

LING/C SC 581:

Advanced Computational Linguistics

Lecture 19

Prof. Sandiway Fong

Today's Topic

- Some lemma methods:
 - `.derivationally_related_forms()` (n \Rightarrow a)
 - `.pertainyms()` (a \Rightarrow n)
- WordNet size:
 - how many words, maximum number of senses, total number of synsets etc.
- word2vec: inflectional morphology
- Semantic Opposition and WordNet

WordNet Relations

- **Derivationally related to** (different parts of speech):

1 of 3 senses of virus

Sense 1

virus#1 -- ((virology) ultramicroscopic infectious agent that replicates itself only within cells of living hosts; many are pathogenic; a piece of nucleic acid (DNA or RNA) wrapped in a thin coat of protein)

RELATED TO->(adj) viral#1#1

=> viral#1 -- (relating to or caused by a virus; "viral infection")

```
>>> for ss in wn.synsets('virus'):
...     for lm in ss.lemmas():
...         print(lm, lm.derivationally_related_forms())
...
Lemma('virus.n.01.virus') [Lemma('viral.a.01.viral')]
Lemma('virus.n.02.virus') []
Lemma('virus.n.03.virus') []
Lemma('virus.n.03.computer_virus') []
```

defined for
lemmas only!

```
>>> wn.synset('virus.n.02').definition()
'a harmful or corrupting agency'
```

WordNet Relations

- Lemma method (from adjective to noun): `.pertainyms()`

```
>>> for lm in wn.synset('viral.a.01').lemmas():
...     print(lm, lm.pertainyms())
...
...
Lemma('viral.a.01.viral') [Lemma('virus.n.01.virus')]
```

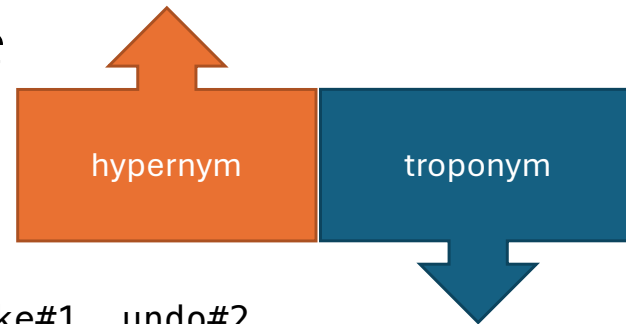
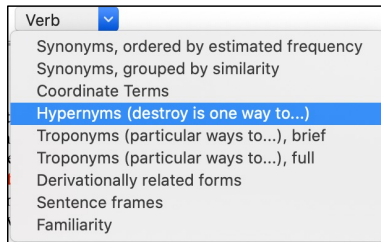
```
>>> for ss in wn.synsets('dental'):
...     for lm in ss.lemmas():
...         print(lm, lm.pertainyms())
...
...
Lemma('alveolar_consonant.n.01.alveolar_consonant') []
Lemma('alveolar_consonant.n.01.dental_consonant') []
Lemma('alveolar_consonant.n.01.alveolar') []
Lemma('alveolar_consonant.n.01.dental') []
Lemma('dental.a.01.dental') [Lemma('tooth.n.01.tooth')]
Lemma('dental.a.02.dental') [Lemma('dentistry.n.01.dentistry')]
```

Examples in WordNet

- ✗ Adjective: *Criminal* -> **Pertainym (Noun):** *Crime*
- Adjective: *Dental* -> **Pertainym (Noun):** *Tooth*
- ✗ Adjective: *Equal* -> **Pertainym (Noun):** *Equality* WordNet

WordNet Relations: *verbs*

- Verbs



destroy (one way to):

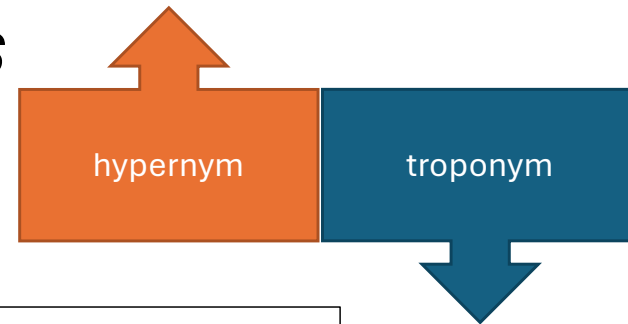
- **destroy#1** => **unmake#1**, **undo#2**
- **destroy#3** => **get the better of#1**, **overcome#1**, **defeat#1**
- **destroy#4** => **kill#1**

The verb **destroy** has 4 senses (first 3 from tagged texts)

1. (42) **destroy#1**, **destruct#2** -- (do away with, cause the destruction or undoing of; "The fire destroyed the house")
2. (28) **destroy#2**, **ruin#1** -- (destroy completely; damage irreparably; "You have ruined my car by pouring sugar in the tank!"; "The tears ruined her make-up")
3. (2) **demolish#3**, **destroy#3** -- (defeat soundly; "The home team demolished the visitors")
4. **destroy#4**, **put down#6** -- (put (an animal) to death; "The customs agents destroyed the dog that was found to be rabid"; "the sick cat had to be put down")

WordNet Relations: *verbs*

- Troponyms (particular ways to *destroy#v#2*):
 - e.g. you have *ruined* my car!



Sense 2
destroy#2, ruin#1 -- (destroy completely; damage irreparably; "You have ruined my car by pouring sugar in the tank!"; "The tears ruined her make-up")

- => burn#1, fire#8, burn down#2 -- (destroy by fire; "They burned the house and his diaries")
- => backfire#3 -- (set a controlled fire to halt an advancing forest to prairie fire)
- => cremate#1 -- (reduce to ashes; "Cremate a corpse")
- => torch#1 -- (burn maliciously, as by arson; "The madman torched the barns")
- => scorch#3 -- (destroy completely by or as if by fire; "The wildfire scorched the forest and several homes"; "the invaders scorched the land")
- => lay waste to#1, waste#9, devastate#1, desolate#3, ravage#2, scourge#3 -- (cause extensive destruction or ruin utterly; "The enemy lay waste to the countryside after the invasion")
- => ruin#4 -- (reduce to ruins; "The country lay ruined after the war")
- => harry#2, ravage#1 -- (make a pillaging or destructive raid on (a place), as in wartimes)
- => break#50 -- (find a flaw in; "break an alibi"; "break down a proof")
- => break#4, bust#1 -- (ruin completely; "He busted my radio!")
- => break down#6 -- (cause to fall or collapse)
- => vandalize#1, vandalise#1 -- (destroy wantonly, as through acts of vandalism; "vandalize the park")
- => key#3 -- (vandalize a car by scratching the sides with a key; "His new Mercedes was keyed last night in the parking lot")
- => do a job on#1 -- (destroy completely or make ugly or useless; "The dog did a job on my pillow"; "The seamstress did a job on my wedding gown")
- => subvert#4 -- (destroy completely; "we must not let our civil liberties be subverted by the current crisis")
- => get#32 -- (overcome or destroy; "The ice storm got my hibiscus"; "the cat got the goldfish")
- => devour#1 -- (destroy completely; "Fire had devoured our home")
- => rape#2, spoil#7, despoil#2, violate#6, plunder#4 -- (destroy and strip of its possession; "The soldiers raped the beautiful country")
- => explode#5 -- (destroy by exploding; "The enemy exploded the bridge")
- => consume#4 -- (destroy completely; "The fire consumed the building")
- => shipwreck#4 -- (destroy a ship; "The vessel was shipwrecked")
- => bust up#1, wreck#1, wrack#1 -- (smash or break forcefully; "The kid busted up the car")
- => kick in#3, kick down#1 -- (open violently; "kick in the doors")
- => wash out#3 -- (wear or destroy by the force of water; "The hail storms had washed out the bridges")

WordNet Relations: *verbs*

destroy#v#4

Verb ▼

- Synonyms, ordered by estimated frequency
- Synonyms, grouped by similarity
- Coordinate Terms
- Hypernyms (destroy is one way to...)
- Troponyms (particular ways to...), brief
- Troponyms (particular ways to...), full
- Derivationally related forms
- Sentence frames
- Familiarity

destroy#v#4 -up->
kill#v#1 -down-> ...

destroy#4, put down#6 -- (put (an animal) to death; "The customs agents destroyed the dog that was found to be rabid"; "the sick cat had to be put down")

- > kill#1 -- (cause to die; put to death, usually intentionally or knowingly; "This man killed several people when he tried to rob a bank"; "The farmer killed a pig for the holidays")
- => eliminate#3, annihilate#1, extinguish#5, eradicate#1, wipe out#2, decimate#2, carry off#3 -- (kill in large numbers; "the plague wiped out an entire population")
- => decimate#1 -- (kill one in every ten, as of mutineers in Roman armies)
- => drown#4 -- (kill by submerging in water; "He drowned the kittens")
- => massacre#1, slaughter#2, mow down#1 -- (kill a large number of people indiscriminately; "The Hutus massacred the Tutsis in Rwanda")
- => erase#1, wipe out#4 -- (remove from memory or existence; "The Turks erased the Armenians in 1915")
- => butcher#1, slaughter#1 -- (kill (animals) usually for food consumption; "They slaughtered their only goat to survive the winter")
- => poison#2 -- (kill with poison; "She poisoned her husband")
- => stone#1, lapidate#1 -- (kill by throwing stones at; "People wanted to stone the woman who had a child out of wedlock")
- => poison#4 -- (kill by its poison; "This mushrooms can poison")
- => commit suicide#1 -- (kill oneself; "the terminally ill patient committed suicide")
- => dispatch#5 -- (kill without delay; "the traitor was dispatched by the conspirators")
- => zap#2, vaporize#1 -- (kill with or as if with a burst of gunfire or electric current or as if by shooting; "in this computer game, space travellers are vaporized by aliens")
- => sacrifice#2 -- (kill or destroy; "The animals were sacrificed after the experiment"; "The general had to sacrifice several soldiers to save the regiment")
- => take off#8 -- (prove fatal; "The disease took off")
- => tomahawk#2 -- (kill with a tomahawk)
- => destroy#4, put down#6 -- (put (an animal) to death; "The customs agents destroyed the dog that was found to be rabid"; "the sick cat had to be put down")
- => saber#2, sabre#2 -- (kill with a saber)
- => overlie#2, overlay#2 -- (kill by lying on; "The sow overlay her piglets")
- => brain#2 -- (kill by smashing someone's skull)
- => put away#5, put to sleep#2 -- (kill gently, as with an injection; "the cat was very ill and we had to put it to sleep")
- => neutralize#4, neutralise#1, liquidate#1, waste#5, knock off#1, do in#1 -- (get rid of (someone who may be a threat) by killing; "The mafia liquidated the informer"; "the double agent was neutralized")
- => exterminate#1, kill off#1 -- (kill en masse; kill on a large scale; kill many; "Hitler wanted to exterminate the Jews, Gypsies, Communists, and homosexuals of Europe")
- => smother#2, asphyxiate#1, suffocate#1 -- (deprive of oxygen and prevent from breathing; "Othello smothered Desdemona with a pillow"; "The child suffocated herself with a plastic bag that the parents had left on the floor")
- => strangle#1, strangulate#1, throttle#2 -- (kill by squeezing the throat of so as to cut off the air; "he tried to strangle his opponent"; "A man in Boston has been strangling several dozen prostitutes")
- => decapitate#1, behead#1, decollate#1 -- (cut the head of; "the French King was beheaded during the Revolution")
- => impale#2, stake#5 -- (kill by piercing with a spear or sharp pole; "the enemies were impaled and left to die")
- => dismember#1 -- (separate the limbs from the body; "the tiger dismembered the tourist")
- => martyr#1 -- (kill as a martyr; "Saint Sebastian was martyred")
- => shed blood#1 -- (kill violently; "They will never stop shedding the blood of their enemies")
- => murder#1, slay#1, hit#1, dispatch#3, bump off#1, off#1, polish off#2, remove#7 -- (kill intentionally and with premeditation; "The mafia boss ordered his enemies murdered")
- => assassinate#1 -- (murder; especially of socially prominent persons; "Anwar Sadat was assassinated because many people did not like his peace politics with Israel")
- => execute#1, put to death#1 -- (kill as a means of socially sanctioned punishment; "In some states, criminals are executed")
- => draw#23, quarter#2, draw and quarter#1 -- (pull (a person) apart with four horses tied to his extremities, so as to execute him; "in the old days, people were drawn and quartered for certain crimes")
- => lynch#1 -- (kill without legal sanction; "The blood-thirsty mob lynched the alleged killer of the child")
- => shoot#2, pip#1 -- (kill by firing a missile)
- => electrocute#2, fry#3 -- (kill by electrocution, as in the electric chair; "The serial killer was electrocuted")

WordNet senses are incomplete

But language is highly
productive, and
WordNet pre-dates
Facebook.

Word to search for:

Display Options:

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations
Display options for sense: (gloss) "an example sentence"
Display options for word: word#sense number

Noun

- [S:](#) (n) **friend#1** (a person you know well and regard with affection and trust) *"he was my best friend at the university"*
- [S:](#) (n) [ally#2](#), **friend#2** (an associate who provides cooperation or assistance) *"he's a good ally in fight"*
- [S:](#) (n) [acquaintance#3](#), **friend#3** (a person with whom you are acquainted) *"I have trouble remembering the names of all my acquaintances"; "we are friends of the family"*
- [S:](#) (n) [supporter#1](#), [protagonist#1](#), [champion#3](#), [admirer#1](#), [booster#1](#), **friend#4** (a person who backs a politician or a team etc.) *"all their supporters came out for the game"; "they are friends of the library"*
- [S:](#) (n) **Friend#5**, [Quaker#1](#) (a member of the Religious Society of Friends founded by George Fox (the Friends have never called themselves Quakers))

WordNet senses are incomplete

- **Question:** *Which word do you think has the most senses?*
- NPR Pop Culture:
 - One three-letter word does much of the heavy lifting in the English language. The little word "run" — in its verb form alone — has 645 distinct meanings.
 - Top three verbs: *run, put, set*.
 - <https://www.npr.org/2011/05/30/136796448/has-run-run-amok-it-has-645-meanings-so-far>

WordNet: *run*

```
>>> wn.synsets('run')
```

```
[Synset('run.n.01'), Synset('test.n.05'), Synset('footrace.n.01'), Synset('streak.n.01'),  
  Synset('run.n.05'), Synset('run.n.06'), Synset('run.n.07'), Synset('run.n.08'), Synset('run.n.09'),  
  Synset('run.n.10'), Synset('rivulet.n.01'), Synset('political_campaign.n.01'), Synset('run.n.13'),  
  Synset('discharge.n.06'), Synset('run.n.15'), Synset('run.n.16'), Synset('run.v.01'),  
  Synset('scat.v.01'), Synset('run.v.03'), Synset('operate.v.01'), Synset('run.v.05'),  
  Synset('run.v.06'), Synset('function.v.01'), Synset('range.v.01'), Synset('campaign.v.01'),  
  Synset('play.v.18'), Synset('run.v.11'), Synset('tend.v.01'), Synset('run.v.13'), Synset('run.v.14'),  
  Synset('run.v.15'), Synset('run.v.16'), Synset('prevail.v.03'), Synset('run.v.18'),  
  Synset('run.v.19'), Synset('carry.v.15'), Synset('run.v.21'), Synset('guide.v.05'),  
  Synset('run.v.23'), Synset('run.v.24'), Synset('run.v.25'), Synset('run.v.26'), Synset('run.v.27'),  
  Synset('run.v.28'), Synset('run.v.29'), Synset('run.v.30'), Synset('run.v.31'), Synset('run.v.32'),  
  Synset('run.v.33'), Synset('run.v.34'), Synset('ply.v.03'), Synset('hunt.v.01'), Synset('race.v.02'),  
  Synset('move.v.13'), Synset('melt.v.01'), Synset('ladder.v.01'), Synset('run.v.41')]
```

```
>>> len(wn.synsets('run'))
```

```
57
```

```
>>> len(wn.synsets('put'))
```

```
10
```

```
>>> len(wn.synsets('set'))
```

```
45
```

WordNet: *run*

Verb

- **S: (v) run#1** (move fast by using one's feet, with one foot off the ground at any given time) "*Don't run--you'll be out of breath*"; "*The children ran to the store*"
- **S: (v) scat#1, run#2, scarper#1, turn tail#1, lam#1, run away#1, hightail it#1, bunk#3, head for the hills#1, take to the woods#1, escape#6, fly the coop#1, break away#5** (flee; take to one's heels; cut and run) "*If you see this man, run!*"; "*The burglars escaped before the police showed up*"
- **S: (v) run#3, go#7, pass#6, lead#6, extend#2** (stretch out over a distance, space, time, or scope; run or extend between two points or beyond a certain point) "*Service runs all the way to Cranbury*"; "*His knowledge doesn't go very far*"; "*My memory extends back to my fourth year of life*"; "*The facts extend beyond a consideration of her personal assets*"
- **S: (v) operate#1, run#4** (direct or control; projects, businesses, etc.) "*She is running a relief operation in the Sudan*"
- **S: (v) run#5, go#6** (have a particular form) "*the story or argument runs as follows*"; "*as the saying goes...*"
- **S: (v) run#6, flow#2, feed#8, course#2** (move along, of liquids) "*Water flowed into the cave*"; "*the Missouri feeds into the Mississippi*"
- **S: (v) function#1, work#4, operate#2, go#12, run#7** (perform as expected when applied) "*The washing machine won't go unless it's plugged in*"; "*Does this old car still run well?*"; "*This old radio doesn't work anymore*"
- **S: (v) range#1, run#8** (change or be different within limits) "*Estimates for the losses in the earthquake range as high as \$2 billion*"; "*Interest rates run from 5 to 10 percent*"; "*The instruments ranged from tuba to cymbals*"; "*My students range from very bright to dull*"
- **S: (v) campaign#1, run#9** (run, stand, or compete for an office or a position) "*Who's running for treasurer this year?*"
- **S: (v) play#18, run#10** (cause to emit recorded audio or video) "*They ran the tapes over and over again*"; "*I'll play you my favorite record*"; "*He never tires of playing that video*"

- **S: (v) run#11** (move about freely and without restraint, or act as if running around in an uncontrolled way) "*who are these people running around in the building?*"; "*She runs around telling everyone of her troubles*"; "*let the dogs run free*"
- **S: (v) tend#1, be given#1, lean#3, incline#1, run#12** (have a tendency or disposition to do or be something; be inclined) "*She tends to be nervous before her lectures*"; "*These dresses run small*"; "*He inclined to compulence*"
- **S: (v) run#13** (be operating, running or functioning) "*The car is still running--turn it off!*"
- **S: (v) run#14** (change from one state to another) "*run amok*"; "*run rogue*"; "*run riot*"
- **S: (v) run#15** (cause to perform) "*run a subject*"; "*run a process*"
- **S: (v) run#16** (be affected by; be subjected to) "*run a temperature*"; "*run a risk*"
- **S: (v) prevail#3, persist#1, die hard#1, run#17, endure#7** (continue to exist) "*These stories die hard*"; "*The legend of Elvis endures*"
- **S: (v) run#18** (occur persistently) "*Musical talent runs in the family*"
- **S: (v) run#19, execute#5** (carry out a process or program, as on a computer or a machine) "*Run the dishwasher*"; "*run a new program on the Mac*"; "*the computer executed the instruction*"
- **S: (v) carry#15, run#20** (include as the content; broadcast or publicize) "*We ran the ad three times*"; "*This paper carries a restaurant review*"; "*All major networks carried the press conference*"
- **S: (v) run#21** (carry out) "*run an errand*"
- **S: (v) guide#5, run#22, draw#29, pass#11** (pass over, across, or through) "*He ran his eyes over her body*"; "*She ran her fingers along the carved figurine*"; "*He drew her hair through his fingers*"
- **S: (v) run#23, lead#13** (cause something to pass or lead somewhere) "*Run the wire behind the cabinet*"
- **S: (v) run#24** (make without a miss)
- **S: (v) run#25, black market#1** (deal in illegally, such as arms or liquor)
- **S: (v) run#26** (cause an animal to move fast) "*run the dogs*"
- **S: (v) run#27, bleed#4** (be diffused) "*These dyes and colors are guaranteed not to run*"
- **S: (v) run#28** (sail before the wind)

WordNet: *run*

- [S: \(v\) run#29](#) (cover by running; run a certain distance) "*She ran 10 miles that day*"
- [S: \(v\) run#30, run for#1](#) (extend or continue for a certain period of time) "*The film runs 5 hours*"
- [S: \(v\) run#31](#) (set animals loose to graze)
- [S: \(v\) run#32, consort#3](#) (keep company) "*the heifers run with the bulls to produce offspring*"
- [S: \(v\) run#33](#) (run with the ball; in such sports as football)
- [S: \(v\) run#34](#) (travel rapidly, by any (unspecified) means) "*Run to the store!*"; "*She always runs to Italy, because she has a lover there*"
- [S: \(v\) ply#3, run#35](#) (travel a route regularly) "*Ships ply the waters near the coast*"
- [S: \(v\) hunt#1, run#36, hunt down#1, track down#1](#) (pursue for food or sport (as of wild animals)) "*Goering often hunted wild boars in Poland*"; "*The dogs are running deer*"; "*The Duke hunted in these woods*"
- [S: \(v\) race#2, run#37](#) (compete in a race) "*he is running the Marathon this year*"; "*let's race and see who gets there first*"
- [S: \(v\) move#13, go#14, run#38](#) (progress by being changed) "*The speech has to go through several more drafts*"; "*run through your presentation before the meeting*"
- [S: \(v\) melt#1, run#39, melt down#1](#) (reduce or cause to be reduced from a solid to a liquid state, usually by heating) "*melt butter*"; "*melt down gold*"; "*The wax melted in the sun*"
- [S: \(v\) ladder#1, run#40](#) (come unraveled or undone as if by snagging) "*Her nylons were running*"
- [S: \(v\) run#41, unravel#3](#) (become undone) "*the sweater unraveled*"

Also, *run* has 16 senses as a noun.

i. To (cause to) move.

i.i. Senses relating to locomotion involving the use of the legs, and uses deriving from these (frequently retaining some implication of the physical sense).

i.i.1.a. **intransitive**. To go with **Old English**-quick steps on alternate feet, never having both or (in the case of many animals) all feet on the ground at the same time; to make one's way or cover the ground in this manner.

Frequently with various prepositions and adverbs; for idiomatic uses arising from such constructions see [Phrasal verbs PV.1](#) and [Phrasal verbs PV.2](#).

to run in place: see [place n.1](#) Phrases P.2a.i.
to run on the spot: see [on the spot adv. A.5](#).

OE [Northumbrian dialect]
*Et exierunt cito de
monumento..currentes
nuntiare discipulis eius :*

OED: over
800 pages
long!

WordNet: *put*

Verb

- [S:](#) (v) [put#1](#), [set#1](#), [place#1](#), [pose#5](#), [position#2](#), [lay#1](#) (put into a certain place or abstract location) *"Put your things here"; "Set the tray down"; "Set the dogs on the scent of the missing children"; "Place emphasis on a certain point"*
- [S:](#) (v) [put#2](#) (cause to be in a certain state; cause to be in a certain relation) *"That song put me in awful good humor"; "put your ideas in writing"*
- [S:](#) (v) [frame#4](#), [redact#1](#), [cast#10](#), [put#3](#), [couch#1](#) (formulate in a particular style or language) *"I wouldn't put it that way"; "She cast her request in very polite language"*
- [S:](#) (v) [put#4](#), [assign#5](#) (attribute or give) *"She put too much emphasis on her the last statement"; "He put all his efforts into this job"; "The teacher put an interesting twist to the interpretation of the story"*
- [S:](#) (v) [invest#1](#), [put#5](#), [commit#5](#), [place#13](#) (make an investment) *"Put money into bonds"*
- [S:](#) (v) [place#11](#), [put#6](#), [set#20](#) (estimate) *"We put the time of arrival at 8 P.M."*
- [S:](#) (v) [put#7](#) (cause (someone) to undergo something) *"He put her to the torture"*
- [S:](#) (v) [put#8](#) (adapt) *"put these words to music"*
- [S:](#) (v) [arrange#7](#), [set up#13](#), [put#9](#), [order#8](#) (arrange thoughts, ideas, temporal events) *"arrange my schedule"; "set up one's life"; "I put these memories with those of bygone times"*

- Plus 1 as a noun

WordNet: set

Verb

- [S: \(v\) put#1](#), [set#1](#), [place#1](#), [pose#5](#), [position#2](#), [lay#1](#) (put into a certain place or abstract location) "Put your things here"; "Set the tray down"; "Set the dogs on the scent of the missing children"; "Place emphasis on a certain point"
- [S: \(v\) determine#3](#), [set#2](#) (fix conclusively or authoritatively) "set the rules"
- [S: \(v\) specify#2](#), [set#3](#), [determine#4](#), [define#5](#), [fix#3](#), [limit#3](#) (decide upon or fix definitely) "fix the variables"; "specify the parameters"
- [S: \(v\) set#4](#), [mark#10](#) (establish as the highest level or best performance) "set a record"
- [S: \(v\) set#5](#) (put into a certain state; cause to be in a certain state) "set the house afire"
- [S: \(v\) set#6](#) (fix in a border) "The goldsmith set the diamond"
- [S: \(v\) fix#12](#), [prepare#1](#), [set up#15](#), [ready#2](#), [gear up#1](#), [set#7](#) (make ready or suitable or equip in advance for a particular purpose or for some use, event, etc) "Get the children ready for school!"; "prepare for war"; "I was fixing to leave town after I paid the hotel bill"
- [S: \(v\) set#8](#) (set to a certain position or cause to operate correctly) "set clocks or instruments"
- [S: \(v\) set#9](#), [localize#4](#), [localise#4](#), [place#10](#) (locate) "The film is set in Africa"
- [S: \(v\) set#10](#), [go down#7](#), [go under#2](#) (disappear beyond the horizon) "the sun sets early these days"
- [S: \(v\) arrange#6](#), [set#11](#) (adapt for performance in a different way) "set this poem to music"
- [S: \(v\) plant#1](#), [set#12](#) (put or set (seeds, seedlings, or plants) into the ground) "Let's plant flowers in the garden"
- [S: \(v\) set#13](#) (apply or start) "set fire to a building"
- [S: \(v\) jell#1](#), [set#14](#), [congeal#1](#) (become gelatinous) "the liquid jelled after we added the enzyme"

- [S: \(v\) typeset#1](#), [set#15](#) (set in type) "My book will be typeset nicely"; "set these words in italics"
- [S: \(v\) set#16](#) (put into a position that will restore a normal state) "set a broken bone"
- [S: \(v\) set#17](#), [countersink#1](#) (insert (a nail or screw below the surface, as into a countersink))
- [S: \(v\) set#18](#) (give a fine, sharp edge to a knife or razor)
- [S: \(v\) sic#1](#), [set#19](#) (urge to attack someone) "The owner sicked his dogs on the intruders"; "the shaman sics sorcerers on the evil spirits"
- [S: \(v\) place#11](#), [put#6](#), [set#20](#) (estimate) "We put the time of arrival at 8 P.M."
- [S: \(v\) rig#4](#), [set#21](#), [set up#14](#) (equip with sails or masts) "rig a ship"
- [S: \(v\) set up#4](#), [lay out#2](#), [set#22](#) (get ready for a particular purpose or event) "set up an experiment"; "set the table"; "lay out the tools for the surgery"
- [S: \(v\) adjust#1](#), [set#23](#), [correct#7](#) (alter or regulate so as to achieve accuracy or conform to a standard) "Adjust the clock, please"; "correct the alignment of the front wheels"
- [S: \(v\) fructify#3](#), [set#24](#) (bear fruit) "the apple trees fructify"
- [S: \(v\) dress#16](#), [arrange#5](#), [set#25](#), [do#12](#), [coif#2](#), [coiffe#1](#), [coiffure#1](#) (arrange attractively) "dress my hair for the wedding"

Plus 13 as a noun and 7 senses as an adjective

WordNet: words ()

```
>>> len(list(wn.words()))
147306
>>> list(wn.words())[0]
'.22-caliber'
>>> list(wn.words())[-1]
'zoom_in'
>>> sum([len(wn.synsets(word)) for
        word in wn.words()])
227368
```

```
>>> max = 0; maxword = ""
>>> for word in wn.words():
...     n = len(wn.synsets(word))
...     if n > max:
...         max = n; maxword = word
...
>>> max
75
>>> maxword
'break'
```

word2vec

- Examples (inflectional morphology):

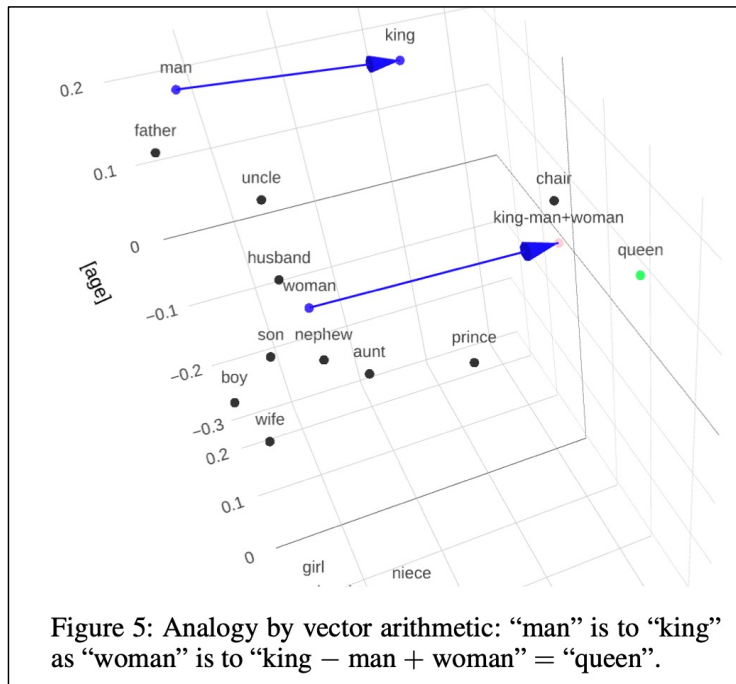
- `model.most_similar(positive=['tables','bicycle'],negative=['bicycles'],topn=3)`
[('table', 0.5977630019187927), ('Tables', 0.520125687122345), ('napkin', 0.4212760031223297)]

- `model.most_similar(positive=['table','geese'],negative=['goose'],topn=3)`
[('tables', 0.5640795826911926), ('Tables', 0.3900391459465027), ('seated', 0.3859478235244751)]

- `model.most_similar(positive=['sheep','geese'],negative=['goose'],topn=3)`
[('cows', 0.6649561524391174), ('cattle', 0.6110979318618774), ('lambs', 0.609976053237915)]

- Let's test a few more?

word2vec



- Semantic dimensions:

- <https://www.cs.cmu.edu/~dst/WordEmbeddingDemo/EAAI-2022-Word-Embedding.pdf>
- given the word “king”, we measure its position along the gender axis by taking the dot product of its embedding vector with a “gender” unit vector.

Gender Dimension		Age Dimension		Royalty Dimension	
man	woman	man	boy	man	king
king	queen	woman	girl	woman	queen
prince	princess	king	prince	boy	prince
husband	wife	queen	princess	girl	princess
father	mother	father	son	woman	duchess
son	daughter	mother	daughter	woman	countess
uncle	aunt	uncle	nephew	woman	baroness
nephew	niece	aunt	niece		
boy	girl				
male	female				

Using WordNet: Example

Event Template Representation

Change of State Verbs:

John mended the *torn/red* dress

mend: x CAUS y BECOME <STATE (*mended*)>

John CAUS the *torn/red* dress BECOME <STATE (*mended*)>

- Antonym relation between adjective and end state

Semantic Opposition: *mend* vs. *tear/torn*

The verb mend has 2 senses (first 2 from tagged texts)

1. (5) repair#1, **mend**#1, fix#1, bushel#1, doctor#3, furbish up#1, restore#4, touch on#3 -- (restore by replacing a part or putting together what is torn or broken; "She repaired her TV set"; "Repair my shoes please")
2. (1) **mend**#2, heal#1 -- (heal or recover; "My broken leg is mending")

The verb tear has 5 senses (first 4 from tagged texts)

1. (19) **tear**#1, rupture#1, snap#2, bust#3 -- (separate or cause to separate abruptly; "The rope snapped"; "tear the paper")
2. (7) **tear**#2 -- (to separate or be separated by force; "planks were in danger of being torn from the crossbars")
3. (2) **tear**#3, shoot#7, shoot down#1, charge#4, buck#3 -- (move quickly and violently; "The car tore down the street"; "He came charging into my office")
4. (1) pluck#5, pull#14, **tear**#4, deplume#2, deplumate#1, displume#2 -- (strip of feathers; "pull a chicken"; "pluck the capon")
5. **tear**#5 -- (fill with tears or shed tears; "Her eyes were tearing")

The adj torn has 2 senses (first 2 from tagged texts)

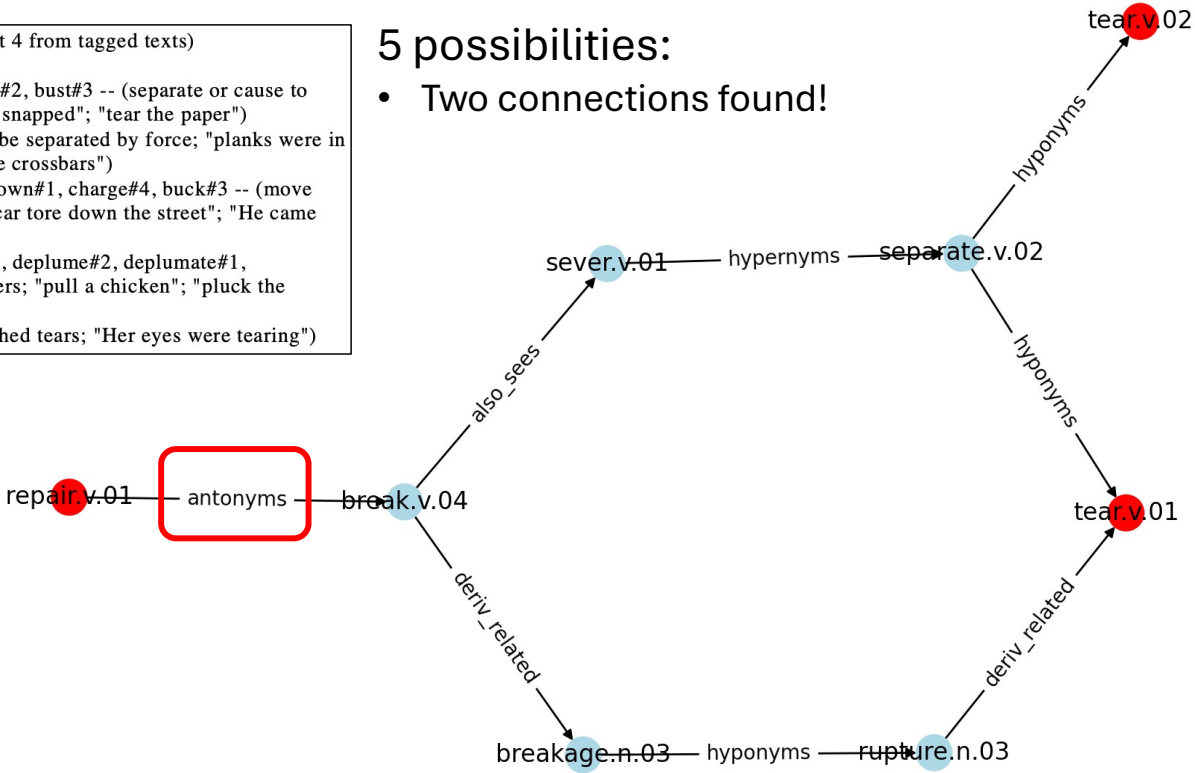
1. (5) lacerate#2, lacerated#2, mangled#1, **torn**#1 -- (having edges that are jagged from injury)
2. (2) **torn**#2 -- (disrupted by the pull of contrary forces; "torn between love and hate"; "torn by conflicting loyalties"; "torn by religious dissensions")

Semantic Opposition: *mend* vs. *tear/torn*

The verb tear has 5 senses (first 4 from tagged texts)

- (19) **tear**#1, rupture#1, snap#2, bust#3 -- (separate or cause to separate abruptly; "The rope snapped"; "tear the paper")
- (7) **tear**#2 -- (to separate or be separated by force; "planks were in danger of being torn from the crossbars")
- (2) **tear**#3, shoot#7, shoot down#1, charge#4, buck#3 -- (move quickly and violently; "The car tore down the street"; "He came charging into my office")
- (1) pluck#5, pull#14, **tear**#4, deplume#2, deplumate#1, displume#2 -- (strip of feathers; "pull a chicken"; "pluck the capon")
- tear**#5 -- (fill with tears or shed tears; "Her eyes were tearing")

5 possibilities:
 • Two connections found!



Semantic Opposition: *mend* vs. *tear/torn*

Do a minimal distance search for a graph connection between two synsets

- using *breadth-first search* (bfs)

```
$ python3 bfs.py mend.v.01 tear.v.01 mend.v.01 tear.v.02
start: mend.v.01 is in synset repair.v.01
end: tear.v.01 is in synset tear.v.01
Found at distance 4 (13614 nodes expanded)
tear.v.01 deriv_related rupture.n.03 hyponyms breakage.n.03
  deriv_related break.v.04 antonyms repair.v.01
Found at distance 4 (13856 nodes expanded)
tear.v.01 hyponyms separate.v.02 hypernyms sever.v.01 also_sees
  break.v.04 antonyms repair.v.01
Search space complete
DiGraph with 7 nodes and 7 edges
start: mend.v.01 is in synset repair.v.01
end: tear.v.02 is in synset tear.v.02
Found at distance 4 (13847 nodes expanded)
tear.v.02 hyponyms separate.v.02 hypernyms sever.v.01 also_sees
  break.v.04 antonyms repair.v.01
```

Search space complete

DiGraph with 8 nodes and 8 edges

```
$ python3 bfs.py mend.v.01 tear.v.03
```

```
start: mend.v.01 is in synset repair.v.01
```

```
end: tear.v.03 is in synset tear.v.03
```

```
Not found (distance 5 and 100175 nodes expanded)
```

```
$ python3 bfs.py mend.v.01 tear.v.04
```

```
start: mend.v.01 is in synset repair.v.01
```

```
end: tear.v.04 is in synset pluck.v.05
```

```
Not found (distance 5 and 100124 nodes expanded)
```

```
$ python3 bfs.py mend.v.01 tear.v.05
```

```
start: mend.v.01 is in synset repair.v.01
```

```
end: tear.v.05 is in synset tear.v.05
```

```
Not found (distance 5 and 100128 nodes expanded)
```

Semantic Opposition: *mend* vs. *tear/torn*

- Cross-category searching is fragile:
 - 4 sub-networks for nouns, verbs, adjectives and adverbs are not well-connected

```
$ python3 bfs.py -m 300000 tear.v.01 torn.a.01 tear.v.02 torn.a.02
```

```
start: tear.v.01 is in synset tear.v.01
```

```
end: torn.a.01 is in synset lacerate.s.02
```

```
Not found (distance 6 and 300098 nodes expanded)
```

```
start: tear.v.02 is in synset tear.v.02
```

```
end: torn.a.02 is in synset torn.s.02
```




```
Not found (distance 6 and 300017 nodes expanded)
```

Semantic Opposition and ChatGPT

SA

John mended the torn dress. Is the dress torn?






Based on the given sentence "John mended the torn dress," it can be inferred that the dress was torn at some point in time, but it has been mended by John. Therefore, as of now, the dress is not torn anymore.   

SA

John mended the red dress. Is the dress red?



Yes, the dress is red. The sentence "John mended the red dress" implies that the dress in question is red.   

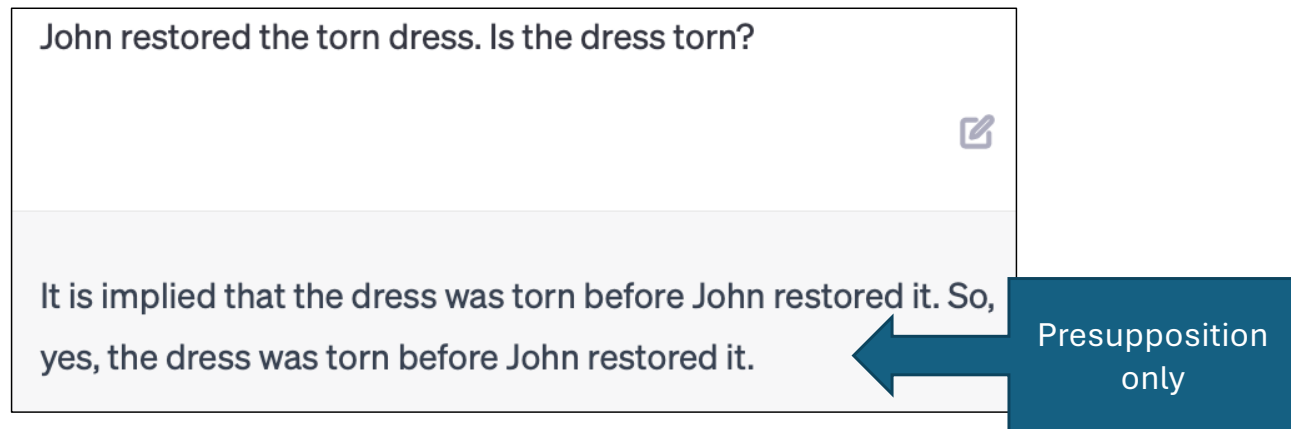
Semantic Opposition and ChatGPT

- Synset: {*repair, fix, restore, mend, ...* }

John restored the torn dress. Is the dress torn?

It is implied that the dress was torn before John restored it. So, yes, the dress was torn before John restored it.

Presupposition only

The diagram illustrates a semantic presupposition. It shows a question: "John restored the torn dress. Is the dress torn?" followed by an answer: "It is implied that the dress was torn before John restored it. So, yes, the dress was torn before John restored it." A blue callout box on the right, labeled "Presupposition only", has an arrow pointing to the answer text, specifically highlighting the phrase "the dress was torn before John restored it".

Semantic Opposition and ChatGPT

- Synset: {*repair*, *fix*, *restore*, *mend*, ... }

The image shows two screenshots of a ChatGPT interface. The top screenshot shows a user asking "John fixed the torn dress. Is the dress torn?" and ChatGPT responding "It can be inferred that the dress was torn before John fixed it." A blue arrow points from a box labeled "Presupposition only" to this response. The bottom screenshot shows a user asking "John repaired the torn dress. Is the dress torn?" and ChatGPT responding "The given sentence, 'John repaired the torn dress,' implies that the dress was torn before John repaired it. Therefore, the dress was torn, but it is not torn anymore after John repaired it." Both screenshots include a small 'SA' icon in the top left of the user's message box and the OpenAI logo in the top left of the assistant's response box. The bottom screenshot also includes a copy icon and thumbs up/down icons in the top right of the response box.

SA John fixed the torn dress. Is the dress torn?

It can be inferred that the dress was torn before John fixed it.

Presupposition only

SA John repaired the torn dress. Is the dress torn?

The given sentence, "John repaired the torn dress," implies that the dress was torn before John repaired it. Therefore, the dress was torn, but it is not torn anymore after John repaired it.

Semantic Opposition: *clean* vs. *dirty*

Mary cleaned the <i>dirty</i> table	Change of State
The waiter filled every <i>empty</i> glass	
Mary fixed the <i>flat</i> tire	
Bill swept the <i>dirty</i> floor	Activity
Bill swept the <i>dirty</i> floor clean	Accomplishment

resultative

The verb clean has 10 senses (first 4 from tagged texts)

1. (16) **clean**#1, make clean#1 -- (make clean by removing dirt, filth, or unwanted substances from; "Clean the stove!"; "The dentist cleaned my teeth")
2. (3) **clean**#2, pick#6 -- (remove unwanted substances from, such as feathers or pits; "Clean the turkey")
3. (2) houseclean#1, clean house#1, **clean**#3 -- (clean and tidy up the house; "She housecleans every week")
4. (1) cleanse#1, **clean**#4 -- (clean one's body or parts thereof, as by washing; "clean up before you see your grandparents"; "clean your fingernails before dinner")
5. **clean**#5 -- (be cleanable; "This stove cleans easily")
6. **clean**#6 -- (deprive wholly of money in a gambling game, robbery, etc.; "The other players cleaned him completely")
7. **clean**#7, strip#7 -- (remove all contents or possession from, or empty completely; "The boys cleaned the sandwich platters"; "The trees were cleaned of apples by the storm")
8. **clean**#8 -- (remove while making clean; "Clean the spots off the rug")
9. scavenge#4, **clean**#9 -- (remove unwanted substances from)
10. **clean**#10 -- (remove shells or husks from; "clean grain before milling it")


More examples

- *Event-based Models of Change and Persistence in Language* (Pustejovsky, 2000).
- Adapted examples:
 1. The waiter filled every empty glass
 2. Mary fixed the flat tire
 3. Mary fixed the leaky tire
 4. John comforted the crying child
 5. John rescued the drowning man
 6. The nurse mixed the powdered milk
- Which ones work?
- Can you think of others?

Semantic Opposition

- Other accomplishment verbs:
 - The waiter filled the *empty* glass
 - Mary fixed the *flat* tire

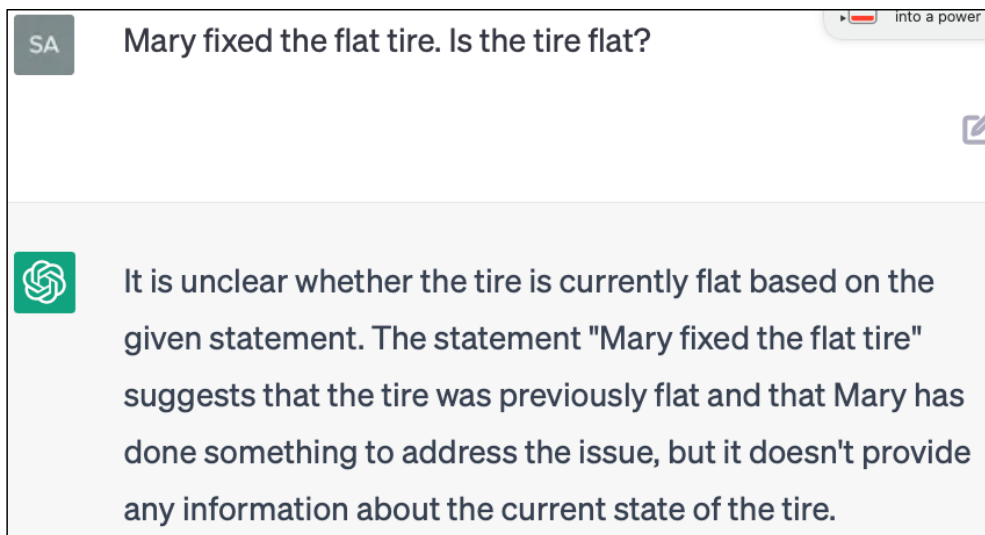
SA The waiter filled the empty glass. Is the glass empty?

 Based solely on the information given in the sentence, it can be inferred that the glass was empty before the waiter filled it.

Presupposition
only

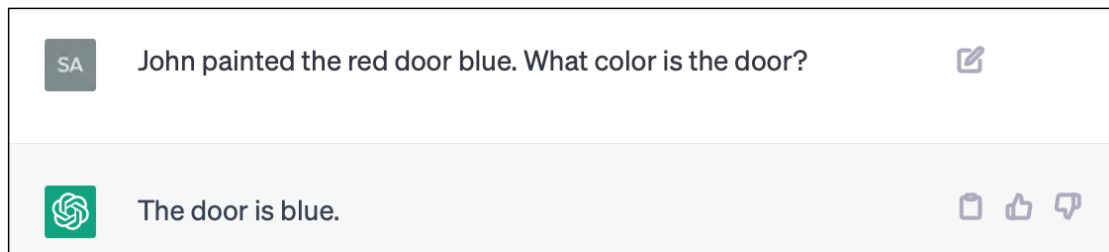
Semantic Opposition and ChatGPT

- Other accomplishment verbs:
 - The waiter filled the *empty* glass
 - Mary fixed the *flat* tire









Semantic Opposition and ChatGPT

- Activity verbs and resultatives:
 - John painted the *red* door *blue*
 - John swept the *dirty* floor
 - John swept the *dirty* floor *clean*



Semantic Opposition and ChatGPT

- Activity verbs and resultatives:
 - John swept the *dirty* floor
 - John swept the *dirty* floor *clean*

<p>SA John swept the dirty floor. Is the floor dirty?</p>	<p>SA John swept the dirty floor clean. Is the floor dirty?</p> 
<p> Yes, based on the given statement, the floor is dirty. The statement "John swept the dirty floor" suggests that the floor was dirty and John took action to clean it.</p>	<p> Yes, according to the sentence "John swept the dirty floor clean", it is implied that the floor was dirty before John swept it clean.</p>
<p>  </p>	

