Time and Tense in Language

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Events and Relations

Event expressions;

    tensed verbs; has left, was captured, will resign;

    stative adjectives; sunken, stalled, on board;

    event nominals; merger, Military Operation, Gulf War;

Dependencies between events and times:

    Anchoring; John left on Monday.

    Orderings; The party happened after midnight.

    Embedding; John said Mary left.

Tense

- Grammatical expression of the time of the situation described, relative to some other time (e.g., moment of speech)

PAST   PRESENT   FUTURE

George admires Adolf.
George admired Jesus.

Reichenbach

- Tensed utterances introduce references to 3 'time points'
  - Speech Time: S
  - Event Time: E
  - Reference Time: R

    $_S$I had [mailed the letter]$_E$ [when John came & told me the news]$_R$
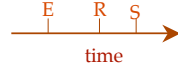
    $E < R < S$

    E   R S

          time

- The concept of 'time point' is an abstraction –- it can map to an interval
- Three temporal relations are defined on these time points
  - at, before, after
- 13 different relations are possible

Tense as Anaphor: Reichenbach

- Tensed utterances introduce <u>references</u> to 3 'time points'
  - Speech Time: S
  - Event Time: E
  - Reference Time: R

  $_S$*I had [mailed the letter]$_E$ [when John came & told me the news]$_R$*

  $E < R < S$

  time

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Reichenbachian Tense Analysis

Relation	Reichenbach's Tense Name	English Tense Name	Example
E<R<S E=R<S	Anterior past Simple past	Past perfect Simple past	I had slept I slept
R<E<S R<S=E R<S<E	Posterior past		I would sleep
E<S=R S=R=E S=R<E	Anterior present Simple present Posterior present	Present perfect Simple present Simple future	I have slept I sleep I will sleep *Je vais dormir*
S<E<R S=E<R E<S<R	Anterior future	Future perfect	I will have slept
S<R=E	Simple future	Simple future	I will sleep *Je dormirai*
S<R<E	Posterior future		I shall be going to sleep

- <u>Tense</u> is determined by relation between R and S
  - R=S, R<S, R>S
- <u>Aspect</u> is determined by relation between E and R
  - E=R, E < R, E> R
- Relation of E relative to S not crucial
  - Represent R<S=E as E>R<S
- Only 7 out of 13 relations are realized in English
  - 6 different forms, simple future being ambiguous
  - Progressive no different from simple tenses
    - But I was eating a peach ≠> I ate a peach

Tense as Operator: Prior

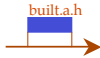| Relation	Reichenbach's Tense Name	PRIOR	English Tense Name	Example
E<R<S E=R<S	Anterior past Simple past	PP? P?	Past perfect Simple past	I had slept I slept
R<E<S R<S=E R<S<E	Posterior past	PF?		I would sleep
E<S=R S=R=E S=R<E	Anterior present Simple present Posterior present	P? ? F?	Present perfect Simple present Simple future	I have slept I sleep I will sleep *Je vais dormir*
S<E<R S=E<R E<S<R	Anterior future	FP?	Future perfect	I will have slept
S<R=E	Simple future	F?	Simple future	I will sleep *Je dormirai*
S<R<E	Posterior future	FF?		I shall be going to sleep

- Free iteration captures many more tenses,
  - *I would have slept* $PFP\phi$
- But also expresses many non-NL tenses
  - PPPPϕ *[It was the case]⁴ John had slept*
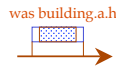
Aspect

- Two Varieties
  - Grammatical Aspect
    - Distinguishes viewpoint on event
  - Lexical Aspect
    - Distinguishes types of events (situations)(eventualities)
    - Also called Aktionsarten

Grammatical Aspect

- Perfective – focus on situation <u>as a whole</u>
  - John built a house

built.a.h

- Imperfective – focus on <u>internal phases</u> of situation
  - John was building a house

was building.a.h

Aktionsarten

- STATIVES *know, sit, be clever, be happy,*
  - can refer to state itself (ingressive) *John knows*, or to entry into a state (inceptive) *John realizes*
  - **John is knowing Bill, *Know the answer, *What John did was know the answer*
- ACTIVITIES *walk, run, talk, march, paint*
  - if it occurs in period t, a part of it (also an activity) must occur for every/most sub-periods of t
  - X is Ving entails that X has Ved
  - *John ran for an hour,*John ran in an hour*

- ACCOMPLISHMENTS *build, cook, destroy*
  - culminate (telic)
  - x Vs for an hour does not entail x Vs for all times in that hour
  - X is Ving does not entail that X has Ved.
  - *John booked a flight in an hour, John stopped building a house*
- ACHIEVEMENTS *notice, win, blink, find, reach*
  - instantaneous accomplishments
  - **John dies for an hour, *John wins for an hour, *John stopped reaching New York*

	Telic	Dynamic	Durative	E.g.
Stative	-	-	+	know, have
Activity	-	+	+	walk, paint
Accomplishment	+	+	+	destroy, build
Achievement	+	+	-	notice, win

Different types of tense systems across languages

- Using verbal inflection:
  - Languages with a two-way contrast:
    - <u>English</u>: Past (before the moment of speaking) vs. Nonpast
      past -*ed*:   *She worked hard.*
      nonpast (unmarked): *We admire her. I will leave tomorrow.*
    - <u>Dyirbal</u> (Australian language): Future vs. nonfuture:
      future -*ñ*:   *bani-ñ*   'will come'
      nofuture -*ñu*:   *bani-ñu*   'came, is coming'
  - Languages with a three-way distinction:
    - <u>Catalan, Lithuanian</u>: Past vs. Present vs. Future
      (Cat.)   past: *treball-à.*   (Lit.)   *Dirb-au.*   'I worked'
               present: *treball-a.*   *Dirb-u.*   'I work'
               future: *treball-arà.*   *Dirb-siu.* 'I will work'

Different types of tense systems across languages

- A much richer distinction:
  - <u>ChiBemba</u> (Bantu language):
    For past:
    - Remote past (before yesterday) *Ba-àlí-bomb-ele*   'they worked'
    - Removed past (yesterday)   *Ba-àlíí-bomba*   'they worked'
    - Near past (earlier today)   *Ba-àcí-bomba*   'they worked'
    - Immediate past (just happened)   *Ba-á-bomba*   'they worked'

    For future:
    - Immediate future (very soon)   *Ba-áláá-bomba*   'they'll work'
    - Near future (later today)   *Ba-léé-bomba*   'they'll work'
    - Removed future (tomorrow)   *Ba-kà-bomba*   'they'll work'
    - Remote future (after tomorrow) *Ba-ká-bomba*   'they'll work'

Aspect

- Internal temporal organization of the situation described by an event.
- Most common:
  - **Perfective:** Situation viewed as a bounded whole.
  - **Imperfective:** Looking inside the temporal boundaries of the situation.
    - **Habitual**
    - **Progressive**
- Other related aspectual distinctions:
  - **Iterative:** The action is repeated.
  - **Inceptive:** The action is began.
  - **Inchoative:** Entering into a state.

Different types of aspect systems across languages

- Some languages use auxiliaries and particles associated with the verb:

  English:
  - **Perfective:** *have* + Past Participle — *I have eaten.*
  - **Progressive:** *be* + Present Participle — *I am eating.*
  - **Habitual:** *use to* + Base form — *I used to sing.*

  Catalan:
  - **Habitual:** *soler* + Infinitive
    - *Sol parlar.* — 'She generally talks.'
    - *Solia cantar.* — 'She used to talk'
  - **Iterative:** *anar*$_{(past)}$ ('to go') + Present Part
    - *Va   tornant* — 'She keeps coming back'
    - go$_{past}$ coming_back

Different types of aspect systems across languages

- Other languages use a derivational component:

  Russian: by means of a system of verbal prefixes
  - **Imperfective:** simple verbs   *Ja ˇcitál* — 'I was reading'
  - **Perfective:** prefixed verbs   *Ja proˇcitál* — 'I (did) read'

  Finnish: by means of the case of the object
  - **Perfective:**   *Hän luki kirjan*$_{(acc.)}$ 'He read the book'
  - **Imperfective:**   *Hän luki kirjaa*$_{(part.)}$ 'He was reading the book'.
    - Basic meaning: only part of the object being referred to is affected by the situation.

Tense and Aspect

- Aspect and Tense generally cross-classify:
  - Russian:
    - Present:
      - Only imperfective: *ˇcitáju* — 'I read'
    - Past:
      - Imperfective: *Ja ˇcitál* — 'I was reading'
      - Perfective: *Ja proˇcitál* — 'I (did) read'
    - Future:
      - Imperfective: ??
      - Perfective: *Ja proˇcitáju* — 'I shall read'

Tense and Aspect

   – Basque:
- Present:
  - Imperfect (Gerund + Present tense auxiliary)   *ekartzen du*   'he is bringing it'
  - Perfect (Past Participle + Present tense aux.)   *ekarri du*   'he has brought it'
- Past:
  - Imperfect (Gerund + Past tense aux.)   *ekartzen zuen* 'he brought, used to bring'
  - Perfect (Past Participle + Past tense aux.)   *ekarri zuen* 'he brought, had brought'
- Future:
  - Simple (Future Participle + Pres. tense aux.)   *ekarriko du*   'he will bring it'
  - Past Future (Future Participle + Past tense aux.) *ekarriko zuen* 'he would bring'

An interesting case

- Tense and Aspect in 2 different creoles, evolved independently from each other:

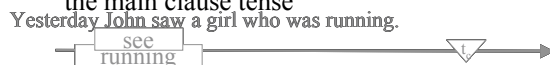|	Hawaiian Creole	Haitian Creole
Base Form (he walks, he walked)	*He walk*	*Li maché*
Progressive he is walking, he was walking	*He stay walk*	*L'ap maché* (*Li ap maché*)
Perfective he has walked, he had walked	*He bin walk*	*Li té maché*
Perfective Progressive (he has/had been walking)	*He bin stay walk*	*Li t'ap maché* (*Li té ap maché*)
Irreal (he would walk, he will walk)	*He go walk*	*L'av maché*
Irreal Progressive (he would/will be walking)	*He go stay walk*	*L'av ap maché* (*Li av ap maché*)
Irreal Perfective (he would/will have walked)	*He bin go walk*	*Li t'av maché* (*Li té av maché*)
Irreal perfective Progressive he would/will have been	*He bin go stay walk*	*Li t'av ap maché* (*Li té av maché*)

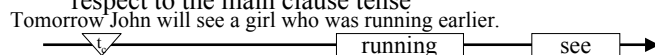# Embedded tenses in English

Three interpretations of embedded tenses:

Absolute: embedded tense is independent of main clause tense

Yesterday John saw a girl who was running this morning.

This morning John saw a girl who was running yesterday.
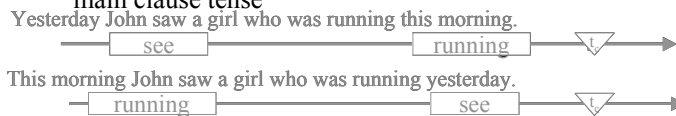
Anaphoric: embedded tense is anaphoric on the main clause tense

Yesterday John saw a girl who was running.

Relative: embedded tense is interpreted with respect to the main clause tense

Tomorrow John will see a girl who was running earlier.

Constraints on interpretation

- Tense interpretation displays both structural restrictions and lexical preferences

    Relative clause interpretation:
    At the party John danced with the woman (previously/later) he ate dinner with.

    At the party John met the woman he married

    Complement clause interpretation

    At the party John said that he (previously/??later) ate dinner with a certain woman.

Crosslinguistic variation

Variation in relative clause interpretation

- Japanese

  Mariko-wa naiteiru otokonoko-ni hanasikaketa
  Mariko-TOP cry-teiru-PRES boy-to talk-PAST
  "Mariko talked to the boy who is/was crying"

- Russian

  Maˇsa videla ˇceloveka, kotoryj placet.
  Masha see-PAST-IMP man who cry-PRES
  "Masha saw a/the man who is crying"

Crosslinguistic variation

Variation in complement clauses interpretation

- Japanese

  Bernhard-wa Junko-ga byookida to it-ta
  B.-TOP J.-NOM sick-PRES comp say-PAST
  "Bernhard said that Junko was sick"

- Russian

  Maˇsa skazala, cto Vova spit.
  Masha say-PAST-PERF that Voval sleep-PRES
  "Masha said that Vova was sleeping"

Embedded tenses cross-linguistically

	Relative Clause	Complement Clause
English	absolute relative anaphoric	relative anaphoric
Japanese	absolute relative	relative
Russian	absolute anaphoric	relative

Via cross-linguistic investigation a picture of embedded tenses emerges:
- Absolute tense is limited to relative clauses
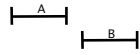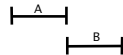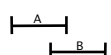- Relative tense is predominant in complement clauses

The Conceptual and Linguistic Basis

- TimeML presupposes the following temporal entities and relations.

- Events are taken to be situations that occur or happen, punctual or lasting for a period of time. They are generally expressed by means of tensed or untensed verbs, nominalisations, adjectives, predicative clauses, or prepositional phrases.

- Times may be either points, intervals, or durations. They may be referred to by fully specified or underspecified temporal expressions, or intensionally specified expressions.

- Relations can hold between events and events and times. They can be temporal, subordinate, or aspectual relations.

Allen (1984) Temporal Logic

- **Time primitives are temporal intervals.**

- **No branching into the future or the past**

- **13 basic (binary) interval relations**
  - **[b,a,eq,o,oi,s,si,f,fi,d,di,m,mi],**
    (six are inverses of the other six)

- **Supported by a transitivity table that defines the conjunction of any two relations.**

- **All 13 relations can be expressed using meet:**
  - **Before (X, Y) ⇒ ∃Z , (meets(X, Z) ∧ (meets (Z, Y))**

Allen's 13 Temporal Relations

A is EQUAL to B	B is EQUAL to A
A is BEFORE B	B is AFTER A
A MEETS B	B is MET by A
A OVERLAPS B	B is OVERLAPPED by A
A STARTS B	B is STARTED by A
A FINISHES B	B is FINISHED by A
A DURING B	B CONTAINS A

Allen's Temporal Ontology

- *Properties* **hold over every subinterval of an interval**

  —> Holds(p, T) e.g., "John was sick for a day."

- *Events* **hold only over an interval and not over any subinterval of it.**
  —> Occurs(e, T) e.g., "Mary wrote a letter this afternoon."

- *Processes* **hold over some subintervals of the interval they occur in.**
  —> Occuring(p, T) e.g., "Mary is writing a letter today."

Situation Type: Formal Constraints

- Homogeneity
  - All subevents of P are also of P (downward entailment)
    - though only down to a minimal size
  - The sum of all subevents of P are also of P (upward entailment)

- Subinterval Property
  - Activity: x Ps for t => x P's for all subintervals of t. excluding those below a minimal size and excluding certain gaps
    - *For* is downward entailing, but the maximal interval is more felicitous
  - Accomplishment: x Ps in t => there is a subinterval t' of t in which Become(x, P) is true
    - *In* is upward entailing, but the minimal interval is more felicitous
    - In-adverbials apply to quantized event predicates
      - A predicate is quantized iff whenever it applies to e it doesn't apply to subparts of e

Event Structure

- Quantification over events as individuals: I.e., events as first-order objects.
- Finer-grain representation than Prior's tense logic.
- Allows representation of word-based causality.
- Simplifies reasoning with identity and overlap relations.

Theories of Event Structure

Davidson (1967): Proposes individuation over events.

Kamp (1968): Formal Model for tensed events, extending Prior's Tense Logic to predicates.

Moens and Steedman (1988): Finite-state model of event phases.

Pustejovsky (1991): Phrase structure model for subevent semantics for word meaning.

McCarthy and Hayes (1969)
The Situation Calculus

- Represents actions and their effects on the world
- The world is represented as a set of **states.**
- **Fluents** are time-varying properties of individuals.
- **Actions** are functions that map states to states.
- Used for multiple tasks, especially planning
- Major problems:
  - Concurrent actions cannot be represented
  - No duration of actions or delayed effects

Hayes 1985
Histories in Naïve Physics

- A **history** is an entity that incorporates time and space
- An **object** O in a **situation** s is the intersection of the situation with the object's history
- Permanent locations are bound spatially, but are restricted temporally
- Situations are unbound spatially, but are limited temporally by surrounding events
- Most objects are between these two extremes
- **Events** are instantaneous
- **Episodes** have a duration

- The history of an object is described over time

Kowalski & Sergot (1986)
Event Calculus

- Developed for updating databases and for narrative understanding

- Based on the notion of an event and its descriptions (relationships)

- Relationships are ultimately over time points

   after(e) = the period of time started by event e

- Udates can only add; deletions add new information about the end of the period of time over which the old relationship holds

- Uses nonmonotonic, default reasoning since relations change as new information arrives (a new event can signal the end of an old one)

- Allows partial description of events, using semantic cases

- Defined and interpreted as Horn clauses in Prolog

Properties of Events

Events have parts:

   The rock broke the window.

   $\exists e1 \exists e2[action(e1,rock,window)$ &
   $broken(e2,window)$ & $e1<e2]$

Actions have consequences:

   Mary arrived in Boston.

   $\exists e1 \exists e2[action(e1,mary,boston)$ &
   $in(e2,mary,boston)$ &
   $e1<e2]$