Syntax: The Study of Sentence Structure

- How words are put together to make larger expressions.
- How expressions are put together to make sentences.

- **Reminder:** We’ve already seen structure at the word level.
Morphological Structure

- [[[tabe + sase] + rare] + ta]
- [a + [ta + [ni + [piga]]]]
- [[nép + [köz + [[ta:rʃ + ɔʃ] + aːg]]] + utsɔ]
Morphological Structure in English

- missile: ‘ICBM’
- anti-tank missile: ‘missile targetting tanks’
- anti-aircraft missile: ‘missile targetting aircraft’
- anti-missile missile: ‘missile targetting ICBMs’
Morphological Rules

- Rule: Anti-X missile is a missile targeting Xs.
- What kind of missile targets anti-missile-missiles?
  - anti-anti-missile-missile-missile

- Meaning and structure go hand-in-hand.
- Other examples?
Morphological Rules

- GNoun → great GNoun

- Defines structures like:

  - [great + grandmother]
  - [great + [great + grandmother]]
Elephant Sounds (VOA August 29, 2011)

Elephant Communication

http://en.wikipedia.org/wiki/Cercopithecus_nictitans
(Spot-Nosed Monkeys may have some syntax)

(Animal Sounds)
A Simple Domain:
The Syntax of Directions

E.g. How do I get from the top of the oval to SFO?
The Syntax of Mapquest 1

Start out going NORTH on PALM DR toward ARBORETUM RD.
Merge onto EL CAMINO REAL / CA-82 N via the ramp on the LEFT. 3.8 miles
Turn RIGHT onto LAUREL ST. 0.1 miles
Turn SLIGHT LEFT to take the WOODSIDE RD EAST / CA-84 E ramp. 0.1 miles
Merge onto WOODSIDE RD. 0.8 miles
Merge onto US-101 N toward SAN FRANCISCO. 13.1 miles
Take the exit toward SAN FRANCISCO INTL AIRPORT. 0.4 miles
The Grammar of Mapquest

S → merge | turn | start out going | take the exit...
   ((slight) right | left | north,...) (on | onto Roadname)
   (via Roadname) (toward Name) (i.j miles).
Roadname → Woodside Road, Palm Drive, ...
Name → Roadname | Placename
Placename → SF, Woodside, ...
Placename → Placename / Placename
The Syntax of Mapquest 1

That grammar licenses (or ‘generates’) structures like this:

```
S
  turn
  right
  onto Roadname
  Roadname
    Woodside Road / CA-84 E
```
How do I get to Valley Forge from the UPenn Linguistics Department?
The Syntax of Mapquest 2

Start out going East on SPRUCE ST toward Center City (...mi)
SPRUCE ST becomes SOUTH ST.

Merge onto I-76 W via the ramp on the left. (...mi)

Merge onto W DEKALB PIKE / US-202 S via exit number 328
toward US-422 W / SWEDESFORD RD. (...mi)

Merge onto COUNTY LINE EXWY / US-422 W toward
POTTSTOWN. (...mi)

Merge onto W VALLEY FORGE RD / PA-23 W toward VALLEY
FORGE... (...mi)
The Grammar of Mapquest Revised

\[ S \rightarrow \text{merge} | \text{turn} | \text{start out going} | \text{take the} \ \text{Roadname} \]
\[ \quad ((\text{slight}) \ \text{right} | \text{left} | \text{north},...) \ \text{(on} | \text{onto} \ \text{Roadname}) \]
\[ \quad (\text{via} \ \text{Roadname}) \ \text{(toward} \ \text{Name}) \ \text{(i.j miles).} \]

\[ S \rightarrow \ \text{Roadname becomes} \ \text{Roadname.} \]
\[ \text{Roadname} \rightarrow \text{Palm Drive, South Street, HS-422 W, ...} \]
\[ \text{Name} \rightarrow \text{Roadname} | \text{Placename} \]
\[ \text{Placename} \rightarrow \text{SF, Woodside, Pottstown, Valley Forge,...} \]
\[ \text{Roadname} \rightarrow \text{Roadname} / \text{Roadname} \]
Head northeast from Palm Dr - go 0.9 mi
Turn left onto the CA-82 ramp - go 0.2 mi
Bear right at El Camino Real - go 3.7 mi
Turn right at Laurel St - go 399 ft
Bear left onto the Woodside Rd ramp - go 0.2 mi
Bear right at Woodside Rd - go 0.9 mi
Take the US-101 N ramp to San Francisco - go 13 mi
Take the exit to San Francisco Intl Airport - go 0.5 mi
The Grammar of Google Maps

\[ S \rightarrow S_1 - S_2 \]
\[ S_1 \rightarrow \text{bear} | \text{turn (right|left...)} | (\text{at|into Roadname}) | \text{take the Roadname (to Name)} \]
\[ S_2 \rightarrow - \text{go Z.U miles} \]
\[ \text{Roadname} \rightarrow \text{Palm Dr, Woodside Rd, El Camino Real, ...} \]
\[ \text{Name} \rightarrow \text{Roadname | Placename} \]
\[ \text{Placename} \rightarrow \text{San Francisco, Woodside, ...} \]
Head west from Spruce St - go 0.1 mi

Turn left at S 38th St - go 0.1 mi

Continue on S University Ave - go 0.3 mi

Bear right into the I-76 W entry ramp - go 18 mi

Take the US-202 N/US-202 S/US-422 W exit 328B-A to West Chester/King of Prussia/Pottstown - go 0.7 mi

Bear right at W. DeKalb Pike - go 0.0 mi

Bear left - go 0.1 mi...
S → S₁ - S₂
S₁ → bear | turn | head (right | left...) (at | into Roadname) |
    take the Name exit / continue on Roadname (to Name)
S₂ → go Z.U miles
Roadname → Palm Dr, Woodside Rd, El Camino Real, ...
Name → Roadname | Placename
Placename → San Francisco, Woodside, ...
Roadname → Roadname / Roadname
English Compound Nouns have More Structure

[[Academic Enrichment] Program]
Creative Writing Courses
Littlefield Management Center
[[United Nations] [Security Council]]
U.S. Supreme Court nominee Harriet Miers
Gas price fixing suit
[[[Time Warner] [chief executive]] [Richard Parsons]]
The Principle of Compositionality

- Usually attributed to Gottlob Frege (1848-1925).

- An expression’s meaning is determined by the meanings of its parts and their ‘mode of combination’.

- An expression’s meaning is determined by the words it contains and its structure.
Compositionality in Arithmetic

\[
\frac{(23 \times 5) + 2}{3 + (9 \times 4)}
\]
\[
\frac{115 + 2}{3 + 36}
\]
\[
\frac{117}{39}
\]
\[
3
\]
No Ambiguity in Arithmetic

24 × 17
(24 × 17)
1 + 2 × 3
(1 + 2) × 3
1 + (2 × 3)
Morphological Ambiguity: Un-Ambiguity 1

- **unusable** is unambiguous

- Prefix **un-** to a certain kind of verb to make another verb.
  
  E.g. *untie, undo, unfasten, unblock,*...  
  but *unread, *unuse,*...

- Prefix **un-** to a certain kind of adjective to make another adjective.
  
  E.g. *unhappy, unambiguous, unaware,*...  
  but *unalive, *unawake,*...

- Suffix **-able** to a certain kind of verb to make an adjective,..

- **[un + [use + able]]** but [*[un + use] + able]*
Un-Ambiguity 2

- **unlock** the door
- Now that we have the right key, the box is finally **unlockable**. \([\text{un} + \text{lock} + \text{able}]\)
- Don’t store your money in that box, it’s **unlockable**. \([\text{un} + [\text{lock} + \text{able}]]\)
Compound Noun Ambiguity

((light house) keeper) vs. (light (house keeper))
((ancient culture) center) vs.
(ancient (culture center))
(linguistics (graduate group)) vs.
((linguistics graduate) group)
Syntactic (Structural) Ambiguity

- I saw the astronomer with a telescope.
- We enjoyed the movie with Cher.
- The room contained noisy children and animals.
- People with children who use drugs should be locked up.
- I forgot how good beer tastes.
Other Ambiguity: Lexical Ambiguity

- They could build a better pen.
- Their class was bothersome.
- I don’t like their band.
- I want the best dresser in the world.
- That phone bothers me.
Other Ambiguity

- [ɑː(y)lbi’liːvənyuː] (Country Western Lyric)
- I read it every day.
- Some student invited each professor.
- She likes Jones more than Sandy.
- Some student talked to every teacher.
Complex Ambiguity

- I saw that gas can explode.
- Visiting relatives can be boring.
- Flying planes can be dangerous.
- This animal has four legs and flies.
- I saw her duck.
Ambiguity

- Some expressions can be constructed in more than one way.
- Some expressions must be with two distinct tree structures.
- Each of these structures will determine a distinct meaning.
I forgot [how [[good beer] tastes]].
I forgot [[how good] [beer tastes]].
I saw [that [gas [can explode]]].
I [saw [[that [gas can]] explode]].