Anaphora without indices: Dynamics of centering

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Abstract
The standard way to represent anaphoric dependencies is to co-index the anaphor with its antecedent in the syntactic input to semantic rules, which then interpret such indices as variables. Dynamic theories (e.g. Kamp's DRT, Heim's File Change Semantics, Muskens's Compositional DRT, etc) combine syntactic co-indexation with semantic left-to-right asymmetry. This captures the fact that the anaphor gets its referent from the antecedent and not vice versa. Formally, a text updates the input state of information to the output state. In particular, an indexed antecedent updates the entity assigned to its index, and the output entity is then picked up as the referent by any subsequent co-indexed anaphor.

The elephant in the room is that the all-important indices have no audible reflex in any natural language—e.g. no language contrasts he_{17} vs. he_{123}. Adding to the embarrassment, actual anaphoric contrasts are not interpreted like contrasting variables in formal logics—e.g. *zero* (i.e. missing argument) vs. *pronoun tā* in Mandarin Chinese; or *proximate* vs. *obviative* 3rd person in languages with grammatical obviation (e.g., *-ni* vs. *-a* in Kalaallisut). Yet actual anaphoric systems render anaphora unambiguous (Mandarin, Kalaallisut), or much less ambiguous than predicted (English), by mechanisms that index-based theories have no tools to explicate. A yet another mystery for index-based theories is why anaphora resolution does not get increasingly harder as discourse progresses, since every sentence adds to the set of potential antecedents. Yet, intuitively, in a long novel a pronoun at the end is just as easy to resolve as a pronoun in paragraph one.

Intuitively, this is because a pronoun refers to a *salient* antecedent, and the set of currently salient antecedents changes but does not grow. Previous attempts to implement this common-sense idea (*centering theory* of Grosz *et al* 1995 and related work) have been criticized into oblivion (see e.g. Kehler 1997). But the basic idea still makes intuitive sense. In this talk, I use formal tools of update semantics to propose a new implementation, which fits both the facts of actual anaphoric systems and the assumptions of directly compositional theories (e.g. CCG).

Outline
1. Grammatical centering systems
2. Mandarin in *Update with Centering*
3. Kalaallisut in *Update with Centering*
4. English in *Update with Centering*
5. Conclusion

1 GRAMMATICAL CENTERING SYSTEMS

• TENTATIVE UNIVERSALS

***Obs*. 1** *Centering systems* disambiguate anaphora by grammatically tracking the current center & background of attention. (cf. focal vs. peripheral vision).

Obs. 2 Anaphors refer to the *top-ranked discourse referent* on the relevant tier—e.g. *top-ranked* center-stage (⊤*-dref*) or *top-ranked* in the background (⊥*-dref*).

Obs. 3 Nominal centering distinguishes *subcategorized arguments*—i.e. subjects, objects, and possessors. (Optional adjuncts are not eligible for top rank on any tier)

• MANDARIN CHINESE: main unit of discourse is a *topic chain*—i.e. chain of clauses sharing the same topic (⊤-dref)—not a sentence (Tsao 1979, Chu 1998, Li 2005).

(1) $[[_{i}$ topic-update ($np^{\top}$) , comment$_1$ ($_{\top}$n)]
$[_{ii}$ comment$_2$ ($_{\top}$v) , comment$_3$ ($_{\top}$v)]]$_{\top\text{-}chain}$

i. Xiǎoli *niánqīng piàoliang , gōnzuò yě hǎo*.
Xiaoli$^{\top}$ young pretty , $_{\top}$job also good
Xiaoli$^{\top}$ is young and pretty. She$_{\top}$ has a good job, too.

ii. *Suīrán yǒu ge nánpéngyou , kěshì bù xiǎng jié.hūn* .
although $_{\top}$have CL boyfriend , but $_{\top}$NOT wish get.married
She$_{\top}$ has a boyfriend, but $_{\top}$doesn't wish to get married. [Li:185]

(2) $[[_{Si}$ topic-update ($np^{\top}$), comment$_1$ ($_{\top}$n), comment$_2$ ($_{\top}$n), comment$_3$ ($np^{\perp}$ $v_{\top}$)]
$[_{Sii}$ comment$_4$ ($_{\perp}v_{\top}$), comment$_5$ ($_{\perp}v_{\top}$), comment$_6$ ($_{\perp}v_{\top}$), comment$_7$ ($_{\perp}v_{\top}$)]]$_{\top\text{-}chain}$

i. Nà-liàng chē, *jiàqián tài guì, yánsè yě bù hǎo* , Lisi *bù xǐhuan*.
that-CL car$^{\top}$, $_{\top}$price too high, $_{\top}$color also NOT good , Lisi$^{\perp}$ NOT like$_{\top}$
That car$^{\top}$ is too expensive and it$_{\top}$'s an ugly color. Lisi$^{\perp}$ doesn't like it$_{\top}$.

ii. *Zuótiān qù kàn-le , hái kāi-le yíhuìr , háishì bù xǐhuan* ,
yesterday $_{\perp}$go look$_{\top}$-PNC, even $_{\perp}$drive$_{\top}$-PNC M$_{a.while}$, still NOT $_{\perp}$like$_{\top}$,
méi mǎi .
NOT $_{\perp}$buy$_{\top}$
Yesterday he$_{\perp}$ went to take a look at it$_{\top}$. He$_{\perp}$ even took it$_{\top}$ out for a spin, but he$_{\perp}$ still didn't like it$_{\top}$. He$_{\perp}$ didn't buy it$_{\top}$. [Li:2]+[fw]

• KALAALLISUT: arguments expressed as *pronominal affixes* (pn); two forms of 3rd person pn-arguments: proximate for ⊤ v. obviative for ⊥ (e.g. *-ni* '$3s_{⊤}$' v. *-a* '$3s_{⊥}$'); full np's interpreted as re-centering updates, setting local context for pn-arguments.

Context for (3)-(3′): Yesterday the children$^{⊤}$ had a dog-sled race.

(3) *Ole-p* *ikinnguta-a* *ajugaa-ga-mi* *nuannaar-pu-q.*
Ole-ERG$^{⊥}$ [friend-$3s_{⊥}$]$^{⊤}$ win-FCT$_{⊤}$-$3s_{⊤}$ happy-DEC$_{⊤}$-3S
Ole$^{⊥}$'s friend$^{⊤}$ won, so she$_{⊤}$ (= friend) was happy.

(3′) *Ole-p* *ikinngun-ni* *ajugaa-mm-at* *nuannaar-pu-q.*
Ole-ERG$^{⊤}$ [friend-$3s_{⊤}$]$^{⊥}$ win-FCT$_{⊥}$-$3s_{⊥}$ happy-DEC$_{⊤}$-3S
Ole$^{⊤}$'s friend$^{⊥}$ won, so she$_{⊤}$ (= Ole) was happy.

(4) i. *Ilaanni* anguti-tuqa-*p* nulia-*ni* *kisimi-i-qatig(i-p)a-a*
once man-old-ERG$^{⊤}$ [wife-$3s_{⊤}$]$^{⊥}$ alone-be-with-DEC$_{⊤⊥}$-3S.3S
Once an old man$^{⊤}$ was alone with his$_{⊤}$ wife$^{⊥}$,
irnir-*tik* *piniar-riar-sima-mm-at.*
[son-$3P_{⊤+}$]$^{⊥}$ hunt-go-prf-FCT$_{⊥}$-$3s_{⊥}$
because their$_{⊤+⊥}$ son$^{⊥}$ was away on a hunting trip.

ii. Aavi-*rsuaq* *isissaa-lir-mm-at*
walrus-big$^{⊥}$ visible-begin-FCT$_{⊥}$-$3s_{⊥}$
When a big walrus$^{⊥}$ showed up,
piniar-niar-llu-gu *qain-ni* *atir-vigi-lir-pa-a.*
hunt-intend-ELA$_{⊤}$-$3s_{⊥}$ kayak-$3s_{⊤}$ go.down-to-begin-DEC$_{⊤⊥}$-3S.3S
(ELA$_{⊤}$: elaboration of ⊤)
he$_{⊤}$ headed down to his$_{⊤}$ kayak to go after it$_{⊥}$ (*lit.* $_{⊤}$intending to …).

iii. *Nuli-ata* *inirtir-aluar-pa-a*
[wife-$3s_{⊥}$.ERG]$^{⊤}$ forbid-in.vain-DEC$_{⊤⊥}$-3S.3S
His$^{⊥}$ wife$^{⊤}$ tried to stop him$_{⊥}$,
kisimi-i-mm-at *avala-qqu-na-gu.*
alone-be-FCT$_{⊥}$-$3s_{⊥}$ set.out-tell-not.ELA$_{⊤}$-$3s_{⊥}$
begging$_{⊤}$ him$_{⊥}$ not to set out because he$_{⊥}$ was alone.

iv. *Ui-ata=li* *tusar-uma-na-gu*
[husband-$3s_{⊥}$.ERG]$^{⊤}$ listen-want-not-not.ELA$_{⊤}$-$3s_{⊥}$
But he$^{⊤}$ (*lit.* her$^{⊥}$ husband$^{⊤}$) refused to listen to her$_{⊥}$ and
aavi-rsuaq *nalip-pa-a.*
walrus-big$^{⊥}$ harpoon-DEC$_{⊤⊥}$-3S.3S
$_{⊤}$harpooned the great walrus$^{⊥}$.

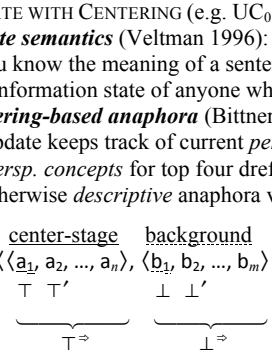
v. *Nali-mm-a.ni* *upa-annar-pa-a* *qaja-a* *tulur-lu-gu.*
harpoon-FCT$_{⊥}$-$3s_{⊥}$.$3s_{⊤}$ turn.on-just-DEC$_{⊤⊥}$-3S.3S kayak-$3s_{⊥}$ gore-ELA$_{⊤}$-$3s_{⊥}$
As soon as he$^{⊥}$ hit it$^{⊤}$, it$_{⊤}$ turned on him$_{⊥}$, $_{⊤}$goring his$_{⊥}$ kayak$^{⊥}$ with its tusks

2 MANDARIN IN UPDATE WITH CENTERING

• UPDATE WITH CENTERING (e.g. UC_0 in Appendix)

- ***Update semantics*** (Veltman 1996):
"You know the meaning of a sentence if you know the change it brings about in the information state of anyone who accepts the news conveyed by it."

- ***Centering-based anaphora*** (Bittner 2011; cf. Dekker '94, Groenendijk *et al* '95)
(a) update keeps track of current *perspective* = center-stage + background
(b) *persp. concepts* for top four drefs: ⊤ (ctr), ⊤′ (2ry ctr), ⊥ (bck), ⊥′ (2ry bck)
(c) otherwise *descriptive* anaphora via $⊤^{⇒}$ (ctr-stage set) & $⊥^{⇒}$ (background set)



• MANDARIN CHINESE: From discourse (2) to UC_0 (see also Bittner 2011b)

(5) i. That car$^{⊤}$ is too expensive and it$_{⊤}$'s an ugly color. Lisi$^{⊥}$ doesn't like it$_{⊤}$.
(input) that-CL car$^{⊤}$, $_{⊤}$price too high ,
$^{⊤}$[x| *car*⟨x⟩, $x ∈ ⊥^{⇒}$] ; [x| *price*⟨x, ⊤⟩, *too.high*⟨x⟩] ;
⟨⟨ ⟩, ⟨…, 🚗⟩⟩ ⟨⟨🚗⟩, ⟨…, 🚗⟩⟩ ⟨⟨🚗⟩, ⟨$, …, 🚗⟩⟩

$_{⊤}$color also NOT good , Lisi$^{⊥}$ NOT like$_{⊤}$
[x| *color*⟨x, ⊤⟩, ~*good*⟨x⟩] ; [x| *lisi*⟨x⟩, $x ∈ ⊥^{⇒}$, ~*like*⟨x, ⊤⟩] ;
⟨⟨🚗⟩, ⟨●, $, …, 🚗⟩⟩ ⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩

ii. (Yesterday) he$_{⊥}$ went to take a look at it$_{⊤}$. He$_{⊥}$ even took it out for a spin, …
$_{⊥}$go look$_{⊤}$-PNC , even $_{⊥}$drive$_{⊤}$-PNC $M_{a.while}$, …
[*go.look.at*⟨⊥, ⊤⟩] ; [*drive.a.while*⟨⊥, ⊤⟩] ; …
⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩ ⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩

(6) i. Jiajia *bing le,* *zuotian* *wanshang jiu* *fa.shao.* [Li:89]
Jiajia$^{⊤}$ sick SFP, yesterday night then $_{⊤}$run.a.fever
Jiajia$^{⊤}$ is sick. She$_{⊤}$ ran a fever last night.

ii. Lisi *zhidao* ta-de mama *hen mang,* *mei gan* *gaosu ta,*
Lisi$^{⊤}$ know $3s_{⊤}$-'s mom$^{⊥}$ very busy, NOT $_{⊤}$dare tell $3s_{⊥}$,
dai *ta* *qu* *kan-le* jizhen, *da-le* *zhen.*
$_{⊤}$take $3s_{⊤'}$ go see-PNC ER$^{⊥}$, $_{⊥}$do-PNC injection
Lisi$^{⊤}$ knew her$_{⊤'}$ mom$^{⊥}$ was busy, so he$_{⊤}$ didn't want to tell her$_{⊥}$. He$_{⊤}$ just took her$_{⊤'}$ to the ER$^{⊥}$ (*lit.* to see ER$^{⊥}$) and they$_{⊥}$ gave her$_{⊤'}$ an injection.

• Toward CCG + UC_0 FRAGMENT OF MANDARIN
– ***basic entries*** for verbs, e.g.

bìng	⊢	s\np: $\lambda \underline{x}_{se}[sick\langle \underline{x} \rangle]$	(intransitive verb)
xǐhuan	⊢	s\np/np: $\lambda \underline{y}_{se} \lambda \underline{x}_{se}[like\langle \underline{x}, \underline{y} \rangle]$	(transitive verb)

– lexical ***centering operators***

$_{\top}(\cdot)$	⊢	s/(s\np): $\lambda \underline{P}(\underline{P}\ \top)$	(missing ⊤-subject)
$_{\bot}(\cdot)$	⊢	s/(s\np): $\lambda \underline{P}([\top \neq \bot]; \underline{P}\ \bot)$	(missing ⊥-subject)
$(\cdot)_{\top}$	⊢	(s\np)/(s\np/np): $\lambda \underline{R} \lambda \underline{x}_{se}([\underline{x} \neq \top]; \underline{R}\ \top\ \underline{x})$	(missing ⊤-object)
$(\cdot)_{\bot}$	⊢	(s\np)/(s\np/np): $\lambda \underline{R} \lambda \underline{x}_{se}([\underline{x} \neq \bot]; \underline{R}\ \bot\ \underline{x})$	(missing ⊥-object)

– Hence ***derived entries*** for verbs with 'missing arguments', e.g.

$_{\top}$*xǐhuan*	⊢	s/np: $\lambda \underline{y}_{se}[like\langle \top, \underline{y} \rangle]$	(missing ⊤-subject)
xǐhuan$_{\top}$	⊢	s\np: $\lambda \underline{x}_{se}([\underline{x} \neq \top]; [like\langle \underline{x}, \top \rangle])$	(missing ⊤-object)
$_{\bot}$(*xǐhuan*$_{\top}$)	⊢	s: $([\top \neq \bot]; [like\langle \bot, \top \rangle])$	(missing ⊥-subject & ⊤-object)

3 KALAALLISUT IN UPDATE WITH CENTERING

• KALAALLISUT: From discourse (4) to UC_0 (see also Bittner 2011a)

(7)i. Once an old man$^{\top}$ was alone with his$_{\top}$ wife$^{\bot}$,

once	man-old-ERG$^{\top}$	[wife-3S$_{\top}$]$^{\bot}$	alone-with-DEC$_{\top\bot}$-3S.3S
	$^{\top}$[x| *old.man*⟨x⟩];	[x| *wife.of*⟨x, ⊤⟩];	[*alone.with*⟨⊤, ⊥⟩]
	⟨⟨☺⟩, ⟨⟩⟩	⟨⟨☺⟩, ⟨♥⟩⟩	
	⋮		
	⟨⟨☺$_n$⟩, ⟨⟩⟩		

because their$_{\top+\bot}$ son$^{\bot}$ was away on a hunting trip.

[son-3P$_{\top+}$]$^{\bot}$	hunt-go-prf-FCT$_{\bot}$-3S$_{\bot}$
[x| *son.of*⟨x, ⊤+⊥⟩];	[*gone.hunting*⟨⊥⟩]
⟨⟨☺⟩, ⟨ , ♥⟩⟩	

ii. When a big walrus$^{\bot}$ showed up,

[walrus-big$^{\bot}$	be.visible-begin-FCT$_{\bot}$-3S$_{\bot}$]
[x| *big.walrus*⟨x⟩];	[*show.up*⟨⊥⟩];
⟨⟨☺⟩, ⟨ , , ♥⟩⟩	

he$_{\top}$ went down to his$_{\top}$ kayak to go after it$_{\bot}$.

hunt-intend-ELA$_{\top}$-3S$_{\bot}$	kayak-3S$_{\top}$	go.down-to-begin-DEC$_{\top\bot}$-3S.3S
[*intend.to.hunt*⟨⊤, ⊥⟩];	[x| *kayak.of*⟨x, ⊤⟩];	[*go.down.to*⟨⊤, ⊥⟩]
	⟨⟨☺⟩, ⟨ , , , ♥⟩⟩	

iii. His$^{\bot}$ wife$^{\top}$ tried to stop him$_{\bot}$,

[wife-3S$_{\bot}$.ERG]$^{\top}$	forbid-in.vain-DEC$_{\top\bot}$-3S.3S
[x| $x = \top$]; $^{\top}$[x| *wife.of*⟨x, ⊥⟩, $x \in \bot^{\Rightarrow}$];	[⊤ ≠ ⊥]; [*try.to.stop*⟨⊤, ⊥⟩];
⟨⟨♥, ☺⟩, ⟨☺, , , , ♥⟩⟩	

begging$_{\top}$ him$_{\bot}$ not to set out because he$_{\bot}$ was alone.

alone-be-FCT$_{\bot}$-3S$_{\bot}$	set.out-tell-not.ELA$_{\top}$-3S$_{\bot}$
[*alone*⟨⊥⟩];	[*beg.not.to.set.out*⟨⊤, ⊥⟩]

iv. But he$^{\top}$ (*lit.* her$^{\bot}$ husband$^{\top}$) refused to listen to her$_{\bot}$ and

[husband-3S$_{\bot}$.ERG]$^{\top}$	listen-want-not.ELA$_{\top}$-3S$_{\bot}$
[x| $x = \top$]; $^{\top}$[x| *husband*⟨x, ⊥⟩, $x \in \bot^{\Rightarrow}$];	[*refuse.to.listen.to*⟨⊤, ⊥⟩]
⟨⟨☺, ♥, ☺⟩, ⟨♥, ☺, , , , ♥⟩⟩	

harpooned the great walrus$^{\bot}$.

walrus-big$^{\bot}$	harpoon-DEC$_{\top\bot}$-3S.3S
[x| *big.walrus*⟨x⟩, $x \in \bot^{\Rightarrow}$];	[⊤ ≠ ⊥]; [*harpoon*⟨⊤, ⊥⟩]
⟨⟨☺, ♥, ☺⟩, ⟨ , ♥, ☺, , , , ♥⟩⟩	

v. As soon as he$^{\bot}$ hit it$^{\top}$, it$_{\top}$ turned on him$_{\bot}$,

harpoon-FCT$_{\bot}$-3S$_{\bot}$.3S$_{\top}$	turn.on-just-DEC$_{\top\bot}$-3S.3S
$^{\top}$[x| $x = \bot$]; [x| *harpoon*⟨x, ⊤⟩, $x \in \top^{\Rightarrow}$];	[⊤ ≠ ⊥]; [*turn.on*⟨⊤, ⊥⟩];
⟨⟨ , ☺, ♥, ☺⟩, ⟨☺, , ♥, ☺, , , , ♥⟩⟩	

$_{\top}$puncturing his$_{\bot}$ kayak$^{\bot}$ with its$_{\top}$ tusks.

qaja-q	*tulur-lu-gu.*
kayak-3S$_{\bot}$	gore-ELA$_{\top}$-3S$_{\bot}$
[x| *kayak*⟨x, ⊥⟩];	[*puncture.w.tusks*⟨⊤, ⊥⟩]
⟨⟨ , ☺, ♥, ☺⟩, ⟨ , ☺, , ♥, ☺, , , , ♥⟩⟩	

• Toward CCG + UC_0 FRAGMENT OF KALAALLISUT (as in Bittner 2011a)
– ***verb roots***, e.g.

naparsima-	⊢	s\pn: $\lambda \underline{x}_{se}[sick\langle \underline{x} \rangle]$	(intransitive verb)
nuannari-	⊢	s\pn\pn: $\lambda \underline{x}_{se} \lambda \underline{y}_{se}[like\langle \underline{x}, \underline{y} \rangle]$	(transitive verb)

– ***inflectional centering*** by MOOD + pn-arguments, e.g.

-DEC$_{\top}$-3S	⊢	s\(s\pn): $\lambda \underline{P}(\underline{P}\ \top)$	(ctr fact about ⊤)
-DEC$_{\top\bot}$-3S.3S	⊢	s\(s\pn\pn): $\lambda \underline{R}([\top \neq \bot]; \underline{R}\ \top \bot)$	(ctr fact about ⟨⊤, ⊥⟩)
-FCT$_{\top}$-3S$_{\top}$	⊢	(s/s)\(s\pn): $\lambda \underline{P} \lambda K(\underline{P}\ \top; K)$	(bck fact abt input ⊤)
		(s/s)\(s\pn): $\lambda \underline{P} \lambda K(^{\top}[x = \bot]; \underline{P}\ \top; K)$	(… output ⊤)
-FCT$_{\bot}$-3S$_{\bot}$	⊢	(s/s)\(s\pn): $\lambda \underline{P} \lambda K(\underline{P}\ \bot; K; [\top \neq \bot])$	(bck fact abt input ⊥)
		(s/s)\(s\pn): $\lambda \underline{P} \lambda K([x = \top]; \underline{P}\ \bot; K; [\top \neq \bot])$	(… output ⊥)

4 ENGLISH IN UPDATE WITH CENTERING

• APPROACHES TO PRONOUN INTERPRETATION
– ***coherence***-driven (Hobbs 1979)
(8) *The city council denied the demonstrators a permit because …*
a. … *they* feared *violence*. (*they* = the city council)
b. … *they* advocated *violence*. (*they* = the demonstrators)

– ***parallelism***-driven (Sidner 1983). Kehler's (9) shows the strength of this effect.
(9) *Margaret Thatcher* admires *Hilary Clinton,*
and *George W. Bush absolutely* worships *her*. (*her* = Hilary Clinton)

– ***attention***-driven (Sidner '83, Kameyama '86, Brennan *et al* '87, Grosz *et al* '95)
(10) a. *John hit Bill. Mary told him to go home*. (*him* = John)
b. *Bill was hit by John. Mary told him to go home*. (*him* = Bill)

– ***attention+coherence***-driven (Kehler 2002: Ch. 6)
"My analysis of pronoun interpretation [is] based on the interaction of two aspects of interpretation:
(i) the linguistic properties of the linguistic form in question, and
(ii) the properties of the process of establishing coherence for my three types of relations [*causal*, e.g. (8); *resemblance*, e.g. (9); *contiguity*, e.g. (10)]
… [re (i)] pronouns [are] linguistic devices … that encode signals to the hearer about the degree of salience the referent holds within the current discourse state …[i.e. signals] that this level of salience is high." (Kehler 2002:156)

• ATTENTION + COHERENCE IN UC_0:
Causal relation **(***Explanation***)**: signaled by the complementizer *because*
(8′) *The city council*$^{\top}$ *denied the demonstrators*$^{\perp}$ *a permit* because …
$^{\top}[x|\ city.council\langle x\rangle, x \in \perp^{\Rightarrow}]; [x|\ demonstrators\langle x\rangle, x \in \perp^{\Rightarrow}]; [deny\langle \top, \perp\rangle];$
a. … they$_{\top}$ *feared violence*.
$[fear.violence\langle \top\rangle]$ (⊤: the city council)
b. … they$_{\perp}$ *advocated violence*.
$[advocate.violence\langle \perp\rangle]$ (⊥: the demonstrators)

Resemblance rel. **(***Parallel***)**: signaled by *and* & near synonyms *admire…worship*
(9′) *Margaret Thatcher*$^{\top}$ admires *Hilary Clinton*$^{\perp}$, and …
$^{\top}[x|\ margaret\langle x\rangle, x \in \perp^{\Rightarrow}]; [x|\ hilary\langle x\rangle, x \in \perp^{\Rightarrow}]; [admire\langle \top, \perp\rangle];$
… *George W. Bush*$^{\top}$ *absolutely* worships *her*$_{\perp}$.
$^{\top}[x|\ george\langle x\rangle, x \in \perp^{\Rightarrow}]; [\top \neq \perp]; [worship\langle \top, \perp\rangle]$ (⊥: Hilary Clinton)

Contiguity relation **(***Occasion***)**: default in story telling
Kehler's (11), problem for *static* centering theory ([BFP], [GJW]), but not UC:
$\langle\langle\rangle, \langle \ldots, ☺, ☻\rangle\rangle$ (initial input: ☺ = Terry, ☻ = Tony)
(11) i. *Terry*$^{\top}$ *set out for an outdoor excursion on Monday*.
$^{\top}[x|\ terry\langle x\rangle, x \in \perp^{\Rightarrow}]; \quad ^{\top}[t_1|\ set.out\langle \top, t\rangle, monday\langle t\rangle, \ldots];$
$\langle\langle ☺\rangle, \langle \ldots, ☺, ☻\rangle\rangle \quad \langle\langle t_1, ☺\rangle, \langle \ldots, ☺, ☻\rangle\rangle$ (t_1: topic time)
ii. *It*$_{\top\tau}$ *was a beautiful day, hovering around 83 degrees*.
$[beautiful.day\langle \top\tau\rangle, \ldots];$
iii. *He*$_{\top}$ *was excited about trying out his*$_{\top}$ *new sailboat*$^{\perp}$.
$[x|\ new.sailboat.of\langle x, \top\rangle]; [excited.about.trying.out\langle \top, \perp\rangle]$
$\langle\langle ☺\rangle, \langle ▂, \ldots, ☺, ☻\rangle\rangle$ (entity dref's only)
iv. *He*$_{\top}$ *wanted Tony*$^{\perp}$ *to join him*$_{\top}$ *on a sailing expedition*.
$[x|\ tony\langle x\rangle, x \in \perp^{\Rightarrow}]; [\top \neq \perp]; [want.to.join.on.sailing.exp\langle \top, \perp\rangle];$
$\langle\langle ☺\rangle, \langle ☻, ▂, \ldots, ☺, ☻\rangle\rangle$
v. *The*$_{\top}$ *marina*$^{\perp}$ …
$^{\top}[x|\ marina\langle x\rangle, use\langle \top, x\rangle];$
$\langle\langle □, ☺\rangle, \langle ☻, ▂, \ldots, ☺, ☻\rangle\rangle$
… *is actually very close to Tony's house.*
$[tony\langle \perp\rangle, \perp \in \perp^{\Rightarrow}]; [x|\ house.of\langle x, \perp\rangle]; [very.close.to\langle \top, \perp\rangle]$
$\langle\langle □, ☺\rangle, \langle ■, ☻, ▂, \ldots, ☺, ☻\rangle\rangle$
vi. *He*$_{\top'}$$^{\top}$ *called him*$_{\perp'}$$^{\perp}$ *at 6 AM.*
$^{\top}[x|\ x = \top']; [x|\ x = \perp']; [\top \neq \perp]; [call.at.6AM\langle \top, \perp\rangle];$
$\langle\langle ☺, □, ☺\rangle\rangle, \langle ☻, ■, ☻, ▂, \ldots, ☺, ☻\rangle\rangle$
vii. *He*$_{\top}$ *was sick and furious with him*$_{\perp}$ *for waking him*$_{\top}$ *up so early.* **??!**
$[sick\langle \top\rangle]; [\top \neq \perp]; [furious.with\langle \top, \perp\rangle, wake.up\langle \perp, \top\rangle]$ ***garden path*****!**

5 CONCLUSION

- NL anaphors refer to *perspective*-dependent entities (e.g. ⊥ for 'top-ranked entity in the background'), where the curr. *discourse perspective* is an empirical notion.
- The clearest and most direct evidence comes from *centering systems*, which grammatically track the current discourse perspective and make use of *top-level anaphors* (e.g. Mandarin '$_{\perp}$like$_{\top}$', Kalaallisut 'like-FCT$_{\perp}$-3S$_{\perp}$-3S$_{\top}$')
- *English pronouns* can refer to any of the top four drefs (i.e. ⊤, ⊤′, ⊥, ⊥′). Still, coherence relations and/or gender presuppositions usu. successfully disambiguate
- All languages use *full np*'s for *descriptive anaphora* (to $\top^{\Rightarrow}$-set or $\perp^{\Rightarrow}$-set). In UC only this form of anaphora is available for lower-ranked drefs (below ⊤′, ⊥′).

APPENDIX: ***Update with Nominal Centering*** (UC_0)

D1 (UC_0 *types* Θ).
i. $t, e, s \in \Theta$ (*truth values*, *entities*, *perspectives*)
ii. $(ab) \in \Theta$, if $a, b \in \Theta$

D2 A UC_0-*frame* is a set $\{\mathcal{D}_a | \ a \in \Theta\}$ of non-empty *a-domains* $\mathcal{D}_a$ such that:
i. $\mathcal{D}_t = \{1, 0\}$ and $\mathcal{D}_e$ are non-empty disjoint sets
$\mathcal{D}_s = \cup_{n \geq 0,\, m \geq 0} \{\langle\langle \mathsf{a}_1, ..., \mathsf{a}_n\rangle, \langle \mathsf{b}_1, ..., \mathsf{b}_m\rangle\rangle : \mathsf{a}_i, \mathsf{b}_j \in \mathcal{D}_e\}$
ii. $\mathcal{D}_{(ab)} = \{f | \ \mathrm{Dom}\ f \subseteq \mathcal{D}_a \ \&\ \mathrm{Ran}\ f \subseteq \mathcal{D}_b\}$

D3 A UC_0-*model* is a pair, $\mathcal{M} = \langle \mathcal{D}, [\![\cdot]\!] \rangle$ such that $\mathcal{D} = \{\mathcal{D}_a : a \in \Theta\}$ is a UC_0-frame and $[\![\cdot]\!]$ maps any $A \in Con_a$ to $[\![A]\!] \in \mathcal{D}_a$. Moreover, for all $\mathsf{i} = \langle \mathsf{i}_1, \mathsf{i}_2 \rangle \in \mathcal{D}_s$:

$[\![\top]\!](\mathsf{i}) \doteq (\mathsf{i}_1)_1$ $\quad$ $[\![\bot]\!](\mathsf{i}) \doteq (\mathsf{i}_2)_1$ $\quad$ ('$\doteq$' for '$=$, if defined')
$[\![\top^{\curlywedge}]\!](\mathsf{i}) \doteq (\mathsf{i}_1)_2$ $\quad$ $[\![\bot^{\curlywedge}]\!](\mathsf{i}) \doteq (\mathsf{i}_2)_2$
$[\![\top^{\Rightarrow}]\!](\mathsf{i}) = {}^{\chi}\{(\mathsf{i}_1)_n : n \geq 1\}$ $\quad$ $[\![\bot^{\Rightarrow}]\!](\mathsf{i}) = {}^{\chi}\{(\mathsf{i}_2)_n : n \geq 1\}$ $\quad$ ($^{\chi}$ for char. function)

D4.1 (UC_0 syntax) For any type $a \in \Theta$, we define the set of *a-terms*, Trm_a:

b.	$A \in Trm_a$	if $A \in Con_a \cup Var_a$
a.	$BA \in Trm_b$	if $B \in Trm_{(ab)}$ & $A \in Trm_a$
$\boldsymbol{\lambda}$.	$\lambda u_a(B) \in Trm_{(ab)}$	if $u_a \in Var_a$ & $B \in Trm_b$
$=$.	$(A = B) \in Trm_t$	if $A, B \in Trm_a$
$\neg$.	$\neg A \in Trm_t$	if $A \in Trm_t$
$\wedge$.	$(A \wedge B) \in Trm_t$	if $A, B \in Trm_t$
$\bullet$.	$(A\ ^{\intercal}\!\bullet B), (A \bullet B) \in Trm_s$	if $A \in Trm_e$ & $B \in Trm_s$

D4.2 (UC_0-semantics). For any model $\mathcal{M} = \langle \mathcal{D}, [\![\cdot]\!] \rangle$ and $\mathcal{M}$-assignment g, define:

b.	$[\![A]\!]^g$	$=$ $[\![A]\!]$	if $A \in Con_a$	
		$=$ $g(A)$	if $A \in Var_a$	
a.	$[\![BA]\!]^g$	$\doteq$ $[\![B]\!]^g([\![A]\!]^g)$		
λ.	$[\![\lambda u_a(B)]\!]^g(d)$	$\doteq$ $[\![B]\!]^{g[u/\mathsf{d}]}$	for any $\mathsf{d} \in \mathcal{D}_a$	
$=$.	$[\![(A = B)]\!]^g$	$=$ 1	if $[\![A]\!]^g = [\![B]\!]^g$	; $=$ 0, otherwise
$\neg$.	$[\![\neg A]\!]^g$	$=$ 1	if $[\![A]\!]^g = 0$	; $=$ 0, otherwise
$\wedge$.	$[\![(A \wedge B)]\!]^g$	$=$ 1	if $[\![A]\!]^g = 1$ & $[\![B]\!]^g = 1$	; $=$ 0, otherwise
$\bullet$.	$[\![(A\ ^{\intercal}\!\bullet B)]\!]^g$	$\doteq$ $\langle([\![A]\!]^g \cdot \mathsf{i}_1), \mathsf{i}_2\rangle$	where $\langle \mathsf{i}_1, \mathsf{i}_2\rangle = [\![B]\!]^g$	
	$[\![(A \bullet B)]\!]^g$	$\doteq$ $\langle \mathsf{i}_1, ([\![A]\!]^g \cdot \mathsf{i}_2)\rangle$	& $(\mathsf{d} \cdot \langle \mathsf{d}_1, ..., \mathsf{d}_n\rangle) := \langle \mathsf{d}, \mathsf{d}_1, ..., \mathsf{d}_n\rangle$	

D5 (Truth). For any (*st*)*st*-term K, model $\mathcal{M}$, and info-state $\mathsf{c} \in \mathcal{D}_{st,\,\mathcal{M}}$:
K is *true* in $\mathcal{M}$ given c, iff $\forall g$: $[\![K]\!]^g(\mathsf{c}) \neq {}^{\chi}\emptyset$

ABBREVIATIONS

A1 (implication & quantifiers)
i. $(\varphi_t \rightarrow \psi_t)$ $:= \neg(\varphi \wedge \neg\psi)$
ii. $\forall u_a \varphi_t$ $:= (\lambda u_a(\varphi) = \lambda u_a(u = u))$
$\exists u_a \varphi_t$ $:= \neg\forall u \neg\varphi$

A2 (DRT-notation). Example/description
i. perspectival concepts (type *se*)
$A_e{}^{\circ}$ $:= \lambda i_s(A)$ $\quad$ $x_e{}^{\circ} := \lambda i_s(x)$
$A_{se}{}^{\circ}$ $:= \lambda i_s(Ai)$ $\quad$ $\top^{\circ} := \lambda i_s(\top i) = \top$
ii. conditions (type *st*)
$B\langle A_1, \ldots, A_n\rangle$ $:= \lambda i_s(B\ A_1{}^{\circ} i, \ \ldots, \ A_n{}^{\circ} i)$ $\quad$ $car\langle\bot\rangle := \lambda i_s(car\ \bot i)$
$(A =_i B)$ $:= \lambda i_s(A^{\circ} i = B^{\circ} i)$ $\quad$ $(\top =_i x) := \lambda i_s(\top i = x)$
iii. updates (type (*st*)*st*)
$[C_{st}]$ $:= \lambda I_{st} \lambda j_s(Ij \wedge Cj)$ (test)
$[x_e |\ C_{st}]$ $:= \lambda I_{st} \lambda j_s(\exists x_e \exists i_s(Ii \wedge Ci \wedge j = x \bullet i)$ ($\bot$-update with test)
$^{\intercal}[x_e |\ C_{st}]$ $:= \lambda I_{st} \lambda j_s(\exists x_e \exists i_s(Ii \wedge Ci \wedge j = x\ ^{\intercal}\!\bullet i)$ ($\top$-update with test)
$(K_{(st)st}\ ;\ K'_{(st)st})$ $:= \lambda I_{st} \lambda j_s(K' K I j)$ (sequencing)

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