

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:rj + ɔj] + a:g]]] + 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'

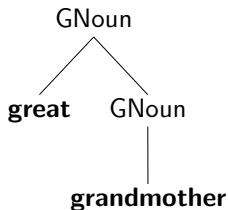
Morphological Rules

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

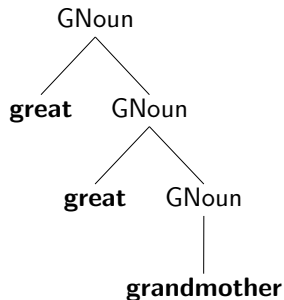
- ▶ Meaning and structure go hand-in-hand.
- ▶ Other examples?

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)

<http://www.fatpigdog.com/SpectrumAnalyzer/Sounds/Sounds.html>
(Animal Sounds)

Sentence Structure

- ▶ 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, ...**

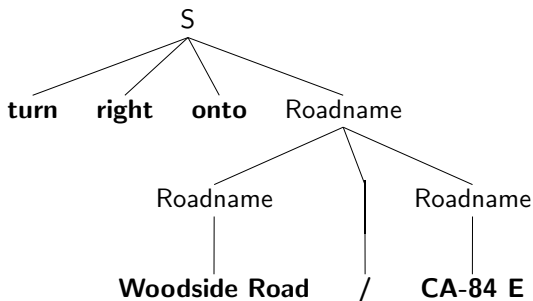
Name → Roadname | Placename

Placename → **SF, Woodside, ...**

Placename → Placename / Placename

The Syntax of Mapquest 1

That grammar licenses (or 'generates') structures like this:



The Syntax of Mapquest 2

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 → **merge|turn|start out going|take the** Roadname
((**slight**) **right|left|north**,...) (**on|onto** Roadname)
(**via** Roadname) (**toward** Name) (i.j **miles**).

S → Roadname **becomes** Roadname.

Roadname → **Palm Drive, South Street, HS-422 W, ...**

Name → Roadname | Placename

Placename → **SF, Woodside, Pottstown, Valley Forge,...**

Roadname → Roadname / Roadname

The Syntax of Google Maps 1

- ▶ 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

$S \rightarrow S_1 - S_2$

$S_1 \rightarrow$ **bear|turn (right|left...)** (**at|into** Roadname)|
take the Roadname (**to** Name)

$S_2 \rightarrow$ - **go** Z.U **miles**

Roadname \rightarrow Palm Dr, Woodside Rd, El Camino Real, ...

Name \rightarrow Roadname | Placename

Placename \rightarrow San Francisco, Woodside, ...

The Syntax of Google Maps 2

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...

The Grammar of Google Maps 2

$S \rightarrow S_1 - S_2$

$S_1 \rightarrow \mathbf{bear|turn|head (right|left...)} (\mathbf{at|into Roadname})|$

$\mathbf{take the Name exit/continue on Roadname (to Name)}$

$S_2 \rightarrow \mathbf{go Z.U miles}$

$Roadname \rightarrow \mathbf{Palm Dr, Woodside Rd, El Camino Real, ...}$

$Name \rightarrow Roadname | Placename$

$Placename \rightarrow \mathbf{San Francisco, Woodside, ...}$

$Roadname \rightarrow Roadname / Roadname$

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

$$((23 \times 5) + 2) / (3 + (9 \times 4))$$

$$(115 + 2) / (3 + 36)$$

$$117 / 39$$

$$3$$

No Ambiguity in Arithmetic

$$24 \times 17$$

$$(24 \times 17)$$

$$1 + 2 \times 3$$

$$(1 + 2) \times 3$$

$$1 + (2 \times 3)$$

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.
[[un + lock] + able]
- ▶ Don't store your money in that box, it's unlockable.
[un + [lock + 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

- ▶ [a:(y)lbi'li:vənyu:] (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.

Constituency: Syntactic Constituent Structure

I forgot [how [[good beer] tastes]].

I forgot [[how good] [beer tastes]].

I saw [that [gas [can explode]]].

I [saw [[that [gas can]] explode]].