Dynamic Semantics (4)
Temporality

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Theoretical background: English

LANGUAGE TYPE: **tense**-based temporal reference

- Mainstream view: English tenses are **temporal anaphors**
  - anaphora to an aforementioned *reference point*, construed either as a *time* (e.g. Reichenbach 1947) or as an *event* (e.g. Kamp 1981, Webber 1988).
  - parallels with *nominal anaphora*
    - *tense ~ pronoun* (e.g. Partee 1973, 1984, Stone 1997, Kratzer 1998)
    - *tense ~ anchored (in)definite* (e.g. Webber 1988, Moens & Steedman 1988; see also Kamp & Reyle 1993)
- Competing view: English tenses are **temporal indefinites**
  - *tenses* (introduce new times) ~ *indefinites* (introduce new individuals)
  - *indexical anchor* to speech act only, no discourse anaphora
  - possible *pragmatic enrichment* to establish coherence may lead to additional inferences about temporal relations

  (e.g. Comrie 1981, Lascarides & Asher 1993, Kehler 1994, 2002)

Theoretical background: Mandarin

LANGUAGE TYPE: **aspect**-based temporal reference, no grammatical tense

- Mainstream view (formal syntax & semantics): Temporal reference in Mandarin can be analyzed in terms of **English-based categories**, including:
  - English-style *syntactic sentences* (e.g. Huang 1982, Huang *et al.* 2009)
  - English-based *aspectual classes* (e.g. achievement, accomplishment), *grammatical aspects* (e.g. perfective, progressive), *reference times, …*

    (see Li & Thompson 1981, Smith 1991/7, Smith & Erbaugh 2005, Wu 2003, 2009, Xiao & McEnery 2004, Lin 2006, and many others).
- Competing view (a few Mandarin scholars, Chinese language textbooks) Proper analysis of Mandarin discourse requires **Mandarin-based categories**, including:
  - Mandarin-based *pragmatic 'sentences'* ('。'), *zero anaphora*, *topic chains, …* (e.g. Tsao 1979, 1990, Chu 1998, Li 2005)
  - Mandarin-based *aspectual classes* (e.g. dur. 'action' v. pnc. 'resultative action') (e.g. Chao 1968, Henne *et al.* 1977, Tai 1984, DeFrancis, J. ed. 2003)

Today's lecture

Main goal: Unified approach to temporal reference that factors out *semantic universals* while allowing for different *language types* and *contextual variation* (Bittner 2014)

- **Basic idea**: *Universally*, temporal reference relies on grammatical centering systems of obligatory grammatical categories that keep track of top-ranked temporal drefs (events, states, times). Within this space, there is room for *linguistic diversity*, e.g.:
  - English has a grammatical system of **tense markers** (**TNS**, e.g. past PST v. present PRS) which introduce or refer to *top-ranked times* (usually topic time, sometimes background time) and may anchor them to input background event.
  - Mandarin has a grammatical system of **aspect features** (**ASP**, e.g. eventive E/ v. stative S/) which introduce background eventualities (events or states) and anchor them to input topic state or input background eventuality (event or state).
- **Universal logic**: Nobody's categories are universal; but all can be analyzed in terms of *universal primitives* (e.g. *event*, *state*, *time*, *consequent state*, *dref hierarchy*, etc). To represent temporal reference, extend UC_{ε} to UC_{τ}, with *time drefs* and generalized *temporal dref algebra* (building on Bach 1986, Moens & Steedman 1988).

Outline

- English: TNS-based temporality
- Mandarin: ASP-based temporality
- Implementation in UC_{τ}
- Conclusion

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English: Indefinite np^x ~ TNS^t

Indefinite np^x ~ TNS^t (Comrie 1981, Lascarides & Asher 1993, Kehler 1994)

(N) An *indefinite np* (e.g. a man^x) introduces a *new individual* into discourse (possibly restricted by a pragmatic coherence relation)

(T) An *indefinite* TNS *marker* (e.g. PST^t, FUT^t) introduces a *new time* into discourse (possibly restricted by a pragmatic coherence relation)

e.g.

(1) i. Al **went** (PST^{t1} go^{e1}) into a florist $shop^x$.

ii. He **promised** (PST^{t2} $promise^{e2}$) his wife fresh flowers.

iii. He **bought** (PST^{t3} buy^{e3}) $some^y$ beautiful roses.

EXPLANATION: $e_2 < e_1$

RESULT : $e_1 < e_3$

But problems with negation & quantification (see Partee 1973), e.g.:

(2) i. Al went (PST^{t1} go^{e1}) into a florist shop.

ii. He **didn't buy** (PST^{t2} not buy^{e2}) anything.

too strong: $\neg\exists t_2(t_2 < now \wedge \exists e_2(e_2 \subseteq t_2 \wedge e_1 < e_2 \wedge \exists y\ buy(e_2, al, y)))$

too weak: $\exists t_2(t_2 < now \wedge \neg\exists e_2(e_2 \subseteq t_2 \wedge e_1 < e_2 \wedge \exists y\ buy(e_2, al, y)))$

English: Pronoun ~ TNS

- **{indexical, anaphoric} pronoun ~ TNS** (Partee 1973, Stone 1997, etc)
  - (N) A *pronoun* refers to an *individual* that satisfies its presuppositions about the relation to the *speaker* (e.g. I) or to an *antecedent individual* (e.g. he_x in (3ii))
  - (T) A *TNS* marker refers to a *time* that satisfies its presuppositions about the relation to the *speech time* (e.g. PRS) or to an *antecedent time* (e.g. PST_{t1} in (3ii)).

e.g.

(3) i. Once upon a time^{t} there **was** (PST_{t1} be^{s1}) an old king^{x}. $t_1 \subseteq s_1$

ii. He$_x$ **was** (PST_{t1} be^{s2}) very rich. ELABORATION: $t_1 \subseteq s_2$

- **But** pn ≁ TNS in *discourse-initial contexts* (e.g. ✓(4a) v. #(4b))

(4) Entering a store, Customer addresses an unfamiliar Shop Assistant:

a. I **bought** (PST^{t1} go) something here and I want (PRS want) to exchange it.
(~ 'dog' in langs. w/o articles, e.g. anaphoric 'dog$_x$' ⇒ 'dog^{x}' if no antecedent)

b. #**He**^{x} bought (PST go) something here and **he** wants (PRS want) to exchange it.

English: Anchored $\text{np}_x^{\,y}$ ~ $\text{TNS}_e^{\,t}$

- **anchored np ~ tns** (Webber 1988, building on Moens & Steedman 1988)
  - (N) An *anchored np* (e.g. $\text{np}_x^{\,y}$ in (5)) introduces a *new individual* ($\ldots^{y}$) that is anaphorically anchored to a salient *antecedent individual* ($\ldots_{x}$).
  - (T) An *anchored TNS* (e.g. $\text{TNS}_e^{\,t}$ in (5)–(7)) introduces a *new time* ($\ldots^{t}$) that is anaphorically anchored to a salient *antecedent event* ($\ldots_{e}$).
- **event algebra** (Moens & Steedman 1988 in MB notation):
  $\triangleright e$ = *consequent state* of event e, $\blacktriangleleft e$ = *preparatory process* of event e, …
- (5) i. A bus^{x} drove up (PST^{t1} drive.up^{e1}). $\vartheta e_1 \subseteq t_1$
  ii. The driver$_x^{y1}$ **opened** (PST$_{e1}^{\,t2}$ open^{e2}) the doors$_x^{y2}$. RESULT: $\vartheta e_2 \subseteq t_2 \subseteq \vartheta^{\triangleright} e_1$
  iii. A passenger$_x^{z}$ **got off** (PST$_{e2}^{\,t3}$ get.off^{e3}). RESULT: $\vartheta e_3 \subseteq t_3 \subseteq \vartheta^{\triangleright} e_2$
- (6) i. Al^{x} went into (PST^{t1} go.into^{e1}) a florist shop. $\vartheta e_1 \subseteq t_1$
  ii. He **promised** (PST$_{e1}^{\,t2}$ promise^{e2}) Bea fresh flowers. EXPLANATION: $\vartheta e_2 \subseteq t_2 \subseteq \vartheta^{\blacktriangleleft} e_1$
- (7) i. Al^{x} went into (PST^{t1} go.into^{e1}) a florist shop. $\vartheta e_1 \subseteq t_1$
  ii. He **did** <u>not</u> buy (PST$_{e1}^{\,t}$ <u>not</u> buy^{e}) anything. RESULT: $\neg\exists t, e: \vartheta e \subseteq t \subseteq \vartheta^{\triangleright} e_1 \ldots$

English: Aspectual shifts

- Generalized **event algebra** (M&S + Bach + Bittner): $\langle \mathcal{D}_\varepsilon \cup \mathcal{D}_\sigma, \sqsubseteq, \triangleright, \blacktriangleleft, \triangledown, \blacktriangle, \blacktriangleright, \blacktriangleleft \rangle$

INPUT	OPERATION	OUTPUT	GRAPHIC REP.	
point, e			●	
point, e	$\triangleright e = s$	*consequent state,* s	———	M&S 1988
point, e	$\blacktriangleleft e = e'$	*preparatory process,* e′	●●●●	M&S 1988
process, e′	$\triangledown e' = s'$	*state equivalent,* s′	———	Bach 1986
process, e′	$\blacktriangle e' = e''$	*point equivalent,* e″	●●●●	Bach 1986
state, s′	$\blacktriangleright s' = e'''$	*start point,* e‴	●	Bittner 2014
state, s′	$\blacktriangleleft s' = e$	*c(ulmination-)point,* e	●	Bittner 2014

- **grinding: vp**[process → state] **~ np**[object → mass] (modified Bach 1986)

(8) **vp**. Al is^{s} {**work**ing$^{e'}$, **leav**ing^{e}}. $\{s \sqsubseteq \triangledown e' \ , s \sqsubseteq \triangledown(\blacktriangleleft e)\}$

np. Al added _^{y} {**oil**$^{y'}$, **egg**^{x}} to the salad. $\{y \sqsubseteq y' \ , y \sqsubseteq \triangledown x\}$

- **packaging: vp**[pl → atomic event] **~ np**[pl → atomic object] (modified Bach 1986)

(9) **vp**. Al did a bit$^{e''}$ of {**work**$^{e'}$, ***leav**ing^{e}}. $\{e'' = \blacktriangle e' \ , \text{no } \blacktriangle e \text{ for atomic } e\}$

np. Al ate a portion$^{x''}$ of {**eggs**$^{x'}$, ***an egg**^{x}}. $\{x'' = \blacktriangle x' \ , \text{no } \blacktriangle x \text{ for atomic } x\}$

English TNS as temporal centering

- **Top-level reference by English TNS**

  $\top$-**reference**: speech event — topic time

  $\bot$-**reference**: background event — background time

e.g.	relation 1:	relation 2 (& 3)		
	time–$\top\varepsilon$	situation–**time**(–$\bot\varepsilon$)	source	coherence relation
(1) i.	Al **went** into (**PST**$_{\top}{}^{t}$ go.into^{e}) a florist shop.			
	$t_1 < \vartheta e_0$	$\vartheta e_1 \subseteq t_1$	**PST**$_{\top}{}^{t}$	
ii.	He **promised** (**PST**$_{\top\bot}{}^{t}$ promise^{e}) his wife fresh flowers.			
	$t_2 < \vartheta e_0$	$\vartheta e_2 \subseteq t_2 \subseteq \vartheta^{\blacktriangleleft} e_1$	**PST**$_{\top\bot}{}^{t}$	EXPLANATION (i-ii)
iii.	He **asked** (**PST**$_{\top\top}$ ask^{e}) the assistant for some roses.			
	$t_1 < \vartheta e_0$	$\vartheta e_3 \subseteq t_1 \subseteq \vartheta^{\triangleright} e_2$	**PST**$_{\top\top}$	RESULT (ii-iii)

English TNS as temporal centering

- **Top-level reference by English TNS**

  $\top$-**reference**: speech event — topic time

  $\bot$-**reference**: background event — background time

e.g.	**time**–$\top\varepsilon$	situation–**time**(–$\bot\varepsilon$)	source	coherence relation
(10) i.	Al **played** chess ($\mathbf{PST}_{\top}{}^{t}$ play.chess^{e}) today.			
	$t_1 < \vartheta e_0$	$\vartheta e_1 \subseteq t_1$	$\mathbf{PST}_{\top}{}^{t}$	
ii.	He **started** ($\mathbf{PST}_{\top\bot}{}^{t}$ start$_{\bot\varepsilon}{}^{e}$) badly …			
	$t_2 < \vartheta e_0$	$\vartheta e_2 \subseteq t_2 \subseteq \vartheta^{\triangledown} e_1$	$\mathbf{PST}_{\top\bot}{}^{t}$	ELABORATION (i-ii)
		$e_2 = {}^{\triangledown}\!\blacktriangleleft e_1$	start$_{\bot}{}^{e}$	
ii′.	… but in the end$_{\bot'\varepsilon}{}^{t}$ …			
		$t'_2 \subseteq \vartheta^{\triangledown}\!\blacktriangleleft e_1$	but in the end$_{\bot'\varepsilon}{}^{t}$	CONTRAST (ii-ii′)
	… he **won** ($\mathbf{PST}_{\top\top}$ win$_{\bot'\varepsilon}{}^{e}$).			
	$t'_2 < \vartheta e_0$	$\vartheta e_3 \subseteq t'_2$	$\mathbf{PST}_{\top\top}$	ELABORATION (i-ii′)
		$e_3 = {}^{\triangledown}\!\blacktriangleleft e_1$	win$_{\bot'\varepsilon}{}^{e}$	

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Mandarin: Topic prominence

- Mandarin discourse consists of **topic chains** (Tsao 1979, Chu 1998, Li 2005, etc), i.e. chains of 1+ open stop 'sentences' (units marked by 。) about a topical individual.

(11) 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.

(12) 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$_{\top}$ has 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$_{\top}$, …
Yest. he$_{\perp}$ went to look at it$_{\top}$ and even $_{\perp}$took it$_{\top}$ for a spin. He$_{\perp}$ still didn't like it$_{\top}$, …

Mandarin: Aspect prominence

- A MANDARIN VERB is compositionally built out of:
  - an **ASP feature** (eventive E/ or stative S/), which introduces an eventuality (event or state) and relates it to the input topic state (E_T/ or S_T) or bckground eventuality ($E_\perp$/ or $S_\perp$/)
  - an **eventuality predicate**, which specifies the eventuality introduced by ASP

Mandarin: Aspect prominence (2)

- Hence **ASP**-PROMINENCE at every level:
  - lexicon:
    - *compound verb* = **ASP** feature + complex eventuality predicate of compositionally predictable type
    - *reduplicated verb* = **ASP** feature + complex eventuality predicate of compositionally predictable type
  - syntax:
    - *serial verb construction (SVC)* = **ASP** feature + compositional series of eventuality predicates which all co-specify the eventuality introduced by ASP
    - grammatical *aspect markers* (e.g. punctual le 'PNC', durative zhe 'DUR') form anaphoric chains with antecedent **ASP** features (e.g. E/ … PNC)
  - discourse:
    - **aspectual topic chain** ('。'): topic state update (terminating in topic-setting pause $|^s$) followed by 1^+ comment clauses with $\top\sigma$-anaphors ($\textbf{ASP}_\top$/, $\text{PNC}_\top$).
    - **(individual) topic chain** (zero anaphora): 1^+ aspectual topic chains about topic states that are (a) centered on the same individual, and (b) related closely enough for zero anaphora (e.g. *central-part* as in (11i–ii)).

Mandarin lexicon: ASP-prominent verbs

E/ (✓*n*-ci '*n*-events')

combines with:

v_ε: event predicate (✓zài 'be in prg')

v_ε: xué 'study/learn', mǎi 'shop/buy', dǎ 'beat/hit', kàn 'look/see/read', $xiǎng_\varepsilon$ 'think', $zuò_\varepsilon$ 'sit down'

v_ε-v_ε: gòu-mǎi (purchase-buy) 'buy'

v_ε-n: kàn-shū (read-book) 'read'

v_σ-v_ε: àn-shā (dark-kill) 'assassinate'

$v_{\varepsilon\bullet}$: pt event predicate (*zài 'be in prg')

$v_{\varepsilon\bullet}$: lái 'come', qù 'go', dào 'get to', wán 'finish', yíng 'win', sǐ 'die'

v_ε~v_ε: kànkàn 'take a look, read a bit'

v_ε-$v_{\varepsilon\bullet}$: dǎ-sǐ (beat-die) 'beat to death'

v_ε-$v_{\sigma(\bullet)}$: xiě-cuò 'write wrong'

$v_{\varepsilon\bullet}$-n: dào-jiā (arr-home) 'come home'

S/ (n*-ci '*n*-events')**

combines with:

v_σ: state predicate (✓hěn 'very')

v_σ: $qīng_1$ 'clean/clear', $qīng_2$ 'light/low', lèi 'tired', duō 'many/much', tèng 'ache', ài 'love', $xiǎng_\sigma$ 'wish/miss', yǒu 'have'

v_σ-v_σ: gān-zào (dry-arid) 'dry'

v_σ-n: ài-guó (love-country) 'patriotic'

n-v_σ: tóu-téng (head-ache) 'have a headache'

$v_{\sigma\bullet}$: pt scale state predicate (*hěn 'very')

$v_{\sigma\bullet}$: $zuò_{\sigma\bullet}$ 'seated', $zhàn_{\sigma\bullet}$ 'stand', cuò 'wrong', zài 'be in/on/at/in prg', méiyǒu 'have no'

v_σ~v_σ: qīngqīngchǔchǔ 'perfectly clear'

v_σ-$v_{\varepsilon\bullet}$: lèi-si (tired-die) 'dead tired'

v_ε-$v_{\sigma\bullet}$: zhù-zài (live-be.in) 'live in'

$v_\varepsilon\langle v_{\sigma\bullet}\rangle v_{\varepsilon\bullet}$: kāi$\langle bu_{\sigma\bullet}\rangle$guò 'unable to drive across'

Mandarin syntax: ASP-prominent verb series

- **serial verb construction (SVC)** = ASP feature + compositional series of eventuality predicates which all co-specify the eventuality introduced by ASP
  - in (13i), $E_{\top}$/ introduces a process (e_1) whose *progress state* ($^{\triangledown}e_1$) *starts* with Xiaoli going to town ($^{\blacktriangleleft\triangledown}e_1$) and *culminates* in her buying something ($^{\blacktriangleright\triangledown}e_1$)
  - in (13ii), $E_{\perp}$/ introduces a point (e_2) whose *preparatory process* ($^{\blacktriangleleft}e_2$) is Xiaoli's walk (part of process e_1) and whose *consequent state* is a state of her being tired ($^{\triangleright}e_2$)
  - in (13ii), $E_{\top}$/ introduces a point (e_3) in which Xiaoli sits down (with the intention that) the *consequent state culminate* in her resting a bit ($^{\blacktriangleright\triangleright}e_3$)

(13) i. Xiǎoli jīntiān jìn.chéng qù mǎi dōngxi le 。
Xiaoli$^{\top}$ today $|^{s}$ $E_{\top}$/**enter.town go buy things** $PNC_{\top}$ 。
Xiaoli$^{\top}$ went shopping in town today.

ii. Tā zǒu lèi le , zuò.xiàlai xiūxi~xiūxi 。
s/he$_{\top}$ $E_{\perp}$/**walk tired** $PNC_{\top}$,$|^{s}$ $E_{\top}$/**sit.down rest.a.bit** 。
When she$_{\top}$ got tired of walking, she$_{\top}$ sat down to rest a bit.

Mandarin syntax: ASP-dependent markers

- **punctual aspect** marker (-)**le** '**PNC**' (a.k.a 'perfective') highlights a **verifiable point**

INPUT	e•. point event	e. (*n*-atom) event	s•. pt scale state	s. (*n*-degree) state
OUTPUT	**e•**	**▲e**	**s•, ◣s, ◢s**	**◣s, ◢s**

(14) e•. Wǒ xiě-wán-**le** xìn。
1SG E/write-finish-**PNC** letter
e•. I finished writing a letter (**verifiable pt event, e•**).

e. Wǒ xiě-**le** xìn kěshì mei xiě-wán。
1SG E/write-**PNC** letter but not write^{e}-finish•
▲e. I did a bit of letter writing but didn't finish. (**verifiable pt equivalent**, ▲e)

s•. Chènshān xiǎo-**le** yi.diǎn。
shirt [S/small-**PNC** a.M$_{bit}$•]
s•. The shirt is a bit small. (**verifiable scalar pt, s•**).
◣s•. The shirt got a bit smaller. (**verifiable start pt,** ◣s•)

s. Tā bìng-**le** sān-tiān。
3SG [S/sick-**PNC** three-M$_{day}$]
◣s, ◢s. He was sick for three days (**verifiable start pt,** **◣s**; 3 days from **◣s** to **◢s**)

Mandarin discourse: ASP-prominent units

- The *minimal unit* of Mandarin discourse is an **open stop sentence** ('。').
  - It begins with the introduction of a topic state (terminating in *topic-setting pause* $|^{s}$) followed by one or more comments about this topic state (terminating in '。').
  - Each comment is a clause with an **ASP-feature**, which introduces a background eventuality and relates it to the current topic state, either directly ($E_{\top\sigma}$/ or $S_{\top\sigma}$/) or via an anaphoric chain with a dependent aspect marker (e.g. S/… $PNC_{\top\sigma}$)
- The *next larger unit* is an **(individual) topic chain** (zero anaphora)
  - It begins with the introduction of a **topical individual** as part of topic state update, and consists of one or more open stop sentences whose *topic states* are:
    - centered on that **topical individual**
    - related *closely enough* for zero anaphora (e.g. 'central part' as in (11i–ii))

Mandarin discourse: ASP-based temporality

(Individual) topic chain (11i–ii) (zero anaphora) consists of 2 aspectual topic chains ('。'):

(11) i. [Xiaoli is young and pretty. She has a good job too.]
topic state $^{\top}s_1$: e_0-present state of $^{\top}$Xiaoli
Xiaoli$^{\top}$ $|^{s}$ …

comment 1: $^{\top}s_1$ is a *central part of* a state s_{11} of $^{\top}$Xiaoli being young and pretty
$s_{\top\sigma}/_{\top}$young $s_{\top\sigma}/_{\top}$pretty , …

comment 2: $^{\top}s_1$ is also a *central part of* a state s_{12} of $^{\top}$Xiaoli having a good job
$_{\top}$job also $s_{\top\sigma}$/good 。(end of comments about $^{\top}s_1$)

ii. [Although she has a boyfriend, she doesn't wish to marry.]
topic state $^{\top}s_2$: larger state of $^{\top}$Xiaoli ($s_1 \sqsubseteq_{\uparrow} s_2$), extended to current boyfriend$^{\perp}$
although $s_{\top\sigma}/_{\top}$have CL boyfriend ,$|^{s}$ …

comment 1: $^{\top}s_2$ is a *central part* of a state s_{21} of Xiaoli not wanting to marry
but not $s_{\top\sigma}/_{\top}$wish E/marry 。(end of comments about $^{\top}s_2$)

Mandarin '。' v. English '.'

- **Tsao's (1990) experiment**

  Native English speakers, and native Mandarin speakers learning English, were shown English and Mandarin texts with capitalization and full stops removed. They were asked to restore the full stops. Native English speakers were mostly in agreement on *English sentence* boundaries ('.'). Native Mandarin speakers were found to …

  … mostly *agree* with English speakers on *English sentence* boundaries ('.')

  … but ***not*** with other Mandarin speakers on *Mandarin sentence* boundaries ('。')

- **Explanation**

  - *English sentences* are units of syntax. Their boundaries are usually recoverable from syntactic markers (e.g. TNS).
  - *Mandarin sentences* are units of information structure, not syntax. A topic state update (terminating in a topic-setting pause, $|^{s}$) is followed by *n* comment(s) (clauses with topic state anaphors E_T/, S_T/, or PNC_T). Since states do not have visible boundaries, speakers may disagree where one topic state ends and the next one begins (e.g. whether the Mandarin discourse (11i–ii) is about *two* topic states ($^{\top}s_1$ and $^{\top}s_2$, as on the previous slide), or *one* ($^{\top}s'_1$, present state of Xiaoli).

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UC_τ: UC_ε extended with time drefs …

Typed dref entities

type:	δ	ε	σ	τ
dref entity:	x (individual)	e (event)	s (state)	t (time)
UC_τ *variable*:	x	e	s	t

Centering-based anaphora, e.g.

center of attn. backgr. of attn.

$\langle\langle t_2,\ s_1,\ x_1,\ e_0\rangle, \langle e_2,\ e_1,\ s_2,\ t_1\rangle\rangle$ *dref hierarchy*

$\top\tau\ \top\sigma\ \top\delta\ \top\varepsilon\ \ \bot\varepsilon\ \bot'\varepsilon\ \bot\sigma\ \bot\tau$ *typed anaphors*

Start-up update

Speaking up (e_0) focuses attention, giving rise to (e_0-)*minimal info-state*:
$\{\langle\langle e_0\rangle, \langle\rangle\rangle\}$

Reference to f-values (á la Moens & Steedman 1988, see also next slide)

ϑe	*time* of event *e*	ϑs	*time* of state *s*
$\uparrow e$	*central individual* in event *e*	$\uparrow s$	*central individual* in state *s*
$\downarrow e$	*background individual* in event *e*	$\downarrow s$	*background individual* in state *s*

UC_τ: … and general event algebra

Figure 3. UC_τ *event algebra*: $\langle \mathcal{D}_\varepsilon \cup \mathcal{D}_\sigma, \sqsubseteq_\varepsilon, \sqsubseteq_\sigma, \triangleright, \blacktriangleleft, \triangledown, \blacktriangle, \blacktriangleright, \blacktriangleleft, \ldots \rangle$

INPUT	OPERATION	OUTPUT	GRAPHIC REP.	
point, e			●	
point, e	$\triangleright$e = s	*consequent state*, s	———	M&S 1988
point, e	$\blacktriangleleft$e = e′	*preparatory process*, e′	●●●●	M&S 1988
process, e′	$\triangledown$e′ = s′	*state equivalent*, s′	———	Bach 1986
process, e′	$\blacktriangle$e′ = e″	*point equivalent*, e″	●●●●	Bach 1986
state, s′	$\blacktriangleright$s′ = e‴	*start point*, e‴	●	Bittner 2014
state, s′	$\blacktriangleleft$s′ = e	*culmination point*, e	●	Bittner 2014

ASP-based Mandarin (13i) in UC_τ

(13) i. Xiǎoli jīntiān jìn.chéng qù mǎi dōngxi le 。
Xiaoli$^\top$ today $|^s$ $E_\top$/enter.town go buy things $PNC_{\perp\top}$ 。
Xiaoli$^\top$ went shopping in town today.

Model for Mandarin (13i)

Dref	*Symbol*: *Description*	*Temp. conds.*	*Source*
●	$^\top e_0$: $\uparrow e_0$ speaks up		e_0
■■■■■■■	t_1: part of e_0-day	$t_1 \subseteq e_0$-day	today^t
———	$^\top s_1$: $^\top$Xiaoli x_1 within t_1	$s_1 \subseteq t_1$	$_{\perp\tau}|^s$
●●●	e_1: x_1 goes to town ($\blacktriangleright^\triangledown e_1$) & buys things ($\blacktriangleleft^\triangledown e_1$)	$^\triangledown e_1 \sqsubseteq_\uparrow s_1$ $\blacktriangleleft(^\triangledown e_1) = \blacktriangleleft s_1 < e_0$	$E_\top/v_{\varepsilon\bullet}$ $v_{\varepsilon\bullet}$ v_ε $PNC_{\perp\top}$

TNS-based English (13'i) in UC_τ

(13') i. Xiǎoli went shopping in town today.
Xiaoli$^{\top}$ PST^{t} go^{e} shopping in town today$_{\top}$

Model for English (13'i)

Dref	*Symbol*: *Description*	*Temp. conds.*	*Source*
•	$^{\top}e_0$: $\uparrow e_0$ speaks up		e_0
■■■■■■■	$^{\top}t_1$: e_0-past,	$t_1 < \vartheta e_0$	PST^{t}
	part of e_0-day	$t_1 \subseteq e_0$-day	today
●●●	e_1: Xiaoli x_1 goes shopping	$\vartheta e_1 \subseteq t_1$	PST^{t} V^{e}

ASP-based Mandarin (13ii) in UC_τ

(13) ii. Tā zǒu lèi le , zuò.xiàlai xiūxi~xiūxi 。
s/he$_\top$ $E_\perp$/walk tired $PNC_{\perp\top}$,$|^s$ $E_\top$/sit.down rest.a.bit 。
When she$_\top$ got tired of walking, she$_\top$ sat down to rest a bit.

Model for Mandarin (13i–ii)

Dref	*Symbol*: *Description*	*Temp. conds.*	*Source*
●	$^\top e_0$: $\uparrow e_0$ speaks up		e_0
■■■■■■■	t_1: part of e_0-day	$t_1 \subseteq e_0$-day	today^t
———	$^\top s_1$: $^\top$Xiaoli x_1 within t_1	$s_1 \subseteq t_1$	$_{\perp\tau}\|^s$
●●●	e_1: x_1 goes to town ($^\blacktriangleright{}^\triangledown e_1$)	$^\triangledown e_1 \sqsubseteq_\uparrow s_1$	$E_\top/v_{\varepsilon\bullet}\ v_{\varepsilon\bullet}\ v_\varepsilon$
	& buys things ($^\blacktriangle{}^\triangledown e_1$)	$^\blacktriangle(^\triangledown e_1) = {}^\blacktriangle s_1 < e_0$	$PNC_{\perp\top}$
●	e_2: x_1 gets tired ($^\triangleright e_2$)	$e_2 \sqsubseteq_\uparrow e_1$	$E_\perp/v_\varepsilon\ v_\sigma$
	from walking ($^\blacktriangleleft e_2$)	$e_2 = {}^\blacktriangleright s_2 < e_0$	$PNC_{\perp\top}$
———	$^\top s_2$: $^\top$Xiaoli x_1 within t_1 after e_2	$s_2 \subseteq t_1$	$_{\perp\tau}\|^s$
●●	e_3: x_2 sits down ($^\blacktriangleright{}^\triangledown e_3$)	$^\triangledown e_3 \sqsubseteq_\uparrow s_2$	$E_\top/v_{\varepsilon\bullet}\ v_{\varepsilon\bullet}$
	to rest a bit ($^\blacktriangle{}^\triangledown e_3$)		

TNS-based English (13'ii) in UC_τ

(13') ii. When she got tired of walking, she sat down to rest a bit.

[when^t [she$_\top$ $PST_{\perp\perp}$ get^e tired of walking]]^t, she$_\top$ $PST_{\top\perp}$ sit.down^e to rest a bit

Model for English (13'i–ii)

Dref	*Symbol: Description*	*Temp. conds.*	*Source*
●	$^\top e_0$: $\uparrow e_0$ speaks up		e_0
■■■■■■	$^\top t_1$: e_0-past,	$t_1 < \vartheta e_0$	PST^t
	part of e_0-day	$t_1 \subseteq e_0$-day	$today_\top$
●●●	e_1: Xiaoli x_1 goes shopping	$\vartheta e_1 \subseteq t_1$	PST^t V^e
■■	t_2: e_0-past, part of e_1-prg.time	$t_2 < \vartheta e_0$, $t_2 \subseteq \vartheta^{\triangledown} e_1$	$when^t$ $PST_{\perp\perp}$
●	e_2: x_1 gets tired ($^{\triangleright} e_2$)	$\vartheta e_2 \subseteq t_2$	$PST_{\perp\perp}$ V^e
	of walking ($^{\blacktriangleleft} e_2$)		
■■■	$^\top t_3$: e_0-past, part of e_2-con.time	$t_3 < \vartheta e_0$, $t_3 \subseteq \vartheta^{\triangleright} e_2$	[when]^t $PST_{\top\perp}$
●●	e_3: x_1 sits down ($^{\blacktriangleright\triangledown} e_3$)	$\vartheta e_3 \subseteq t_3$	$PST_{\top\perp}$ V^e
	to rest a bit ($^{\blacktriangleleft\triangledown} e_3$)		

English *when* as temporal topic-comment

Moens & Steedman (1988) idea implemented in UC_τ

(15) When they built that bridge, a famous architect **drew up** the plans .

[when^t [$PST_\perp$ build^e that bridge]]^t $PST_{\top\perp}$ draw.up^e the plans$_\perp$

●●● e_2: they build that bridge $\vartheta e_2 \subseteq t_2$ $PST_\top V^e$

■■ t_3: e_0-past, part of e_2-**pre**.time $t_3 < \vartheta e_0$, $t_3 \subseteq \vartheta^{\blacktriangleleft} e_2$ [when]^t $PST_{\top\perp}$

(16) … , they **used** the best materials .

$PST_{\top\perp}$ use^e the best materials$_\perp$

●●● e_2: they build that bridge $\vartheta e_2 \subseteq t_2$ $PST_\top V^e$

■■ t_3: e_0-past, part of e_2-**prg**.time $t_3 < \vartheta e_0$, $t_3 \subseteq \vartheta^{\triangledown} e_2$ [when]^t $PST_{\top\perp}$

(17) … , my commute **got** a lot easier .

$PST_{\top\perp}$ get^e a lot easier

●●● e_2: they build that bridge $\vartheta e_2 \subseteq t_2$ $PST_\top V^e$

■■ t_3: e_0-past, part of e_2-**con**.time $t_3 < \vartheta e_0$, $t_3 \subseteq \vartheta^{\triangleright} e_2$ [when]^t $PST_{\top\perp}$

Outline

- English: TNS-based temporality
- Mandarin: ASP-based temporality
- Implementation in UC_τ
- Conclusion

Conclusion

- UC_τ has logical tools for a unified analysis of temporal reference, which factors out *semantic universals* while allowing for *linguistic diversity* & *coherence-driven variation*
- **Universally**, temporal reference relies on grammatical centering systems of obligatory gramm. categories that keep track of top-ranked temp. drefs (events, states, times).
- **Linguistic diversity**, e.g.
  - English has a grammatical system of **tense markers** (**TNS**, e.g. PST v. PRS) which introduce or refer to the topic time or background time and may anchor this dref to the input background event.
  - Mandarin has a grammatical system of **aspect features** (**ASP**, e.g. E/ v. S/) which introduce background eventualities (events or states) and anchor them to the input topic state (either directly or via anaphorically linked aspect markers) or to the input background eventuality (event or state).
- **Coherence-driven semantic variation**
  - lexical *meaning adjustments* ~ *phonological adjustments* (e.g. assimmilation)
  - *accommodation* (e.g. discourse-initial $PST_T \rightarrow (PST_T)^t$ or *coherence* (e.g. ▷ v. ◀)

Tomorrow: Quantification

- **Basic ideas**
  - In discourse, plurals and quantifiers can function as antecedents or anaphors, because they can introduce or refer to *ranked drefs for sets*.
  - Logical representation in UC_0 extended with drefs and anaphors for sets of individuals ($UC_{\delta\|}$)
- **Suggested readings**
  - Berg, M. van den. 1993. Full Dynamic Plural Logic. *Proceedings of the 4th Symposium on Logic and Language.*
  - Berg, M. van den, 1994. A direct definition of generalized dynamic quantifiers. *Proceedings of the 9th Amsterdam Colloquium.*

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