6.863J Natural Language Processing
Lecture 15: Word semantics – Working with Wordnet

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The Menu Bar

- Administrivia:
- Lab 4 due April 9 (Weds.);
  - Start w/ final projects, unless there are objections
- *Agenda:*
- Working with Wordnet
  - What's Wordnet
  - What can we do with it?
  - Solving *some* reasoning problems:
  - Mending a torn dress
  - Enjoying a movie; What's a shelf?
  - Implementing EVCA and Wordnet together

Wordnet motivation

But people have persistent problem. When they look up a word, especially a commonly used word, they often find a dozen or more different meanings. What the dictionary does not make clear are the contexts in which each of these different meanings would be understood. So we know what kind of information is required, but we have not yet learned how to provide it to a computer.

(G. Miller, U.S./Japan Joint Workshop on Electronic Dictionaries and Language Technologies January 23--25, 1993.)

What's Wordnet?

- Psychological motivation
- Nouns, verbs, adjectives organized into (fairly) distinct networks of
- Synonym Sets (synsets)
- Each synset = 1 concept
- Supposedly intersubstitutable within synset ("synonomy")

Practical motivation

- What's not in a dictionary?
- Take example, like *tree* – "large, woody perennial plant with a distinct trunk"
- What info is missing?

Psychological motivation

- Why these categories?
- Words association: first word thought of drawn from difft syntactic categories
- Modal response – same as probe: noun probes elicit nouns 79% of the time; verbs, v's, 43%; adjs, adjs 65%
- Not just contiguity (since that fails)
- "Middle level" descriptions for nouns

Psychological motivation

- Where do categories come from??
- How do we ‘carve up’ nature at its joints?

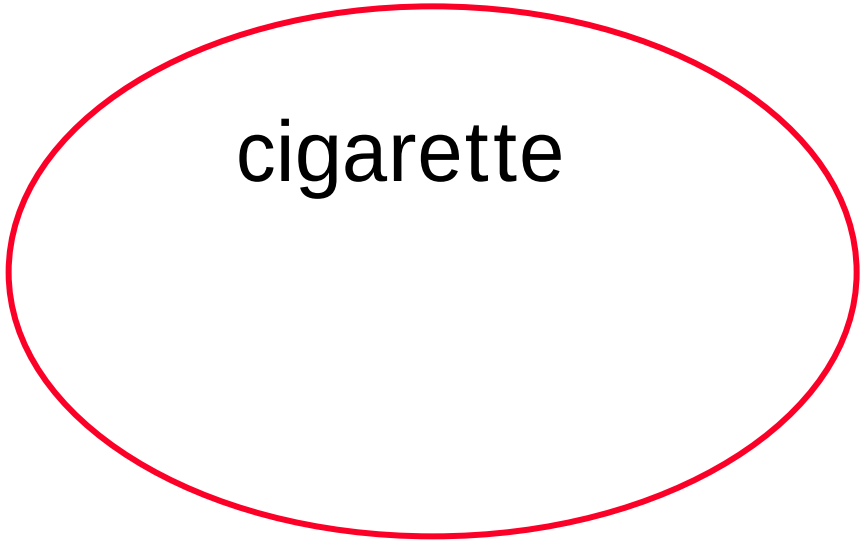
Synonomy

- Two entries synonyms if the can be substituted in some context
- set of synonyms= Synset
  - {chump, fish, fool, gull, mark, patsy, fall guy, sucker, schlemiel, shlemiel, soft touch, mug}
  - “easy to take advantage of”
  - A concept that has been lexicalized

Basic stats

POS	Unique Strings	Synsets	Word-Sense Pairs
Noun	109195	75804	134716
Verb	11088	13214	24169
Adjective	21460	18576	31184
Adverb	4607	3629	5748
Totals	146350	111223	195817

Example synset



U do it

smoke

Add relations... then stir

- Concepts related through (possibly iterated) applications of basic relation:
  1. Is-a relation (Hypernym): from concept to superordinate (denoted $\rightarrow$)

     e.g., breakfast $\rightarrow$ meal

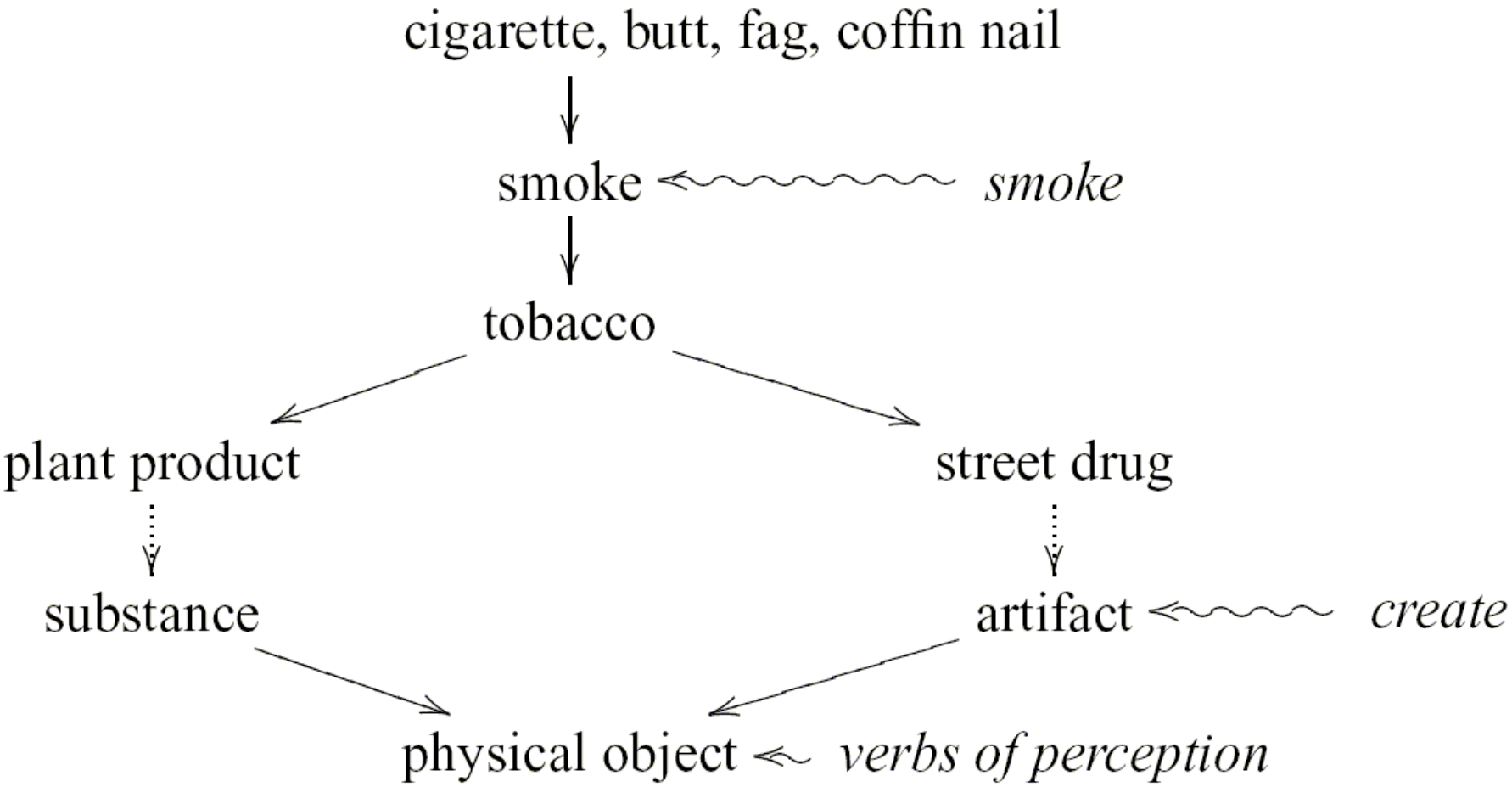
     This is unidirectional
  2. Meronymy (“part of”)
  3. Antonymy (opposite)

Note: multiple inheritance;

No unique ‘top’ concept: *dirt* has top concept *entity*; while *gossip* has *act*

Is-a merges function/nonfunctional *isa* relations

Wordnet relations



Wordnet Relations

X hyp Y	Y hypernym of X	x-repair, y-improve
X ent Y	X entails Y	x-breathe, y-inhale
X sim Y	(adj) Y similar X	x-achromatic, y-white
X cs Y	Y is a cause of X	x-anesthetize, y-sleep
X vgp Y	(verbs) Y similar X	x-behave, y-pretend
X ant Y	X, Y antonyms	x-present, y-absent
X sa Y	X, see also Y	x-breathe, y-breathe out
X ppl Y	X participle of Y	x-applied, y,apply
X per y	X pertains to Y	x-abaxial, y-axial

Noun relations

Relation	Definition	Example
Hypernym	From concepts to superordinates	*breakfast* → *meal*
Hyponym	From concepts to subtypes	*meal* → *lunch*
Has-Member	From groups to their members	*faculty* → *professor*
Member-Of	From members to their groups	*copilot* → *crew*
Has-Part	From wholes to parts	*table* → *leg*
Part-Of	From parts to wholes	*course* → *meal*
Antonym	Opposites	*leader* → *follower*

Verb relations

Relation	Definition	Example
Hypernym	From events to superordinate events	*fly* $\rightarrow$ *travel*
Troponym	From events to their subtypes	*walk* $\rightarrow$ *stroll*
Entails	From events to the events they entail	*snore* $\rightarrow$ *sleep*
Antonym	Opposites	*increase* $\Longleftrightarrow$ *decrease*

Wordnet: why?

- Can draw inferences about some events
- We'll give 3 case studies...

- Consider first:
  1. Susan mended the *torn* dress
  2. Susan mended the *red* dress

- *Mend* refers to some action, resulting in a change of state for direct objects

The inferential questions

- For 1: After the dress is mended, is it still torn?
- For 2: After the dress is mended, is it still red?
- Call this ‘semantic opposition’, e.g.:
  - The woman on the boat jumped into the river
  - The prisoner escaped from prison

“event template” idea doesn’t help

- [x cause [become [y <mended>]]]

And more examples

- The plumber fixed every leaky faucet
- The plumber fixed every blue faucet
- Mary fixed the flat tire
- The mother comforted the crying child
- John painted the white house blue
- Mary rescued the drowning man

These are all examples of the famous...

Frame Problem in AI!

- Which things remain the same in a changing world?
- McCarthy and Hayes “Some Philosophical Problems from the Standpoint of Artificial Intelligence, (1969).(Machine Intelligence 4, 463-502)
- “except for things explicitly known to change, everything else remains the same”

Yet other examples

- Not just change of state verbs:
  - John brushed the dirty carpet
  - John brushed the dirty carpet clean
- (seep, wipe, broom, paint,...)

Wordnet solution

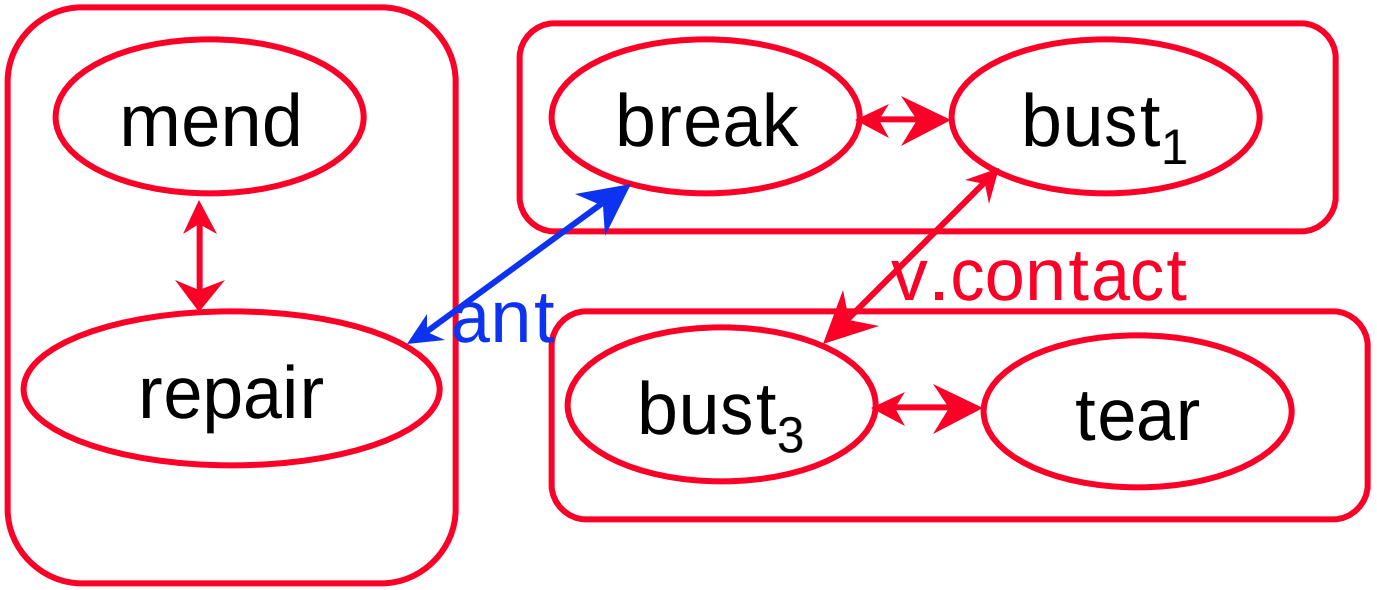
- Use transitivity of hypernym relation
- Given adjective & change of state verb:
  - Compute shortest path between them in Wordnet
  - If antonym exists on the path, then *cancel* the adjective
  - Otherwise, the adjective still prevails
- A test of transitivity, and Wordnet

Example

- mend vs. tear

- *Repair* is in same synset
- *Break* and *bust#1* are in same synset
- *Bust#1* and *Bust#3* both verbs of contact
- *Bust#3* in same synset as *tear*
- So chain looks like this:

This path or bust



Len=5

Can’t get there from here

- 5 other ways (longer chains) between *mend* and *tear* (one w/o antonym):
  1. Mend and fix in same synset
  2. Fix1 and Fix3 in synsets related by verb change
  3. Fix3 is an instance of attach
  4. Attach1 and attach3 in synsets related by verb contact
  5. Attach3 instance of touch
  6. Touch1 and touch3 in synsets related by verb contact
  7. Touch see also touch down
  8. Touch down instance of land
  9. Land and shoot down in same synset
  10. Shoot down1 and shoot down2 in synsets related by verb of motion
  11. Shoot down2 and tear in same synset

OK, how does this work?

- Do BFS on nodes - unidirectional
- Bi-directional would work even better
- 11 test examples 9 work, 2 don’t

Mary rescued...

Parsing: Mary rescued the drowning man
drown/v (200329171,1)
instance of eliminate/v (200328742,1)
instance of destroy/v (201114042,1)
instance of unmake/v (201113462,1)
and make/v (201113245,2) are antonyms
and make/v (201185771,4) in synsets related by verb.creation
instance of direct/v (201661432,1)
instance of deal/v (201658906,2)
and deal/v (201619807,1) in synsets related by verb.social
instance of deport/v (201716569,4)
and deport/v (201706176,3) in synsets related by verb.social
and deliver/v (201706176,2) in same synset
and deliver/v (201739567,2) in synsets related by verb.social
and rescue/v (201739567,1) in same synset

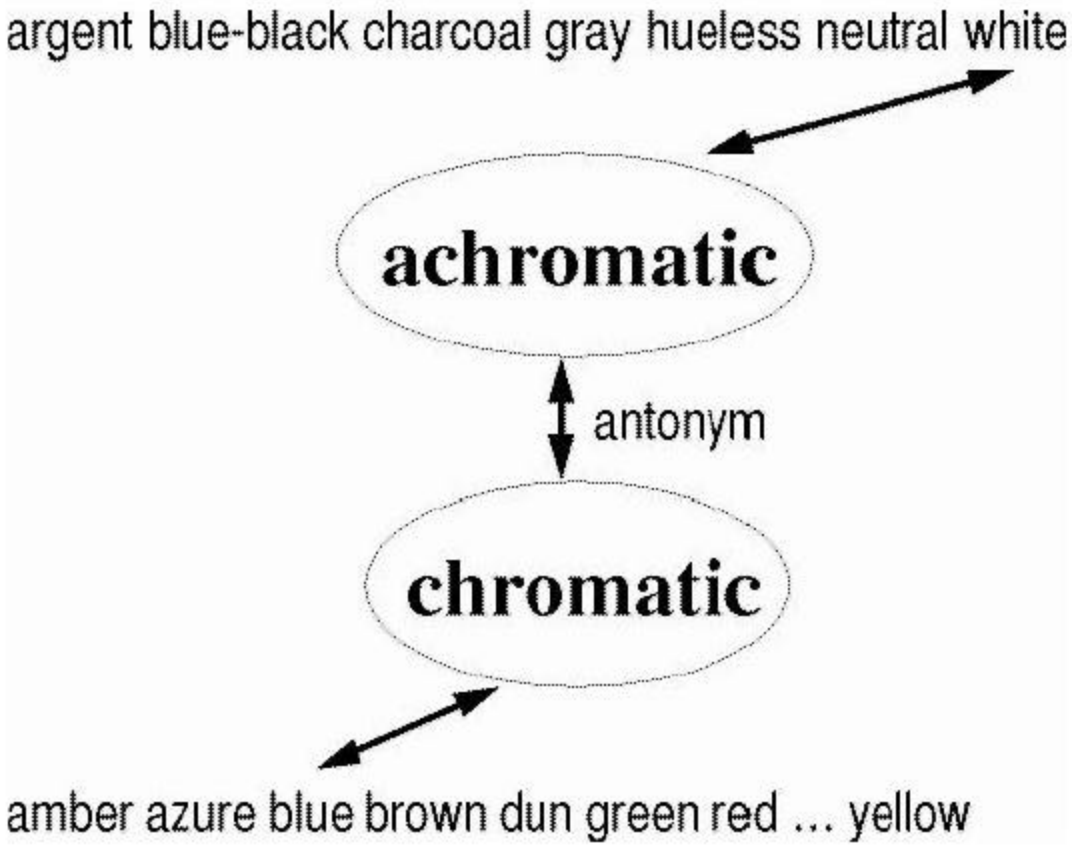
Test cases

Pair	Chain len	Semantic opposition	Search size
mend-tear	5	Yes	1261
mend-red	-	No	11974
fix-leaky	5	Yes	12167
fix-blue	11	No	14553
fix-flat	-	No	12286
mix-powdered	6	Yes	11931
comfort-crying	9	Yes	11359
blue-white	-	No	24431
rescue-drowning	13	Yes	9142
clean-dirty	1	Yes	61
fill-empty	1	Yes	48

Why the failures - analysis

- Can we reduce length threshold below 11? No...
- Why does the color system fail?

Color system in Wordnet



1. *white* and *achromatic* (300367747,2) in same synset
2. *achromatic* (300364634,1) and *chromatic* (300355823,1) are antonyms
3. *chromatic* (300355823,1) and *blue* are similar

Wordnet defects for semantic inference

- Shortest path/threshold only work if length of chain inversely correlated with reliability
- Semantic opposition not always encoded – how to do this?

Application 2: logical metonomy: telic (functional/purposive) roles distinguished

- What's that?

(1) a. John began the novel (*reading/writing*)
b. The author began the unfinished novel back in 1962 (*writing*)

- *Begin* can have Agent role, for the writer, or it can be a Telic role (function), for the reader
- Problem is how to define 'context' here

Application 2: Metonomy

- John began the novel (reading/writing)
- Context can alter: He realy enjoyed your book (reading)
- My dog eats anything
- He really enjoyed your book (eating)

- !John enjoyed the rock
- !! John enjoyed the door

Using Wordnet here

- Wordnet can pick out contexts in which NPs represent events, relative to classes (types)

- Point is: locus of variation is not lexical structure, but in more general ontology (we shall return to this point later)

‘Enjoy’ has lots of purposes...

a. Mary enjoyed *seeing* the garden
b. Mary enjoyed *inspecting* the garden
c. Mary enjoyed *visiting* the garden
d. Mary enjoyed *strolling* through the garden
e. Mary enjoyed *rollerblading* in the garden
f. Mary enjoyed *sitting* in the garden
g. Mary enjoyed *dozing* in the garden

How can we recover these – distinguish between agent and telic (function) roles?

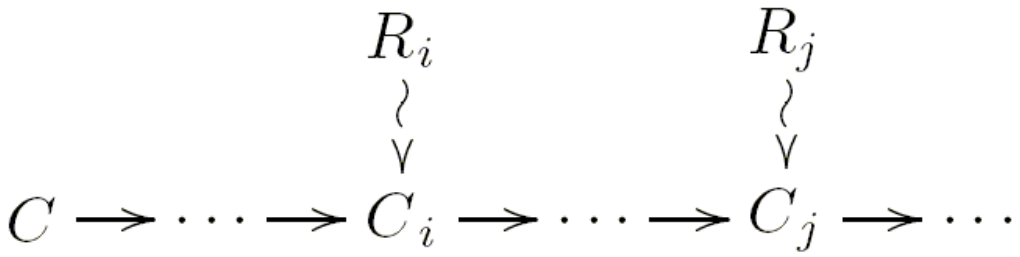
Context can be subtle

- He really enjoyed your book (reading)

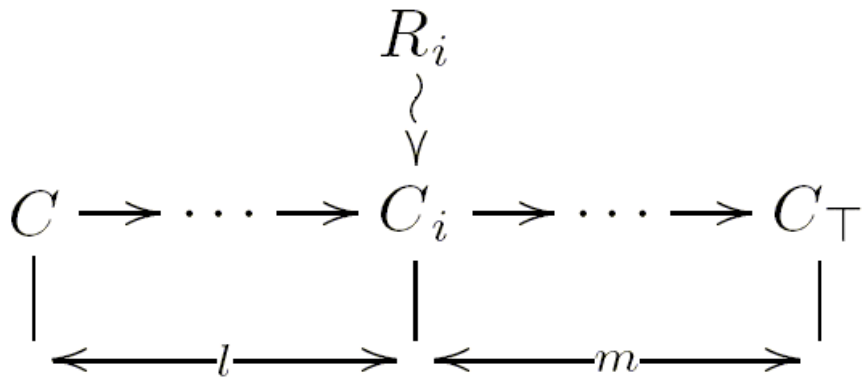
- My dog eats anything
- He really enjoyed your book (eating)

2 contextual function search rules using Wordnet

Principle of Specificity: Prefer R_i to R_j in the sequence



Principle of Locality: Plausibility of R_i scales with m and inversely with l in



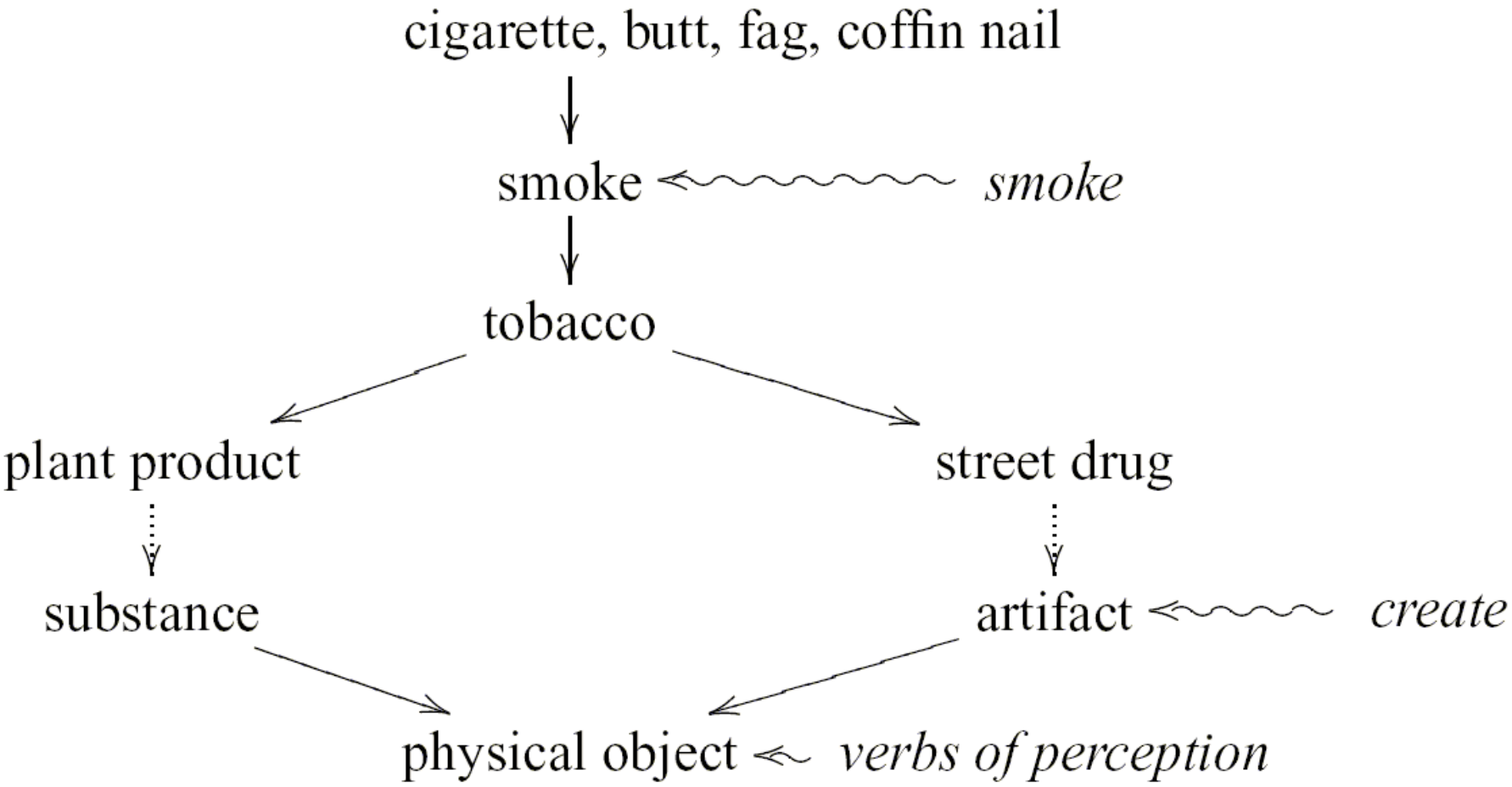
Test verb

a. EXP enjoy NP

b. EXP_i enjoy [PRO_i [V(ing) NP]]

Mary enjoyed the cigarette (*smoking*)

Wordnet


cigarette, butt, fag, coffin nail
smoke
smoke
tobacco
plant product
street drug
substance
artifact
create
physical object
verbs of perception

Check

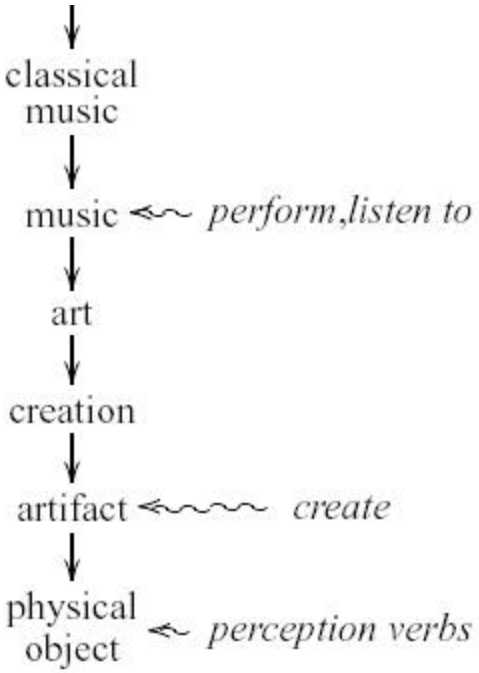
Mary enjoyed the cigarette (*smoking*)

Given the hypernym hierarchy in (13), *smoke*(PRO,*cigarette*) is the strongly preferred interpretation since the concept *smoke* is highly specific (l small) and distant from general concepts *artifact* and *physical object* (m large).

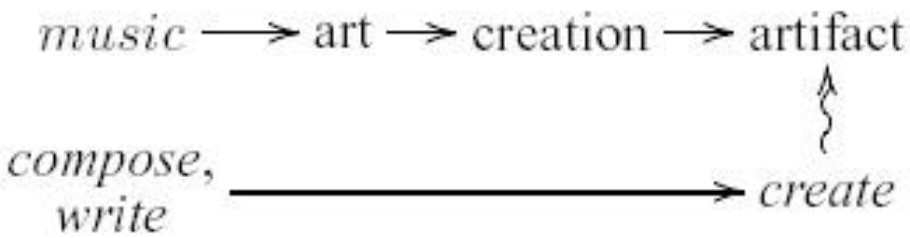
Links for sonata

a. Mary enjoyed the sonata (*listening to*/*playing*)

b. Mary began the sonata (*playing*/*composing*)

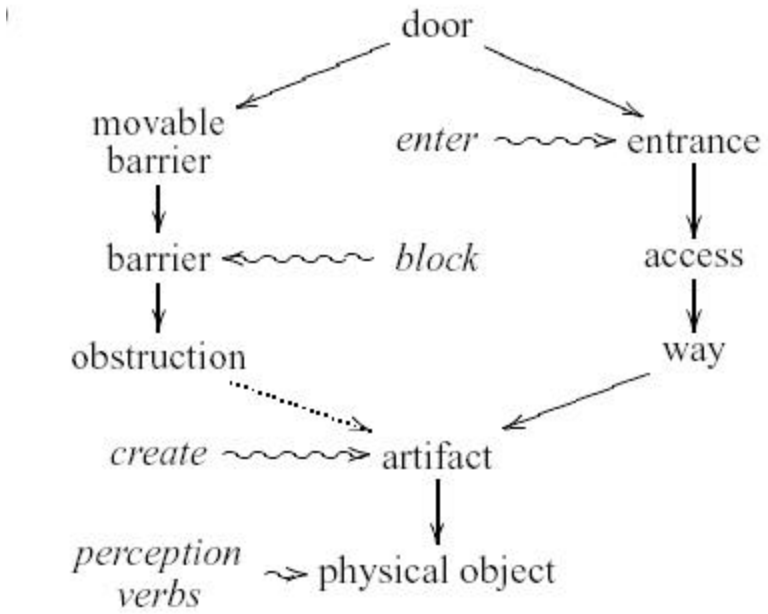


For *begin*



Door…

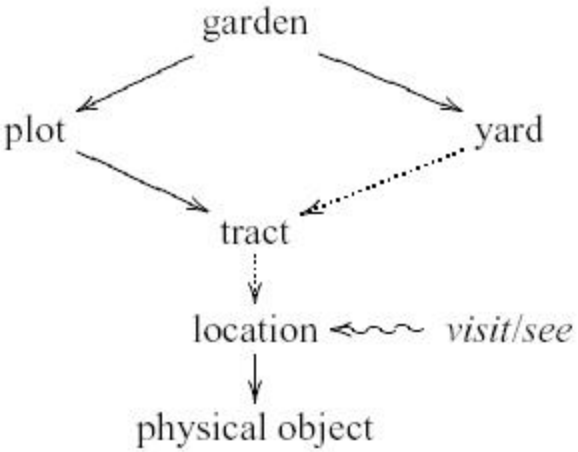
!!John enjoyed the door



Specifically, a door can function both as an entrance (*enter*) and a barrier (*block*) to an enclosure. However, the telic verb *block* has form *block*(*door*,ENCLOSURE), which is incompatible with the prototype *V*(PRO,*door*), thus ruling out *block*. Similar reasoning applies to *enter*(PRO,ENCLOSURE). At the other end of the hierarchy, the canonical events associated with *physical object* are predicted to be implausible (l large, m small).

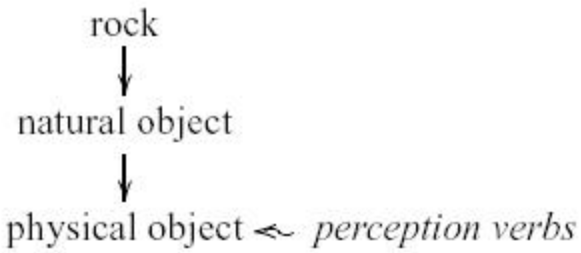
Enjoy Garden

Mary enjoyed the garden (*seeing/visiting*)



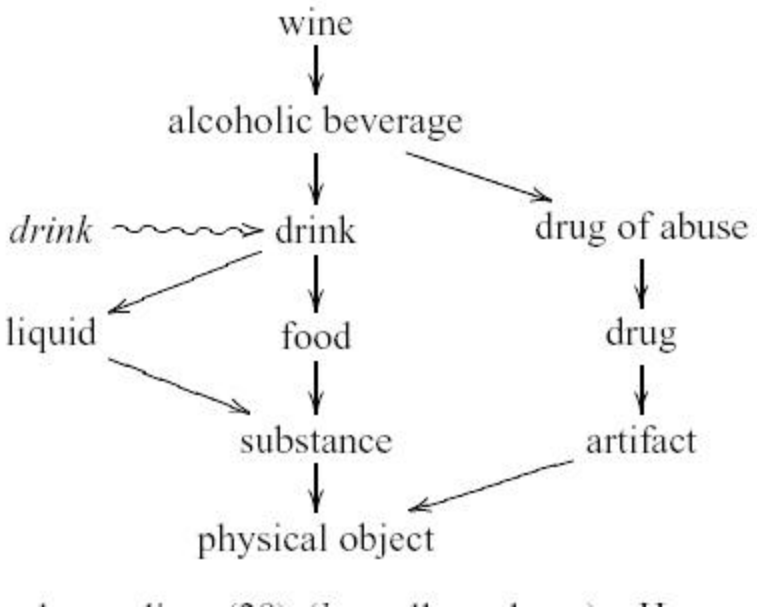
Enjoy rock

!John enjoyed the rock



Enjoy wine

Mary enjoyed the wine (*drinking*)

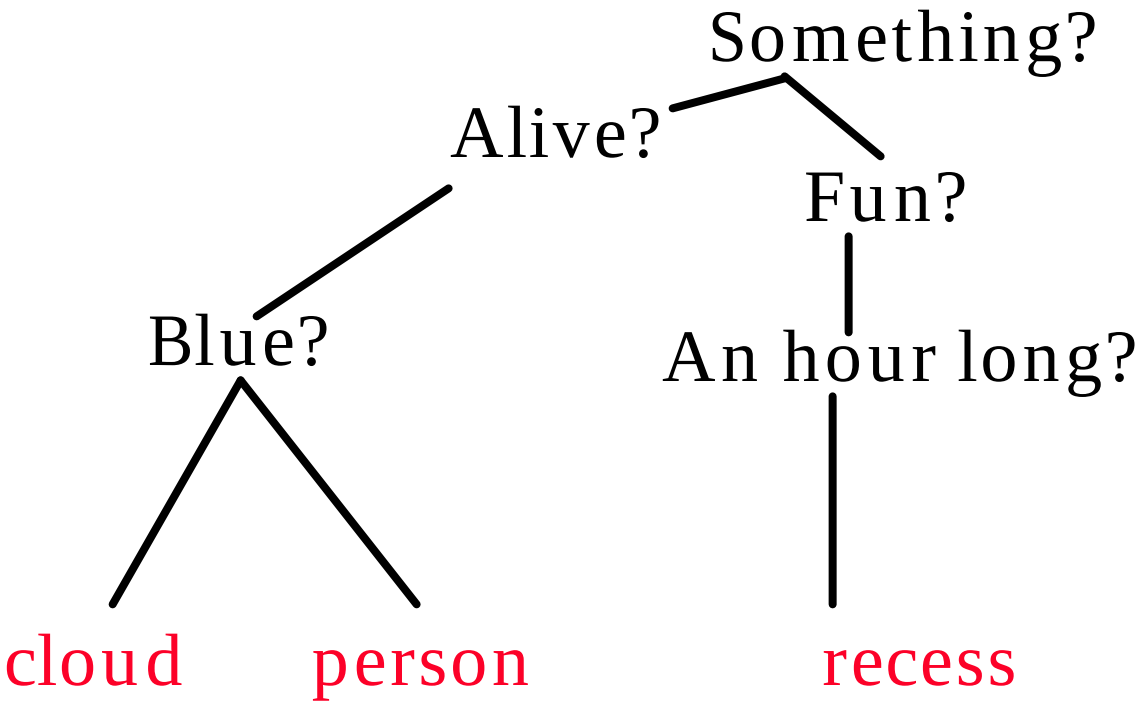


Where do classes come from?

What's a natural word?

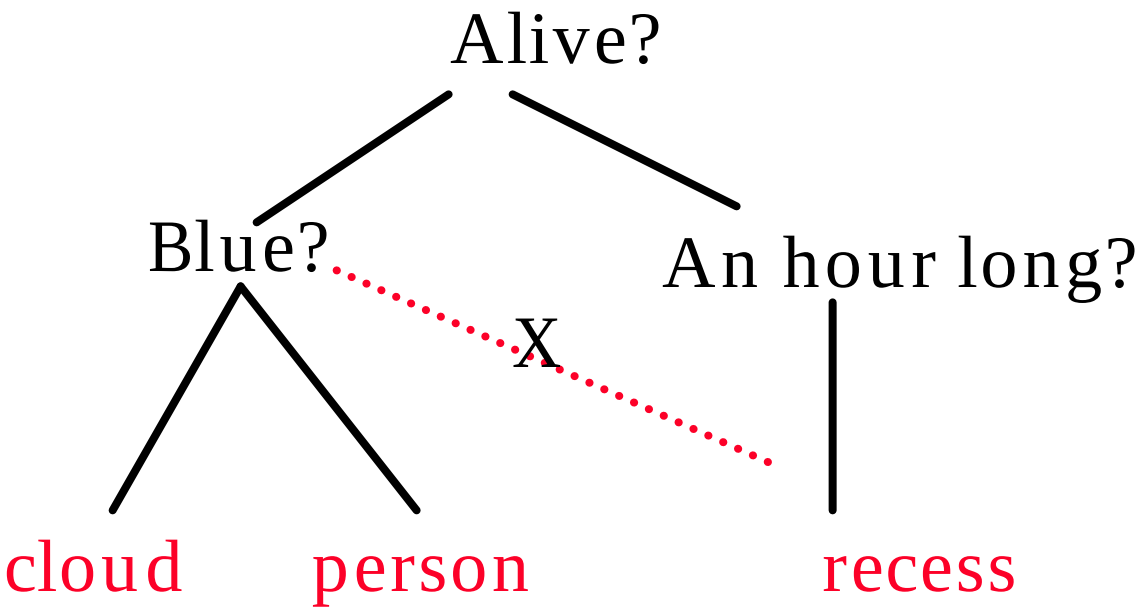
- NO: NALL = 'not all'
- NO: green and an hour long
- Nonconstituent: John ate pizza and Mary, bread = "Mary bread"

A tree grows in Brooklyn



These are the ‘natural classes’

Keil's predicability tree and conceptual 'naturalness'



Bleaching – noun meaning bleached

a. John boxed the present
b. John PUT the present IN a <BOX>
c. John boxed the present in a gift box
d. # John boxed the present in a brown paper bag

a. Mary buttered the piece of toast
b. Mary PUT <BUTTER> ON the piece of toast
c. Mary buttered the toast with margarine/unsalted butter
d. # Mary buttered the toast with marmalade/onions

More examples

a. Peter shelved a book
b. Peter shelved a book on the windowsill/mantelpiece/table/stand
c. # Peter shelved a book on the ball/spike/ceiling/floor/balcony

a. Sue breaded the fish
b. Sue breaded the fish with breadcrumbs/shredded coconut/crushed almonds
c. # Sue breaded the fish with marmalade/butter/treacle/ice

a. x PUT y ON <SHELF>
b. x PUT y ON z & shelf-like-object(z)

a. # x PUT <BREAD> ON y
b. x PUT crumbs of <BREAD> ON y
c. x PUT crumbs of z ON y

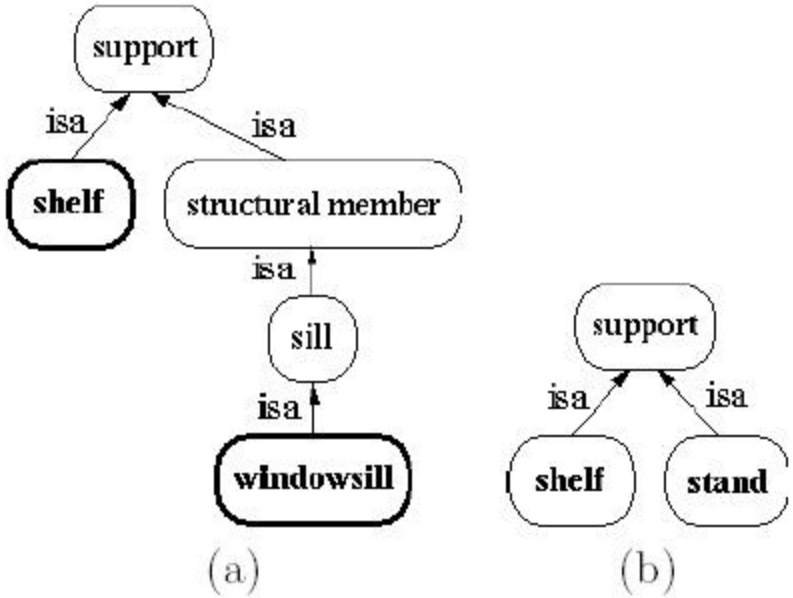
Wordnet hypothesis

Denominal root Y may be bleached using X if

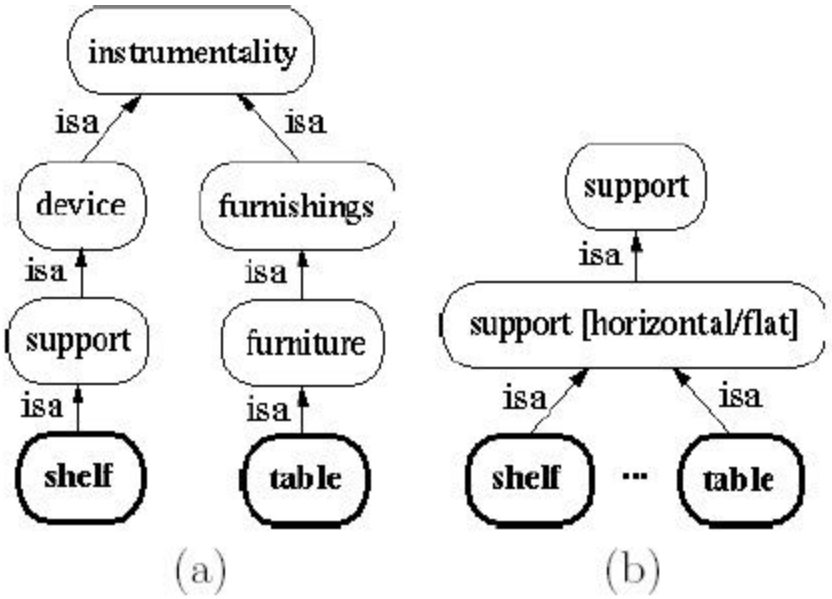
a. X is a hyponym* of Y, or

b. Z is a functional hypernym+ of Y, and X is a hyponym+ of Z

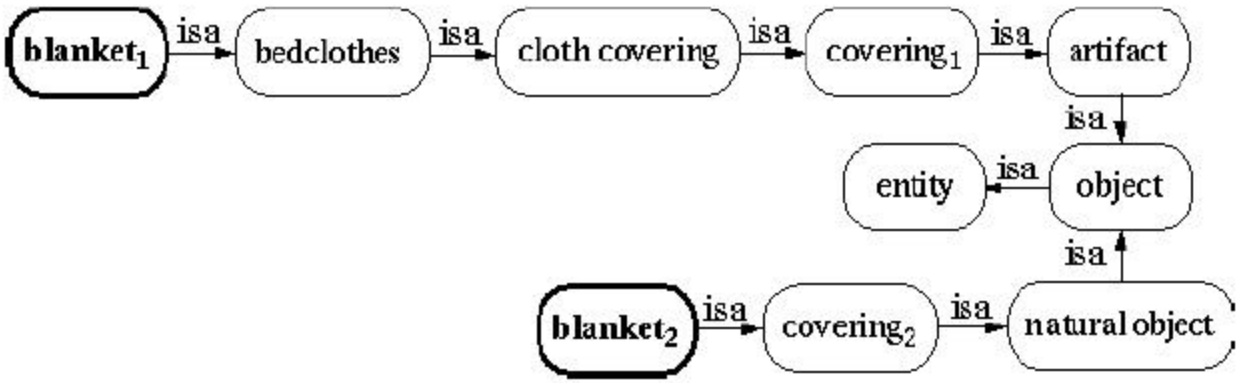
Path from shelf to windowsill



More about shelf



Blanket

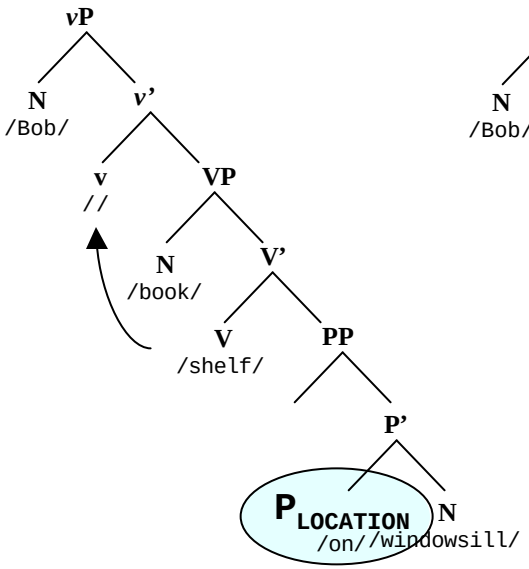

blanket1
isa
bedclothes
isa
cloth covering
isa
covering1
isa
artifact
isa
entity
isa
object
isa
blanket2
isa
covering2
isa
natural object

What information is in the lexicon?

/shelf/ vs. /put/ vs. /butter/

/shelf/

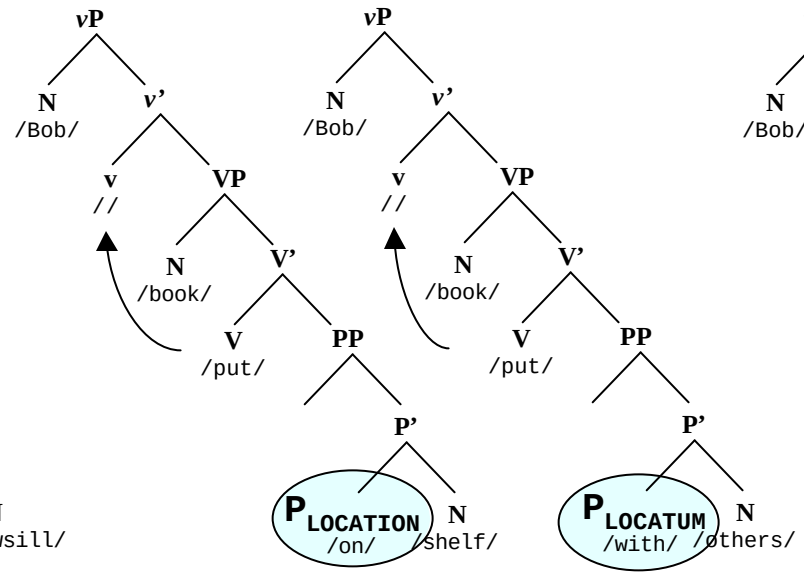
Bob shelved the book on the windowsill.



/put/

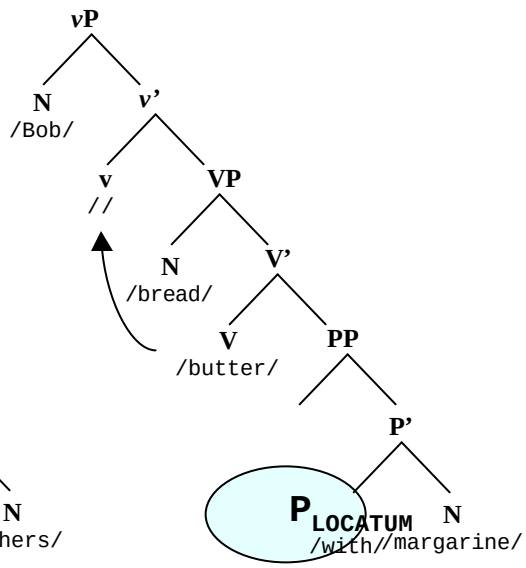
Bob put the book on the shelf.

Bob put the book with the others.



/butter/

He buttered the bread with margarine.



/put/, /shelf/ imposes $\mathbf{p}_{\mathbf{LOCATION}}$ on arguments

/put/, /butter/ imposes $\mathbf{p}_{\mathbf{LOCATUM}}$ on arguments

Hypothesis 1: Lexicon Contains Selection Criteria

/shelf/ has $\mathbf{p}_{\mathbf{LOCATION}}$ *selection* in lexicon (=$\mathbf{p}_{\mathbf{LOCATION}}$ =**d(et) V**)

Also: /shelf/ is $\mathbf{n}_{\mathbf{LOCATION}}$

/butter/ has $\mathbf{p}_{\mathbf{LOCATUM}}$ *selection* in lexicon (=$\mathbf{p}_{\mathbf{LOCATUM}}$ =**d(et) V**)

Also: /butter/ is $\mathbf{n}_{\mathbf{LOCATUM}}$

So then the Lexicon cannot derive:

* 1. Bob shelved the windowsill with the book.
* 2. Bob buttered the margarine onto the bread.

Information about butter and shelf – where is it located?

Hypothesis 1 Problem

Problem: How does Lexicon acquire the following:

/shelf/	$n_{LOCATION}$	$=p_{LOCATION}$ =d V
/butter/	$n_{LOCATUM}$	$=p_{LOCATUM}$ =d V
/shovel/	$n_{INST-MOT}$	$=p_{INST-MOT}$ $=p_{LOCATION}$ =d V
/pencil/	$n_{INST-IMP}$	$=p_{INST-IMP}$ $=p_{LOCATION}$ =d V
/mop/	$n_{INST-REMOVAL}$	$=p_{INST-REMOVAL}$ $=p_{SOURCE}$ =d V
/email/	$n_{INST-COMM}$	$=p_{INST-COMM}$ $=p_{HAVE}$ =d V $=p_{INST-COMM}$ $=p_{DEST}$ =d V
etc.		

Solution 1: Solve the above problem

Solution 2: Push problem OUT of Lexicon and INTO Encyclopedia

Solution 2: Push problem OUT of Lexicon and INTO Encyclopedia

Encyclopedia, not lexicon, is *source* of 'Oddness' of:

(1) Bob shelved the windowsill with the book.

(2) Bob buttered the margarine onto the bread.

Lexicon is NOT:

/shelf/ =p$_{LOCATION}$ =d(et) V **/butter/ =d +k p$_{LOCATUM}$**

/into/ =d +case p$_{LOCATION}$ **/with/ =d +case p$_{LOCATUM}$**

But instead:

/shelf/ =p =d V **/butter/ =d +case p**

/into/ =d +case p **/with/ =d +case p**

Thus insofar as the lexicon is concerned,

(1) and (2) are GRAMMATICAL.

Encyclopedia vs. Lexicon

Lexicon does NOT hold real-world knowledge, only:

ROOT	Lexicon	Examples
arrive	+v, +DP, –cause	John arrived. The arrival of John
big	–v, +DP	The big X.
open	±v, +DP, ±cause	John opened X. X opened.
destroy	+v, +DP, +cause	John destroyed X. John's destruction of X.
grow	+v, +DP, ±cause	Tomatoes grew. John grew tomatoes. John's growth of tomatoes.

Encyclopedia holds knowledge 'rejecting' the following GRAMMATICAL sentences:

John thought the book to Mary
John's growth of tomatoes
Sue walked in an hour
Bob shelved the windowsill with the book.
Bob buttered the margarine onto the bread.

2 Language Acquisition Problems: Lexicon vs Encyclopedia

ROOT	LEXICON ENTRIES
/shelf/	n, =p =d V_{+cause}
/butter/	n, = =d V_{+cause}
/into/	=d +k p
/with/	=d +k p

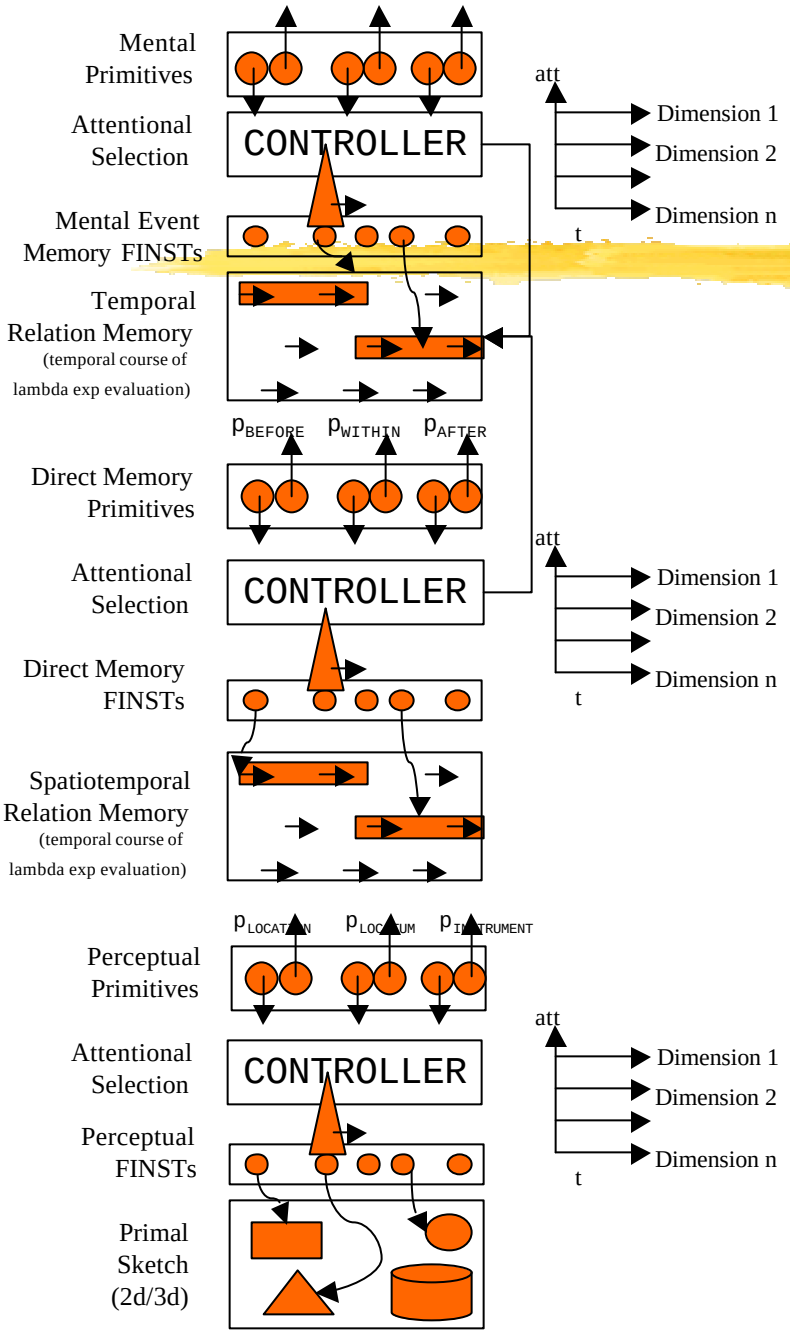
LEXICON ACQUISITION:

How do LEXICAL roots get assigned to feature set?

ROOT		ENCYCLOPEDIA ENTRIES
/shelf/		$n_{LOCATION}$, $=p_{LOCATION}$ =d V
/butter/		$n_{LOCATUM}$, $=p_{LOCATUM}$ =d V
/into/		=d +k $p_{LOCATION}$
/with/		=d +k $p_{LOCATUM}$

ENCYCLOPEDIA ACQUISITION:

How do ENCYCLOPEDIA roots get assigned to feature set?



Distributed Semantics

Encyclopedic roots distributed *everywhere* in mental architecture. Lexicon roots are convenient *abstractions* for encyclopedic roots so syntax operates autonomously:

- v -subj, +comp p +subj, +comp
- n -subj, -comp a +subj, -comp

`/x/` meaning X is placeholder for experiences of X. What 'experiences' of X are requires theorizing about attention, iconic bottlenecks, etc.

`/butter/` is understood as plocatum and nlocatum because BUTTER memories contain a relatively higher frequency of plocatum over plocation primitives activated. `/shelf/` is the opposite.

When `/x/` has "two entries", there is a bimodal distribution of utterances associated with two primitives firing, neither more 'defining' or 'core' than the other. Try /color/, /open/, /ache/, /see/, /look/, /remember/, /forget/, /think/.

Interface conditions of encyclopedia to roots to these modules

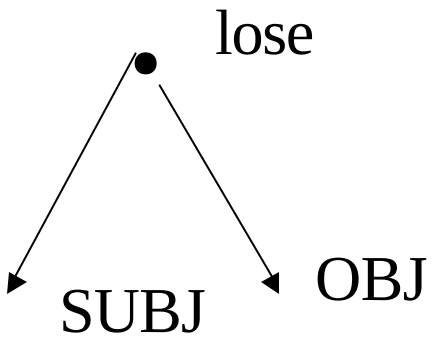
Predicate-arguments to thematic roles

- Use *linking rules*
- These say whether, e.g, Subject is the agent...
- Is there a theory for this?
- How do we build this knowledge?

Predicate-argument structures for *lose*

lose1 (*Agent*: animate,
Patient: physical-object)

lose2 (*Agent*: animate,
Patient: competition)



Agent <=> subj
Patient <=> obj

Machine Translation Lexical Choice- Word Sense Disambiguation

Iraq lost the battle.

Ilakuka centwey ciessta.

[Iraq] [battle] [lost].

John lost his computer.

John-i computer-lul ilepelyessta.

[John] [computer] [misplaced].

Word sense disambiguation with Source Language Semantic Class Constraints (co-occurrence patterns)

lose1(*Agent*, *Patient*: competition) <=> ciessta

lose2 (*Agent*, *Patient*: physobj) <=> ilepelyessta

Is there enough data?

- Break

Levin classes (3100 verbs)

- 47 top level classes, 150 second and third level
- Based on pairs of syntactic frames.

  John broke the jar. / Jars break easily. / The jar broke.
  *John cut the bread. / Bread cuts easily. / *The bread cut.*
  *John hit the wall. / *Walls hit easily. / *The wall hit.*

- Reflect underlying semantic components

  contact, directed motion,
  exertion of force, change of state

- Synonyms, syntactic patterns, relations

Another alternation example

- Another example: Causative/inchoative
- The window broke
- John broke the window
- The rabbit suddenly appeared
- *The magician appeared the rabbit

- Benefactive:
- Sue carved a toy out of wood for Hansel
- Sue carved hansel a toy out of wood
- Sue carved some wood into a toy for Hansel
- *Sue carved Hansel some wood into a toy

- Middle formation:
- The whale frightens easily
- *The whale sees easily

Alternations..

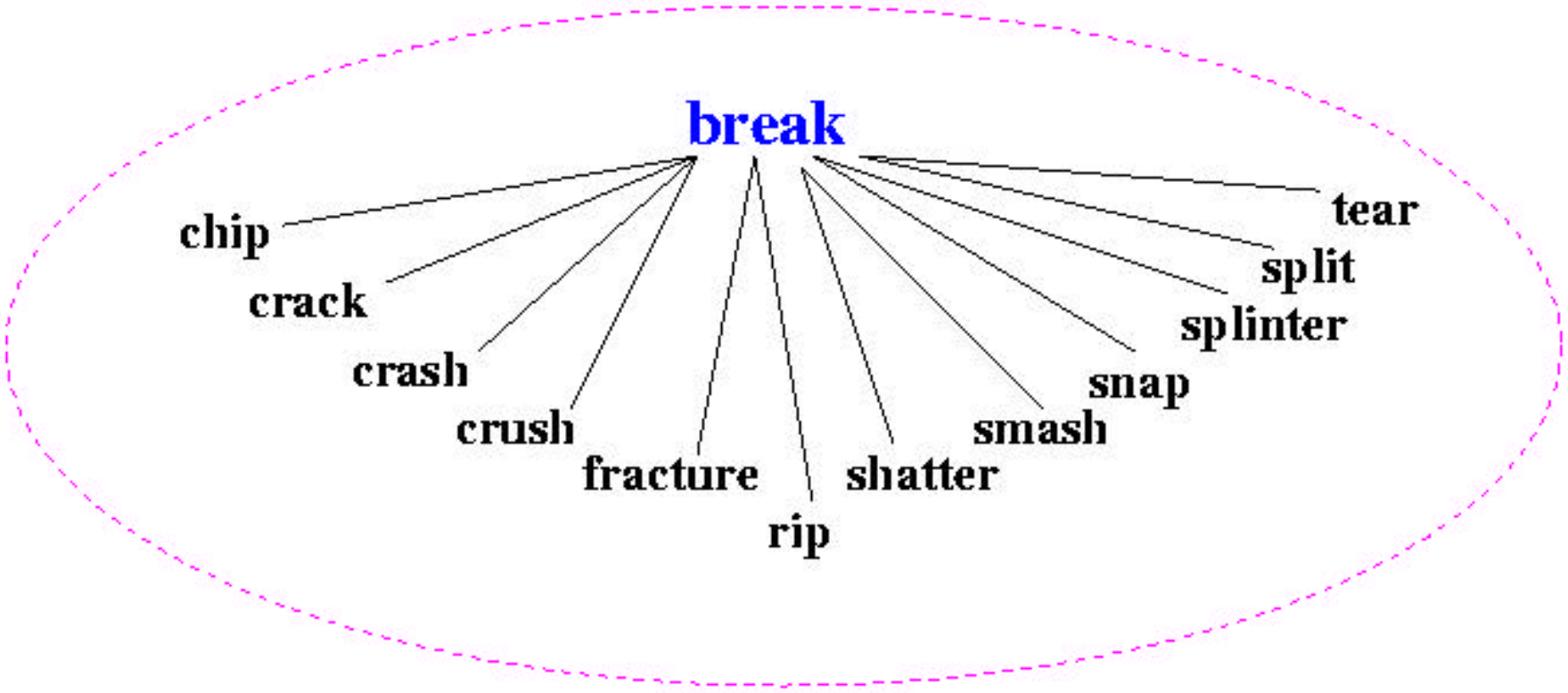
- Sue broke the vase/ The vase broke (change-of-state)
- The vase broke easily
- Conative: *Sue broke at the vase

- Bill cut the bread/ *The bread cut (change-of-state, no “telic” endpoint)
- The bread cut easily
- Bill cut at the bread

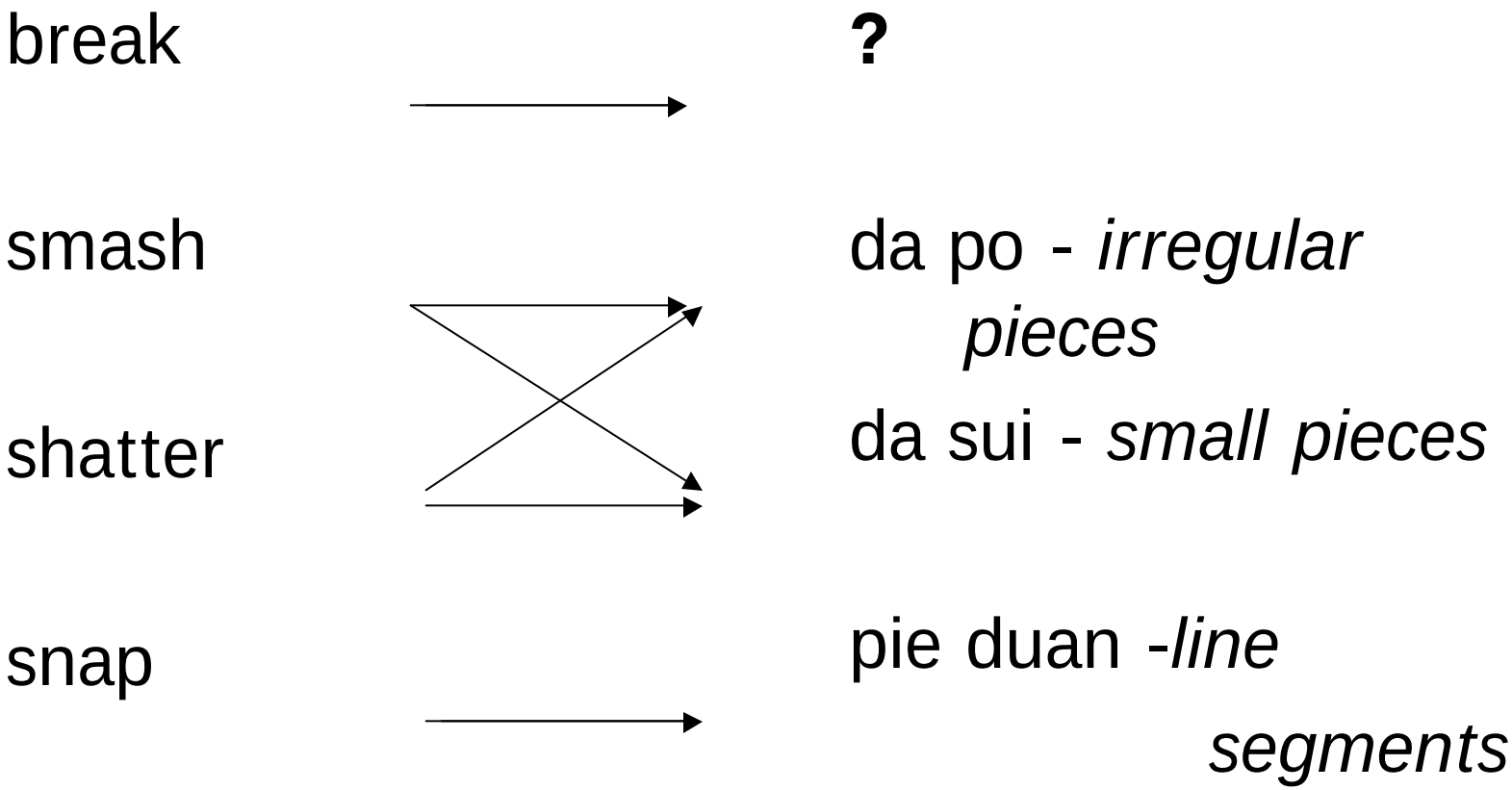
- Mary touched the cat / *The cat touched
- *The cat touched easily (no change-of-state)
- *Mary touched at the cat

- Joe kicked the tire / *The tire kicked
- *The tire kicked easily
- Joe kicked at the tire
- Alternations can be lang-specific: "break" is a causative/inchoative in English, but not Italian.

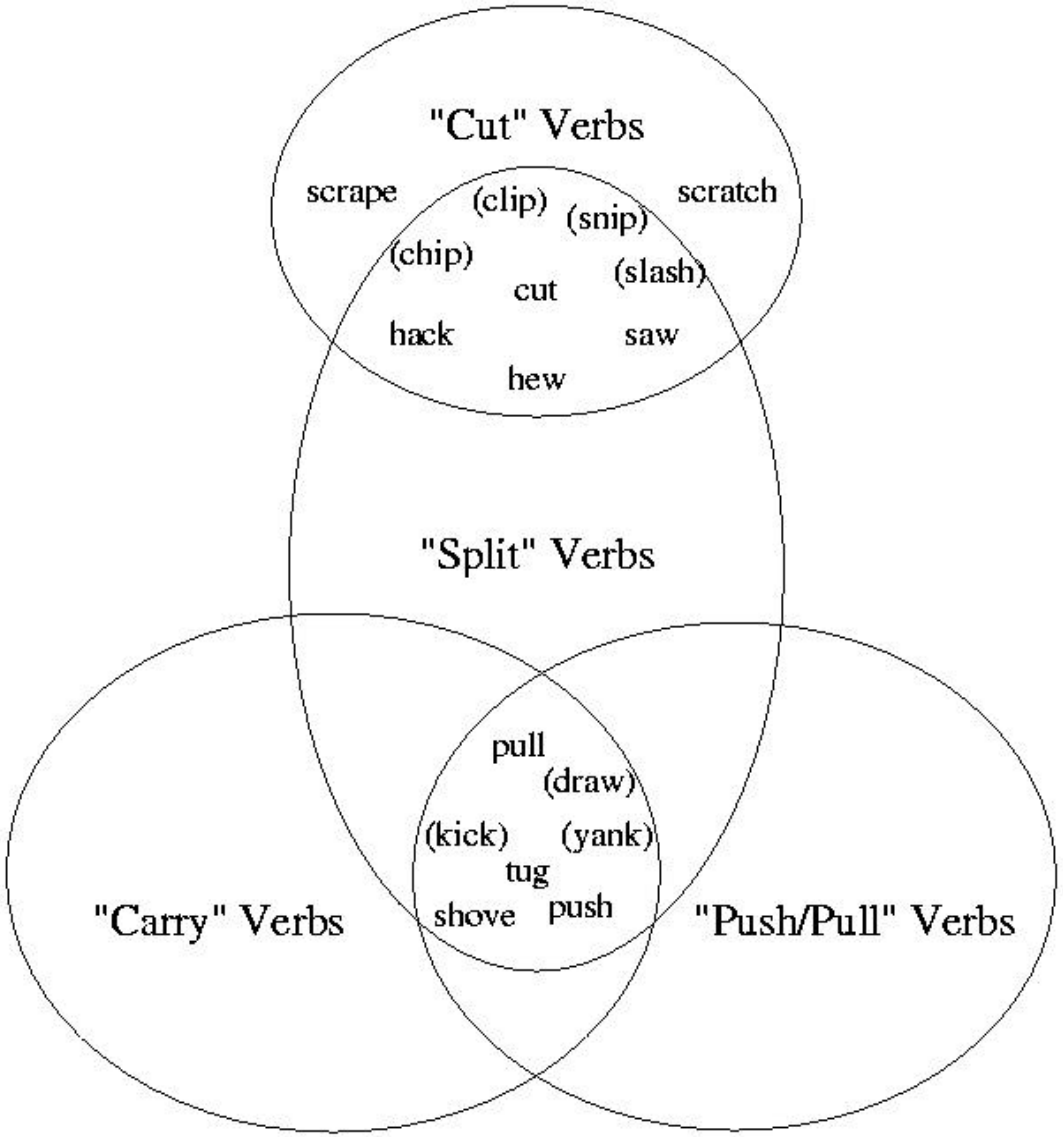
Break Levin class - *Change-of-state*



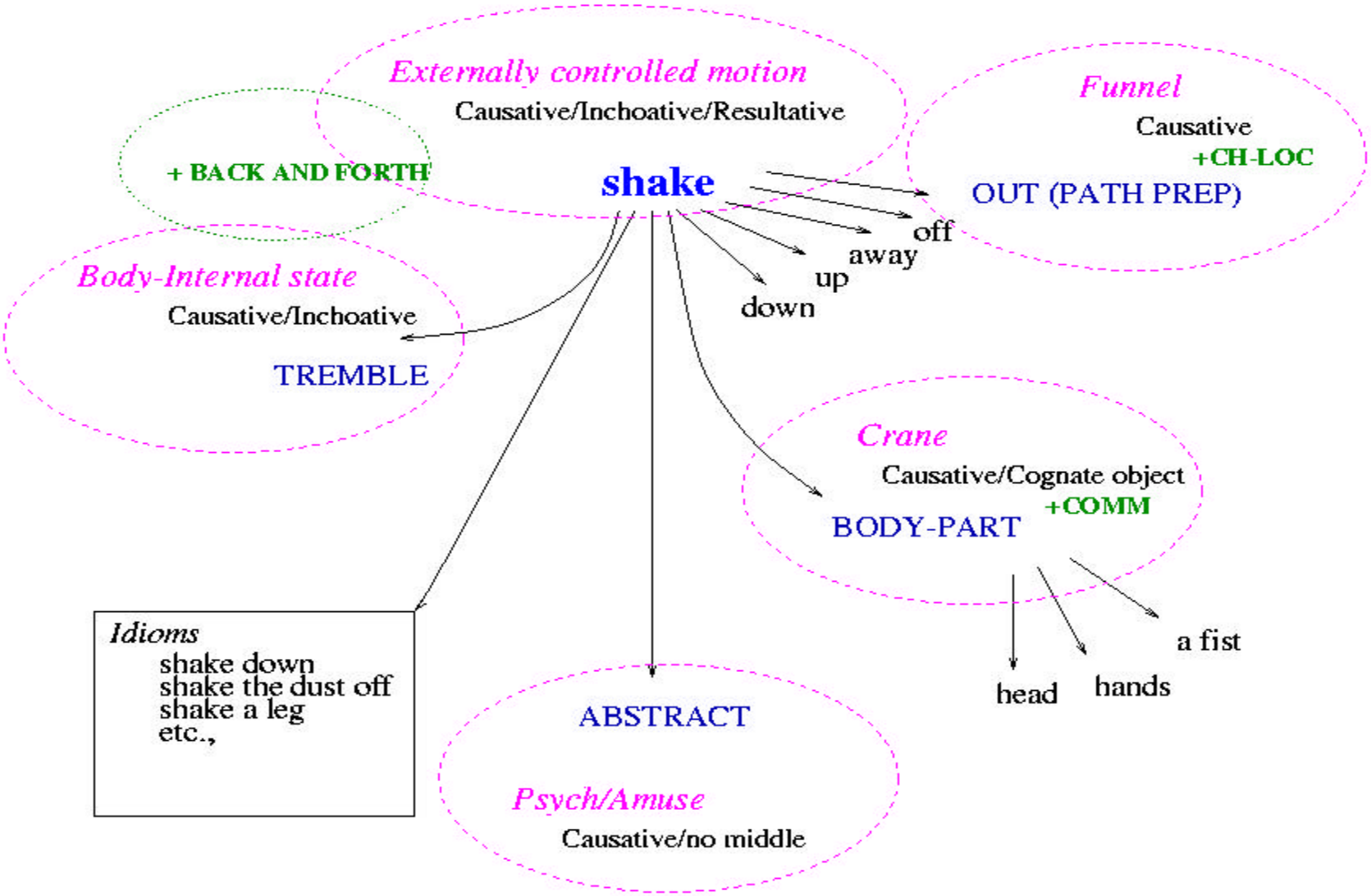
Lexical Gaps: English to Chinese



Intersective Levin classes



So we want...


Externally controlled motion
Causative/Inchoative/Resultative
+ BACK AND FORTH
shake
Funnel
Causative
+CH-LOC
OUT (PATH PREP)
off
away
up
down
Body-Internal state
Causative/Inchoative
TREMBLE
Crane
Causative/Cognate object
+COMM
BODY-PART
a fist
head
hands
Idioms
shake down
shake the dust off
shake a leg
etc.,
ABSTRACT
Psych/Amuse
Causative/no middle

Thematic Roles

- E w,x,y,z Giving (x) ^ Giver(w,x) ^ Givee(z, x) ^ Given(y,x)
- E w,x,z Breaking (x) ^ Breaker(w,x) ^ Broken(z,x)
- A set of roles:
  - agent, experiencer, force, theme, result, content, instrument, beneficiary, source, goal,...

The dog ate the cheeseburger.

What is cheeseburger?

The sniper shot his victim with a rifle.

What is rifle?

Schank's Conceptual Dependency

- Eleven predicate primitives represent all predicates
- Objects decomposed into primitive categories and modifiers
- But few predicates result in very complex representations of simple things

Ex,y Atrans(x) ^ Actor(x,John) ^
Object(x,Book) ^ To(x,Mary) ^ Ptrans(y) ^
Actor(y,John) ^ Object(y,Book) ^ To(y,Mary)

John caused Mary to die vs. John killed Mary

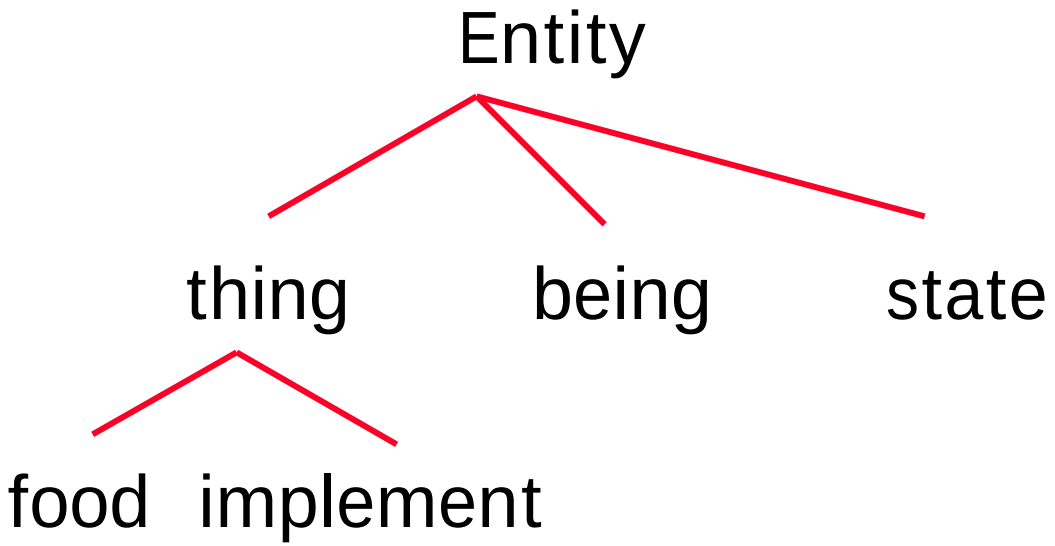
Selection via sortal hierarchy

- John ate a clam
- They served clams

- “logical” form: ∃ x,y,e[eat(e) & eater(e,y) & eaten(e,x) & john(y) & clam(x) & past(e)]

- So…

Sortal hierarchy (‘ontology’)



Selection via sortal hierarchy

1. eater([Eating],[Being])
2. eat([Eating])
3. eaten([Eating],[Food])
4. server([Serving],[Being])
5. $serve_1$([Serving])
6. served([Serving],[Food])
7. john([Person])
8. they([Person])
9. $mussel_1$([Food])
10. $mussel_2$([Creature])

But...

- Which airlines serve Denver?
- You ate glass on an empty stomach
- Metonomy: What airlines fly to Boston?

But how can we/computer learn this?

- Two parts: pred-arg linking to thematic roles – which verbs do what
- Selectional restrictions

pour vs. *fill*

- Different linking entails semantic difference - when in Object position, the Goal seems "affected" in a way not so in the PP
- *Fill*: Cause X to become full of Y by means of causing Y to be in X
- *Pour*: Cause X to go in a downward stream into Y
- *Fill* has two events: a state change (the glass) and a location change (the water)
- *Pour* has one event: location change
- The Main-change argument gets Old-Info structure and main event status. Main event of *Fill*: state change of glass

Look! He's sebbing!

Look! A seb!

Look, some seb!

/seb/ means MIXING

/seb/ means BOWL

/seb/ means STUFF

KEY HUMAN COMPETENCE:

- One-shot integration of syntax & semantics

The Problem of Ambiguity

Possible Hypotheses

- **Rabbit (whole object)**
- **Animal (superordinate)**
- **Flopsie (individual)**
- **Furry (property)**
- **Ear (part)**
- **Walk by (activity)**
- **Undetached rabbit parts .....**

Two Bootstrapping Proposals

- Children use syntactic cues to verb meaning (Gleitman 1990)
- Children use (verb) meaning to figure out how its arguments are realized in the syntax of the language (Pinker 1989)

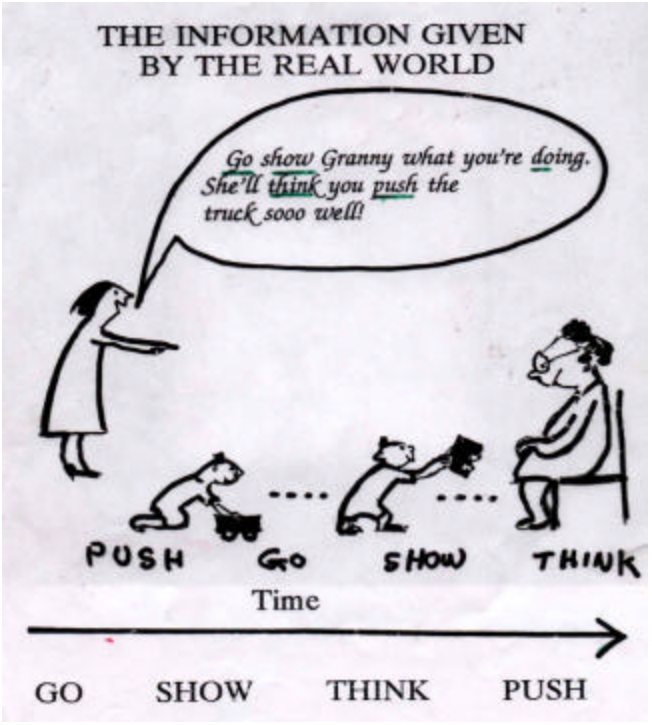
Semantic Bootstrapping

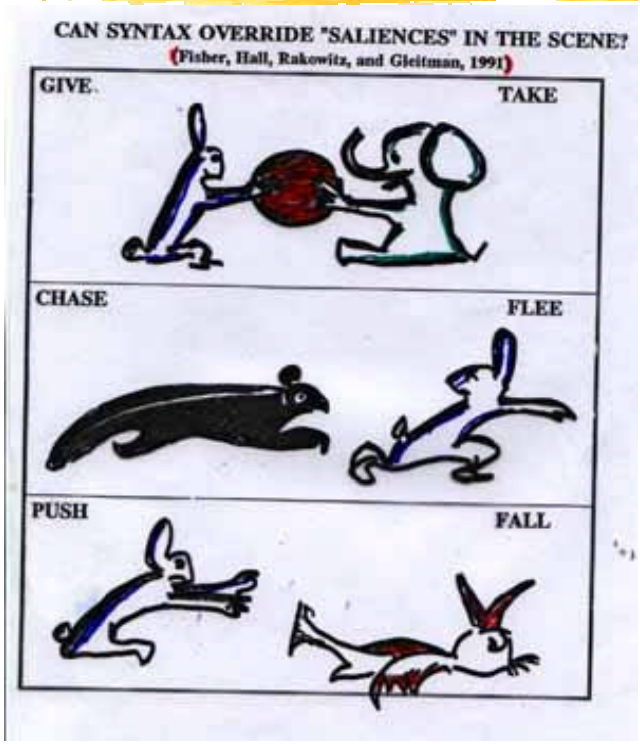
(Pinker 1984)

Semantic Bootstrapping involves the pairing of a situational context with some syntactic pattern.

- Kids learn syntax by first learning the semantic argument structure of the verb.
  - SWIM = one participant (the “swimmer”)
  - EAT = two participants (“eater”, “eatee”)
  - TAKE = two/three participants (“taker”, “takee”, and “person taken from”...)

Gleitman: Not So Fast, Pinker…





Temporal ambiguity

Situation ambiguity

Mental unobservable!

… more than <u>just</u> real-world observation…

Syntactic Bootstrapping

(Landau and Gleitman 1986, Naigles 1990)

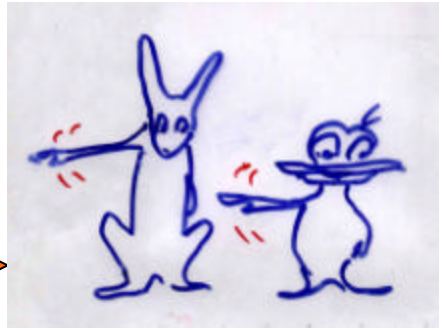
Syntactic frames provide *evidence* for meaning:

/X and Y are gorping!/

/Look, gorping!/

/X is gorping Y!/

H_1: arm wheel



H_2: cause to squat

Verbs Classes Grouped by Cause Feature

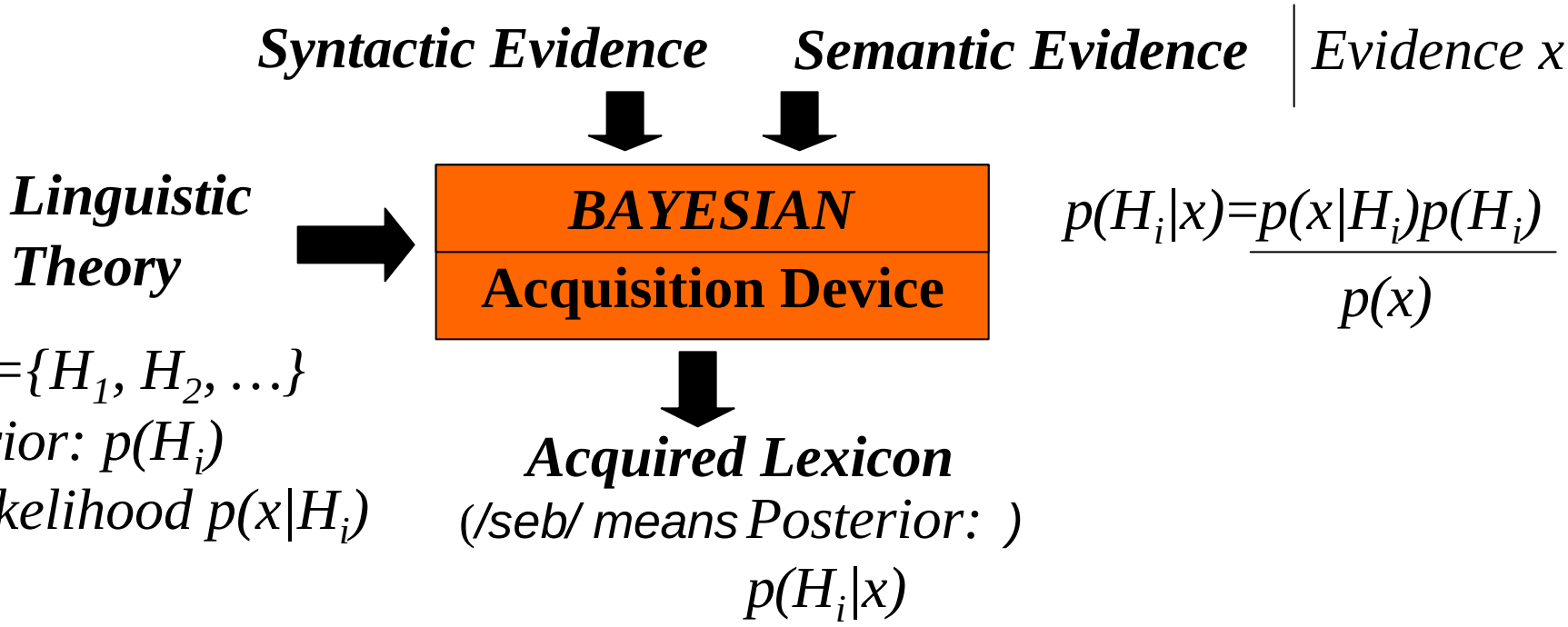
H_i	*Verb Class*
H_1	Externally Caused (*touch*, *load*)
	F1: He touched the glass.
	** F0: The glass touched.*
H_0	Internally Caused *(laugh, glimmer)*
	** F1: He laughed the child.*
	F0: He laughed.
H_*	Externally Causable *(open, break)*
	F1: He opened the door.
	F0: The door opened.

***Hypothesis space* H**
Hi in H

Evidence x in X = {0, 1}

One-shot learning

within a Bayesian framework.



Learning Value of Verbs Cause Feature

Syntactic Evidence:

/He glipped the balloon/

x=F1

Syntactic Theory:

$\boldsymbol{H}=\{H_1, H_0, H_*\}$

Prior:

$p(H_i) = .333$

$$p(H_i|x)=\frac{p(x|H_i)p(H_i)}{p(H_i)}$$

Likelihood

$p(x|H_i)$

	x=F0	x=F1
H_1	.05	.95
H_0	.95	.05
H_*	.50	.50

Acquired Lexicon

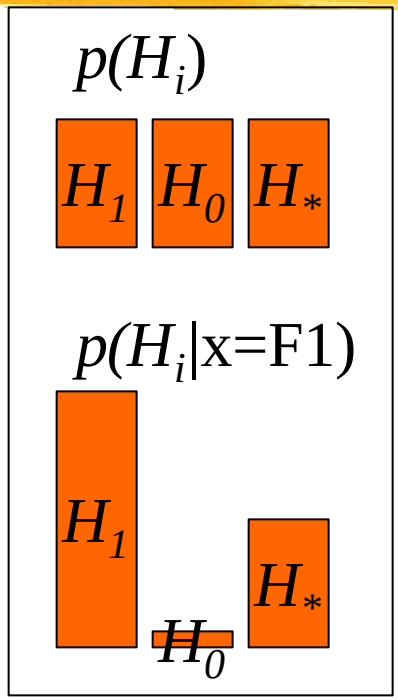
Posterior $p(H_i|x)$

$p(H_1|x=F1) = .633$

$p(H_0|x=F1) = .033$

$p(H_*|x=F1) = .333$

$$= \frac{(.95)(.33)}{(.05+.95+.50)(.33)}$$



Syntactic Evidence X:

/He glipped the balloon/
/X gorped Y/, /X gorped Y/
/X sebbed Y/, /Y sebbed/
/X meefed Y/[5]*, /Y meefed/*
/Y foomed/[6]

Syntactic Theory:

H=$\{H_1, H_0, H_*\}$
Prior $p(H_i)$
Likelihood $p(x|H_i)$

Bayesian Language Acquisition Device

Acquired Syntactic Knowledge

Lexicon:	***Evidence X***	$p(H_1\|X)$	$p(H_0\|X)$	$p(H_*\|X)$
/glip/	*F1*	*.633*	*.033*	*.333*
/gorp/	*F1, F1*	*.781*	*.002*	*.217*
/seb/	*F1, F0*	*.137*	*.137*	*.724*
/meef/	*F1*[5]*, F0*	*.712*	*5e-6*	*.288*
/foom/	*F0*[6]	*2e-8*	*.979*	*.021*

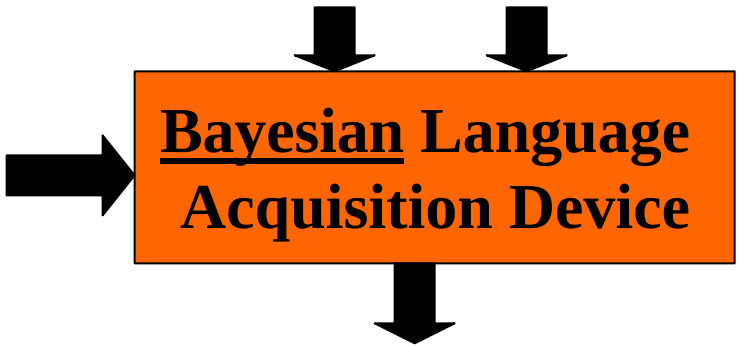
Bayesian Learning at the Syntax-Semantics Interface

Syntactic Evidence

/X is gorping Y into Z/
/X is pilking Z with Y/
/Look! jebbing!/

Semantic Evidence

Person pours water into a glass, filling it
Person pours water into a glass, filling it
Person pours water into a glass, filling it



Linguistic Theory

$H=\{H_1, H_2, \ldots\}$
Prior: $p(H_i)$
Likelihood $p(x|H_i)$

Acquired Lexicon $p(Hi|x)$

	p(POUR|x)	p(FILL|x)	p(MOVE|x)
/gorp/	***.880***	.000	.101
/pilk/	.001	***.989***	.000
/jeb/	***.463***	***.463***	.005

How to get ‘real semantics’ in?