Frames in formal semantics
Montague’s temperature and Fernando’s event strings

Robin Cooper
Outline

Puzzles about temperatures and prices

Frames and typed records

Frames as arguments

Events as strings of frames

Conclusions
Puzzles about temperatures and prices

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Conclusions
Montague’s temperature

*a puzzle due to Barbara Partee (beginning of the seventies)*

The temperature is 90°F

\[ X \] The temperature is rising

\[ 90°F \text{ is rising} \]
Montague’s temperature

*a puzzle due to Barbara Partee (beginning of the seventies)*

The temperature is 90°F

\[ \text{The temperature is rising} \]

\[ 90°F \text{ is rising} \]

The price is $50

\[ \text{The price is rising} \]

\[ $50 \text{ is rising} \]
Formulating the puzzle

$$\exists x [\text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land x = 90]$$

$$\exists x [\text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land \text{rise}(x)]$$

$$\text{rise}(90)$$
Formulating the puzzle

\[\exists x [\text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land x = 90]\]
\[\exists x [\text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land \text{rise}(x)]\]
\[\text{rise}(90)\]

Montague’s solution
Let \( x \) and \( y \) range over individual concepts (functions from possible worlds to individuals)
Formulating the puzzle

\[ \exists x [ \text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land x = 90 ] \]

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\[ \text{rise}(90) \]

**Montague’s solution**

Let \( x \) and \( y \) range over *individual concepts* (functions from possible worlds to individuals)

\[ \exists x [ \text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land [\ulcorner x \urcorner] = 90 ] \]

\[ \exists x [ \text{temperature}(x) \land \forall y [\text{temperature}(y) \rightarrow y = x] \land \text{rise}(x) ] \]

\[ \text{rise}(90) \]
A Montagovian strategy

- Complicate the semantics to *prevent* an inference
Complicate the semantics to *prevent* an inference

...but we don’t get any *additional* inferences as a result of the complication
A Montagovian strategy

- Complicate the semantics to *prevent* an inference
- ...but we don’t get any *additional* inferences as a result of the complication
- impression of semantics as *damage limitation* rather than *explanatory theory*
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(Fillmore, early eighties)

Frame semantics comes out of traditions of empirical semantics rather than formal semantics. It is most akin to ethnographic semantics, the work of the anthropologist who moves into an alien culture and asks such questions as, ‘What categories of experience are encoded by the members of this speech community through the linguistic choices that they make when they talk?’ A frame semantics outlook is not (or is not necessarily) incompatible with work and results in formal semantics; but it differs importantly from formal semantics in emphasizing the continuities, rather than the discontinuities, between language and experience. The ideas I will be presenting in this paper represent not so much a genuine theory of empirical semantics as a set of warnings about the kinds of problems such a theory will have to deal with. If we wish, we can think of the remarks I make as ‘pre-formal’ rather than ‘non-formalist’; I claim to be listing, and as well as I can to be describing, phenomena which must be well understood and carefully described before serious formal theorizing about them can become possible.
Frames in FrameNet

(A)mbient _temperature_

Definition:

The **Temperature** in a certain environment, determined by **Time** and **Place**, is specified. It’s **too HOT** to do anything today. **Nome** is pretty **COLD** this time of year. Last Tuesday was a **real** **SCORCHER**. Tomorrow is gonna be **CHILLY**.
### Ambient temperature core frame elements

<table>
<thead>
<tr>
<th>Attribute [att]</th>
<th>The temperature feature of the weather.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree [deg]</td>
<td>A modifier expressing the deviation of the <strong>Temperature</strong> from the norm.</td>
</tr>
<tr>
<td>Semantic Type</td>
<td><strong>Degree</strong></td>
</tr>
<tr>
<td></td>
<td>It's like <strong>totally CHILLY</strong>, dude, like, totally.</td>
</tr>
<tr>
<td>Place [pl]</td>
<td>The <strong>Place</strong> where it is a certain <strong>Temperature</strong>.</td>
</tr>
<tr>
<td>Semantic Type</td>
<td><strong>Locative_relation</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Chicago</strong> is <strong>HOT</strong> today.</td>
</tr>
<tr>
<td>Temperature [tem]</td>
<td>A quantity or other characterization of the <strong>Temperature</strong> of the environment.</td>
</tr>
<tr>
<td>Semantic Type</td>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td></td>
<td>The <strong>TEMPERATURE</strong> was <strong>85 F</strong> in the shade today.</td>
</tr>
<tr>
<td>Time [tim]</td>
<td>The <strong>Time</strong> during which an ambient environment has a particular <strong>Temperature.</strong></td>
</tr>
<tr>
<td>Semantic Type</td>
<td><strong>Time</strong></td>
</tr>
</tbody>
</table>
Ambient temperature non-core frame elements

Some specification of the circumstances under which the ambient Temperature is as specified.

It's plenty COOL in the shade
Rise core frame elements

**Attribute [att]** The **Attribute** is a scalar property that the **item** possesses.

- Oil **ROSE in price** by 2%.

**Difference [Diff]** The distance by which an **item** changes its position on the scale.

- Oil **ROSE in price** by 2%.

**Final_state [finis]** A description that presents the **item**'s state after the change in the **Attribute**'s value as an independent predication.

- It was never bad (1 or 2 seizures a year), but this past decade, it has **INCREASED to having them 1 day a month** and on that 1 day I have 6 or 7 seizures.

**Final_value [val2]** The position on the scale where the **item** ends up.

- Microsoft shares **FELL to 7 5/8**.

**Initial_state [inis]** A description that presents the **item**'s state before the change in the **Attribute**'s value as an independent predication.

- Diesels have **INCREASED from having a 20% market share in 1995** to just over 30% in 2004.

**Initial_value [val1]** The initial position on the scale from which the **item** moves away.

- Microsoft shares **FELL from 12 3/8 to 7 5/8**.

**Item [ite]** The entity that has a position on the scale.

- I fear **this service will DIMINISH** in quality.

**Value_range []** A portion of the scale, typically identified by its end points, along which the values of the **Attribute** fluctuate.

- The patient's temperature **FLUCTUATED** between 28.5 and 29.5.
Rise non-core frame elements, 1

<table>
<thead>
<tr>
<th>Frame</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumstances</td>
<td>The Circumstances under which the change of position takes place. The eggs will only increase under pressure.</td>
</tr>
<tr>
<td>Correlate</td>
<td>The Correlate is a directional path (or ordered collection of values) that the (dependent) Attribute is measured against. Note that normally, the Correlate is simply (forward-directional) time. The amount of power increases with the frequency of the laser. As you travel along the Quan-duo road, the poverty level soars dramatically.</td>
</tr>
<tr>
<td>Degree</td>
<td>Degree to which event occurs</td>
</tr>
<tr>
<td>Final correlate</td>
<td>The value, location, or state-of-affairs that corresponds to the Final value of the Attribute. From Monterrey to southern Oregon, tree height increases steadily in this species to a stunning 50 meters.</td>
</tr>
<tr>
<td>Group</td>
<td>The Group in which an Item changes the value of a Attribute in a specified way. Colon cancer incidence fell by 50% among men over 30. Net foreign debt has more than tripled in Africa over this decade.</td>
</tr>
</tbody>
</table>
Rise non-core frame elements, 2

Manner [Mann]

Semantic Type
Manner

Manner of performing an action

Particular_iteration []

Expressions marked with this extra-thematic FE modify a non-iterative use of the target, and indicate that it is conceived as embedded within an iterated series of similar events or states.

Path [Path]

Any expression that gives information about points on the scale that the item traverses between the starting and ending point of its movement along the scale.

The price of oil moved up last month.

Period of iterations []

The length of time from when the event denoted by the target began to be repeated to when it stopped.

Place []

Semantic Type
Locative_relation

A location where Attribute is measured

Result [Result]

Semantic Type
Result

Result of an event

Speed [Speed]

Semantic Type
Speed

The rate of change of the Value.

Prices are rising by 2% a year.

Time []

Semantic Type
Time

The Time is the time-frame in which the change of position occurs.
Core and non-core frame elements

Why is time core for ambient temperature and non-core for rise?
Core and non-core frame elements

- Why is time core for ambient temperature and non-core for rise?
- Ruppenhofer et al. (2006) *FrameNet II: Extended Theory and Practice* (available on FrameNet website)
- p. 26:

  A core frame element is one that instantiates a conceptually necessary component of a frame, while making the frame unique and different from other frames. For example, in the Revenge frame, AVENGER, PUNISHMENT, OFFENDER, INJURY, and INJURED_PARTY are all core frame elements, because an avenging event necessarily includes these participants. One cannot imagine an act of revenge that is not preceded by a (perceived) offense or one that is not directed against anybody.
Core and non-core frame elements, *contd.*

- p. 27:

Frame elements that do not introduce additional, independent or distinct events from the main reported event are characterized as peripheral. Peripheral FEs mark such notions as Time, Place, Manner, Means, Degree, and the like. They do not uniquely characterize a frame, and can be instantiated in any semantically appropriate frame. In respect to the Revenge frame, any report of an event of revenge may also include explicit information about the parameters of time, place, manner, etc. of the revenge, an example of which is given below.

(8) The bereaved family retaliated [immediately Time].
Core and non-core frame elements, *contd.*

- p. 27:

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  (8) The bereaved family retaliated [immediately *Time*].

- We will not draw the distinction
Frames and compositional semantics

- How do the frames for ambient temperature and rise figure in the meaning of *the temperature is rising*?
Frames and compositional semantics

- How do the frames for ambient temperature and rise figure in the meaning of *the temperature is rising*?
- Should frames be combined in some way?
Frames as records

An ambient temperature frame is a record of type

\[
\begin{bmatrix}
  x & : & Ind \\
  e\text{-time} & : & Time \\
  e\text{-location} & : & Loc \\
  c_{\text{temp\_at\_in}} & : & \text{temp\_at\_in}(e\text{-time}, e\text{-location}, x)
\end{bmatrix}
\]

Call this \textit{AmbTemp}
Frames as records

An ambient temperature frame is a record of type

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\begin{bmatrix}
  x & : & \text{Ind} \\
  \text{e-time} & : & \text{Time} \\
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A record of this type will:

- contain \textit{at least} fields with the same labels as the type
Frames as records

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- contain \textit{at least} fields with the same labels as the type
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Frames as records

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\begin{itemize}
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  \item types constructed with predicates such as ‘temp\_at\_in’
\end{itemize}
Frames as records

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  - can be dependent
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- each field will contain an object of the type in the corresponding field of the type
- types constructed with predicates such as ‘temp\_at\_in’
  - can be dependent
  - can be types of objects which “prove a proposition”, e.g. events, states, thermometer readings
Outline

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Conclusions
Frame constraint on the predicate ‘temperature’

If temperature\((a)\) is a non-empty type then \(a:Amb\text{Temp}\)
“Ordinary” verbs pick out the x-field in a frame

\[
\text{run} - \lambda r : [x: \text{Ind}] \left( \begin{array}{l}
\text{c}_{\text{run}} : \text{run}(r.x) \\
\end{array} \right) \\
is 90 - \lambda r : [x: \text{Ind}] \left( \begin{array}{l}
\text{c}_{\text{is.90}} : \text{eq}(r.x, 90) \\
\end{array} \right)
\]
“Frame-level” verbs predicate of the whole frame

\[ \text{rise} \equiv \lambda r : \left[ x : \text{Ind} \right] \left( \left[ c_{\text{rise}} : \text{rise}(r) \right] \right) \]
Constraint on the predicate ‘rise’

If  \( a:\text{rise}(r) \) and  \( r:\text{AmbTemp} \), then  \( a \) is a pair  \( \langle r, r' \rangle \) such that

1.  \( r':\text{AmbTemp} \)
2.  \( r.e\text{-time} < r'.e\text{-time} \)
3.  \( r.e\text{-location} = r'.e\text{-location} \)
4.  \( r.x < r'.x \)
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Fernando’s event strings

event-token \approx \text{comic strip}

event-type \approx \text{set of comic strips}

rain for two days

\begin{align*}
\text{rain} & \quad 0(\tau) & \quad \text{rain} \\
\text{rain} + & \quad \text{rain} \\
& \quad 2\text{dy}(\tau)
\end{align*}

= \text{rain}^+ \& 0(\tau)^+ \cdot 2\text{dy}(\tau)

two days
Fernando’s event strings using “frame” types, 1

Regular types

1. if $T_1, T_2 \in \textbf{Type}$, then $T_1 T_2 \in \textbf{Type}$
   
   $a : T_1 T_2$ iff $a = x \sqcap y$, $x : T_1$ and $y : T_2$

2. if $T \in \textbf{Type}$ then $T^+ \in \textbf{Type}$.
   
   $a : T^+$ iff $a = x_1 \sqcap \ldots \sqcap x_n$, $n > 0$ and for $i, 1 \leq i \leq n$, $x_i : T$
Fernando’s event strings using “frame” types, 2

Rain for two days

\[
\begin{align*}
\left[ c_1 : \text{rain} \right]^+ \\
\wedge \\
\left[ c_2 : 0(\tau) \right] \text{Rec}^+ \left[ c_2 : 2\text{days}(\tau) \right] \\
\approx \\
\left[ c_1 : \text{rain} \right] \left[ c_1 : \text{rain} \right]^+ \left[ c_1 : \text{rain} \right] \left[ c_2 : 2\text{days}(\tau) \right]
\end{align*}
\]
Event type for rising temperature

\[
\begin{align*}
\text{earlier} &: \ Time \\
\text{later} &: \ Time \\
\text{c}_{\text{earlier}\_\text{later}} &: \ \text{earlier} < \text{later} \\
\text{location} &: \ Loc \\
\text{temp-earlier} &: \ Ind \\
\text{temp-later} &: \ Ind \\
\text{event} &: \begin{cases} \\
\text{x= temp-earlier: Ind} \\
\text{e-time= earlier: Time} \\
\text{e-location= location: Loc} \\
\text{c}_{\text{temp}\_\text{at}\_\text{in}: \text{temp}\_\text{at}\_\text{in}(e-time, e-location, x)} \\
\text{x= temp-later: Ind} \\
\text{e-time= later: Time} \\
\text{e-location= location: Loc} \\
\text{c}_{\text{temp}\_\text{at}\_\text{in}: \text{temp}\_\text{at}\_\text{in}(e-time, e-location, x)}
\end{cases}
\end{align*}
\]
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Informal representation of the solution

\[\exists r [\text{temperature}(r) \land \forall r' [\text{temperature}(r') \rightarrow r' = r] \land r.x = 90] \]

\[\exists r [\text{temperature}(r) \land \forall r' [\text{temperature}(r') \rightarrow r' = r] \land \text{rise}(r)] \]

\[\text{rise}(90) \]
Montagovian strategy + frame inferences
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- Similar to Montague’s strategy – predicate “rises” to frame-level to prevent inference
Montagovian strategy + frame inferences

- Similar to Montague’s strategy – predicate “rises” to frame-level to prevent inference
- but frames yield information while individual concepts did not
Frames and the Generative Lexicon
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- rising for prices doesn’t mean quite the same as for temperature
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- for prices the commodity has to be kept constant, possibly also the location
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Frames and semantic coordination

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Frames and semantic coordination

what exactly is required for the price of bread to rise?

an increase in one shop from one day to the next?

and if the price goes down the day after?

a trend over a certain period in a certain area?

blip vs price-rise

need to coordinate precise meaning

what consequences does the answer have for FrameNet?

always a common frame, but conditions change?

or does the frame itself change?
Frames and semantic coordination

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- Connects “ethnographic” semantics with logical semantics
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- Connects “ethnographic” semantics with logical semantics
- Provides a level of semantic detail which makes the study of semantic coordination necessary