] \wedge j \equiv_Q i)]]\!]^{g[i/w0]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \equiv_Q w_0)\}$
$= {}^{\chi}\{v \in D_s |\ \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \in q\}$
$\quad = \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge w_0 \in q\}$
$\quad = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in \{[\![al]\!], [\![ed]\!]\}\}\} \quad = {}^{\chi}\{\mathbf{w_0}\}$

$[\![\lambda j[\exists Q(Q = \lambda p[\exists x(p = \lambda k.sick(k, x))] \wedge j \equiv_Q i)]]\!]^{g[i/w1]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \equiv_Q w_1)\}$
$= {}^{\chi}\{v \in D_s |\ \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \in q\}$
$\quad = \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge w_1 \in q\}$
$\quad = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in \{[\![al]\!]\}\}\} \quad = {}^{\chi}\{\mathbf{w_1}\}$

$[\![\lambda j[\exists Q(Q = \lambda p[\exists x(p = \lambda k.sick(k, x))] \wedge j \equiv_Q i)]]\!]^{g[i/w2]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \equiv_Q w_2)\}$
$= {}^{\chi}\{v \in D_s |\ \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \in q\}$
$\quad = \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge w_2 \in q\}$
$\quad = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in \{[\![ed]\!]\}\}\} \quad = {}^{\chi}\{\mathbf{w_2}\}$

$[\![\lambda j[\exists Q(Q = \lambda p[\exists x(p = \lambda k.sick(k, x))] \wedge j \equiv_Q i)]]\!]^{g[i/w3]}$
$= {}^{\chi}\{v \in D_s |\ \exists Q(Q = \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \equiv_Q w_3)\}$
$= {}^{\chi}\{v \in D_s |\ \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge v \in q\}$
$\quad = \{q|\ q \in \{[\![\lambda k[sick(k, x)]]\!]^{g[x/d]} |\ d \in D_e\} \wedge w_3 \in q\}$
$\quad = \{\}\} \quad = {}^{\chi}\{\mathbf{w_3}\}$

4 TOWARD INCREMENTAL TRANSLATION

• TWO-SORTED UPDATE WITH CENTERING (UC2): Basic terms

$\mathsf{a} \in Typ$	${}^{\top}Var_{\mathsf{a}}$	${}^{\perp}Var_{\mathsf{a}}$	Con_{a}	Name of objects
s		i, j		indices ($\top\perp$-lists)
st		I, J		infotention states
e	$\mathbf{x}$	y	$al, bill, \ldots$	entities
ω	$\mathbf{w}$	v		worlds
$\omega t := \Omega$	$\mathbf{p}$	q		propositions (sets of worlds)
Ωt	$\mathbf{Q}$	Q		sets of propositions
ωet			$man, sick, \ldots$	ωet-relations
ωeet			$like, \ldots$	ωeet-relations
$s\mathsf{a}$			$\mathbf{d}\mathsf{a}_n, d\mathsf{a}_n$	a-projections, $\mathsf{a} \in \{e, \omega, \Omega\}$

• MATRIX IND WITH DEFAULT ORDER

Ex1:

$p_0 = \{w_0, w_1\} =: {}_{01}$ $\quad\langle w_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$

$*p_0 := \{\langle\langle v, p_0\rangle, \langle\,\rangle\rangle : v \in p_0\}$ $\quad\langle w_1, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

$*({}_{01})$

$\langle\langle w_0, {}_{01}\rangle, \langle\,\rangle\rangle$

$\langle\langle w_1, {}_{01}\rangle, \langle\,\rangle\rangle$

(I^2) (sentence 2 in inference (I))

Al	be.IND	sick	. (prosody)
$[\mathbf{x}\vert\ (\mathbf{x} = al)°];$	${}^{P}[\mathbf{d}\omega \in \mathbf{d}\omega\{\vert\}];$	$[sick\langle\mathbf{d}\omega, \mathbf{d}e\rangle];$	$[\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{\vert\}]$
c_1	c_1	c_2	c_3 $({}_0 := \{w_0\})$
$\langle\langle[\![al]\!], w_0, {}_{01}\rangle, \langle\,\rangle\rangle$		$\langle\langle[\![al]\!], w_0, {}_{01}\rangle, \langle\,\rangle\rangle$	$\langle\langle{}_0, [\![al]\!], w_0, {}_{01}\rangle, \langle\,\rangle\rangle$
$\langle\langle[\![al]\!], w_1, {}_{01}\rangle, \langle\,\rangle\rangle$			

(II^2) (sentence 2 in inference (II))

Al	be.IND	not[
$[\mathbf{x}\vert\ (\mathbf{x} = al)°];$	${}^{P}[\mathbf{d}\omega \in \mathbf{d}\omega\{\vert\}];$	$[p\ w\vert\ \mathbf{d}\omega \notin p, w \in p];$
c_1	c_1	c_2 $({}_1 := \{w_1\})$
$\langle\langle[\![al]\!], w_0, {}_{01}\rangle, \langle\,\rangle\rangle$		$\langle\langle[\![al]\!], w_0, {}_{01}\rangle, \langle{}_1, w_1\rangle\rangle$
$\langle\langle[\![al]\!], w_1, {}_{01}\rangle, \langle\,\rangle\rangle$		$\langle\langle[\![al]\!], w_1, {}_{01}\rangle, \langle{}_0, w_0\rangle\rangle$

sick	]	. (prosody)
$[sick\langle d\omega, \mathbf{d}e\rangle];$	$[d\Omega = d\omega\{\vert_{\mathbf{d}e}\}];$	$[\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{\vert\}]$
c_3	c_4	c_5
$\langle\langle[\![al]\!], w_1, {}_{01}\rangle, \langle{}_0, w_0\rangle\rangle$	$\langle\langle[\![al]\!], w_1, {}_{01}\rangle, \langle{}_0, w_0\rangle\rangle$	$\langle\langle{}_1, [\![al]\!], w_1, {}_{01}\rangle, \langle{}_0, w_0\rangle\rangle$

• EMBEDDED [*that*…IND]

<u>Ex2</u>:

$\mathtt{p}_0 = \{\mathtt{w}_0, \mathtt{w}_1, \mathtt{w}_2, \mathtt{w}_3\}$
$\quad =: {}_{0\text{–}3}$

$\langle \mathtt{w}_0, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$ $\qquad \langle \mathtt{w}_0, [\![ed]\!], {}_{01}\rangle \in {}^{\{\}}[\![bel]\!]$
$\langle \mathtt{w}_1, [\![al]\!]\rangle \in {}^{\{\}}[\![sick]\!]$ $\qquad \langle \mathtt{w}_1, [\![ed]\!], {}_{023}\rangle \in {}^{\{\}}[\![bel]\!]$
$\langle \mathtt{w}_2, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$ $\qquad \langle \mathtt{w}_2, [\![ed]\!], {}_{23}\rangle \in {}^{\{\}}[\![bel]\!]$
$\langle \mathtt{w}_3, [\![al]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$ $\qquad \langle \mathtt{w}_3, [\![ed]\!], {}_{123}\rangle \in {}^{\{\}}[\![bel]\!]$

$*({}_{0\text{–}3})$
$\langle\langle \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle\rangle\rangle$
$\langle\langle \mathtt{w}_1, {}_{0\text{–}3}\rangle, \langle\rangle\rangle$
$\langle\langle \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle\rangle\rangle$
$\langle\langle \mathtt{w}_3, {}_{0\text{–}3}\rangle, \langle\rangle\rangle$

(I^3) (sentence 3 in inference (I))

Ed	know-	-IND[
$[\mathbf{x}\vert\ (\mathbf{x} = ed)°]$;	$[p\vert\ (\mathbf{d}\omega \in p)°, bel\langle \mathbf{d}\omega, \mathbf{d}e, p\rangle]$;	${}^{P}[\mathbf{d}\omega \in \mathbf{d}\omega\{\vert\}]$;
$\mathtt{c}_1$	$\mathtt{c}_2$	$\mathtt{c}_2$
$\langle\langle [\![ed]\!], \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle\ \rangle\rangle$	$\langle\langle [\![ed]\!], \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle {}_{01}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle {}_{012}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle {}_{013}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_0, {}_{0\text{–}3}\rangle, \langle {}_{0\text{–}3}\rangle\rangle$	
$\langle\langle [\![ed]\!], \mathtt{w}_1, {}_{0\text{–}3}\rangle, \langle\ \rangle\rangle$	$\langle\langle [\![ed]\!], \mathtt{w}_1, {}_{0\text{–}3}\rangle, \langle {}_{0\text{–}3}\rangle\rangle$	
$\langle\langle [\![ed]\!], \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle\ \rangle\rangle$	$\langle\langle [\![ed]\!], \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle {}_{23}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle {}_{023}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle {}_{123}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_2, {}_{0\text{–}3}\rangle, \langle {}_{0\text{–}3}\rangle\rangle$	
$\langle\langle [\![ed]\!], \mathtt{w}_3, {}_{0\text{–}3}\rangle, \langle\ \rangle\rangle$	$\langle\langle [\![ed]\!], \mathtt{w}_3, {}_{0\text{–}3}\rangle, \langle {}_{123}\rangle\rangle$	
	$\langle\langle [\![ed]\!], \mathtt{w}_3, {}_{0\text{–}3}\rangle, \langle {}_{0\text{–}3}\rangle\rangle$	

THAT[	Al	be.IND
$[\mathbf{w}\vert\ (\mathbf{w} \in d\Omega)°]$;	$[\mathbf{x}\vert\ (\mathbf{x} = al)°]$;	${}^{P}[\mathbf{d}\omega \in \mathbf{d}\omega\{\vert\}]$;
$\mathtt{c}_3$	$\mathtt{c}_4$	$\mathtt{c}_4$

sick	$]_{\text{THAT}}$
$[sick\langle \mathbf{d}\omega, \mathbf{d}e\rangle]$;	$[\mathbf{x}\vert\ (\mathbf{x} = \mathbf{d}e_2)°]$; $[\mathbf{w}\vert\ (\mathbf{w} = \mathbf{d}\omega_2)°]$;
$\mathtt{c}_5$	$\mathtt{c}_6$

$]_{know}$	. (prosody)
$[d\Omega = \mathbf{d}\omega_2\{\vert_{\mathbf{d}\omega,\, \mathbf{d}e}\}]$;	$[\mathbf{p}]$; $[\mathbf{d}\Omega = \mathbf{d}\omega\{\vert\}]$
$\mathtt{c}_7$	$\mathtt{c}_8$

APPENDIX UC: *Update with Centering*

D1.1 Definition (Infotention states). Let D be a non-empty set of objects.

- $Z^{n,m} = D^n \times D^m$ is the set of structured stacks with n topical objects and m background objects, for all natural numbers $n, m \in \mathbf{N}$
- $C^{n,m} = Pow(Z^{n,m})$ is the set of states of infotention about n topical objects and m background objects
- $C = \cup_{n, m \in \mathbf{N}} C^{n,m}$ is the set of states of infotention

A1 Abbreviations (Stacks, cardinality, extensions)

- For $\mathtt{z} = \langle \mathtt{z}_1, \mathtt{z}_2 \rangle \in Z^{n,m}$, $\top\mathtt{z} := \mathtt{z}_1$ is the top stack of $\mathtt{z}$ and $\bot\mathtt{z} := \mathtt{z}_2$ is the bottom stack of $\mathtt{z}$
- For $\mathtt{z} \in Z^{n,m}$ ($\mathtt{c} \in C^{n,m}$), $|\mathtt{z}|_\top := n$ ($=: |\mathtt{c}|_\top$) and $|\mathtt{z}|_\bot := m$ ($=: |\mathtt{c}|_\bot$)
- $(\mathtt{x} \cdot \mathtt{y}) := \langle \mathtt{x}_1, \ldots, \mathtt{x}_n, \mathtt{y}_1, \ldots, \mathtt{y}_m \rangle \in D^{n+m}$, for $\mathtt{x} \in D^n$ and $\mathtt{y} \in D^m$
- $\mathtt{y}$ extends $\mathtt{x}$, $\mathtt{x} \leq \mathtt{y}$, iff $\exists \mathtt{x}'$: $\mathtt{y} = (\mathtt{x}' \cdot \mathtt{x})$

D1.2 Definition (Infotention update) State $\mathtt{c}'$ is an *update* of state $\mathtt{c}$, $\mathtt{c} \leq \mathtt{c}'$, iff $|\mathtt{c}|_\top \leq \mathtt{c}'|_\top \wedge |\mathtt{c}|_\bot \leq |\mathtt{c}'|_\bot \wedge \forall \mathtt{z}' \in \mathtt{c}' \exists \mathtt{z} \in \mathtt{c}(\top\mathtt{z} \leq \top\mathtt{z}' \wedge \bot z \leq \bot\mathtt{z}')$

D2.1 Definition (*UC* types). The set of *UC* types, *Typ*, is the smallest set Y such that (i) $\{\alpha, \beta, \varepsilon, \sigma, \tau, \omega, s, t\} \subseteq Y$, and (ii) $(\mathsf{ab}) \in Y$ if $\mathsf{a}, \mathsf{b} \in Y$.

The subset $DTyp := \{\alpha, \beta, \varepsilon, \sigma, \tau, \omega, (\omega\varepsilon), (\omega t), ((\omega t)t)\} \subseteq Typ$ is the set of UC types of discourse objects.

D2.2 Definition (UC frames). A UC frame is a set of sets $\{D_\mathsf{a}\}_{\mathsf{a} \in Typ}$ where

i. $D_\alpha, D_\beta, D_\varepsilon, D_\sigma, D_\tau, D_\omega$ and D_t are non-empty pairwise disjoint sets

ii. $D_\alpha = \{\mathtt{a} \subseteq \mathbf{A} | \ \mathtt{a} \neq \varnothing\}$ for some non-empty set $\mathbf{A}$ (of α-*atoms*)

$D_\tau = \{\mathtt{t} \subseteq \mathbf{Z} | \ \mathtt{t} \neq \varnothing \wedge \forall n, n' \in \mathtt{t} \forall m \in \mathbf{Z}(n < m < n' \rightarrow m \in \mathtt{t})\}$

iii. $D_t = \{1, 0\}$

iv. $D_s = \cup_{n, m \in \mathbf{N}} (D^n \times D^m)$, where $D = \cup_{\mathsf{a} \in DTyp} D_\mathsf{a}$

v. $D_{(\mathsf{ab})} = \{f | \ \varnothing \subset \text{Dom } f = D_\mathsf{a} \wedge \text{Ran } f \subseteq D_\mathsf{b}\}$, if $\mathsf{b} = t$

$= \{f | \ \varnothing \subset \text{Dom } f \subseteq D_\mathsf{a} \wedge \text{Ran } f \subseteq D_\mathsf{b}\}$, if $\mathsf{b} \neq t$

A2 Abbreviations (Basic terms of UC)

$\mathsf{a} \in Typ$	$^{\top}Var_{\mathsf{a}}$	$^{\bot}Var_{\mathsf{a}}$	Con_{a}	Name of objects
s		i, j		structured stacks
st		I, J		infotention states
α	$\mathbf{a}$	a	$john$	animate (entities)
β	$\mathbf{b}$	b	$John$	inanimate (entities)
ε	$\mathbf{e}$	e		events
σ	$\mathbf{s}$	s		states (of entities)
τ	$\mathbf{t}$	t		times
ω	$\mathbf{w}, \mathbf{v}$	w, v		worlds
$\omega\varepsilon$	$\underline{\mathbf{e}}$	$\underline{e}$		event concepts
$\omega t =: \Omega$	$\mathbf{p}, \mathbf{q}$	p, q		propositions (sets of worlds)
Ωt	$\mathbf{Q}$	Q		sets of propositions
$\omega\tau\alpha t$			man, …	$\omega\tau\alpha$-relations
$\omega\sigma\alpha t$			$happy$, …	$\omega\sigma\alpha$-relations
$\omega\varepsilon\alpha t$			$speak$, …	$\omega\varepsilon\alpha$-relations
$\omega\sigma\alpha\Omega t$			$hope$, …	$\omega\sigma\alpha\Omega$-relations
$\omega\varepsilon\alpha\Omega t$			$promise$, …	$\omega\varepsilon\alpha\Omega$-relations
$\omega\varepsilon\alpha\alpha\Omega t$			$direct.to$, …	$\omega\varepsilon\alpha\alpha\Omega$-relations
$\omega\varepsilon\alpha(\Omega t)t$			ask, …	$\omega\varepsilon\alpha(\Omega t)$-relations
$\varepsilon\alpha$			AGT	ε-dependent animates
$\varepsilon\sigma$			CON	ε-dependent states
$\sigma\varepsilon$			BEG, END	σ-dependent events
$s\mathsf{a}$			$\mathbf{d}\mathsf{a}_1, \mathbf{d}\mathsf{a}_2, \ldots$ $d\mathsf{a}_1, d\mathsf{a}_2, \ldots$	a-projections ($\mathsf{a} \in DTyp$)

A3 Abbreviations (Functions, projections, **τ**-precedence and **τ**-sum)

- For $f \in D_{\mathsf{a}1\ldots\mathsf{a}n t}$ and $\langle a_1, \ldots, a_n\rangle \subseteq D_{\mathsf{a}1} \times \ldots \times D_{\mathsf{a}n}$,
  $f(a_1, \ldots, a_n) := f(a_1)\ldots(a_n)$
  ${}^{\{\}}(f) := \{\langle a_1,\ldots a_n\rangle: f(a_1,\ldots a_n) = 1\}$ is the set characterized by f
  ${}^{\chi}(A) := f$ is the characteristic function of A, iff ${}^{\{\}}(f) = A$
- For $x \in D^{n+m}$, $(x)_n$ is the nth coordinate of x, and ${}^{\mathsf{a}}(x)$ (read: the a-subsequence of x) is the sequence of the D_{a}-coordinates of x
- t **τ**-precedes t', $t <_{\tau} t'$, iff $t, t' \in D_{\tau} \wedge \forall m \in t \forall n \in t'(m < n)$
  $t \cup_{\tau} t' := \inf_{\subseteq}\{t'' \in D_{\tau} | \, t \subseteq t'' \wedge t' \subseteq t''\}$

D2.3 Definition (UC models). A UC model is a pair $\langle\{D_{\mathrm{a}}\}_{\mathrm{a}}, [\![\cdot]\!]\rangle$ where $\{D_{\mathrm{a}}\}_{\mathrm{a}}$ is a UC frame and $[\![\cdot]\!]$ assigns $[\![A]\!] \in D_{\mathrm{a}}$ to each $A \in Con_{\mathrm{a}}$. Moreover:

i. $\mathrm{Dom}\,[\![\mathbf{d}\mathrm{a}_n]\!] = \{\mathrm{z} \in D_s | \exists m \in \mathbf{N}: {}^{\mathrm{a}}(\top\mathrm{z}) \in (D_{\mathrm{a}})^{n+m}\}$
$\wedge\ \forall \mathrm{z} \in \mathrm{Dom}\,[\![\mathbf{d}\mathrm{a}_n]\!]: [\![\mathbf{d}\mathrm{a}_n]\!](\mathrm{z}) = ({}^{\mathrm{a}}(\top\mathrm{z}))_n$
$\mathrm{Dom}\,[\![d\mathrm{a}_n]\!] = \{\mathrm{z} \in D_s | \exists m \in \mathbf{N}: {}^{\mathrm{a}}(\bot\mathrm{z}) \in (D_{\mathrm{a}})^{n+m}\}$
$\wedge\ \forall \mathrm{z} \in \mathrm{Dom}\,[\![d\mathrm{a}_n]\!]: [\![d\mathrm{a}_n]\!](\mathrm{z}) = ({}^{\mathrm{a}}(\bot\mathrm{z}))_n$

ii. $\varnothing \subset \mathrm{Dom}\,[\![\mathrm{AGT}]\!] = D_\varepsilon \backslash(\mathrm{Ran}\,[\![\mathrm{BEG}]\!] \cup \mathrm{Ran}\,[\![\mathrm{END}]\!])$
$\varnothing \subset \mathrm{Dom}\,[\![F]\!] \subseteq D_\varepsilon \cup D_\sigma \wedge \mathrm{Ran}\,[\![F]\!] \subseteq D_\alpha$ for $F \in \{\mathrm{EXP}, \mathrm{CTR}\}$
$\varnothing \subset \mathrm{Dom}\,[\![\mathrm{CTR}']\!] \subseteq D_\varepsilon \cup D_\sigma \wedge \mathrm{Ran}\,[\![\mathrm{CTR}']\!] \subseteq D_\beta$
$\forall \mathrm{e} \in \mathrm{Dom}\,[\![\mathrm{AGT}]\!]: [\![\mathrm{CTR}]\!](\mathrm{e}) = [\![\mathrm{AGT}]\!](\mathrm{e}) = [\![\mathrm{EXP}]\!]([\![\mathrm{CON}]\!](\mathrm{e}))$
$\forall \mathrm{e} \in \mathrm{Dom}\,[\![\mathrm{EXP}]\!]\backslash\mathrm{Dom}\,[\![\mathrm{AGT}]\!]: [\![\mathrm{EXP}]\!](\mathrm{e}) = [\![\mathrm{EXP}]\!]([\![\mathrm{CON}]\!](\mathrm{e}))$
$\forall \mathrm{s} \in \mathrm{Dom}\,[\![\mathrm{EXP}]\!]: [\![\mathrm{EXP}]\!](\mathrm{s}) = [\![\mathrm{EXP}]\!]([\![\mathrm{BEG}]\!](\mathrm{s})) = [\![\mathrm{EXP}]\!]([\![\mathrm{END}]\!](\mathrm{s}))$
$\forall \mathrm{e} \in \mathrm{Dom}\,[\![\mathrm{CTR}]\!]\backslash\mathrm{Dom}\,[\![\mathrm{AGT}]\!]: [\![\mathrm{CTR}]\!](\mathrm{e}) = [\![\mathrm{CTR}]\!]([\![\mathrm{CON}]\!](\mathrm{e})))$
$\forall \mathrm{s} \in \mathrm{Dom}\,[\![\mathrm{CTR}]\!]: [\![\mathrm{CTR}]\!](\mathrm{s}) = [\![\mathrm{CTR}]\!]([\![\mathrm{BEG}]\!](\mathrm{s})) = [\![\mathrm{CTR}]\!]([\![\mathrm{END}]\!](\mathrm{s}))$

iii. $\forall \mathrm{w} \in D_\omega(\varnothing \subset \mathrm{Dom}\,[\![\vartheta]\!](\mathrm{w}) \subseteq D_\varepsilon \cup D_\sigma \wedge \mathrm{Ran}\,[\![\vartheta]\!](\mathrm{w}) \subseteq D_\tau$
$\wedge\ \forall \mathrm{e} \in \mathrm{Dom}\,[\![\vartheta]\!](\mathrm{w})\exists n \in \mathbf{Z}([\![\vartheta]\!](\mathrm{w}, \mathrm{e}) = \{n\}$
$\wedge\ [\![\vartheta]\!](\mathrm{w}, [\![\mathrm{BEG}]\!]([\![\mathrm{CON}]\!](\mathrm{e}))) = \{(n+1)\}$
$\wedge\ (\mathrm{e} \in \mathrm{Dom}\,[\![\mathrm{AGT}]\!] \rightarrow |[\![\vartheta]\!](\mathrm{w}, [\![\mathrm{CON}]\!](\mathrm{e})| > 1))$
$\wedge\ \forall \mathrm{s} \in \mathrm{Dom}\,[\![\vartheta]\!](\mathrm{w})([\![\vartheta]\!](\mathrm{w}, [\![\mathrm{BEG}]\!](\mathrm{s})) = \{\inf_<[\![\vartheta]\!](\mathrm{w}, \mathrm{s})\}$
$\wedge\ [\![\vartheta]\!](\mathrm{w}, [\![\mathrm{END}]\!](\mathrm{s})) = \{\sup_<[\![\vartheta]\!](\mathrm{w}, \mathrm{s})\} \wedge (|[\![\vartheta]\!](\mathrm{w}, \mathrm{s})| > 1$
$\rightarrow [\![\vartheta]\!](\mathrm{w}, \mathrm{s}) = [\![\vartheta]\!](\mathrm{w}, [\![\mathrm{BEG}]\!](\mathrm{s})) \cup [\![\vartheta]\!](\mathrm{w}, [\![\mathrm{CON}]\!]([\![\mathrm{BEG}]\!](\mathrm{s}))))$

D3 Definition (UC syntax). For each UC type $\mathrm{a} \in Typ$,

i. $Con_{\mathrm{a}} \cup {}^{\top}Var_{\mathrm{a}} \cup {}^{\bot}Var_{\mathrm{a}} \subseteq Term_{\mathrm{a}}$
ii. $BA \in Term_{\mathrm{b}}$, if $A \in Term_{\mathrm{a}}$ and $B \in Term_{\mathrm{ab}}$
iii. $(A = B) \in Term_t$, if $A, B \in Term_{\mathrm{a}}$
iv. $\neg\phi, (\phi \wedge \psi), (\phi \vee \psi), (\phi \rightarrow \psi) \in Term_t$, if $\phi, \psi \in Term_t$
v. $\exists u\phi, \forall u\phi \in Term_t$, if $u \in {}^{\top}Var_{\mathrm{a}} \cup {}^{\bot}Var_{\mathrm{a}}$ and $\phi \in Term_t$
vi. $\lambda u(B) \in Term_{\mathrm{ab}}$, if $u \in {}^{\top}Var_{\mathrm{a}} \cup {}^{\bot}Var_{\mathrm{a}}$ and $B \in Term_{\mathrm{b}}$
vii. $(u \cdot B) \in Term_s$, if $u \in {}^{\top}Var_{\mathrm{a}} \cup {}^{\bot}Var_{\mathrm{a}}$, $\mathrm{a} \in DTyp$ and $B \in Term_s$.
viii. $(A + B) \in Term_{\mathrm{a}}$, if $A, B \in Term_{\mathrm{a}}$ and $\mathrm{a} \in \{\tau, \alpha\} \cup \{\mathrm{b}_1\ldots\mathrm{b}_n t$: $\mathrm{b}_1,\ldots, \mathrm{b}_n \in Typ\}$
ix. $(A \subset B), (A \varnothing B) \in Term_t$, if $A, B \in Term_{\mathrm{a}}$ and $\mathrm{a} \in \{\tau, \alpha\} \cup \{\mathrm{b}_1\ldots\mathrm{b}_n t$: $\mathrm{b}_1,\ldots, \mathrm{b}_n \in Typ\}$
x. $(A < B) \in Term_t$, if $A, B \in Term_\tau$
xi. $\mathrm{EXP}\,A, \mathrm{CTR}\,A \in Term_\alpha$ and $\mathrm{CTR}'\,A \in Term_\beta$, if $A \in Term_\varepsilon \cup Term_\sigma$
xii. $\vartheta(W, A) \in Term_\tau$, if $W \in Term_\omega$ and $A \in Term_\varepsilon \cup Term_\sigma$

D4 Definition (UC semantics). The value $\llbracket A \rrbracket^g \in D_{\mathsf{a}}$ of a term $A \in Term_{\mathsf{a}}$ in a model $M = \langle \{D_{\mathsf{a}}\}_{\mathsf{a} \in Typ}, \llbracket \cdot \rrbracket \rangle$ under an M-assignment g is defined as follows. (Meta-language $\wedge$, $\vee$, $\rightarrow$, $\exists$, $\forall$, etc, have their usual meaning.)

i.	$\llbracket A \rrbracket^g$	=	$\llbracket A \rrbracket$	if $A \in Con_{\mathsf{a}}$
	$\llbracket u \rrbracket^g$	=	$g(u)$	if $u \in {}^{\top}Var_{\mathsf{a}} \cup {}^{\perp}Var_{\mathsf{a}}$
ii.	$\llbracket B_{\mathsf{ab}} A_{\mathsf{a}} \rrbracket^g$	=	$\llbracket B \rrbracket^g(\llbracket A \rrbracket^g)$	if $\mathsf{b} \neq t \wedge \llbracket B \rrbracket^g(\llbracket A \rrbracket^g) \in D_{\mathsf{b}}$
		=	$\llbracket B \rrbracket^g(\llbracket A \rrbracket^g)$	if $\mathsf{b} = t \wedge \llbracket A \rrbracket^g \in \text{Dom}\, \llbracket B \rrbracket^g$
		=	0	otherwise
iii.	$\llbracket A = B \rrbracket^g$	=	1	iff $(\llbracket A \rrbracket^g = \llbracket B \rrbracket^g) \wedge \llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\mathsf{a}}$
iv.	$\llbracket \neg\phi \rrbracket^g$	=	1	iff $\llbracket \phi \rrbracket^g = 0$
	$\llbracket (\phi \wedge \psi) \rrbracket^g$	=	1	iff $(\llbracket \phi \rrbracket^g = 1 \wedge \llbracket \psi \rrbracket^g = 1)$
	$\llbracket (\phi \vee \psi) \rrbracket^g$	=	1	iff $(\llbracket \phi \rrbracket^g = 1 \vee \llbracket \psi \rrbracket^g = 1)$
	$\llbracket (\phi \rightarrow \psi) \rrbracket^g$	=	1	iff $(\llbracket \phi \rrbracket^g = 1 \rightarrow \llbracket \psi \rrbracket^g = 1)$
v.	$\llbracket \exists u_{\mathsf{a}} \phi \rrbracket^g$	=	1	iff $\exists \mathrm{d} \in D_{\mathsf{a}}: \llbracket \phi \rrbracket^{g[u/\mathrm{d}]} = 1$
	$\llbracket \forall u_{\mathsf{a}} \phi \rrbracket^g$	=	1	iff $\forall \mathrm{d} \in D_{\mathsf{a}}: \llbracket \phi \rrbracket^{g[u/\mathrm{d}]} = 1$
vi.	$\llbracket \lambda u_{\mathsf{a}}(B_{\mathsf{b}}) \rrbracket^g(\mathrm{d})$	=	$\llbracket B \rrbracket^{g[u/\mathrm{d}]}$	if $\mathrm{d} \in D_{\mathsf{a}} \wedge \llbracket B \rrbracket^{g[u/\mathrm{d}]} \in D_{\mathsf{b}} \wedge \mathsf{b} \neq t$
		=	$\llbracket B \rrbracket^{g[u/\mathrm{d}]}$	if $\mathrm{d} \in D_{\mathsf{a}} \wedge \llbracket B \rrbracket^{g[u/\mathrm{d}]} \in D_{\mathsf{b}} \wedge \mathsf{b} = t$
		=	0	otherwise
vii.	$\llbracket u_{\mathsf{a}} \cdot B_s \rrbracket^g$	=	$\langle (g(u) \cdot {\top}\llbracket B \rrbracket^g), {\perp}\llbracket B \rrbracket^g \rangle$	if $u \in {}^{\top}Var_{\mathsf{a}} \wedge \llbracket B \rrbracket^g \in D_s$
		=	$\langle {\top}\llbracket B \rrbracket^g, (g(u) \cdot {\perp}\llbracket B \rrbracket^g) \rangle$	if $u \in {}^{\perp}Var_{\mathsf{a}} \wedge \llbracket B \rrbracket^g \in D_s$
viii.	$\llbracket A + B \rrbracket^g$	=	$\llbracket A \rrbracket^g \cup_{\tau} \llbracket B \rrbracket^g$	if $\llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\tau}$
		=	$\llbracket A \rrbracket^g \cup \llbracket B \rrbracket^g$	if $\llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\alpha}$
		=	${}^{\chi}({}^{\{\}}\llbracket A \rrbracket^g \cup {}^{\{\}}\llbracket B \rrbracket^g)$	if $\llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\mathsf{b}1\ldots\mathsf{b}nt}$
ix.	$\llbracket A \subset B \rrbracket^g$	=	1	if $\llbracket A \rrbracket^g \subset \llbracket B \rrbracket^g \wedge \llbracket A \rrbracket^g \in D_{\tau} \cup D_{\alpha}$
		=	1	if ${}^{\{\}}\llbracket A \rrbracket^g \subset {}^{\{\}}\llbracket B \rrbracket^g \wedge \llbracket A \rrbracket^g \in D_{\mathsf{b}1\ldots\mathsf{b}nt}$
		=	0	otherwise
	$\llbracket A \varnothing B \rrbracket^g$	=	1	if $\llbracket A \rrbracket^g \cap \llbracket B \rrbracket^g = \varnothing$ $\wedge \llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\tau} \cup D_{\alpha}$
		=	1	if ${}^{\{\}}\llbracket A \rrbracket^g \cap {}^{\{\}}\llbracket B \rrbracket^g = \varnothing$ $\wedge \llbracket A \rrbracket^g, \llbracket B \rrbracket^g \in D_{\mathsf{b}1\ldots\mathsf{b}nt}$
		=	0	otherwise
x.	$\llbracket A < B \rrbracket^g$	=	1	iff $\llbracket A \rrbracket^g <_{\tau} \llbracket B \rrbracket^g$
xi.	$\llbracket F\, A \rrbracket^g$	=	$\llbracket F \rrbracket(\llbracket A \rrbracket^g)$	if $F \in \{\text{EXP}, \text{CTR}, \text{CTR}'\}$
xii.	$\llbracket \vartheta(W, A) \rrbracket^g$	=	$\llbracket \vartheta \rrbracket(\llbracket W \rrbracket^g)(\llbracket A \rrbracket^g)$	

D5.1 Definition (Initial contexts). An initial context is a stack $\langle \mathtt{p}_0, \mathtt{e}_0 \rangle \in D_\Omega \times D_\varepsilon$ where (i) ${}^{\{\}}\mathtt{p}_0 \neq \varnothing$, (ii) $\forall \mathtt{w} \in {}^{\{\}}\mathtt{p}_0(\langle \mathtt{w}, \mathtt{e}_0, [\![\text{AGT}]\!](\mathtt{e}_0)\rangle \in {}^{\{\}}[\![\mathit{speak}]\!])$ and (iii) $\forall \mathtt{w}, \mathtt{v} \in {}^{\{\}}\mathtt{p}_0([\![\vartheta]\!](\mathtt{w}, \mathtt{e}_0) = [\![\vartheta]\!](\mathtt{v}, \mathtt{e}_0))$

D5.2 Definition (Initial states). $\langle \mathtt{p}_0, \mathtt{e}_0 \rangle$ induces the initial infotention state
$*\langle \mathtt{p}_0, \mathtt{e}_0 \rangle := {}^{\chi}\{\langle\langle \mathtt{t}, \mathtt{w}, \mathtt{p}_0, \mathtt{e}_0\rangle, \langle \underline{\mathtt{e}}\rangle\rangle \in D_s |$
$\mathtt{w} \in {}^{\{\}}\mathtt{p}_0 \wedge \mathtt{t} = [\![\vartheta]\!](\mathtt{w}, \mathtt{e}_0) \wedge \underline{\mathtt{e}} = \{\langle \mathtt{v}, \mathtt{e}_0\rangle : \mathtt{v} \in {}^{\{\}}\mathtt{p}_0\}\}$

D6 Definition (truth & falsity). Said in an initial context $\langle \mathtt{p}_0, \mathtt{e}_0 \rangle$,
K is *true* in $\mathtt{w}$, iff
${}^{\{\}}((\top \mathtt{z})_1 \in D_\Omega \wedge \mathtt{w} \in {}^{\{\}}\mathtt{p}_0 \wedge \exists \mathtt{z} \forall g(\mathtt{z} \in {}^{\{\}}[\![K]\!]^g(*\langle \mathtt{p}_0, \mathtt{e}_0\rangle) \wedge \mathtt{w} \in {}^{\{\}}((\top \mathtt{z})_1))$
K is *false* in $\mathtt{w}$, iff
${}^{\{\}}((\top \mathtt{z})_1 \in D_\Omega \wedge \neg(\mathtt{w} \in {}^{\{\}}\mathtt{p}_0 \wedge \exists \mathtt{z} \forall g(\mathtt{z} \in {}^{\{\}}[\![K]\!]^g(*\langle \mathtt{p}_0, \mathtt{e}_0\rangle) \wedge \mathtt{w} \in {}^{\{\}}((\top \mathtt{z})_1)))$

A4 Abbreviations (Set theory)

$B(A_1,\ldots, A_n)$	:=	$BA_1\ldots A_n$	
$(A \in B)$	:=	$B_{\mathsf{a}t}A_{\mathsf{a}}$	
$(A \supset B)$	:=	$(B \subset A)$	
$(A \subseteq B)$	:=	$(A = B \vee A \subset B)$	
$(A \leq B)$	:=	$(A = B \vee A < B)$	
$(A <_B A')$	:=	$((\lambda u.\ u \in B \wedge A' \in u) \subset (\lambda u.\ u \in B \wedge A \in u))$	
$\{A_1, \ldots, A_n\}$	:=	$\lambda u.\ u = A_1 \vee \ldots \vee u = A_n$	
$\cap(A)$	:=	$\lambda u. \forall v(v \in A \rightarrow u \in v)$	
$\text{SG}\, A_{\mathsf{a}}$	:=	$\exists u_{\mathsf{a}}(u \subseteq A) \wedge \neg \exists u_{\mathsf{a}}(u \subset A)$	$\mathsf{a} \in \{\tau, \alpha\}$
$\text{PL}\, A_{\mathsf{a}}$	:=	$\exists u_{\mathsf{a}} \exists u'_{\mathsf{a}}(u \subset A \wedge u' \subset A \wedge \neg(u = u'))$	

A5 Abbreviations (Modal, causal, and attitudinal relations)

MIN $:= \lambda Q \lambda p \lambda w.\ w \in p \wedge \neg \exists v(v \in p \wedge v <_Q w)$
$^+$CON $:= \lambda w \lambda e \lambda s.\ \vartheta(w, s) = \vartheta(w, e) + \vartheta(w, \text{CON}\ e) \wedge \text{EXP}\ s = \text{EXP CON}\ e$
BEL $:= \lambda w \lambda e \lambda p.\ \exists s(\vartheta(w, e) \subset \vartheta(w, s) \wedge \text{EXP}\ s = \text{EXP CON}\ e$
$\wedge\ \mathit{believe}(w, s, \text{EXP}\ s, p))$
DES $:= \lambda w \lambda e \lambda p.\ \exists s(\vartheta(w, e) \subset \vartheta(w, s) \wedge \text{EXP}\ s = \text{EXP CON}\ e$
$\wedge\ \mathit{want}(w, s, \text{EXP}\ s, p))$
$^{\text{BEG}}B$ $:= \lambda w \lambda e \lambda p.\ \neg(\cap B(w, e) \subseteq p) \wedge (\cap B(w, \text{BEG CON}\ e) \subseteq p)$

A6 Abbreviations (Dynamic expansions, local conditions, local updates)

$\mathbf{d}\mathsf{a}, d\mathsf{a}$	:=	$d\mathsf{a}_1, d\mathsf{a}_1$	if $\mathsf{a} \in DTyp$
$A_{\mathsf{a}}{}^{\mathrm{o}}$	:=	$\lambda i.\ A$	if $\mathsf{a} \in DTyp$
	:=	A	if $\mathsf{a} \in {}^sDTyp := \{s\mathsf{b} : \mathsf{b} \in DTyp\}$

$A_{\mathsf{a}}{}^{\omega}$	:=	$\lambda i\lambda w.\ A^{\circ}i$	if $\mathsf{a} \in (DTyp \cup {}^{s}DTyp)\backslash\{\omega\varepsilon, s\omega\varepsilon\}$
	:=	$\lambda i.\ A$	if $\mathsf{a} = \omega\varepsilon$
	:=	A	if $\mathsf{a} = s\omega\varepsilon$
$(B(A_1, \ldots A_n))^{\circ}$	:=	$\lambda i.\ B(A_1{}^{\circ}i, \ldots, A_n{}^{\circ}i)$	
$(B(\omega\text{: } A_1, \ldots A_n))^{\omega}$	:=	$\lambda i\lambda w.\ B(w, A_1{}^{\omega}iw, \ldots, A_n{}^{\omega}iw)$	
$R\langle W\text{: } A_1, \ldots, A_n\rangle$	:=	$\lambda i.\ R(W^{\circ}i, A_1{}^{\omega}iW^{\circ}i, \ldots, A_n{}^{\omega}iW^{\circ}i)$	
$R\langle W, A\text{: } f_1, \ldots, f_n\rangle$	:=	$\lambda i.\ R(W^{\circ}i, A^{\omega}iW^{\circ}i, f_1(A^{\omega}iW^{\circ}i), \ldots, f_n(A^{\omega}i\ W^{\circ}i))$	
$R\langle W, A\text{: } f_1, \ldots, f_n\text{: } B\rangle$	:=	$\lambda i.\ R(W^{\circ}i, A^{\omega}iW^{\circ}i, f_1(A^{\omega}iW^{\circ}i), \ldots, f_n(A^{\omega}i\ W^{\circ}i), B^{\circ}i)$	
$R\langle \omega, A\text{: } f_1, \ldots, f_n\rangle$	:=	$\lambda i.\ \forall w(\exists u_{\mathsf{a}}(u = A^{\omega}iw) \rightarrow R(w, A^{\omega}iw, f_1(A^{\omega}iw), \ldots f_n(A^{\omega}iw)))$	
$R\langle \omega, A\text{: } f_1, \ldots, f_n\text{: } B\rangle$	:=	$\lambda i.\ \forall w(\exists u_{\mathsf{a}}(u = A^{\omega}iw) \rightarrow R(w, A^{\omega}iw, f_1(A^{\omega}iw), \ldots f_n(A^{\omega}iw), B^{\circ}i))$	

For $\mathbf{R} \in \{=, \in, \subseteq, \subset, \supset, \varnothing, \leq, <\}$

$(A\ \mathbf{R}\ B)^{\circ}$	:=	$\lambda i.\ A^{\circ}i\ \mathbf{R}\ B^{\circ}i$
$(A\ \mathbf{R}_{\omega}\ B)$	:=	$\lambda i\ \forall w(\exists u\exists u'(u = A^{\omega}iw \wedge u' = B^{\omega}iw) \rightarrow A^{\omega}iw\ \mathbf{R}\ B^{\omega}iw)$
$(A\ \mathbf{R}_{\forall W}\ B)$	:=	$\lambda i\ \forall w(w \in W^{\circ}i \rightarrow A^{\omega}iw\ \mathbf{R}\ B^{\omega}iw)$
$(A\ \mathbf{R}_{\vartheta W}\ B)$	:=	$\lambda i.\ \vartheta(W^{\circ}i, A^{\omega}iW^{\circ}i)\ \mathbf{R}\ \vartheta(W^{\circ}i, B^{\omega}iW^{\circ}i)$
$\mathbf{R}\langle W\text{: } A, T\rangle$	:=	$\lambda i.\ T^{\omega}iW^{\circ}i\ \mathbf{R}\ \vartheta(W^{\circ}i, A^{\omega}iW^{\circ}i)$
$[C]$	:=	$\lambda I\lambda j.\ Ij \wedge Cj$
$[u_1 \ldots u_n]$	:=	$\lambda I\lambda j\ \exists u_1 \ldots u_n\exists i(j = (u_1 \cdot \ldots (u_n \cdot i)) \wedge Ii)$
$[u_1 \ldots u_n \vert\ C]$	:=	$\lambda I\lambda j\ \exists u_1 \ldots u_n\exists i(j = (u_1 \cdot \ldots (u_n \cdot i)) \wedge Ii \wedge Ci)$

A7 Abbreviations (global values, substates, global updates)

$A\{Z\}$	:=	$\lambda u.\ \exists i(Zi \wedge A^{\circ}i = u)$
$Z_{(A1:B1, \ldots, An:Bn)}$	:=	$\lambda i.\ Zi \wedge A_1{}^{\circ}i = B_1 \wedge \ldots \wedge A_n{}^{\circ}i = B_n$
$(K; K')$	:=	$\lambda I.\ K'KI$
$({}^{\mathrm{P}}K)$	:=	$\lambda I\lambda j.\ KIj \wedge \mathbf{d}\omega\{KI\} = \mathbf{d}\omega\{I\}$
$[R\{\omega\text{: } A_1, \ldots A_n\}]$	:=	$\lambda I\lambda j.\ Ij \wedge \forall w(w \in \mathbf{d}\omega\{I\} \rightarrow R(w, A_1{}^{\omega}jw, \ldots A_n{}^{\omega}jw))$
$[\subset\{W\text{: } A, T\}]$	:=	$\lambda I\lambda j.\ Ij \wedge (\exists i(Ii \wedge \text{PL}\ T^{\omega}iW^{\circ}i) \rightarrow \vartheta(W^{\circ}j, A^{\omega}jW^{\circ}j) \subset T^{\omega}jW^{\circ}j) \wedge (\forall i(Ii \rightarrow \text{SG}\ T^{\omega}iW^{\circ}i) \rightarrow T^{\omega}jW^{\circ}j \subset \vartheta(W^{\circ}j, \text{CON}\ A^{\omega}jW^{\circ}j))$

For $\mathbf{R} \in \{=, \in, \subseteq, \subset, \supset, \varnothing\}$

$[A\ \mathbf{R}\ B\{\vert\}]$	:=	$\lambda I\lambda j.\ Ij \wedge A^{\circ}j\ \mathbf{R}\ B\{I\}$
$[A\ \mathbf{R}\ B\{\vert_{C1 \ldots Cn}\}]$	:=	$\lambda I\lambda j.\ Ij \wedge A^{\circ}j\ \mathbf{R}\ B\{I_{(C1\text{: } C1j, \ldots Cn\text{: }Cnj)}\}$

APPENDIX E: *From English verbs to* UC

Sample basic meanings of English verbs. We write ‘$\mathtt{a}_?$’ for an anaphoric presupposition in search of an antecedent of type $\mathtt{a}$ (or $\mathtt{a}$-valued function).

E1. main & auxiliary verbs (sample)

- *go+out*, event v

ε $[e|\ go.out\langle \mathbf{d}\omega,\ e\text{: AGT}\rangle]$

- *like*, state v

σ $[s\ a|\ like\langle \mathbf{d}\omega,\ s\text{: EXP: } a\rangle,\ (\text{EXP } s = \text{CTR } s)^{o}]$

- *have …-en*, state auxiliary + v\v-suffix

σ $[s|\ (\text{EXP } s = \text{CTR } s)^{o}];\ \ldots;\ [(d\sigma = \text{CON } d\varepsilon)^{o}]$

E2. TNS marking: ^{1}tns.presup; ^{2}modal-tmp.upd; ^{3}temporal.attention.update

- -PST (e.g. *was*), on event v
  $^{1}(^{P}[(\mathbf{d}\tau_n < \vartheta(\mathbf{d}\omega,\ \mathbf{d}\varepsilon))^{\circ}]);\ ^{2}[\sqsupset\langle \omega_?\text{: } d\varepsilon,\ \mathbf{d}\tau_n\rangle,\ (\text{CTR } d\varepsilon = \alpha_?)^{o}];$
  $^{3}[\mathbf{t}|\ \mathbf{t} \subset \vartheta(\mathbf{d}\omega,\ \text{CON } d\varepsilon)^{\circ},\ (\mathbf{t} < \vartheta(\omega_?,\ \mathbf{d}\varepsilon)^{\circ}]$
- -NPST (e.g. *is*), on event v
  $^{1}(^{P}[(\vartheta(\mathbf{d}\omega,\ \mathbf{d}\varepsilon) \leq \mathbf{d}\tau_n)^{\circ}]);\ ^{2}[\sqsupset\langle \omega_?\text{: } d\varepsilon,\ \mathbf{d}\tau_n\rangle,\ (\text{CTR } d\varepsilon = \alpha_?)^{o}];$
  $^{3}[\mathbf{t}|\ \mathbf{t} \subset \vartheta(\omega_?,\ \text{CON } d\varepsilon)^{\circ}]$
- FUT (e.g. *will*), on event v
  $^{1}(^{P}[(\vartheta(\mathbf{d}\omega,\ \mathbf{d}\varepsilon) \leq \mathbf{d}\tau_n)^{\circ}]);\ ^{2}([e];\ [\sqsupset\langle \omega_?\text{: } d\varepsilon,\ \mathbf{d}\tau_n\rangle,\ (\text{CTR } d\varepsilon = \alpha_?)^{o}]);$
  $^{3}[\mathbf{t}|\ \mathbf{t} \subset \vartheta(\omega_?,\ \text{CON } d\varepsilon)^{\circ}]$

E3. MODAL marking: (fused w. TNS) ^{1}modal.presup; ^{3}modal.attn.update

- .IND (e.g. *is*)
  $^{P}[\omega_? \in \mathbf{d}\omega\{|\}]$
- .VIV (e.g. *will*), doxastic rdg.
  $\lambda D.\ (^{P}[\mathbf{d}\Omega \subseteq \mathbf{d}\omega\{|\}]);\ [Q|\ (Q \subset \text{BEL}(\omega_?,\ \varepsilon_?))^{\circ}];\ D;$
  $[\text{MIN}(d\Omega t,\ \mathbf{d}\Omega) \subseteq d\omega\{|_{\omega?,\ d\Omega t\}}\}]$

o .REM (e.g. *would*)
  $\lambda D.\ [Q|\ (Q \subset \text{BEL}(\omega_?,\ \varepsilon_?))^{\circ}];\ D;\ [\text{MIN}(d\Omega t,\ \mathbf{d}\Omega) \subseteq d\omega\{|_{\omega?,\ d\Omega t\}}\}]$

E4. MOOD marking prosody

- **.**
  $[\mathbf{p}];\ [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}]$
- **?**
  $[q];\ [d\Omega = d\omega\{|_{\ldots}\}];\ [\mathbf{Q}];\ [\mathbf{d}\Omega t = d\Omega\{|\}]$
- **!**
  $[d\varepsilon =_{\vartheta d\omega} \text{END CON } \mathbf{d}\varepsilon,\ (\text{CTR } d\varepsilon = \text{EXP } \mathbf{d}\varepsilon)^{\circ}];\ [q];\ [d\Omega = d\omega\{|\}];$
  $[\mathbf{t}|\ (\mathbf{t} \subset \vartheta(d\omega,\ \text{CON } d\varepsilon))^{\circ}]$

APPENDIX K: *From Kalaallisut verbs to* UC

Sample basic meanings of Kalaallisut verbs. We write '$a_?$' for an anaphoric presupposition in search of an antecedent of type a (or a-valued function).

K1. Verbal roots and derivational suffixes (sample)

- *ani-* (go.out-), event v-root

$^{\varepsilon}$ $[e|\ go.out\langle \mathbf{d}\omega, e\text{: AGT}\rangle]$

- *anniar-* (in.pain-), state v-root

$^{\sigma}$ $[s|\ in.pain\langle \mathbf{d}\omega, s\text{: EXP}\rangle, (\text{EXP } s = \text{CTR } s)^{o}]$

- *niriug-* (hope-), state v-root

$^{\sigma}$ $[s\ p|\ hope\langle \mathbf{d}\omega, s\text{: EXP: } p\rangle, (\text{EXP } s = \text{CTR } s)^{o}]$

- *-tit* (-cause), event v\v-suffix on state v

$^{\sigma\backslash\varepsilon}$ $[e|\ (\text{CON } e = d\sigma)^{o}, (\text{AGT } e = \text{CTR } e)^{o}, (\text{CTR } e = \text{CTR } d\sigma)^{o}]$

- *-sima* (-prf), state v\v-suffix on event v

$^{\varepsilon\backslash\sigma}$ $[s|\ (s = \text{CON } d\varepsilon)^{o}, (\text{CTR } s = \text{CTR } d\varepsilon)^{o}]$

- *-ssa* (-exp/des), state v\v-suffix on event v

$^{\varepsilon\backslash\sigma}$ $^{P}[(?\Omega \in ?\Omega t)^{o}, (?\Omega t \subseteq \text{BEL+DES}(\mathbf{d}\omega, ?\varepsilon))^{o}]; [\subset\{d\omega\text{: } d\varepsilon, d\tau\}];$
$[s|\ s \in_{\forall\{\mathbf{d}\omega,\ d\omega\}} {}^{+}\text{CON}(\omega\text{: } ?\varepsilon), (\text{CTR } s = \text{CTR } d\varepsilon)^{o}, d\varepsilon <_{\vartheta d\omega} \text{END } s,$
$(\text{MIN}(?\Omega t, ?'\Omega) \in {}^{\text{BEG}}\text{BEL}(d\omega, \text{END } s))^{o}];$
$[\text{MIN}(?\Omega t, ?'\Omega) \subseteq d\omega\{|_{\mathbf{d}\omega,\ d\sigma, ?\Omega t, ?\varepsilon}\}]$

- *-nngit* (-not), state v\v suffix on event v ($^{\varepsilon\backslash\sigma}$) state v ($^{\sigma\backslash\sigma}$)

$^{\varepsilon\backslash\sigma}$ $[\subset\{d\omega\text{: } d\varepsilon, ?\tau\}]; [s|\ (\vartheta(\mathbf{d}\omega, s) = ?\tau)^{o}, (\text{CTR } s = \text{CTR } d\varepsilon)^{o}];$
$[p]; [d\Omega = d\omega\{|_{d\sigma, ?\tau}\}]; [(\{\mathbf{d}\omega\} \varnothing d\Omega)^{o}]$

$^{\sigma\backslash\sigma}$ $[\subset\{d\omega\text{: BEG } d\sigma, ?\tau\}]; [s|\ (\vartheta(\mathbf{d}\omega, s) = ?\tau)^{o}, (\text{CTR } s = \text{CTR } d\sigma)^{o}];$
$[p]; [d\Omega = d\omega\{|_{d\sigma, ?\tau}\}]; [(\{\mathbf{d}\omega\} \varnothing d\Omega)^{o}]$

- *-galuar* (-rem), aspect-preserving v\v-suffix

$^{\_\backslash\_}$ $[p|\ (\{?\omega\} \varnothing p)^{o}, (p \in \text{BEL+DES}(\mathbf{d}\omega, ?\varepsilon))^{o}]$

K2. Illocutionary moods for matrix verbs (sample, general form: ^{1}illoc.presup; ^{2}modal-tmp.upd; ^{3}modal.att.upd; ^{4}illoc.declaration)

- *-pu* (-DEC), on event v ($_{\varepsilon}$), or state v ($_{\sigma}$)

$_{\varepsilon}$ $^{1}(^{P}[d\omega\varepsilon =_{\omega} \mathbf{d}\varepsilon]); {}^{2}([\subset\{\mathbf{d}\omega\text{: } d\varepsilon, \mathbf{d}\tau\}]; [d\varepsilon <_{\vartheta\mathbf{d}\omega} d\omega\varepsilon, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^{o}]);$
$^{3}([\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}])$

$_{\sigma}$ $^{1}(^{P}[d\omega\varepsilon =_{\omega} \mathbf{d}\varepsilon]); {}^{2}([\subset\langle\mathbf{d}\omega\text{: } d\sigma, \mathbf{d}\tau\rangle]; [\text{BEG } d\sigma \leq_{\vartheta\mathbf{d}\omega} d\omega\varepsilon, (\text{CTR } d\sigma = \mathbf{d}\alpha)^{o}]);$
$^{3}([\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}])$

- *-la* ($-\text{DEC}_{\notin}$), on state v

$_{\sigma}$ $^{1}(^{P}[d\omega\varepsilon =_{\omega} \mathbf{d}\varepsilon, (\{\mathbf{d}\omega\} \varnothing d\Omega)^{o}]); {}^{2}([\subset\langle\mathbf{d}\omega\text{: } d\sigma, \mathbf{d}\tau\rangle]; [\text{BEG } d\sigma \leq_{\vartheta\mathbf{d}\omega} d\omega\varepsilon,$
$(\text{CTR } d\sigma = \mathbf{d}\alpha)^{o}]); {}^{3}([\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}])$

• *-pi* (-QUE), on event v

ε $^1(^P[d\omega\varepsilon =_\omega \mathbf{d}\varepsilon]);\ ^2([\subset\{d\omega: d\varepsilon, \mathbf{d}\tau\}]; [d\varepsilon <_{\vartheta d\omega} d\omega\varepsilon, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^o]);$
$^3([p]; [d\Omega = d\omega\{|\}]; [\mathbf{Q}]; [\mathbf{d}\Omega t = d\Omega\{|\}]);\ ^4[ask\langle\omega, d\omega\varepsilon: \text{AGT}: \mathbf{d}\Omega t\rangle]$

• *-li* ($\text{-QUE}_{\notin}$), on event v

ε $^1(^P[d\omega\varepsilon =_\omega \mathbf{d}\varepsilon, (\{d\omega\} \varnothing d\Omega)^o]);\ ^2([\subset\{d\omega: d\varepsilon, \mathbf{d}\tau\}]; [d\varepsilon <_{\vartheta d\omega} d\omega\varepsilon,$
$(\text{CTR } d\varepsilon = \mathbf{d}\alpha)^o]);\ ^3([p]; [d\Omega = d\omega\{|\}]; [\mathbf{Q}]; [\mathbf{d}\Omega t = d\Omega\{|\}]);$
$^4[ask\langle\omega, d\omega\varepsilon: \text{AGT}: \mathbf{d}\Omega t\rangle]$

• *-gi* (-IMP), on event v

ε $^1(^P[d\omega\varepsilon =_\omega \mathbf{d}\varepsilon]);\ ^2([\subset\{d\omega: d\varepsilon, \vartheta(\omega: \text{CON } \mathbf{d}\varepsilon)\}]; [\text{CON } d\omega\varepsilon <_{\vartheta d\omega} \text{CON } d\varepsilon,$
$(\text{CTR } d\varepsilon = \text{EXP } \mathbf{d}\varepsilon)^o]);\ ^3([p]; [d\Omega = d\omega\{|\}]);\ ^4[dir.do\langle\omega, d\omega\varepsilon: \text{AGT}, \text{EXP}: d\Omega\rangle]$

• *-qina* ($\text{-IMP}_{\notin}$), on event v

ε $^1(^P[d\omega\varepsilon =_\omega \mathbf{d}\varepsilon]);\ ^2([\subset\{d\omega: d\varepsilon, \vartheta(\omega: \text{CON } \mathbf{d}\varepsilon)\}]; [d\varepsilon <_{\vartheta d\omega} \text{END CON } d\omega\varepsilon,$
$(\text{CTR } d\varepsilon = \text{EXP } \mathbf{d}\varepsilon)^o]);\ ^3([p]; [d\Omega = d\omega\{|\}]);\ ^4[dir.to\langle\omega, d\omega\varepsilon: \text{AGT}, \text{EXP}: \mathbf{d}\Omega\backslash d\Omega\rangle]$

• *-li* ~ *-la* (-OPT), on event v

ε $^1(^P[d\omega\varepsilon =_\omega \mathbf{d}\varepsilon]);\ ^2([\subset\{d\omega: d\varepsilon, \vartheta(\omega: \text{CON } \mathbf{d}\varepsilon)\}]; [\text{CON } d\omega\varepsilon <_{\vartheta d\omega} \text{CON } d\varepsilon,$
$(\text{CTR } d\varepsilon = \text{EXP } \mathbf{d}\varepsilon)^o]);\ ^3([p]; [d\Omega = d\omega\{|\}]);\ ^4[wish.for\langle\omega, d\omega\varepsilon: \text{AGT}: d\Omega\rangle]$

K3. Subject-centering moods for dependent verbs (sample, general form: $^1\alpha$-recentering.presup; ^{2}modal-tmp.upd; ^{3}mod∨tmp.att.upd)

• *-ga* ($\text{-FCT}_\top$), on event v

ε $^1(^P[\mathbf{a}|\ \mathbf{a} = d\alpha]);\ ^2([\subset\{\mathbf{d}\omega: d\varepsilon, \mathbf{d}\tau\}]; [(?\varepsilon =_{\vartheta \mathbf{d}\omega} d\varepsilon)^o, d\varepsilon <_{\vartheta \mathbf{d}\omega} d\omega\varepsilon,$
$(\text{CTR } d\varepsilon = \mathbf{d}\alpha)^o]);\ ^3[\mathbf{t}|\ (\mathbf{t} \subset \vartheta(\mathbf{d}\omega, \text{CON } d\varepsilon))^o, (\mathbf{t} < \vartheta(\mathbf{d}\omega, d\omega\varepsilon))^o]$

• *-mm* ($\text{-FCT}_\perp$), on event v

ε $^1(^P[a|\ a = \mathbf{d}\alpha]);\ ^2([\subset\{\mathbf{d}\omega: d\varepsilon, \mathbf{d}\tau\}]; [(?\varepsilon =_{\vartheta \mathbf{d}\omega} d\varepsilon)^o, d\varepsilon <_{\vartheta \mathbf{d}\omega} d\omega\varepsilon,$
$(\text{CTR } d\varepsilon = d\alpha)^o]);\ ^3[\mathbf{t}|\ (\mathbf{t} \subset \vartheta(\mathbf{d}\omega, \text{CON } d\varepsilon))^o, (\mathbf{t} < \vartheta(\mathbf{d}\omega, d\omega\varepsilon))^o]$

• *-gu* ($\text{-HYP}_\top$), on event v

ε $^1(^P[\mathbf{a}|\ \mathbf{a} = d\alpha]);\ ^2([\subset\{d\omega: d\varepsilon, ?\tau\}]; [(?\varepsilon <_{\vartheta d\omega} d\varepsilon)^o, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^o]);$
$^3([\mathbf{p}]; [\mathbf{d}\Omega = d\omega\{|_{\mathbf{d}\alpha,\ ?\tau}\}]; [t|\ (t \subset \vartheta(d\omega, \text{CON } d\varepsilon))^o])$

• *-pp* ($\text{-HYP}_\perp$), on state v

σ $^1(^P[a|\ a = \mathbf{d}\alpha]);\ ^2([\subset\langle d\omega: d\sigma, ?\tau\rangle]; [(?\varepsilon <_{\vartheta d\omega} \text{END } d\sigma)^o, (\text{CTR } d\sigma = d\alpha)^o]);$
$^3([\mathbf{p}]; [\mathbf{d}\Omega = d\omega\{|_{d\alpha,\ ?\tau}\}])$

• *-llu*, ($\text{-ELA}_\top$), on event v, after main V

ε $^1(^P[\mathbf{a}|\ \mathbf{a} = d\alpha]);\ ^2([\subset\{\mathbf{d}\omega: d\varepsilon, ?\tau\}]; [(?\varepsilon = d\varepsilon)^o, (\text{CTR } d\varepsilon = \mathbf{d}\alpha)^o]);$
$^3([\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}])$

• *-tu*, ($\text{-ELA}_\perp$.IV), on state v, after main V

σ $^1(^P[a|\ a = \mathbf{d}\alpha]);\ ^2([\subset\langle\mathbf{d}\omega: d\sigma, ?\tau\rangle]; [(?\sigma =_{\vartheta d\omega} d\sigma)^o, (\text{CTR } d\sigma = d\alpha)^o]);$
$^3([\mathbf{p}]; [\mathbf{d}\Omega = \mathbf{d}\omega\{|\}])$