Semantics 1

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Time and tense

- logical quantifiers do not only figure in the interpretation of nominal quantifiers of natural language
- further linguistic phenomenon that can be analyzed as quantification: **Tense**
- basic idea
  - there are variables and constants for *time intervals*
  - situations may be temporally restricted
  - functionτ maps a situation to the time interval where it obtains
  - tense morphemes (*present tense*, *past tense* restrict possible values of the situation variable
  - temporal adverbs (*always*, *sometimes* express quantification over time intervals

Tense: examples

(1) Peter slept.

- intuitive meaning of past tense: Peter's sleep happened at **some** period of time in the past
- sentence is true in a situation s if Peter slept in a situation s' that temporally precedes s

$$\lambda s.\exists s'(\tau(s') < \tau(s) \wedge \text{SLEEP'}(s', p))$$

Tense: examples

- remark:
  - "$<$" is a two-place relation between time intervals
  - correct notation would actually be $<(t_1, t_2)$, but infix notation (predicate symbol between the arguments; $t_1 < t_2$) is widely used
  - intended meaning or "$<$" is "completely precedes"

Tense: examples

(2) Peter always sleeps.

- intuition: (2) is true in a situation s if for each time interval that completely precedes $\tau(s)$, there is a situation in which Peter slept.

$$\lambda s.\forall t(t < \tau(s) \rightarrow \exists s'(\tau(s') = t \wedge \textsc{sleep'}(s', p)))$$

- temporal adverb *always* has similar function as quantifier *every* $\rightsquigarrow$ both introduce universal quantifier
- tense determines the restrictor of the quantifier, i.e. the material to the left of the implication

Tense: examples

(3) Peter slept yesterday.

$$\lambda s.\exists s'(\tau(s') < \tau(s) \wedge \text{YESTERDAY'}(s, s') \wedge \text{SLEEP'}(s', p))$$

- adverbs such as *yesterday* are interpreted as two-place relations between situations
- $\text{YESTERDAY'}(s_1, s_2)$ iff s_2 is, viewed from s_1, happened yesterday

Tense: examples

$$\begin{array}{rcl} \lambda s.\forall t(t < \tau(s) & \rightarrow & \exists s'(\tau(s') = t \wedge \textsc{sleep'}(s', p))) \\ & \subseteq & \\ \lambda s.\exists s'(\tau(s') < \tau(s) & \wedge & \textsc{yesterday'}(s, s') \wedge \textsc{sleep'}(s', p)) \end{array}$$

- part of our semantic knowledge: there was a yesterday, it is completely in the past, and whether a situation happened yesterday only depends on its temporal extension:

$$\forall s_1 \exists s_2 \textsc{yesterday'}(s_1, s_2)$$
$$\forall s_1 \forall s_s(\textsc{yesterday'}(s_1, s_2) \rightarrow \tau(s_1) > \tau(s_2))$$
$$\forall s_1 \forall s_2 \forall s_3(\textsc{yesterday'}(s_1, s_2) \wedge \tau(s_2) = \tau(s_3) \rightarrow \textsc{yesterday'}(s_1, s_3))$$

Tense: examples

- Such constraints on the possible interpretation of expressions (such as those for the interpretation of *yesterday*) are called **Meaning Postulates**.
- therefore prediction: that Peter always slept entails that Peter slept yesterday, even though this is not a logical entailment
- The former sentence and the meaning postulates logically entail the latter though.

Tense: examples

(4) Peter will sleep.

$$\lambda s.\exists s'(\tau(s) < \tau(s') \wedge \text{SLEEP'}(s', p))$$

Tense: examples

(5) *Peter will sleep yesterday.

- intuitively: conflicting information
- *yesterday* implies past, while future tense implies future

$$\lambda s.\exists s'(\tau(s) < \tau(s') \wedge \textsc{yesterday'}(s, s') \wedge \textsc{sleep'}(s', p))$$

Tense: examples

- formula is consistent, even if we add the Meaning postulates on *yesterday*
- however, it is inconsistent with our conceptualization of time as being linearly ordered
- basic assumptions over the structure of time have to be added as **axioms**, e.g.

$$\forall t \neg (t < t)$$
$$\forall t, t', t'' (t < t' \wedge t' < t'' \rightarrow t < t'')$$
$$\forall t, t' \neg (t < t' \wedge t' < t)$$

- interpretation of (5) is inconsistent with the third axiom; therefore (5) is odd