Dynamic Semantics (2)
Anaphora

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About this course

- introduction to **dynamic semantics**, which seeks to explicate the idea that saying something changes the context for what follows (in contrast to **static semantics**, which ignores context change, viewing it as irrelevant to truth conditions.)
- **core questions**
  - What kinds of phenomena in natural languages motivate dynamic semantics?
  - Based on cross-linguistic evidence, how should we implement the key concepts—esp. *information state*, *update*, *discourse referent*—to represent such phenomena?
- **topics**
  - M: Overview
  - *T*: *Anaphora*
  - W: Indexicality
  - Th: Temporality
  - F: Quantification
- **course page:** http://www.users.cloud9.net/~mbittner/nasslli-2016.html

Theoretical background

- The standard way to represent anaphora, in static as well as dynamic semantics, is to co-index the anaphor with the antecedent (e.g. A man^{x1} came in. He_{x1} sat down.) Semantic rules interpret such indices as variables.
- The asymmetric ***superscript*** … ***subscript*** notation (e.g. a man^{x1} … he_{x1}) reflects the fact that the anaphor (he_{x1}) is referentially dependent on the antecedent (a man^{x1}), not vice versa. English-based dynamic theories (e.g. DRT, FCS, DPL, KPL, …) capture this asymmetry as follows:
  - an indexed indefinite description (e.g. a man^{x1}) updates the *input value* of its index to an *output value* that satisfies the description (e.g. a man^{x1} updates the value of x_1 to a man)
  - an indexed anaphor refers to the *input value* of its index set by the co-indexed antecedent (e.g. in the above discourse the anaphoric pronoun he_{x1} refers to the man introduced by the co-indexed antecedent indefinite a man^{x1}).
- **Prediction**
  Natural language anaphors refer to (*input) values* of variables.

Some problems

Problem 1. The supposedly ubiquitous variable-like indices have *no audible reflex* in any natural language, e.g. no language contrasts he_{x17} v. he_{x123}.

Problem 2. Natural languages do have contrasting anaphors, including grammatical systems with *unambiguous anaphora*, e.g.

- Mandarin TOPIC CHAINING contrasts 3rd person zero v. pronoun (e.g. _ v. tā)
- Kalaallisut OBVIATION contrasts 3rd person proximate v. obviative infl. (e.g. -ni v. -at)

However, such unambiguous anaphors are not interpreted like variables in formal logic. That is, actually attested anaphors are rendered unambiguous by mechanisms that semantic theories which represent drefs as variables have no logical tools to explicate.

Problem 3. Since every sentence adds to the set of potential antecedents, variable-based anaphora resolution (i.e. identifying the intended antecedent variable) should get more complex as discourse progresses. But in fact, there is *no increasing complexity*. Even in a long text the last pronoun is just as easy to resolve as the first.

Today's lecture

Basic Idea: Anaphora resolution is always easy because DEFAULT ANAPHORS (e.g. English anaphoric pronouns, Kalaallisut anaphoric inflections, Mandarin zero anaphors) refer to *currently salient* discourse entities. This is a small set of entities that changes but does not grow (like the set of currently salient objects viewed from a moving train).

Early attempts to implement this common-sense idea (CENTERING THEORY developed by Sidner 1983, Kameyama 1986, Brennan et al. 1987, Grosz et al. 1995, and others) have been criticized into oblivion, for good reasons (see e.g. Kehler 1997). However, the basic idea still makes intuitive sense.

Update with Centering (Bittner 2001ff) is a typed dynamic logic with centering-based anaphora to ranked discourse entities (building on Veltman 1990, 1996; Dekker 1994; Muskens 1995, 1996). This dynamic logic can represent anaphora in diverse languages (e.g. Mandarin, Kalaallisut, English). Moreover, UC representations can be derived by type-driven directly compositional rules (e.g. in Categorial Grammar).

Predictions

- ❑ Unambiguous default anaphors refer to *top-ranked* entities (e.g. Kalaallisut, Mandarin).
- ❑ Universally, default anaphors refer to *top-ranked* or *just demoted* entities (e.g. English)

Outline

- Grammatical centering systems
- Simple Update with Centering (UC_0)
- Mandarin zero anaphora
- Kalaallisut anaphoric inflections
- English anaphoric pronouns
- Conclusion

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Grammatical centering: Universals

Universal 1 (grammatical centering)

A grammatical centering system disambiguates anaphora by keeping track of currently top-ranked discourse referents (drefs) in the center and background of attention (linguistic analog of focal and peripheral vision).

Universal 2 (top-level anaphora)

Key role in grammatical centering is played by *top-level anaphors*, i.e. anaphors that can only refer to top-ranked drefs, e.g.

- topic anaphor ($\ldots_{\top}$) refers to the top-ranked dref entity in the center
- background anaphor ($\ldots_{\bot}$) refers to the top-ranked dref entity in the background

Universal 3 (nominal centering)

In nominal centering systems, top-level anaphors always saturate *nominal arguments* (subjects, objects, or possessors) of predicates. They do not function as nominal modifiers (e.g. oblique dependents).

Mandarin: Zero anaphora

Mandarin Chinese discourse consists of **topic chains** (Tsao 1979, Chu 1998, Li 2005, a.m.o). Typically, a topic chain begins with a topic update (…$^{\top}$), which introduces a topical individual ($^{\top}$). This is followed by one or more clauses that comment on this topic by means of a zero anaphor (missing argument) which refers to the topical individual (e.g. missing possessor ($_{\top}$n) in (1i), missing subject ($_{\top}$v) in (1ii), missing object (v$_{\top}$) in (2i–ii)). A Mandarin topic chain may span more than one sentence (as (1) and (2) illustrate).

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

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 jiéhūn 。
although $_{\top}$have CL boyfriend , but not $_{\top}$wish get.married 。
Although she$_{\top}$ has a boyfriend, she$_{\top}$ doesn't wish to get married.

Mandarin: Topic-zero v. background-zero

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

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

ii. Zuótiān qù kàn-le , hái kāi-le yíhuìr ,
yesterday $_{\perp}$go look$_{\top}$-PNC , even $_{\perp}$drive$_{\top}$-PNC $M_{a.while}$,
háishì bù xǐhuan , méi mǎi 。
still not $_{\perp}$like$_{\top}$, not $_{\perp}$buy$_{\top}$ 。
Yesterday he$_{\perp}$ went to look at it$_{\top}$ and even $_{\perp}$took it$_{\top}$ out for a spin.
He$_{\perp}$ still didn't like it$_{\top}$, (so) he$_{\perp}$ didn't buy it$_{\top}$.

Kalaallisut: Anaphoric inflections

In Kalaallisut **pronominal arguments** (subjects, objects, and possessors) are expressed by means of person inflections. For anaphoric inflections, the antecedent is the currently top-ranked individual in the center or background of attention (traditionally, currently 'proximate' or 'obviative' individual), as specified by three grammatical systems:

- form of **3rd person inflection** specifies centering status of antecedent, e.g.
  - -ni '$3S_{\top}$' v. -a(t) '$3S_{\bot}$' anaphora to topical v. background 3rd person
- **matrix clause moods** specify illocutionary force in relation to ⊤-subject, e.g.
  - -pu '$DEC_{\top}$' assertion of *at-issue fact* about ⊤-subject
  - -pa '$DEC_{\top\bot}$' assertion of *at-issue fact* about ⟨⊤-subject, ⊥-object⟩
- **dependent clause moods** specify centering status of dependent subj., e.g.
  - -ga '$FCT_{\top}$' v. -mm '$FCT_{\bot}$' *not-at-issue fact* about ⊤-subject v. ⊥-subject
  - -llu '$ELA_{\top}$' v. -tu '$ELA_{\bot}$' *elaboration* of ⊤-subject v. ⊥-subject

3rd person noun phrases are interpreted as *recentering updates,* i.e. updates that (re)introduce ⊤- or ⊥-antecedents for anaphoric $3_{\top}$ or $3_{\bot}$ inflections.

Kalaallisut: Centering-based anaphora

(3) i. Ilaanni anguti-tuqa-p nulia-ni kisimi-i-qatig(i-p)a-a
once man-old-ERG$^{\top}$ [wife-3S$_{\top}$]$^{\perp}$ alone-be-with-DEC$_{\top\perp}$-3S.3S
Once an old man$^{\top}$ was alone with [his$_{\top}$ wife]$^{\perp}$,
irni-ni piniar-riar-sima-mm-at.
[son-3S$_{\top}$]$^{\perp}$ hunt-go-prf-FCT$_{\perp}$-3S$_{\perp}$
because [his$_{\top}$ son]$^{\perp}$ had gone hunting.

ii. Aavi-rsuaq isissaa-lir-mm-at
walrus-big$^{\perp}$ be.visible-begin-FCT$_{\perp}$-3S$_{\perp}$
Suddenly a big walrus$^{\perp}$ showed up, so
piniar-niar-lu-gu qain-ni atir-vigi-lir-pa-a.
hunt-intend-ELA$_{\top}$-3S$_{\perp}$ [kayak-3S$_{\top}$]$^{\perp}$ go.down-to-begin-DEC$_{\top\perp}$-3S.3S
$_{\top}$intending to go after it$_{\perp}$, he$_{\top}$ headed down to [his$_{\top}$ kayak]$^{\perp}$.

Kalaallisut: Recentering & anaphora

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

iv. Ui-a.ta=li tusar-uma-na-gu
[husband-3S$_\perp$.ERG]$^\top$=but listen-want-not.ELA$_\top$-3S$_\perp$
But he$_\perp{}^\top$ (lit. [her$_\top{}^\perp$ husband]$^\top$) wouldn't listen to her$_\perp$ and
aavi-rsuaq nalip-pa-a.
walrus-big$^\perp$ harpoon-DEC$_{\top\perp}$-3S.3S
$_\top$harpooned the great walrus$^\perp$.

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Simple Update with Centering (UC_0)

Update semantics (Veltman 1990/1996):

"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 2001ff; cf. Grosz et al 1995, Dekker 1994)

update keeps track of ranked dref entities in the center and background of attention

- *entity-level* anaphoric terms: $\top$ (ctr), $\top'$ (2^{nd} ctr), $\bot$ (bck), $\bot'$ (2^{nd} bck)
- *set-level* anaphoric terms: $\top^{\Rightarrow}$ (ctr set), $\bot^{\Rightarrow}$ (bck set)

central drefs — backgr. drefs

$\langle \quad \langle a_1, a_2, \ldots, a_n \rangle, \quad \langle b_1, b_2, \ldots, b_m \rangle \quad \rangle$ *structured list*

$\top \quad \top'$ $\quad$ $\bot \quad \bot'$

$\top^{\Rightarrow}$ $\quad$ $\bot^{\Rightarrow}$

Info-state (about current dref entities & current ranking) is a set of structured lists

- *minimal* info-state (no drefs) $\{\langle\langle\rangle, \langle\rangle\rangle\}$
- *absurd* info-state (e.g. false discourse) $\varnothing$

Update and anaphora in UC_0

Sample **model**, $\mathcal{M}$:

$[\![man]\!] = \{☺, ☻\}$ $[\![friend]\!] = \{\langle ☻, ☺\rangle, \langle ♘, ☺\rangle, \langle ☺, ♘\rangle\}$

$[\![come.in]\!] = \{☺, ☹\}$ $[\![see]\!] = \{\langle ☺, ♘\rangle\}$

Updates of minimal info-state, by discourse (4i–ii) on model $\mathcal{M}$:

$\langle\langle\rangle, \langle\rangle\rangle$

(4) i. A$^{\top}$ man came in

$^{\top}[x|\ man\langle x\rangle]$; $[come.in\langle \top \rangle]$;

$\langle\langle ☺\rangle, \langle\rangle\rangle$ $\langle\langle ☺\rangle, \langle\rangle\rangle$

$\langle\langle ☻\rangle, \langle\rangle\rangle$

ii. He$_{\top}$ saw a$^{\perp}$ friend$_{\top}$.

a$^{\perp}$ friend$_{\top}$ He$_{\top}$ saw …

$[x|\ friend\langle x, \top\rangle]$; $[see\langle \top, \perp\rangle]$

$\langle\langle ☺\rangle, \langle ☻\rangle\rangle$

$\langle\langle ☺\rangle, \langle ♘\rangle\rangle$ $\langle\langle ☺\rangle, \langle ♘\rangle\rangle$

final output is **not** the absurd info-state Ø,
so discourse (4i–ii) is **true** on $\mathcal{M}$

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Mandarin in UC_0: Topic chain (2i–ii)

(2') i. That car$^{\top}$ is too expensive …

(input list)	that-CL car$^{\top}$,	$_{\top}$price$^{\perp}$ too high
	$^{\top}[x\mid car\langle x\rangle, x \in \perp^{\Rightarrow}]$;	$[x\mid price\langle x,\top\rangle, too.high\langle x\rangle]$;
⟨⟨⟩, ⟨…, 🚗⟩⟩	⟨⟨🚗⟩, ⟨…, 🚗⟩⟩	⟨⟨🚗⟩, ⟨$, …, 🚗⟩⟩

… and it$_{\top}$ has an ugly color.	Lisi$^{\perp}$ doesn't like it$_{\top}$.
$_{\top}$color$^{\perp}$ also not good,	Lisi$^{\perp}$ not like$_{\top}$ 。
$[x\mid color\langle x, \top\rangle, not.good\langle x\rangle]$;	$[x\mid lisi\langle x\rangle, x \in \perp^{\Rightarrow}, not.like\langle x, \top\rangle]$;
⟨⟨🚗⟩, ⟨●, $, …, 🚗⟩⟩	⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩

ii. (Yesterday) he$_{\perp}$ went to look at it$_{\top}$ and even took it$_{\top}$ out for a spin. …

$_{\perp}$go look$_{\top}$-PNC,	even $_{\perp}$drive$_{\top}$-PNC $M_{a.while}$, …
$[go.look.at\langle \perp, \top\rangle]$;	$[drive.a.while\langle \perp, \top\rangle]$; …
⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩	⟨⟨🚗⟩, ⟨☹, ●, $, …, 🚗⟩⟩

Mandarin in UC_0: Topic shift

(5) i. Jiajia$^{\top}$ is sick. She$_{\top}$ ran a fever last night.

Jiājiā	bìng	le,	zuótiān	wānshàng	jiù	fā.shāo .
Jiajia$^{\top}$	sick	PNC,	yesterday	night	then	$_{\top}$run.fever

$^{\top}[x|\ jiajia\langle x\rangle, x \in \bot^{\Rightarrow}, sick\langle x\rangle]$; $[run.fever\langle \top \rangle]$

$\langle\langle$ 💊 $\rangle, \langle \ldots \rangle\rangle$

ii. Lisi$^{\top}$ knew [her$_{\top}$, mom]$^{\bot}$ was busy, so he$_{\top}$ didn't want to tell her$_{\bot}$.

Lǐsī	zhīdào	**tā**-de	mama	hěn	máng,	méi	gǎn	gàosu **tā**
Lisi$^{\top}$	know	[**pn**$_{\top}$-'s mom]$^{\bot}$		very	busy,	not	$_{\top}$dare	tell **pn**$_{\bot}$

$^{\top}[x|\ lisi\langle x\rangle, x \in \bot^{\Rightarrow}]$; $[x|\ mom\langle x, \top'\rangle, know.busy\langle \top, x\rangle]$; $[\sim dare.tell\langle \top, \bot\rangle]$

$\langle\langle$ ☺, 💊 $\rangle, \langle \ldots \rangle\rangle$ $\langle\langle$ ☺, 💊 $\rangle, \langle$ 🚹, $\ldots\rangle\rangle$

Toward a fragment of Mandarin

Sample lexical entries for Mandarin items (represented by English glosses):

- **basic entries** for verbs, e.g.

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

- lexical **centering operators** saturate argument np's with top-level anaphors ($\top$ or $\bot$) and simultaneously eliminate these argument np's from the **derived category**:

$_{\top}(\cdot)$	⊢	$\mathbf{s}/(\text{s}\backslash\text{np}): \lambda \underline{P}(\underline{P}\ \top)$	(zero $\top$-subject)
$_{\bot}(\cdot)$	⊢	$\mathbf{s}/(\text{s}\backslash\text{np}): \lambda \underline{P}([\top \neq \bot]; \underline{P}\ \bot)$	(zero $\bot$-subject)
$(\cdot)_{\top}$	⊢	$\mathbf{(s\backslash np)}/((\text{s}\backslash\text{np})/\text{np}): \lambda \underline{R}\ \lambda \underline{x}_{s\delta}([\underline{x} \neq \top]; \underline{R}\ \top\ \underline{x})$	(zero $\top$-object)
$(\cdot)_{\bot}$	⊢	$\mathbf{(s\backslash np)}/((\text{s}\backslash\text{np})/\text{np}): \lambda \underline{R}\ \lambda \underline{x}_{s\delta}([\underline{x} \neq \bot]; \underline{R}\ \bot\ \underline{x})$	(zero $\bot$-object)

Hence **derived entries** for verbs with missing arguments ('zero anaphors'), e.g.

$\text{like}_{\top}$	⊢	$\mathbf{s\backslash np}: \lambda \underline{x}_{s\delta} [like\langle \underline{x}, \top \rangle]$	(zero $\top$-object)
$_{\bot}(\text{like}_{\top})$	⊢	$\mathbf{s}: ([\top \neq \bot]; [like\langle \bot, \top \rangle])$	(zero $\bot$-subject, $\top$-object)

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Kalaallisut in UC_0: $3_\top$ v. $3_\bot$

(3′) i. Once an old man$^\top$ was alone with [his$_\top$ wife]$^\bot$, …

once	man-old-ERG$^\top$	[wife-3S$_\top$]$^\bot$	alone-be-with-DEC$_{\top\bot}$-3S.3S
	$^\top[x\mid \mathit{old.man}\langle x\rangle]$;	$[x\mid \mathit{wife}\langle x, \top\rangle]$;	$[\mathit{alone.with}\langle \top, \bot\rangle]$
	$\langle\langle ☺\rangle, \langle\rangle\rangle$	$\langle\langle ☺\rangle, \langle ♥\rangle\rangle$	

… because [his$_\top$ son]$^\bot$ had gone hunting.

[son-3S$_\top$]$^\bot$	hunt-go-prf-FCT$_\bot$-3S$_\bot$
$[x\mid \mathit{son}\langle x, \top\rangle]$;	$[\mathit{gone.hunting}\langle \bot\rangle]$
$\langle\langle ☺\rangle, \langle$ 🚹 , ♥$\rangle\rangle$	

Kalaallisut in UC_0: Background update

(3′) ii. Suddenly a big walrus$^{\perp}$ showed up, so …

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

… $_{\top}$to go after it$_{\perp}$, he$_{\top}$ headed down to [his$_{\top}$ kayak]$^{\perp}$.

hunt-intend-ELA$_{\top}$-3S$_{\perp}$	[kayak-3S$_{\top}$]$^{\perp}$	go.down-to-begin-DEC$_{\top\perp}$-3S.3S
[*intend.to.hunt*⟨$\top$, $\perp$⟩];	[x| *kayak*⟨x, $\top$⟩];	[*head.down.to*⟨$\top$, $\perp$⟩]
⟨⟨☺⟩, ⟨🦭, 🐋, 🚹, ♥⟩⟩		

Kalaallisut in UC_0: Topic shift

(3′) ii. ⟨⟨ ☺ ⟩, ⟨ , , , ♥⟩⟩

iii. [His$_{\top}{}^{\perp}$ wife]$^{\top}$…

(⊤-to-⊥ recentering)

[x| $x = \top$];

⟨⟨ ☺ ⟩, ⟨ ☺ , , , , ♥⟩⟩

[wife-3S$_{\perp}$.ERG]$^{\top}$

$^{\top}$[x| *wife*⟨x, ⊥⟩, $x \in \perp^{\Rightarrow}$];

⟨⟨♥, ☺ ⟩, ⟨ ☺ , , , , ♥⟩⟩

… $_{\top}$tried to stop him$_{\perp}$,

forbid-in.vain-DEC$_{\top\perp}$-3S.3S

[*try.to.stop*⟨⊤, ⊥⟩];

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

alone-be-FCT$_{\perp}$-3S$_{\perp}$

[*alone*⟨⊥⟩];

set.out-tell-not.ELA$_{\top}$-3S$_{\perp}$

[*tell.not.to.set.out*⟨⊤, ⊥⟩]

Toward a fragment of Kalaallisut

Sample lexical entries for Kalaallisut items (represented by English glosses):

- lexical entries for **verb roots**, e.g.

  sick- |– s\pn: $\lambda \underline{x}_{s\delta}[sick\langle \underline{x} \rangle]$ *intransitive* verb root

  like- |– (s\pn)\pn: $\lambda \underline{x}_{s\delta} \lambda \underline{y}_{s\delta}[like\langle \underline{x}, \underline{y} \rangle]$ *transitive* verb root

- **centering inflections** saturate argument pn's with top-level anaphors e.g.

  -$\text{DEC}_{\top}$-3S |– **s**\(s\pn): $\lambda \underline{P}(\underline{P}\ \top)$ *at-issue fact* about $\top$

  -$\text{DEC}_{\top\bot}$-3S.3S |– **s**\(s\pn\pn): $\lambda \underline{R}([\top \neq \bot]; \underline{R}\ \top \bot)$ *at-issue fact* about $\langle \top, \bot \rangle$

  -$\text{FCT}_{\top}$-$\text{3S}_{\top}$ |– **(s/s)**\(s\pn): $\lambda \underline{P} \lambda \underline{q}(\underline{P}\ \top; \underline{q})$ *not-at-issue fact* about $\top$

  (s/s)\(s\pn): $\lambda \underline{P} \lambda \underline{q}({}^{\top}[x|\ x = \bot]; \underline{P}\ \top; \underline{q})$ …about *output* $\top$

  -$\text{FCT}_{\bot}$-$\text{3S}_{\bot}$ |– **(s/s)**\(s\pn): $\lambda \underline{P} \lambda \underline{q}(\underline{P}\ \bot; \underline{q}; [\top \neq \bot])$ *not-at-issue fact* about $\bot$

  (s/s)\(s\pn): $\lambda \underline{P} \lambda \underline{q}([x|\ x = \top]; \underline{P}\ \bot; \underline{q}; [\top \neq \bot])$ … about *output* $\bot$

Hence derived entries for saturated **verb words**, e.g.

like-$\text{DEC}_{\top\bot}$-3S.3S |– **s**: $([\top \neq \bot]; [like\langle \top, \bot \rangle])$ *at-issue fact* about $\langle \top, \bot \rangle$

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Anaphora resolution in English

- **coherence-driven?** (Hobbs 1979)
  motivated e.g. by Winograd's (6):
  (6) 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)
  motivated e.g. by Kehler's (7):
  (7) Margaret Thatcher admires Hilary Clinton,
  and George W. Bush absolutely worships her. (her = Hilary Clinton)

- **attention-driven?** (Kameyama 1986, Brennan et al 1987, Grosz et al 1995)
  motivated e.g. by Kameyama's (8) v. (9):
  (8) John hit Bill. Mary told him to go home. (him = John)
  (9) Bill was hit by John. Mary told him to go home. (him = Bill)

Kehler's (2002) proposal

Pronoun interpretation is based on the interaction of two aspects of interpretation:

- linguistic properties of the **linguistic form** (e.g. a *pronoun* signals that the referent is salient in the current state of discourse)
- pragmatic process of **coherence establishment**, which adds one of three kinds of COHERENCE RELATIONS (in (6)–(9), signalled by underlined items):
  - CAUSAL, e.g.

    (6) The city council denied the demonstrators a permit because **they** feared/advocated violence.
  - RESEMBLANCE, e.g.

    (7) Margaret Thatcher admires Hilary Clinton, and George W. Bush absolutely worships **her**.
  - CONTIGUITY, e.g.

    (8) John hit Bill. Mary told **him** to go home.

    (9) Bill was hit by John. Mary told **him** to go home.

English in UC_0: Centering + coherence

Coherence relation: CONTIGUITY

Kehler's (10), a problem for static centering theories ([BFP], [GJW]), **not** for UC_0:

$\langle\langle\rangle, \langle \ldots, ☺, ☻\rangle\rangle$ (input list, with ☺ = Terry, ☻ = Tony)

(10)i. Terry$^{\top}$ set out for an outdoor excursion on Monday.

$^{\top}[x|\ terry\langle x\rangle, x \in \perp^{\Rightarrow}]; [set.out\langle \top \rangle];$

$\langle\langle ☺\rangle, \langle \ldots, ☺, ☻\rangle\rangle$

ii. He$_{\top}$ was excited about trying out his$_{\top}$ new sailboat$^{\perp}$.

$[x|\ new.sailboat.of\langle x, \top\rangle]; [excited.about.trying.out\langle \top, \perp\rangle]$

$\langle\langle ☺\rangle, \langle 🚤, \ldots, ☺, ☻\rangle\rangle$

iii. He$_{\top}$ wanted Tony$^{\perp}$ to join him$_{\top}$ on a sailing expedition.

$[x|\ tony\langle x\rangle, x \in \perp^{\Rightarrow}]; [\top \neq \perp]; [want.to.join.on.sailing.exp\langle \top, \perp\rangle];$

$\langle\langle ☺\rangle, \langle ☻, 🚤, \ldots, ☺, ☻\rangle\rangle$

English in UC_0: Garden path explained

iii. ⟨⟨ ☺ ⟩, ⟨ ☻, 🛥, …, ☺, ☻ ⟩⟩

iv. The$_{\top}$ marina$^{\top}$ …

$^{\top}[x|\ marina\langle x\rangle, use\langle \top, x\rangle]$;

⟨⟨ □, ☺ ⟩, ⟨ ☻, 🛥, …, ☺, ☻ ⟩⟩

… is actually very close to Tony$_{\bot}$'s house$^{\bot}$.

$[tony\langle \bot\rangle, \bot \in \bot^{\Rightarrow}]; [x|\ house.of\langle x, \bot\rangle]; [very.close.to\langle \top, \bot\rangle]$

⟨⟨ □, ☺ ⟩, ⟨ ■, ☻, 🛥, …, ☺, ☻ ⟩⟩

v. He$_{\top}$,$^{\top}$ called him$_{\bot}$,$^{\bot}$ at 6 am.

$^{\top}[x|\ x = \top']; [x|\ x = \bot']; [\top \neq \bot]; [call.at.6am\langle \top, \bot\rangle]$;

⟨⟨ ☺, □, ☺ ⟩⟩, ⟨ ☻, ■, ☻, 🛥, …, ☺, ☻ ⟩⟩

vi. He$_{\top}$ was sick and furious with him$_{\bot}$ for waking him$_{\top}$ up so early.

$[sick\langle \top\rangle]; [\top \neq \bot]; [furious.with\langle \top, \bot\rangle, wake.up\langle \bot, \top\rangle]$ **garden path!**

Outline

- Grammatical centering systems
- Simple Update with Centering (UC_0)
- Mandarin zero anaphora
- Kalaallisut anaphoric inflections
- English anaphoric pronouns
- Conclusion

Conclusion

- **Anaphora** involves both *context change* (antecedent update that introduces a dref) and *context dependence* (anaphoric item that presupposes an antecedent dref).
- Grammatical centering systems have **top-level anaphors** (restricted to top-ranked drefs: $\top$ or $\bot$), e.g. Mandarin '$_{\bot}$like$_{\top}$', Kalaallisut '$\text{like-FCT}_{\bot}\text{-3S}_{\bot}\text{-3S}_{\top}$'. In such systems, anaphora resolution is therefore unambiguous.
- English pronouns are **shallow anaphors** (restricted to salient drefs: $\top$, $\top'$, $\bot$, $\bot'$). In English discourse, ambiguous anaphora resolution is not a problem because it is usually resolved by *gender presuppositions* and *coherence establishment.*
- All languages have **descriptive anaphors** (to top-ranked sets: $\top^{\Rightarrow}$, $\bot^{\Rightarrow}$). These are expressed by noun phrases with *not-at-issue content*, e.g.
  - English (articles: a v. the): [A$^{\top}$ cat and a dog]$^{\top}$ came in. The$_{\top^{\Rightarrow}}$ cat was hungry.
  - Kalaallisut, Mandarin (no articles): '[Cat$^{\top}$ and dog]$^{\top}$ came in. Cat$_{\top^{\Rightarrow}}$ was hungry'

Tomorrow: Indexicality

- **Basic ideas**
  - Cross-linguistic evidence shows that *indexicality* likewise involves not only *context dependence,* but also *context change*.
  - UC_0 extended with drefs for *events* and *states* (UC_ε)
- **Suggested readings**
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