Introduction to Cognitive Science: Notes

VII: Semantics is Transparent to Planning

- Readings for this section: Bach 1986.

VII: Semantics is Transparent to Planning

- We are brought up to think of the tense and aspect as reflecting time, modelled on the Newtonianreal-number line.
- That’s the wrong ontology.
- Just as the Navaho nominal system reflects affordances, so does the English verbal system of tenses and aspects

What We Talk About When We Talk About Time

(With apologies to Raymond Carver):

- *We don't know* what we talk about when we talk about time.
  - We talk about plans and contingencies, rather than time as such.
  - Knowledge about events is object-oriented.
  - The plans we talk about are reactive.
  - Implication is linear, and is "fibred" with intuitionistic or standard implication.
  - Instants and states are primitive, not intervals.
  - Temporal Relations are emergent from causality:
    I was hungry. I ate a hamburger.
- *Who cares* about temporal relations? *Where is the Killer App?*

I: Temporal Ontology: the Perfect

- Tenses/Aspects aren't primarily to do with time at all, but rather with causation and contingency

  (1) I have forgotten your name (# but I have remembered it again).

  (2) Yesterday, I forgot your name (but I (have) remembered it again).

- In the absence of identifiable consequent states, the perfect is unacceptable:

  (3) a. #I have breathed
  b. #Einstein has visited Philadelphia

- The temporal location of the event is often indeterminate.

  (4) a. We have lost our way.
  b. I've grown accustomed to your face.
  c. These colors have faded.

Temporal Ontology: The Progressive

- Tenses/Aspects are non-uniform with respect to factive entailment:

  (5) a. Keats was writing $\models$ Keats wrote
  b. Keats was writing a sonnet $\not\models$ Keats wrote a sonnet

- It has been standard in natural language semantics since Aristotle, Jespersen, and Vendler 1967 to analyse such phenomena in terms of ontologies of *types* of events.

- It has also become standard to observe that aspect is not inherent in verbs as such, but rather in the propositions that they convey and the knowledge that relates them.

- It has also become standard to talk of the interaction between semantics proper and world knowledge in terms of "coercion" (Moens and Steedman 1987; Pustejovsky 1991)

Temporal Ontology: Lexical Coercions

- Many verbs have meanings that can be defined in terms of similar coercions—cf. Thomason (1997, 1999).
- *Trying* to do something resembles the progressive in coercing an achievement or accomplishment to the corresponding preparatory activity, and its truth similarly does not hinge on the actual attainment of the achievement.
- *Failing* to do something and *managing* to do it are similar, except that they involve explicit assertion or denial of the attainment of the achievement:
- Many such lexically-governed coercions are derived from nouns. Thomason 1997:820 points out that identifying the meaning of phrases like “Hammer the metal flat” with that of “causing the metal to become flat by hitting it with a hammer” overgeneralize.

Temporal Ontology: Lexical Coercions

- Thomason 1997:820 suggests an analysis paraphrasable as “using a hammer in the normal way for metal to make the metal flat”
- This observation is linked to what Gibson (1966, 1979) called the “affordances” of objects—that is, the events directly made possible by objects such as hammers, such as beating metal, and the consequent states of those events, such as the metal in question being flat.
- Many novel denominal verbs depend on coercions involving the “normal” relations between entities and the events that result in such relations, as in:

  (6) Jeeves deftly trousered the £5 note.

- Such affordance-based coercions are extremely specific. Only Jeeves’ *own* trousers afford securing £5 notes.

The Imperfective Paradox is Out There

Who Cares about the Imperfective Paradox?

- Paradoxical imperfectives (and "nearly," "almost," "fail to',' etc.) are by definition exceptional and hence rare. But they are out there, lying in wait for Temporal Answer-QA.
- Sports and history seem to give rise to the right kind of deterministic defeasable models:
- Did John Swatman [win a $\langle$British Open Gold Medal$\rangle_i$]?
- `http://wolverhampton-judo-club.org.uk/page2.html`
  - In 1980 at 16 years of age he fought his way to $\langle$the final$\rangle_i$ in the under 60 Kg category
  - and was winning $\langle$the contest$\rangle_i$ when he was forced to withdraw through injury.

Ontology of Aspect

- Moens and Steedman (1988) extended the event calculus to a novel ontology covering durative and telic events, in order to support a natural language semantics for tense and temporality.

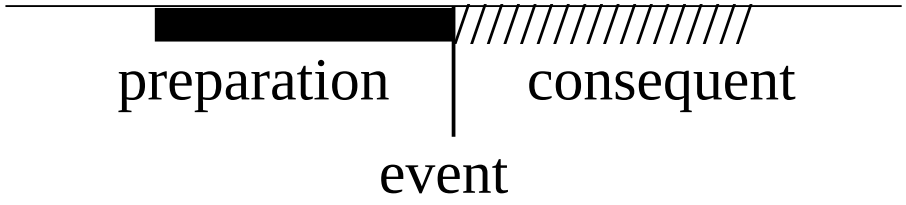

Figure 1: The event nucleus (adapted from Moens et al. 1988)

- Rather than taking intervals as primitive, durative events were represented in terms of inceptive and terminative events with progressive states as their respectively consequent and preparatory states.

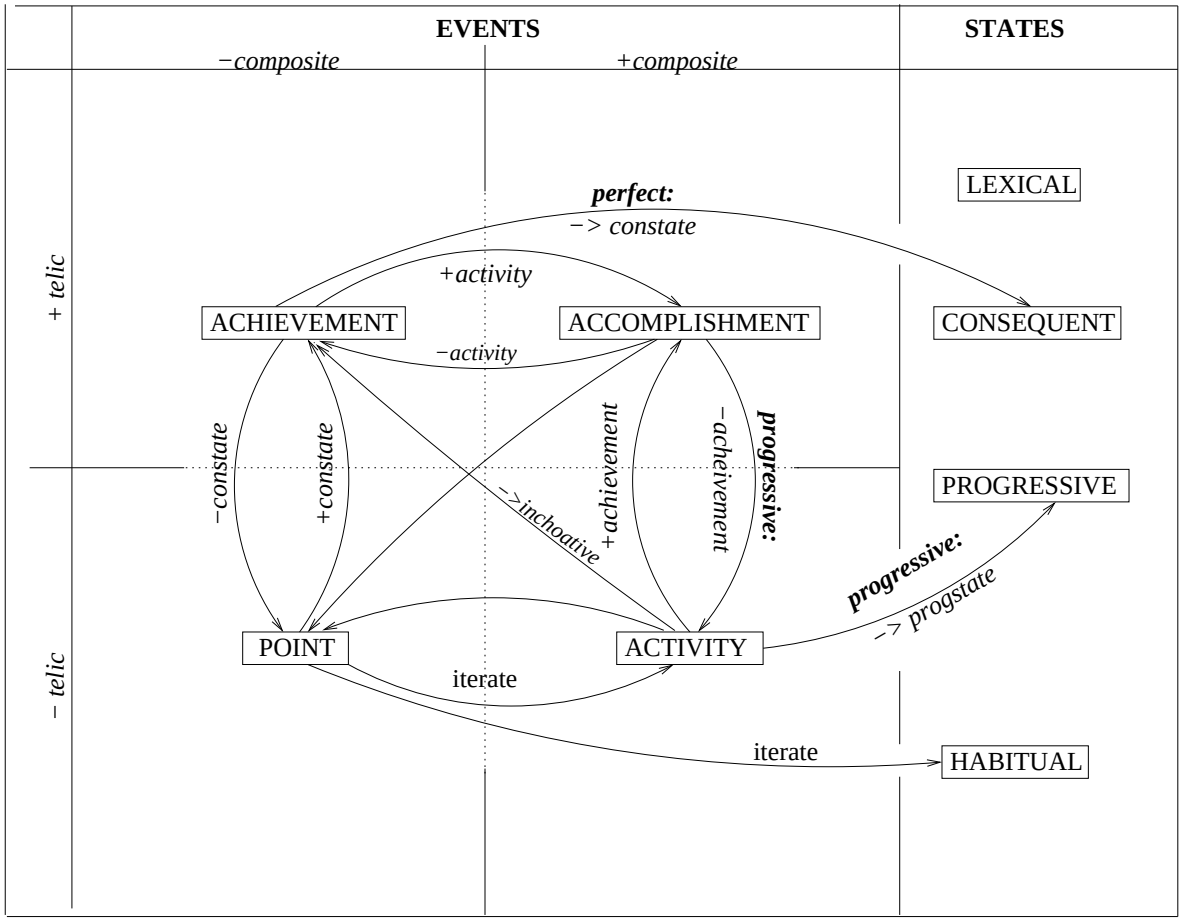

Figure 2: A scheme of aspectual coercion (Moens et al. 1988)

Ontology of Tense

- Reichenbach (1947) analyzed tense in terms of three underlying times: **S**, the time of Speaking; **E**, the time of the Event in question; and **R**, the time that is spoken about.
- We can represent the idea graphically by arranging these three underlying times along a timeline:

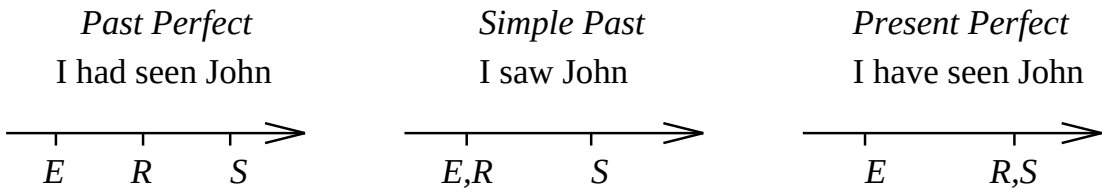

Figure 3: Past vs. Perfect (from Reichenbach 1947)

Reichenbach

- We can recast the relation between **R** and **E** in terms of the notion of *consequent state* invoked by Moens et al.
- That is, the past says that **E** *happened at the same time as*, or equals **R**, whereas the (past or present) perfect says that the *consequences* of **E** hold or held *at* **R**, a relation represented below by the symbol @.
- The important insight here is that the simple past is used to make a statement about a past time, whereas the present perfect is used to make a statement about the present.
- Notice that to say *I saw John*, the particular past occasion has to be known (or at least guessable) by the hearer. This isn't true of the present perfect, because there *is* only one **S** speech time.

The Grammar of Aspect in CCG

- All of this is entirely compositional.

(7) John : – NP : $john$

is : – $(S\backslash NP)/VP_{ING}$: $\lambda p\lambda x.(coerce(p(x),activity,a)$
$\wedge consequent(p(x),c) \wedge prediction(c)$
$\wedge in\_progress(a))@\mathbf{R} \wedge \mathbf{R} = \mathbf{S})$

reaching : – VP_{ING}/NP : $\lambda x\lambda y.reach(x,y)$

- *Coerce* coerces anything that is not an activity to be an activity by finding an accomplishment for which it is the achievement:

(8) a. $activity(p) \Rightarrow coerce(p,activity,p)$
b. $activity(p) \wedge accomplishment(p,q) \Rightarrow coerce(q,activity,p)$

Coercion is Compositional

- It is world knowledge, rather than linguistic semantics, that says that one characteristic activity that results in *reach*ing a location is iterated walking towards that location, where $walk(x,l))$ is an abbreviation for $(\neg at(x,l)?;walk(x,l))^{+}$, that the consequent state of walking is being *tired*, and that that of *reach*ing a location is being *at* that location.

(9) a. $activity(walk(x,l))$

b. $achievement(reach(x,l))$

c. $accomplishment(walk(x,l),reach(x,l))$

d. $consequent(reach(x,l),at(x,l))$

e. $consequent(walk(x,l),tired(x))$

Durative and Telic Events in LDEC

- On the basis of this general knowledge, the following compositionally derived logical form for *John is reaching the other side of the street* (abbreviated $reach(john, other\_side)$) will be true just in case John is walking in that direction with that goal:

(10) $(coerce(reach(john, other\_side), activity, walk(john, other\_side))$
$\wedge consequent(reach(john, other\_side), at(john, other\_side))$
$\wedge goal(at(john, other\_side)))$
$\wedge in\_progress(walk(john, other\_side))@\mathbf{R} \wedge \mathbf{R} = \mathbf{S}$

- The imperfective paradox is avoided: the truth of the proposition is independent of whether or not the goal was achieved.

Planning to Reach The Other Side of the Road

- In order for this to be the case, the agent *john* must plan from the goal $at(john, other\_side)$ using the following knowledge: if you aren't at a place and you aren't walking towards it you can start doing so:

  (11) $\neg at(x,l) \wedge \neg in\_progress(walk(x,l)) \Rightarrow affords(start(walk(x,l)))$

- If you start walking somewhere you are walking somewhere:

  (12) $\{affords(start(walk(x,l)))\} \multimap [start(walk(x,l))]in\_progress(walk(x,l))$

- Walking somewhere and being there affords reaching that place:

  (13) $in\_progress(walk(x,l)) \wedge at(x,l) \Rightarrow affords(reach(x,l))$

- Reaching somewhere means you stop walking and are there:

  (14) $\{affords(reach(x,l))\} \wedge in\_progress(walk(x,l)) \multimap [reach(x,l)]at(x,l)$

Moral for Temporal Semantics

- Aristotelian/Vendlerian States are fluents, or facts in a databases.
- There are many sorts of states, including progressive, futurate, and consequent states related to aspects.
- Aristotelian/Vendlerian events are defined in terms of instantaneous changes to fluents or facts, accompanied by updates as well as preconditions.
- "Temporal" categories are primarily **Causal** in their ontology: quantification over instants on a timeline plays very little part in defining their semantics.
- Causality in this sense is a primitive: it is simply defined by the accessibility relation $\multimap_{[\alpha]}$ over possible worlds.

Denominal Resultative Coercion and Affordance

- Thomason 1997:820's affordance-based lexical coercions can be be represented by LDEC rules like the following:
- A hammer affords hitting metal with it:

  (15) $hammer(h) \wedge metal(m) \Rightarrow afford s((\neg bent(m)?; hit(h,m))^{+})$

- If something is bent and you hit it with a hammer it, it stops being bent and becomes flat:

  (16) $\{afford s((\neg bent(m)?; hit(h,m))^{+})\} \wedge bent(m)$
  $\multimap [(\neg bent(m)?; hit(h,m))^{+}] flat(m)$

Denominal Resultative Coercion III

- Similar axioms define the affordances of hammers with respect to nails.
- A hammer and a nail afford hitting the nail with the hammer:

  (17) $hammer(h) \wedge nail(n) \Rightarrow afford s((proud(n)?; hit(h,n))^{+})$

- If a nail is proud and you hammer it, it stops being proud and becomes flush

  (18) $\{afford s((proud(n)?; hit(h,n))^{+})\} \wedge proud(n)$
  $\multimap [(proud(n)?; hit(h,n))^{+}] flush(n)$

- These axioms represent classic examples of TOTE units/Circular Reactions

Denominal Causative Coercion and Affordance

- Thomason points out that similar conditions of normalcy apply to denominal transitives like *shelve* and *stable*
- A stable and an animal afford sheltering the animal in the stable:

  (19) $stable(s) \wedge animal(a) \rightarrow affords(stable(s,a))$

- If something is cold and you stable it, it stops being cold and and becomes warm:

  (20) $cold(a) \multimap [stable(s,a))]warm(a)$

- The denominal action of trousering a £5 note identified in connection with example (6) generates securing the money. Thus we can write:

  (21) $trousers(t) \wedge £5(n) \wedge \neg in(n,t) \Rightarrow affords(put\_in(n,t))$

  (22) $\{affords(put\_in(n,t))\} \multimap [put\_in(n,t)]in(n,t)$

  (23) $yours(t) \wedge in(n,t) \Rightarrow safe(n)$

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