Event Structure with Subevents (Pustejovsky 1991)

(28) a. EVENT → STATE | PROCESS | TRANSITION

b. STATE: → e

c. PROCESS: → $e_1 \ldots e_n$

d. TRANSITION_{ach}: → STATE STATE

e. TRANSITION_{acc}: → PROCESS STATE

Participant Roles

a. **Agent**: animate and volitional (but not necessarily intentional) initiator or doer of an action: *The boy* broke the watch.
b. **Patient/ Theme**: entity undergoing the action and somehow affected by it (brought into existence, destroyed, moved, modified, etc.). A useful distinction we are going to adopt is *affected* objects (e.g., The boy broke *the watch*) vs. *effected* or *created* objects (e.g. The boy baked *cakes*).
c. **Experiencer**: entity psychologically or emotionally affected by the event: *I* love you/ *We* witnessed the accident.
d. **Benefactive**: entity that benefits from the event: You can't suit *everyone*.
e. **Location**: place where the event takes place: Amber lives in *Boston*.
f. **Source**: the entity or location from which a motion event takes place: We leave *the US*/ *The librarian* handed me a book.
g. **Goal**: the entity or location towards which a motion event takes place: We landed in *Barajas*/ The librarian handed *me* a book.
h. **Instrument**: the entity used to perform an action: The boy broke the watch with *a toy hammer*.
i. **Cause**: non-volitional initiator of an action: *The storm* destroyed the hut.
j. **Measure**: temporal or spatial extent of events and entities: Our enthusiasm lasted *one day*.
k. **Possessor**: entity owning something: Grandma, what big eyes *you* have!
l. **Manner**: the way an action is performed: The kids behaved *well*.

Monday Lecture Outline

- Definitions of event from different fields:
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  qualia structure, affordances, habitats
- Events in Discourse and Narrative

When do Events Happen

- Time as Modality: "add an operator"
  $P(happy(john))$
  (Prior, 1957, Kamp, 1968, Rescher and Urquhart, 1971, Montague, 1973, Tichý, 1971, Gabbay, 1989, etc.)
- Method of Temporal Arguments: "add a t"
  $\exists t[hungy(john, t) \wedge t < now]$
  (Russell, 1903, Kim, 1966, McCarthy and Hayes, 1969, Allen, 1983, etc.)

Interval Relations for Temporal Ordering

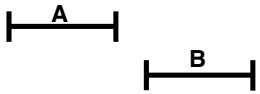
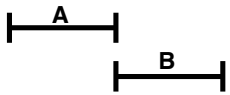
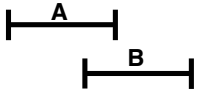
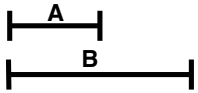
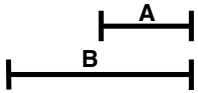
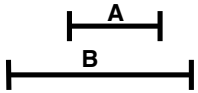
	A EQUALS B
	A is BEFORE B; B is AFTER A
	A MEETS B; B is MET BY A
	A OVERLAPS B; B is OVERLAPPED BY A
	A STARTS B; B is STARTED BY A
	A FINISHES B; B is FINISHED BY A
	A is DURING B; B CONTAINS A

Figure: The interval relations as defined by Allen (1984)

Tense and Aspect 1/2

- Tense is a k-partitioning of the temporal domain, $\mathcal{D}_{\mathcal{T}}$.
  it is nominalized (past, present, future)
  and is ordered.
- Aspect is a binary partitioning relative to this first partition.
- Reichenbach's Reference time can be compared to Temporal Frames of Reference:
  (Moore, 2009, Tenbrink, 2011, Evans, 2012)

Tense and Aspect 2/2

- Simple Past: $E = R$, $R < S$.
  John **ate**$_{E,R}$ dinner.
- Past Perfect. $E < R$, $R < S$.
  John **had eaten**$_{E}$ dinner before noon$_{R}$.
- Past Progressive: $R \subseteq E$, $E < S$.
  John [**was eating**$_{E}$]$_{R}$ dinner.

ISO-TimeML 1/2

(29) a. EVENT: those elements in a text that describe what is conventionally referred to as an *eventuality*. Syntactically, events are typically appear as inflected or uninflected verbs, nominals, and adjectival phrases.
b. TIMEX3: those elements in a text what are explicit temporal expressions, such as times, dates, durations, and quantified temporal expressions.
c. SIGNAL: those elements denoting a temporal relation between events or time expressions.

ISO-TimeML 2/2

(30) a. TLINK: a relation that establishes the ordering of an event or temporal interval relative to another event or interval;
b. ALINK: a relation that establishes an aspectual relationship between two events;
c. SLINK: a relation that introduces a semantically subordinating context, such as that introduced by modality or reporting predicates;
d. MLINK: a relation that establishes a measuring relation between a temporal expression and the event it measures.

Representing Relational Constraints

(31) a. The position of the event or time relative to other entities in an interpreted domain (ORDER):
b. The size of the entity, whether it is an event duration or temporal interval (MEASURE):;
c. The number of events or temporal entities being denoted (QUANTITY):.

Measuring Events

John taught for three hours on Tuesday.

(32) a. teach= e_1, tuesday= t_2, m= 3 hour
b. $\exists e_1 \exists t_2 [\mathit{teach}(e_1) \wedge \mu(\tau(e_1)) = v \wedge v = 3\_\mathit{hour} \wedge \mathit{tuesday}(t_2) \wedge \tau(e_1) \subseteq t_2]$

Quantifying Events

(33) John taught on Tuesday.

(34) a. EVENT tag introduces a quantified event expression $\Longrightarrow$ $\exists e_1[teach(e_1)]$;
b. TIMEX3 tag introduces the temporal expression $\Longrightarrow$ $\exists t_2[tuesday(t_2)]$;
c. TLINK introduces the ordering relation $\Longrightarrow$ $\lambda y \lambda x[\tau(x) \subseteq y]$.

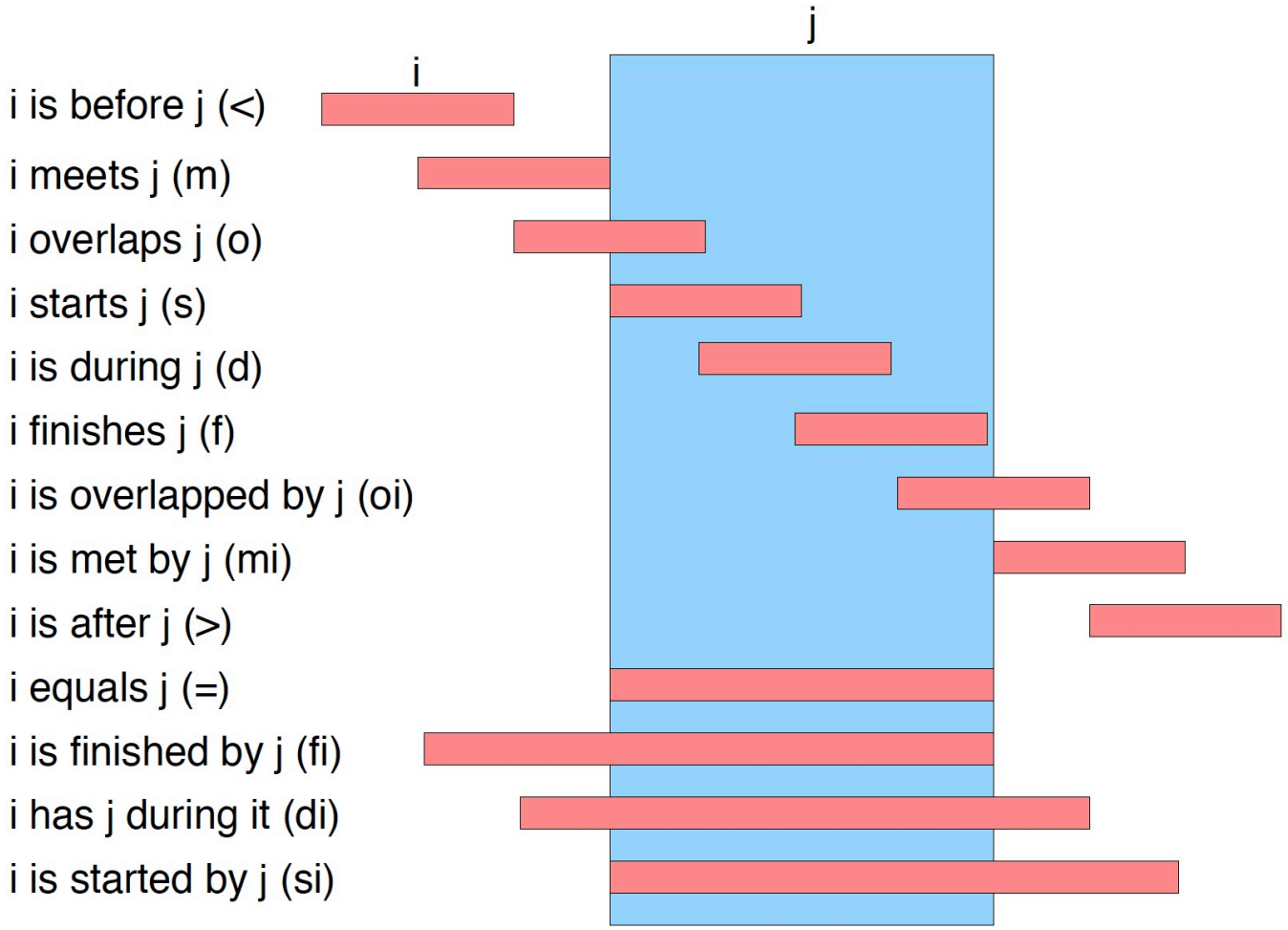
(35) $\exists e_1 \exists t_2[teach(e_1) \wedge tuesday(t_2) \wedge \tau(e_1) \subseteq t_2]$

(36) John taught every Tuesday in November.

(37) $\forall t_1 \exists e_1 \exists t_2[(Tuesday(t_1) \wedge November(t_2) \wedge t_1 \subseteq t_2) \rightarrow (teach(e_1) \wedge \tau(e_1) \subseteq t_1)]$

Relations between intervals

The 13 interval–interval relations are illustrated schematically here:



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Where do Events Happen

- The party was in the basement.
- The committee held a vote in the conference room.
- A poster is taped onto the wall.
- The dog walked on the carpet with his dirty paws.
- Sophie danced in her bedroom.

Not all Events are Situated

- Are there events that are timeless?
  *When is oxygen part of water?
- Are there events thare are spaceless?
  *Where did Obama win the Nobel Prize?

Putting Space in Language

- Space as Modality: "add an operator"
  $P_\alpha(meet(john, mary))$
  (Rescher and Garson, 1968, von Wright, 1979, Bennett, 1995, etc.)
- Method of Spatial Arguments: "add an l in a relation"
  $\exists l[meet(john, mary, l) \wedge in(l, \text{Boston})]$
  (Whitehead, 1929, Randell et al, 1992, Cohn et al, 1997, etc.)

"To each their own" (Vendler, 1967)

- Events are temporal entities:
  modified by temporal predicates
- Objects are spatial entities:
  modified by spatial predicates
- Temporal properties of objects are derivative
- Spatial properties of events are derivative

Locating Events (Davidson, 1967)

- An event is a first-order individual, e:

$$P(x_1, \ldots, x_n, e)$$

- We can identify the location of an event by a relation:

$$loc(e, l)$$

- $\exists e \exists x[smoke(j, e) \wedge in(e, x) \wedge bathroom(x)]$

(38) a. John sang in a field.
$\exists e \exists l[sing(j, e) \wedge in(e, l) \wedge field(l)]$
b. Mary ate her lunch under a bridge.
$\exists e \exists l[eat\_lunch(m, e) \wedge under(e, l) \wedge bridge(l)]$
c. The robbery happened behind a building.
$\exists e \exists l[robbery(e) \wedge behind(e, l) \wedge building(l)]$

How Events Refer to Space

- Semantic Type: Position and Posture verbs: *stand*, *lean*, *hunch over*
- Argument Selection: *fill*, *wipe*, *cover*, *leave*, *enter*
  wipe the table, *erase the whiteboard*
  enter the room, *leave the party*

Spatial Properties of Events

- Mereotopological relations: touches, inside, disconnected
- Orientation (Projective): above, left-of, in front of
- Metric space: near, far
- Movement: walk, fall, leave
- Shape: curved, straight

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Qualia: Implicit Event Structure of Things

Motivation for Qualia relations comes from the idea that there is a *hidden event* in the lexical representation associated with nouns denoting objects made for a particular purpose:

(39) a. a door is for walking through
b. a window is for seeing through
c. a book is for reading
d. a beer is for drinking
e. a cake is for eating
f. a car is for driving
g. a table is for putting things on
h. a desk is for working on
i. a pen is for writing with

Nouns encode events relating to use or function

(40) a. This pen does not work well. (does not write)
b. Can I use your pen? (for writing)
c. Have you got a red pen? (ambiguous, which writes in red)

(41) a. Any chocolate? Not after that cake! (after eating)
b. I prefer cake to biscuits. (prefer eating)
c. We skipped the cake and settled for another coffee. (skipped eating)

(42) a. There's no train till 7:00 pm. (there is no departing)
b. The train was delayed for an hour. (the departure)
c. I left in time to catch the early train. (departing early)

Adjective-Noun Telic Interpretations

(43) a. the next customer (to be taken care of)
c. the next slide (to be projected)

(44) a. This is a difficult problem (to solve).
b. This is a difficult question (to answer).

(45) Telic selectors:
fast food (to eat), a slow oven (to cook), a short novel (to read), a complex question (to answer), an easy place (to get to), useful, an effective antibiotic (to cure), agreeable, avoidable costs (to pay), enjoyable, a good doctor (to heal), a bad singer (to listen to), an interesting book (to read), ready meals (to eat).

Semantically Transparent Nominals

(46) a. functional locations: *library*, *gym*, *church*, *school*;
b. professions: *doctor*, *teacher*, *lawyer*;
c. agentive nominals (individuals engaged in an activity, either habitually or occasionally): *runner*, *passenger*, *movie goer*.

Encoding Events in Qualia Structure

(47)
$$\begin{bmatrix} \textit{cake} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{food} \\ \text{T} = \textbf{eat(human,food)} \end{bmatrix} \end{bmatrix}$$

(48)
$$\begin{bmatrix} \textit{pen} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{tool} \\ \text{T} = \textbf{write\_with} \end{bmatrix} \end{bmatrix}$$

(49)
$$\begin{bmatrix} \textit{singer} \\ \text{QUALIA} = \begin{bmatrix} \text{F} = \textbf{human} \\ \text{T} = \textbf{sing(human, song)} \end{bmatrix} \end{bmatrix}$$

Teleotopology

- The function of space: the actions associated with a region or an object (inherently or opportunistically), i.e., Telic role values.
- The space of function: the regions defined by the Telic actions performed by an agent, or supervenient on the Telic state of an artifact, teleotopology.

Extending Qualia to Modeling Affordances

The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. It implies the complementarity of the animal and the environment. (J. J. Gibson, 1979/1986)

- Gibson (1979), Turvey (1992), Steedman (2002), Sahin et al (2007), Krippendorff (2010);
- Affordance: a correlation between an agent who acts on an object with a systematic or prototypical effect.

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Event Structure above the Atomic Event

- Molecular Event Structure:
  Discourse relations
- Macro-Event Structure:
  Narratives, stories, scripts, conventional sequences

Molecular Event Relations

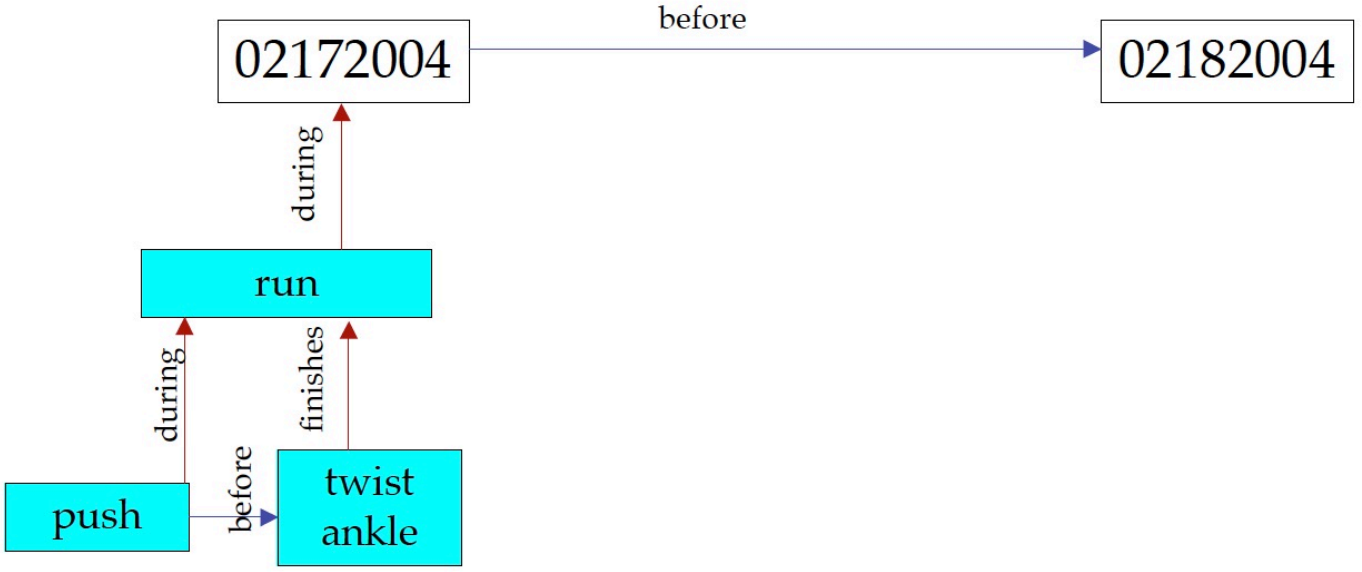
- Bill was running the marathon when he twisted his ankle.
  Narr(run,twist)
- Someone had pushed him.
  Exp(push,twist)
- He fell and didn't finish the race.
  Exp(push,fall)
  Exp(fall,¬finish)

Relations between Events

Temporal Aspects of Narrative Text

Feb. 18, 2004

Yesterday Holly was running a marathon when she twisted her ankle. David had pushed her.



Narrative Structures in Language 1/3

- Miller, Galanter, and Pribram (1960):
  Behavior as plans using the TOTE method – Test, Operate, Test (again), Exit.
- Schank and Abelson (1977), Lehnert (1978), Wilensky (1978):
  scripts, plot units, and story grammars are extra-linguistic information guiding language interpretation.
- Miller and Johnson-Laird (1976):
  Routines encapsulate procedures defining the operational semantics of action sequences.
- Scenario frames in FrameNet (Baker et al., 1998):
  describe how a stereotypical activity is made up of smaller events (frames), which share roles (frame elements) specifying people and objects involved in the events.

Narrative Structures in Language 2/3

- Penn Discourse TreeBank (PDTB):
  Prasad et al (2008), annotated discourse relations between eventualities and other abstract objects in newswire; FDTB, Danlos et al (2012).
- Segmented Discourse Representation Theory (SDRT):
  Asher and Lascarides (1993, 2003). Semantically annotated discourse relations between abstract objects.

Narrative Structures in Language 3/3

- Elson (2012), Elson and McKeown (2010):
  Story Intention Graph: discourse relations representing aspects of narrative, including goal, plan, intention, outcome, affect and time.
- Chambers and Jurafsky (2009), Chambers (2011):
  learn narrative schemas and their participants; they group verbs into schemas by virtue of shared participants assuming that this is an indicator for being part of the same stereotypical activity, without knowing the actual scenarios.
- Regneri et al. (2010):
  learns the temporal order of events occurring in specific stereotypical scenarios, but does not determine participants.

Contextual Interpretation of Events

1. Where do interpretations for missing content come from?
2. Are there motivations for free enrichment?
3. How much of LF is pre-established by sentence composition?

Answer:

- Parametric Factors: Compositionality through lexical typing
- Non-parametric Factors: situational knowledge from embedding the event in context

Sub-atomic Event Structure

- Predicate decomposition as event substructure
- Explicitly representing pre-condition and post-condition as part of the event
- Event types as different event structures
- Represent implicit event arguments
- Distinguish kinds of results

Types of Missing Participants in an Event

1. Locative and temporal determinants of the situation;
2. Pragmatically-controlled zero-anaphora;
3. Presupposed arguments;
4. Entailed arguments;
5. Ellipsis and subpropositional phenomena.

Missing Participants

Fillmore (1985), Rappaport and Levin (1988), Jackendoff (1990), Levin (1993), Pustejovsky (1995), Goldberg (2002)

- John swept the dirt$_{material}$.
- John swept the room$_{region}$.

- The man shoveled the snow$_{material}$.
- The man shoveled the driveway$_{region}$.

- Mary translated the book. (the translation)
- They decorated the Christmas tree. (the decoration)
- Cathie sliced the bread. (slices)

Interpreting Event Participants 1/2

- That book bored me terribly.
- The movie frightened Mary.
- The newspaper article angered the Republicans.

- The boy heard a cat / a dog.
- They heard a bang / cry / rumor / shout / rain.
- !John heard the cloud / star / light.

- Mary believes the rumor.
- She never believes the newspaper.
- The student regrets his last homework assignment.

Interpreting Event Participants 2/2

- Mary began her beer / thesis / dinner / bath.
- John enjoyed his coffee / movie / a cigar.

- John knows that the earth is round.
- Mary knows what time it is.
- Mary knows the time.

- Mary told John where she lives.
- John told me how old he is.

- Mary told John her address.
- John told me his age.
- I just realized the time.

Pragmatics of Contextualizing the Event

1. It's raining.
   here now
2. You're not going to die.
   soon, from your cold
3. I had a big breakfast.
   recently

Viewpoints

- Free enrichment: Any utterance may contain unarticulated constituents which are not part of the LF of the sentence, but are needed to determine a truth-theoretic interpretation. (Recanati, 2002, Carston, 2002)
- Pragmatic saturation: All truth-conditional effects of extra-linguistic context can be traced to logical form. (Stanley, 2000)
- Discourse Structure: A sentential LF embeds within a discourse structure, DRS, where constraints on licensing and accessibility of discourse referents are determined and computed. (DRT, SDRT, DPL)
- Habitats and Simulations: Combines parametric and non-parametric factors to built a context.

Molecular Event Relations

- Bill was running the marathon when he twisted his ankle.
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Conclusion: The Questions Reconsidered

- When do events happen?
- What kinds of events are there?
- What are the participants in events?
- What temporal relations inhere between atomic events?
- Where do events happen?
- What role do events play in entity semantics?
- What is the subatomic structure of events?
- How can we model the larger macro structure of events?
- What comes first: time or events?

Conclusion: Generalizing Event Properties over Different Semantic Levels

- Events as modal structures
- Participants have their own histories through an event
- Levels look at different granularities of the modal structure
- Computing