**Compositional Semantics**

- Syntax-driven approach to semantic interpretation.
- Assumes a close link between syntax and semantics.
- Instead of $S \rightarrow \text{NP } \text{loves} \text{NP}$,
  $\text{loves} (x, y) \rightarrow \text{NP}(x) \text{NP}(y)$.
- Can annotate general rules like $S \rightarrow \text{NP } \text{VP}$.
  $\text{NP}(x) \rightarrow \text{loves}$.
  $\text{VP}(x, y) \rightarrow \text{NP}(x) \text{NP}(y)$.
- Now remove loves and use $\text{subj} \rightarrow \text{NP}$.
- Logical form of sentences can then be derived bottom-up while parsing, using lambda calculus.

**Nouns and Their Modifiers**

- **Expert**
  - $\text{kg } \text{expert}(e)$
  - $\text{big } \text{fat } \text{expert}(e)$
  - $\text{big } \text{fat } \text{expert}(e)$
  - $\text{bogus } \text{expert}(e)$
  - Right: $\text{kg } \text{bogus } \text{expert}(e)$
  - Bogus maps to new concept
  - (every/three) goldfish that Gilly swallowed

  - $\text{kg } \text{goldfish}(e)$, swallowed($\text{Gilly}, g)$
  - Or for real: $\text{kg } \text{goldfish}(e)$, $\exists [\text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{swallowe}(e, \text{act } g, g)]$
  - Like three swallowed-by-_Gilly_ goldfish

**Quantifier Order**

- Gilly swallowed a goldfish in a booth
  - $\exists \text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{exists}(\text{booth, location}(e)), ...$
  - Gilly swallowed a goldfish in every booth
  - $\exists \text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{all}(\text{booth, location}(e)), ...$

  - $\exists \text{goldfish}(e)$, swallowe($e, g$) $\forall \text{booth}(b) \rightarrow \text{location}(e, b)$

  - Does this mean what we'd expect?
    - says that there's only one event
    - with a single goldfish getting swallowed
    - that took place in a lot of booths ...

**Quantifier Order**

- Groucho Marx celebrates quantifier order ambiguity:
  - In this country a woman gives birth every 15 min.
  - Our job is to find that woman and stop her.

  - $\exists \text{woman } (\forall 15 \text{min} \text{ giving birth during woman, } 15 \text{min})$
  - $\forall 15 \text{min} \exists \text{woman giving birth during } 15 \text{min}$

  - Surprisingly, both are possible in natural language!

  - Which is the joke meaning? (where it's always the same woman)

**Quantifier Order**

- Gilly swallowed a goldfish in a booth
  - $\exists \text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{exists}(\text{booth, location}(e)), ...$
  - Gilly swallowed a goldfish in every booth
  - $\exists \text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{all}(\text{booth, location}(e)), ...$

  - $\exists \text{goldfish}(e)$, swallowe($e, g$) $\forall \text{booth}(b) \rightarrow \text{location}(e, b)$

  - Does this mean what we'd expect?
    - It's $\exists \forall$ which means same event for every booth

  - Probably false unless Gilly can be in every booth during her swallowing of a single goldfish

**Quantifier Order**

- Other reading $(\forall \exists)$ involves quantifier raising:
  - $\forall \text{booth } (\exists \text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{location}(e, b))$
  - $\forall \text{all } (\forall \exists [\text{past}(e), \text{act}(e, \text{swallowing}), \text{swallowe}(e, \text{Gilly}), \text{exists}(\text{goldfish}, \text{swallowe}(e), \text{location}(e, b))])$
  - "For all booths b, there was such an event in b"