Lecture 11
HAMBLIN SEMANTICS FOR QUESTIONS

1. <u>From assertions to questions: English to Kalaallisut</u>

All languages distinguish assertions and questions, but the grammatical means vary—e.g. English uses inversion, WH-words, and prosody (compare (1_E)–(3_E) vs. (4_E)–(7_E)), whereas Kalaallisut uses illocutionary mood inflection (compare (1_K)-(3_K) vs. (4_K)–(6_K), where DEC = declarative mood, QUE = interrogative mood, NG = negative, sth = something).

• Assertion

(1_E)	Ole	is	sick **.**	
	Ole	be.TNS	sick	
(2_E)	Ole	has	bought	a dog **.**
	Ole	have.TNS	buy.ASP	A dog
(3_E)	Ole	hasn't	bought	anything **.**
	Ole	have.TNS=N'T	buy.ASP	anything

(1_K)	Ole	naparsimavuq.
	Ole	naparsima-**pu**-q
	Ole	sick-DEC.IV-3SG
(2_K)	Ole	qimmisivuq.
	Ole	qimmiq-si-**pu**-q
	Ole	dog-get-DEC.IV-3SG
(3_K)	Ole	susinngilaq.
	Ole	su-si-nngit-**la**-q
	Ole	sth-get-not-DEC.NG-3SG

• Polar question

(4_E)	**is**	Ole	sick **?**	
	be.TNS	Ole	sick	
(5_E)	**has**	Ole	bought	anything **?**
	have.TNS	Ole	buy.ASP	anything

(4_K)	Ole	naparsimava **?**	
	Ole	naparsima-**pi**-a	
	Ole	sick-QUE-3SG	
(5_K)	Ole	susiva **?**	(YN reading)
	Ole	su-si-**pi**-a	
	Ole	sth-get-QUE-3SG	

• Constituent question

(6_E)	**who**	is	sick **?**	
	who	be.TNS	sick	
(7_E)	**what**	**has**	Ole	bought **?**
	what	have.TNS	Ole	like.ASP

(6_K)	kina	naparsimava **?**	
	kina	naparsima-**pi**-a	
	who	sick-QUE-3SG	
(5_K)	Ole	susiva **?**	(WH reading)
	Ole	su-si-**pi**-a	
	Ole	sth-get-QUE-3SG	

BASIC IDEAS:

a. At each point in the conversation the participants share partial information about the world, i.e. they locate themselves in the class of worlds where that information is true. This class of worlds—the current candidates for the speech world—is the current *common ground* (CG).

b. *Assertion* adds information—i.e. it eliminates those CG-worlds that are incompatible with the new information and thereby updates the common ground to a smaller set (Stalnaker 1978).

c. *Questions* do not add information—i.e. no CG-worlds are eliminated. Instead, to understand a question is to know what would count as an answer (Hamblin 1973). In terms of the common ground update, the speaker introduces a set of propositions (possible answers) compatible with the common ground, which raises the issue which of them are true in the speech world. A cooperative *answer* helps to resolve this issue (Groenendijk and Stokhof 1984 "On the semantics of questions and the pragmatics of answers").

2. Static implementation: Hamblin 1973 in Ty2 (2-sorted TL) + CCG

DEFINITION 1.1 (Ty2-types) The set of Ty2-*types* is the smallest set **Typ** such that:
i. $t, e, s \in \mathbf{Typ}$ ii. $(ab) \in \mathbf{Typ}$ if $a, b \in \mathbf{Typ}$

ABBREVIATION A1: $a_1 \dots a_n b \;:=\; (a_1 \dots (a_n b))$

DEFINITION 1.2 (basic Ty2-terms)

i. $\mathbf{Con}_e = \{ole, ann, \dots\}$
$\mathbf{Con}_{st} = \{rain, \dots\}$
$\mathbf{Con}_{set} = \{sbd, dog, sick, \dots\}$
$\mathbf{Con}_{seet} = \{hsb, buy, \dots\}$

ii. $\mathbf{Var}_e = \{x, y, z, \dots\}$
$\mathbf{Var}_s = \{i, j, k, \dots\}$
$\mathbf{Var}_{st} = \{p, q, \dots\}$
$\mathbf{Var}_{est} = \{P, P', \dots\}$
$\mathbf{Var}_{eest} = \{R, R', \dots\}$

DEFINITION 1.3 (Ty2 syntax). For any Ty2 type a, the set of *a-terms* is defined as follows:

B. $\alpha \in \mathbf{Term}_a$ if $\alpha \in \mathbf{Con}_a \cup \mathbf{Var}_a$
A. $\beta\alpha \in \mathbf{Term}_b$ if $\beta \in \mathbf{Term}_{ab}$ & $\alpha \in \mathbf{Term}_a$
λ. $\lambda u_b(\alpha) \in \mathbf{Term}_{ba}$ if $u_b \in \mathbf{Var}_b$ & $\alpha \in \mathbf{Term}_a$
∧. $(\alpha \wedge \beta) \in \mathbf{Term}_t$ if $\alpha \in \mathbf{Term}_t$ & $\beta \in \mathbf{Term}_t$
¬. $\neg\alpha \in \mathbf{Term}_t$ if $\alpha \in \mathbf{Term}_t$
=. $(\alpha = \beta) \in \mathbf{Term}_t$ if $\alpha \in \mathbf{Term}_a$ & $\beta \in \mathbf{Term}_a$

DEFINITION 2.1 (Ty2-frames). A *standard* Ty2-*frame* is a set $\{D_a\}_{a \in \mathbf{Typ}}$ of *a-domains* D_a s.t.

i. $D_t = \{1, 0\}$
D_e is a non-empty set (of *entities*), disjoint from D_t
D_s is a non-empty set (of *worlds*), disjoint from D_t and D_e.

ii. $D_{(ab)} = \{f \mid \text{Dom } f = D_a \text{ \& Ran } f \subseteq D_b\}$

DEFINITION 2.2 (Ty2-models and assignments)

- A Ty2-*model* is a pair, $M = \langle D^M, [\![\cdot]\!]^M \rangle$, s.t. (i) $D^M = \{D_a\}_{a \in \mathbf{Typ}}$ is a standard Ty2-frame, (ii) $[\![\cdot]\!]^M$ is an *interpretation function* that assigns to each $\alpha \in \mathbf{Con}_a$ a denotation $[\![\alpha]\!]^M \in D_a{}^M$.
- An *M-assignment* is a function g that assigns to each $u \in \mathbf{Var}_a$ a value $g(u) \in D_a{}^M$. If $d \in D_a{}^M$, then $g[u/d]$ is the M-assignment such that (i) $g[u/d](v) = g(v)$ for all $v \neq u$, (ii) $g[u/d](u) = d$.

DEFINITION 2.3 (Ty2-semantics) Given Ty2-model $M = \langle D^M, [\![\cdot]\!]^M \rangle$, M-assignment g, and Ty2-term α, the *denotation* of α *in M under g*, written $[\![\alpha]\!]^{M,g}$, is defined as follows (where $0 = \{\}$, $1 = \{\varnothing\}$):

B. $[\![\alpha]\!]^{M,g} = [\![\alpha]\!]^M$, if $\alpha \in \mathbf{Con}_a$
$= g(\alpha)$, if $\alpha \in \mathbf{Var}_a$
A. $[\![\beta\alpha]\!]^{M,g} \doteq [\![\beta]\!]^{M,g}([\![\alpha]\!]^{M,g})$
λ. $[\![\lambda u_b(\alpha)]\!]^{M,g} \doteq \langle [\![\alpha]\!]^{M,g[u/d]}: d \in D_b{}^M \rangle$
∧. $[\![(\alpha \wedge \beta)]\!]^{M,g} \doteq ([\![\alpha]\!]^{M,g} \cap [\![\beta]\!]^{M,g})$
¬. $[\![\neg\alpha]\!]^{M,g} \doteq (1 - [\![\alpha]\!]^{M,g})$
=. $[\![(\alpha = \beta)]\!]^{M,g} = 1$, if $[\![\alpha]\!]^{M,g} = [\![\beta]\!]^{M,g}$
$= 0$, otherwise

DEFINITION 3 (truth). For any Ty2-model M, world $\mathtt{w} \in D_s{}^M$, and M-assignment g,

- *st*-term ϕ is *true* in $\mathtt{w}$, on M under g, written $\mathtt{w} \models_{M,g} \phi$, iff $[\![\phi]\!]^{M,g}(\mathtt{w}) = 1$
- $(st)t$-term Φ is *true* in $\mathtt{w}$, on M under g, written $\mathtt{w} \models_{M,g} \Phi$, iff $\text{THE}\{\mathtt{p} \mid [\![\Phi]\!]^{M,g}(\mathtt{p}) = 1\}(\mathtt{w}) = 1$

ABBREVIATIONS A2:

$B_W A$	:=	BWA	$(\phi \vee \psi)$	:=	$\neg(\neg\phi \wedge \neg\psi)$
$B_W(A_1, \ldots A_n)$	:=	$BWA_1\ldots A_n$	sth	:=	$\lambda j\lambda x(\neg sbd_j\, x)$

• ASSERTION (temporality ignored until TOPIC 7)

Hamblin 1973. Sec. 1: DECLARATIVE SENTENCE |– *proposition*

(1$_E$)

Ole	be.TNS	sick
np$_N$: ole	vp/prd: λPP	prd: $\lambda xj\, sick_j\, x$

———————————————— <

s: $\lambda j\, sick_j\, ole$

Hamblin 1973. Sec. 8: DECLARATIVE SENTENCE |– SG-*set of propositions*

(1$_E$)

Ole	be.TNS	sick	. (prosody)
np$_N$: ole	vp/prd: λPP	prd: $\lambda xj\, sick_j\, x$	s̲\s: $\lambda qp(p = q)$

———————————————— <

s̲: $\lambda j\, sick_j\, ole$

———————————————————————— <

s: $\lambda p(p = \lambda j\, sick_j\, ole)$

revised cat → tp

s (sentence) → $(st)t$
s̲ (s-radical) → st
vp (:= s̲\np$_N$) → est
prd (:= s̲$_{sc}$\np$_A$) → est
tv (:= vp/np$_A$) → $eest$

(2$_E$)

Ole	have.TNS	buy.ASP	a dog	. (prosody)
np$_N$: ole	vp/vp: λPP	tv: $\lambda yxj\, buy_j(x, y)$	vp\tv: $\lambda Rxj\, \exists y(dog_j\, y \wedge Ryxj)$	s̲\s: $\lambda qp(p = q)$

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vp: $\lambda xj\, \exists y(dog_j\, y \wedge buy_j(x, y))$

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vp: $\lambda xj\, \exists y(dog_j\, y \wedge buy_j(x, y))$

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s̲: $\lambda j.\, \exists y(dog_j\, y \wedge buy_j(ole, y))$

———————————————————————————— <

s: $\lambda p(p = \lambda j\, \exists y(dog_j\, y \wedge buy_j(ole, y)))$

(3$_E$)

Ole	have.TNS=N'T	buy.ASP	anything	. (prosody)
np$_N$: ole	vp/vp: $\lambda Pxj\, \neg Pxj$	tv: $\lambda yxj\, buy_j(x, y)$	vp\tv: $\lambda Rxj\, \exists y(sth_j\, y \wedge Ryxj)$	s̲\s: $\lambda qp(p = q)$

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vp: $\lambda xj\, \exists y(sth_j\, y \wedge buy_j(x, y))$

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vp: $\lambda xj\, \neg\exists y(sth_j\, y \wedge buy_j(x, y))$

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s̲: $\lambda j\, \neg\exists y(sth_j\, y \wedge buy_j(ole, y))$

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s: $\lambda p(p = \lambda j\, \neg\exists y(sth_j\, y \wedge buy_j(ole, y)))$

• POLAR QUESTION: YN-SENTENCE (Hamblin 1973) |– DU-*set of propositions*

(4_E) **YN** **be.TNS** Ole sick

$\text{s}/\underline{\text{s}}: \lambda qp(p = q \vee p = \lambda j\, \neg qj)$ $\underline{\text{s}}/\text{prd}/\text{np}_N: \lambda xP(Px)$ $\text{np}_N: ole$ $\text{prd}: \lambda xj(sick_j\, x)$

\> $\underline{\text{s}}/\text{prd}: \lambda P(P\, ole)$

\> $\underline{\text{s}}: \lambda j(sick_j\, ole)$

\> $\text{s}: \lambda p(p = \lambda j(sick_j\, ole) \vee p = \lambda j(\neg sick_j\, ole))$

(5_E) **YN** **have.TNS** Ole buy.ASP anything

$\text{s}/\underline{\text{s}}: \lambda qp(p = q \vee p = \lambda j\, \neg qj)$ $\underline{\text{s}}/\text{vp}/\text{np}_N: \lambda xP(Px)$ $\text{np}_N: ole$ $\text{vp}: \lambda xj\, \exists y(sth_j\, y \wedge buy_j(x, y))$ <

\> $\underline{\text{s}}/\text{vp}: \lambda P(P\, ole)$

\> $\underline{\text{s}}: \lambda j\, \exists y(sth_j\, y \wedge buy_j(ole, y))$

\> $\text{s}: \lambda p(p = \lambda j\, \exists y(sth_j\, y \wedge buy_j(ole, y)) \vee p = \lambda j\, \neg\exists y(sth_j\, y \wedge buy_j(ole, y)))$

• CONSTITUENT QUESTION: WH-SENTENCE (Hamblin 1973) |– PL-*set of propositions*

Note: context represented by (variable) assignment (standard in static semantics)
world-variable i reserved for the *speech world* (a la Groenendijk & Stokhof 1982)

(6_E) **who** be.TNS sick

$\text{s}/(\underline{\text{s}}\backslash\text{np}_N): \lambda P\lambda p\, \exists x(sbd_i\, x \wedge p = Px)$ $\underline{\text{s}}\backslash\text{np}_N/\text{prd}: \lambda P(P)$ $\text{prd}: \lambda xj(sick_j\, x)$

\> $\underline{\text{s}}\backslash\text{np}_N: \lambda xj(sick_j\, x)$

\> $\text{s}: \lambda p\, \exists x(sbd_i\, x \wedge p = \lambda j(sick_j\, x))$

(7_E) **what** **have.TNS** Ole buy.ASP

$\text{s}/(\underline{\text{s}}/\text{np}_A): \lambda Pp\, \exists y(sth_i\, y \wedge p = Py)$ $\underline{\text{s}}/\text{vp}/\text{np}_N: \lambda xP(Px)$ $\text{np}_N: ole$ $\text{vp}/\text{np}_A: \lambda yxj(buy_j(x, y))$ <

\> $\underline{\text{s}}/\text{vp}: \lambda P(P\, ole)$

\>**B** $\underline{\text{s}}/\text{np}_A\ \lambda yj(buy_j(ole, y))$

\> $\text{s}: \lambda p\, \exists y(sth_i\, y \wedge p = \lambda j(buy_j(ole, y)))$

Lectures 12–13
TOWARD DYNAMIC HAMBLIN SEMANTICS

1. Information vs. attention

BASIC IDEAS:
- at each point in discourse, Stalnaker's common ground (CG) is the current SET OF TOPIC WORLDS
- assertions update *information*: in the output the 1ry topic ($\top_1$) is a TOPICAL PROPOSITION—the output set of topic worlds (output CG), which is a subset of the input CG (Stalnaker's CG update)
- questions update *attention*: in the output the 1ry topic ($\top_1$) is a TOPICAL QUESTION—i.e. the characteristic set of answers (like Hamblin's, but different sets for Is Ole sick? vs. Isn't Ole sick?)

EXAMPLE 1: ASSERTION AS INFORMATION UPDATE
Speaking up focuses attention on the input CG, p_0, e.g.

$p_0 = \{w_0, w_1\}$	$\langle w_0, [\![ole]\!]\rangle \in {}^{\{\}}[\![sick]\!]$
	$\langle w_1, [\![ole]\!]\rangle \notin {}^{\{\}}[\![sick]\!]$

will induce a *default infotention state*, $*p_0$, i.e. default set of *topic* ($\top$)-*background* ($\bot$) *lists*. On each $\top\bot$-list the input CG, p_0, is the TOPICAL PROPOSITION (1st proposition on $\top$-list); a CG-world, $w \in p_0$, is the TOPIC WORLD (1st world on $\top$-list); and there is nothing on the default $\bot$-list ($\langle\,\rangle$):

$*p_0$
$\langle\langle w_0, p_0\rangle, \langle\,\rangle\rangle$
$\langle\langle w_1, p_0\rangle, \langle\,\rangle\rangle$

The default infotention state, $*p_0$, is then updated based on what is said in the speech act, e.g.:

Ole	be.TNS sick	. (prosody)
$[\mathbf{x}\vert\ (\mathbf{x} = ole)^\circ]$;	$[sick_{\top\omega}\ \top\delta]$;	$[\mathbf{p}\vert\ \mathbf{p} = \top\omega\{\vert\}]$
c_1	c_2	c_3 ($\top_1$ = new CG, $\{w_0\}$)
$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle\,\rangle\rangle$	$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle\,\rangle\rangle$	$\langle\langle \{w_0\}, [\![ole]\!], w_0, p_0\rangle, \langle\,\rangle\rangle$
$\langle\langle [\![ole]\!], w_1, p_0\rangle, \langle\,\rangle\rangle$		

EXAMPLE 2: QUESTION AS ATTENTION UPDATE
Same input CG, p_0, induces same default infotention state, $*p_0$, but what follows is a YN question:

YN be.TNS	[Ole	sick	]
$[w\vert\ w \in \top\omega\{\vert\}]$;	$[\mathbf{x}\vert\ (\mathbf{x} = ole)^\circ]$;	$[sick_{\bot\omega}\ \top\delta]$;	$[p\vert\ p = \bot\omega\{\vert\}]$;
c_1	c_2	c_3	c_4
$\langle\langle w_0, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle \{w_0\}, w_0\rangle\rangle$
$\langle\langle w_0, p_0\rangle, \langle w_1\rangle\rangle$	$\langle\langle [\![ole]\!], w_0, p_0\rangle, \langle w_1\rangle\rangle$		
$\langle\langle w_1, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_1, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_1, p_0\rangle, \langle w_0\rangle\rangle$	$\langle\langle [\![ole]\!], w_1, p_0\rangle, \langle \{w_0\}, w_0\rangle\rangle$
$\langle\langle w_1, p_0\rangle, \langle w_1\rangle\rangle$	$\langle\langle [\![ole]\!], w_1, p_0\rangle, \langle w_1\rangle\rangle$		

? (prosody)
$[\mathbf{Q}\vert\ \mathbf{Q} = \bot\omega t\{\vert\}]$

c_5 ($\top_1$ = whether-$\{w_0\}$, no CG-update)
$\langle\langle \{\{w_0\}\}, [\![ole]\!], w_0, p_0\rangle, \langle \{w_0\}, w_0\rangle\rangle$
$\langle\langle \{\{w_0\}\}, [\![ole]\!], w_1, p_0\rangle, \langle \{w_0\}, w_0\rangle\rangle$

2. 2-sorted Update with Centering (UC2)

DEFINITION 1.1 The set of UC2 types is the smallest set **Typ** such that:
- $t, \delta, \omega, s \in \mathbf{Typ}$
- $(ab) \in \mathbf{Typ}$, if $a, b \in \mathbf{Typ}$

The set of discourse object types is the subset $\mathbf{DTyp} = \{\delta, \omega, \omega t\} \cup \{(at): a \in \{\delta, \omega, \omega t\}\}$

ABBREVIATIONS 1

$a_1 \ldots a_n b \ := \ (a_1 \ldots (a_n b))$ $\qquad$ $[\,] \ := \ (st)st$

$\Omega \ := \ \omega t$ $\qquad$ $[a] \ := \ a[\,]$

DEFINITION 1.2 (Basic UC2 terms). For each type $a \in \mathbf{Typ}$, there is a set of a-constants, $\mathbf{Con}_a$, a set of plain a-variables, $^{\perp}\mathbf{Var}_a$, and a set of topic-setting a-variables, $^{\top}\mathbf{Var}_a$, including:

$a \in \mathbf{Typ}$	$^{\perp}\mathbf{Var}_a$	$^{\top}\mathbf{Var}_a$	$\mathbf{Con}_a$	Name of objects
δ	x, y	$\mathbf{x}, \mathbf{y}$	*ole*	(ordinary) individuals
ω	w, v	$\mathbf{w}, \mathbf{v}$		worlds
Ω	p, q	$\mathbf{p}, \boldsymbol{q}$		propositions
δt	X, Y	$\mathbf{X}, \mathbf{Y}$		sets of individuals
Ωt	Q	$\mathbf{Q}$		sets of propositions
$\omega\delta t$			*sbd*, *dog*, *sick*, …	world-dependent sets of individuals
s	i, j, k, h			indices (*aka* topic-background lists)
st	I, J			infotention states
$(st)st$	K			updates

DEFINITION 1.3 (UC2 syntax). For each type $a \in \mathbf{Typ}$ the set of a-terms is defined as follows:

b	$A \in \mathbf{Term}_a$	if $A \in \mathbf{Con}_a \cup {^{\top}\mathbf{Var}_a} \cup {^{\perp}\mathbf{Var}_a}$
a	$\top a_n, \perp a_n \in \mathbf{Term}_{sa}$	if $a \in \mathbf{DTyp}$ & $n \in \{1, 2, \ldots\}$
{}	$B\{A\} \in \mathbf{Term}_{at}$	if $a \in \mathbf{DTyp}$ & $B \in \mathbf{Term}_{sa}$ & $A \in \mathbf{Term}_{st}$
·	$(u_a \cdot B) \in \mathbf{Term}_s$	if $a \in \mathbf{DTyp}$, $u_a \in {^{\top}\mathbf{Var}_a} \cup {^{\perp}\mathbf{Var}_a}$ & $B \in \mathbf{Term}_s$
;	$(A; B) \in \mathbf{Term}_{(st)st}$	if $A, B \in \mathbf{Term}_{(st)st}$
$\boldsymbol{\lambda}$	$\lambda u_a(B) \in \mathbf{Term}_{ab}$	if $u_a \in {^{\top}\mathbf{Var}_a} \cup {^{\perp}\mathbf{Var}_a}$ & $B \in \mathbf{Term}_b$
A	$BA \in \mathbf{Term}_b$	if $B \in \mathbf{Term}_{ab}$ & $A \in \mathbf{Term}_a$
C	$\neg A, (A \rightarrow B), (A \wedge B), (A \vee B) \in \mathbf{Term}_t$	if $A, B \in \mathbf{Term}_t$
Q	$\forall u_a B, \exists u_a B \in \mathbf{Term}_t$	if $u_a \in {^{\top}\mathbf{Var}_a} \cup {^{\perp}\mathbf{Var}_a}$ & $B \in \mathbf{Term}_t$
=	$(A = B) \in \mathbf{Term}_t$	if $A, B \in \mathbf{Term}_a$

DEFINITION 2.1 (UC2 frames). A UC2 frame is a set of sets $\{D_a\}_{a \in \mathbf{Typ}}$ such that:

i. $D_t = \{1, 0\}$, D_δ, and D_ω are non-empty pairwise disjoint sets

ii. $D_s = \cup_{n,\, m \leq 0} (D^n \times D^m)$, where $D = \cup_{a \in \mathbf{DTyp}} D_a$

iii. $D_{ab} = \{\mathtt{f} \mid \varnothing \subset \mathrm{Dom}\ \mathtt{f} \subseteq D_a \ \&\ \mathrm{Ran}\ \mathtt{f} \subseteq D_b\}$

ABBREVIATIONS 2 (lists, projections & extensions). Let $D = \cup_{a \in \mathbf{DTyp}} D_a$.

- For $\mathtt{i} = \langle \mathtt{i}_1, \mathtt{i}_2 \rangle \in D^n \times D^m$, $\top\mathtt{i} = \mathtt{i}_1$ is the *topic list* & $\perp\mathtt{i} = \mathtt{i}_2$ is the *background list* of $\mathtt{i}$
- For $\mathtt{x} \in D^{n+m}$, $(\mathtt{x})_n$ is $\mathtt{x}_n$ (nth coordinate) & $(\mathtt{x})_a$ is the subsequence of type a coordinates
- For $\mathtt{d}_0, \ldots, \mathtt{d}_n \in D$: $(\mathtt{d}_0 \cdot \langle\, \rangle) = \langle \mathtt{d}_0 \rangle$ & $(\mathtt{d}_0 \cdot \langle \mathtt{d}_1, \ldots, \mathtt{d}_n \rangle) := \langle \mathtt{d}_0, \mathtt{d}_1, \ldots, \mathtt{d}_n \rangle$ ($\mathtt{d}_0$-*extensions*)

DEFINITION 2.2 (UC2-models and assignments)

- A UC2-*model* is a pair, $M = \langle \{D_a\}_{a \in \mathbf{Typ}}, [\![\cdot]\!] \rangle$, s.t. (i) $\{D_a\}_{a \in \mathbf{Typ}}$ is a standard UC2-frame, (ii) $[\![\cdot]\!]$ is an *interpretation function* that assigns to each $\alpha \in \mathbf{Con}_a$ a denotation $[\![\alpha]\!] \in D_a$.
- An *M-assignment* is a function g that assigns $g(u) \in D_a$ to each $u \in {^{\top}\mathbf{Var}_a} \cup {^{\perp}\mathbf{Var}_a}$. If $\mathtt{d} \in D_a$ then $g[u/\mathtt{d}]$ is the M-assignment s.t. (i) $g[u/\mathtt{d}](u') = g(u')$ for all $u' \neq u$, (ii) $g[u/d](u) = \mathtt{d}$.

ABBREVIATIONS 3 (Functions & sets). For $f \in D_{a1\ldots an\,t}$ and $\langle a_1, \ldots, a_n\rangle \in D_{a1} \times \ldots \times D_{an}$:

- $f(a_1, \ldots, a_n) := f(a_1)\ldots(a_n)$
- ${}^{\{\}}(f) = \{\langle a_1,\ldots a_n\rangle : f(a_1,\ldots a_n) = 1\}$ (*set characterized* by function f)
- ${}^{\chi}(A)$ (*characteristic function* of set A) is the function f such that ${}^{\{\}}(f) = A$

DEFINITION 2.3 (UC2 semantics). The value $[\![A]\!]^g$ of a term A on a model $M = \langle \{D_a\}_{a \in \mathbf{Typ}}, [\![\cdot]\!]\rangle$ under an assignment g is defined as follows (Note: (i) we use von Neuman's definitions $0 := \{\}$ & $1 := \{\varnothing\}$, (ii) '$X \doteq Y$' means 'X is Y if Y is defined, else X is undefined', and (iii) $a f \doteq f(a)$)

b	$[\![A]\!]^g$	$=$	$[\![A]\!]$	if $A \in \mathbf{Con}_a$
		$=$	$g(A)$	if $A \in {}^{\top}\mathbf{Var}_a \cup {}^{\bot}\mathbf{Var}_a$
a	$[\![\top a_n]\!]^g(i)$	$\doteq$	$((\top i)_a)_n$	for any $i \in D_s$
	$[\![\bot a_n]\!]^g(i)$	$\doteq$	$((\bot i)_a)_n$	for any $i \in D_s$
{}	$[\![B\{A\}]\!]^g$	$\doteq$	${}^{\chi}\{[\![B]\!]^g(i) \mid i \in {}^{\{\}}[\![A]\!]^g\}$	
·	$[\![(u_a \cdot B)]\!]^g$	$\doteq$	$\langle (g(u_a) \cdot \top[\![B]\!]^g), \bot[\![B]\!]^g\rangle$	for any $u_a \in {}^{\top}\mathbf{Var}_a$
		$\doteq$	$\langle \top[\![B]\!]^g, (g(u_a) \cdot \bot[\![B]\!]^g)\rangle$	for any $u_a \in {}^{\bot}\mathbf{Var}_a$
;	$c[\![(A; B)]\!]^g$	$\doteq$	$c[\![A]\!]^g[\![B]\!]^g$	for any $c \in D_{st}$
$\boldsymbol{\lambda}$	$[\![\lambda u_a(B)]\!]^g(d)$	$\doteq$	$[\![B]\!]^{g[u/d]}$	for any $d \in D_a$
A	$[\![BA]\!]^g$	$\doteq$	$[\![B]\!]^g([\![A]\!]^g)$	
C	$[\![\neg A]\!]^g$	$\doteq$	$(1 - [\![A]\!]^g)$	
	$[\![(A \to B)]\!]^g$	$\doteq$	$(1 - ([\![A]\!]^g - [\![B]\!]^g))$	
	$[\![(A \wedge B)]\!]^g$	$\doteq$	$([\![A]\!]^g \cap [\![B]\!]^g)$	
	$[\![(A \vee B)]\!]^g$	$\doteq$	$([\![A]\!]^g \cup [\![B]\!]^g)$	
Q	$[\![\forall u_a A]\!]^g$	$=$	1	if $\forall d \in D_a$: $[\![A]\!]^{g[u/d]} = 1$
		$=$	0	otherwise
	$[\![\exists u_a A]\!]^g$	$=$	1	if $\exists d \in D_a$: $[\![A]\!]^{g[u/d]} = 1$
		$=$	0	otherwise
=	$[\![(A = B)]\!]^g$	$=$	1	if $[\![A]\!]^g, [\![B]\!]^g \in D_a$ & $[\![A]\!]^g = [\![B]\!]^g$
		$=$	0	if $[\![A]\!]^g, [\![B]\!]^g \in D_a$ & $[\![A]\!]^g \neq [\![B]\!]^g$

DEFINITION 3.1 (Initial context & default state). An *initial context* is a proposition $p_0 \in D_\Omega$ s.t. ${}^{\{\}}p_0 \neq \varnothing$. This induces the *default infotention state* $*p_0 = {}^{\chi}\{\langle\langle w, p_0\rangle, \langle\,\rangle\rangle \mid w \in {}^{\{\}}p_0\}$.

DEFINITION 3.2 (Topic, assertion, truth value). For a model M, initial context p_0, and $(st)st$-term K:

i. $\top_{M,\,p0}\mathsf{K} := \{(\top i)_1 \mid \forall g\!: i \in {}^{\{\}}(*p_0[\![\mathsf{K}]\!]^g)\}$ (set of *primary topics* introduced by K wrt M and p_0)

ii. Given M and p_0, K can be used to *assert* a proposition $q \in D_\Omega$, iff $\top_{M,\,p0}\mathsf{K} = \{q\}$

iii. K is *true* in world w wrt M and p_0, iff $\exists q \in D_\Omega$: $\top_{M,\,p0}\mathsf{K} = \{q\}$ & $w \in {}^{\{\}}q$
K is *false* in world w wrt M and p_0, iff $\exists q \in D_\Omega$: $\top_{M,\,p0}\mathsf{K} = \{q\}$ & $w \notin {}^{\{\}}q$

ABBREVIATIONS 4 (Syntactic sugar)

i. $A_a \in B_{at}$	:=	BA		(set theory)
ii. $\top a, \bot a$	:=	$\top a_1, \bot a_1$	if $a \in \mathbf{DTyp}$	(dynamic terms)
$A_a{}^{\circ}$	:=	$\lambda i(A)$	if $a \in \mathbf{DTyp}$	
	:=	A	if $a \in \{sb \mid b \in \mathbf{DTyp}\}$	
iii. $(B_W\, A)$	:=	$\lambda i(B\ W^{\circ}i\ A^{\circ}i)$		(conditions)
$B_W(A_1, \ldots, A_n)$	:=	$\lambda i(B\ W^{\circ}i\ A_1{}^{\circ}i\ \ldots\ A_n{}^{\circ}i)$		
$(A = B)^{\circ}$	:=	$\lambda i(A^{\circ}i = B^{\circ}i)$		
(C_1, C_2)	:=	$\lambda i(C_1 i \wedge C_2 i)$		
iv. $[C]$	:=	$\lambda I \lambda j(Ij \wedge Cj)$		(local drt-boxes)
$[u_1\ldots u_n]$	:=	$\lambda I \lambda j\ \exists u_1\ldots u_n \exists i(j = (u_1 \cdot \ldots (u_n \cdot i)) \wedge Ii)$		
$[u_1\ldots u_n \mid C]$	:=	$\lambda I \lambda j\ \exists u_1\ldots u_n \exists i(j = (u_1 \cdot \ldots (u_n \cdot i)) \wedge Ii \wedge Ci)$		
v. $[u_{at} \mid u = A_{sa}\{\mid\}]$	:=	$\lambda I \lambda j\ \exists u \exists i(j = (u \cdot i) \wedge Ii \wedge u = A\{I\})$		(global drt-boxes)
$[u_a \mid u \in A_{sa}\{\mid\}]$	:=	$\lambda I \lambda j\ \exists u \exists i(j = (u \cdot i) \wedge Ii \wedge u \in A\{I\})$		

3. Topic-background lists & infotention states

Consider a UC2 model $M = \langle\{D_a\}_{a \in \mathbf{Typ}}, [\![\cdot]\!]\rangle$ such that $D_\delta = \{\Delta\}$ and $D_\omega = \{\mathtt{w}_0, \mathtt{w}_1\}$. Then:

• the *domain of things that can be listed as discourse objects* is

$D = \cup_{a \in \mathbf{DTyp}} D_a$

$= D_\delta \cup D_\omega \cup D_\Omega \cup D_{\delta t} \cup D_{\omega t} \cup D_{\Omega t}$ — D1.1.**DTyp**

$= D_\delta \cup D_\omega \cup D_\Omega \cup D_{\delta t} \cup D_{\Omega t}$ — $\Omega := \omega t$

$= \{\Delta\} \cup \{\mathtt{w}_0, \mathtt{w}_1\} \cup \{{}^\chi\mathtt{p} | \mathtt{p} \subseteq \{\mathtt{w}_0, \mathtt{w}_1\}\}$ — D2.1, df. D_δ, D_ω abv

$\cup \{{}^\chi\mathtt{X} | \mathtt{X} \subseteq \{\Delta\}\} \cup \{{}^\chi\mathtt{Q} | \mathtt{Q} \subseteq \{{}^\chi\mathtt{p} | \mathtt{p} \subseteq \{\mathtt{w}_0, \mathtt{w}_1\}\}\}$

• sample *lists* of (topical or background) discourse objects

$\langle\,\rangle$ (empty list)

$\langle\Delta, \mathtt{w}_0, {}^\chi\{\mathtt{w}_0, \mathtt{w}_1\}\rangle$

• *sets of possible lists* of *n* (topical or background) discourse objects

$D^0 = \{\langle\,\rangle\}$

$D^1 = \{\langle\mathtt{d}\rangle | \mathtt{d} \in D\}$

$D^n = \{\langle\mathtt{d}_1, \ldots \mathtt{d}_n\rangle | \mathtt{d}_i \in D\}$

• *domain of topic-background lists*

$D_s = \cup_{n,\, m \geq 0} (D^n \times D^m)$ — D2.1.D_s

$= (D^0 \times D^0) \cup (D^1 \times D^0) \cup (D^0 \times D^1) \cup (D^1 \times D^1) \cup \ldots$ — df. $\cup_{m,\, n \geq 0}$

$= \{\langle\langle\,\rangle, \langle\,\rangle\rangle\} \cup \{\langle\langle\mathtt{d}\rangle, \langle\,\rangle\rangle | \mathtt{d} \in D\} \cup \{\langle\langle\,\rangle, \langle\mathtt{d}\rangle\rangle | \mathtt{d} \in D\}$ — df. D^n, $\times$

$\cup \{\langle\langle\mathtt{d}\rangle, \langle\mathtt{d}'\rangle\rangle | \mathtt{d}, \mathtt{d}' \in D\} \cup \ldots$

• an *infotention state*, $\mathtt{c} \in D_{st}$, is (the characteristic function of) a set of topic-background lists.