







## Uncertainty in terms\*

- Grammar: How much semantics should be in it?
- Grammaticality: Is a semantically anomalous sentence ungrammatical?
  - He gave the book to John.
  - He thought the book to John.
- Grammatical category: What are their essences?
- Word Meaning: What is a meaning representation?
- Concepts: How are they related to words?
  - How is what we know about TIGER related to /tiger/?

\*No one knows the answer! Wait: When did science know the definition of an atom, electron, proton, ...?















## Lexical semantics Primitives

Jackendoff 1983, 1990 Goal: Not just syntax, but <u>cognition</u> If we postulate a CAUSE primitive in /melt/ Entailment Map to syntax: linking rules Present day: Levin and Rappoport 1998

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## Hypothesis 1 Problem

Problem: How does Lexicon acquire the following:

-		
/shelf/	n <sub>location</sub>	$=p_{\text{LOCATION}} = d V$
/butter/	n <sub>locatum</sub>	=p <sub>locatum</sub> =d V
/shovel/	n <sub>inst-mot</sub>	=p <sub>inst-mot</sub> =p <sub>location</sub> =d V
/pencil/	n <sub>inst-imp</sub>	$=p_{\text{INST-IMP}} = p_{\text{LOCATION}} = d V$
/mop/	n <sub>inst-removal</sub>	$=p_{\text{INST-REMOVAL}} = p_{\text{SOURCE}} = d V$
/email/	n <sub>INST-COMM</sub>	$\begin{array}{l} = p_{\text{INST-COMM}} = p_{\text{IAVE}} = d \ V \\ = p_{\text{INST-COMM}} = p_{\text{DEST}} = d \ V \end{array}$
etc.		

Solution 1: Solve the above problem

Solution 2: Push problem OUT of Lexicon and <u>6.863J/9.61TJ SpoFiceCyclopedia</u>



## Encyclopedia vs. Lexicon

Lexicon does NOT hold real-world knowledge, only:

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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.

<u>Encyclopedia</u> 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. 6.8633/9.6113 SP04 Lecture 21





















































	Sv	ntactic Evidend	ce X:	
	/He	e glipped the ballo	on/	
	/X	gorped Y/, /X gorp	oed Y/	
	/X	sebbed Y/, /Y sebb	ed/	
	/X	meefed Y/°, /Y mee	fed/	
Svntactic T	Theory:	foomea/°		
$\frac{\mathbf{B} \mathbf{H}}{\mathbf{H}} = \{H, H\}$	$\frac{H}{H}$	, . , .		
$\mathbf{n} \in \{\mathbf{n}, \mathbf{n}, $	L	anguage Acqui	sition	
U141 014 10/U1				
Prior $p(H_i)$		Device		
$\frac{Prior p(H_i)}{Likelihood}$	$p(x H_i)$	Device		
Prior p(H <sub>i</sub> ) Likelihood	$p(x H_i)$	Device	Syntactic Know	<u>ledge</u>
Prior p(H <sub>i</sub> ) Likelihood Lexicon:	$\frac{p(x H_i)}{X}$	Device <u>Acquired S</u> <u>p(H<sub>1</sub> X)</u>	Syntactic Know p(H <sub>0</sub>  X)	<u>ledge</u> p(H <sub>*</sub>  X
Prior p(H <sub>i</sub> ) Likelihood Lexicon: /glip/	$\frac{p(x H_i)}{\frac{X}{Fl}}$	Device <u>Acquired S</u> p(H <sub>1</sub>  X) .633	<u>Syntactic Know</u> p(H <sub>0</sub>  X) .033	<u>ledge</u> p(H <sub>*</sub>  X .333
Prior p(H <sub>i</sub> ) Likelihood <b>Lexicon:</b> /glip/ /gorp/	$p(x H_i)$ $X$ $F1$ $F1^2$	Device <u>Acquired S</u> p(H <sub>1</sub>  X) .633 .781	<i>Syntactic Know</i> <i>p(H₀ X)</i> .033 .002	<u>ledge</u> p(H <sub>*</sub>  X .333 .002
Prior p(H <sub>i</sub> ) Likelihood <u>Lexicon:</u> /glip/ /gorp/ /seb/	$p(x H_i)$ $\overline{X}$ $F1$ $F1^2$ $F0,F1$	Device <u>Acquired S</u> p(H <sub>1</sub>  X) .633 .781 .137	Syntactic Know p(H <sub>0</sub>  X) .033 .002 .137	<u>ledge</u> p(H∗ X .333 .002 .724
Prior p(H <sub>i</sub> ) Likelihood <b>Lexicon:</b> /glip/ /gorp/ /seb/ /meef/	$p(x H_i)$ $\overline{X}$ $F1$ $F1^2$ $F0,F1$ $F0,F1^5$	Device <u>Acquired S</u> <u>p(H<sub>1</sub> X)</u> .633 .781 .137 .712	Syntactic Know p(H <sub>0</sub>  X) .033 .002 .137 5e-6	<u>ledge</u> p(H∗ X .333 .002 .724 .288
Prior p(H <sub>i</sub> ) Likelihood <b>Lexicon:</b> /glip/ /gorp/ /seb/ /meef/ /foom/	$p(x H_i)$ $X$ F1 F1 <sup>2</sup> F0,F1 F0,F1 <sup>5</sup> F0 <sup>6</sup>	Device <u>Acquired S</u> p(H <sub>1</sub>  X) .633 .781 .137 .712 2e-8	<i>Syntactic Know</i> <i>p(H₀ X)</i> .033 .002 .137 5e-6 .979	<u>ledge</u> p(H* X .333 .002 .724 .288 .021



Verb meanings are logic programs: (Siskind 1996)

General:	cause(e)
One args x:	<pre>move(x), rotate(x), move-dn(x), move-up(x) supported(x), liquid(x), container(x)</pre>
Two args x,y: (if cause(e)=1)	<pre>contact(x,y), support(x,y), attach(x,y)</pre>
Verb         Logic Program           /lower/         1-1*101**-           /raise/         1-1*011**-           /rise/         0-1*01***           /fall/         0-1*10***	ram 11* 11* 11* 11* Hypothesis space H: All LPs Evidence X: Bit Vector Examples (e.g. 1-1010100-110) Learning Problem: p(Hi X) (Inverting a ROM c.f.Yip & Sussman 1997) 6.863J/9.611J SP04 Lecture 21











	fg	manner-of-mot	ion change-of-state
4	Semantic Eviden pour-fill splash-fill spray-fill pour-empty pour-none <u>Syntactic Eviden</u> /X Ved water int /X Ved glass with	<u>ace</u> (G001, W110) (G001, W120) (G001, W130) (G002, W110) (G000, W130) <u>ace Attentic</u> o glass/ W h water/ G	Description         X pours W into G, filling G         X splashes W into G, filling G         X splashes W into G, filling G         X pours W from G, emptying G         X pours W into G         0         Features         1         0
<u>H;</u> POUR SPLASH SPRAY FILL EMPTY MOVE	/X Ved glass with /Look, Ving!/ <u>Features</u> 11* 12* 13* 0*1 0*2 1**	h water/G * Bayesia Acquis	0 ** *** In Language sition Device ired Lexicon
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GRAND FINA	LE					
		<u>Acquire</u>	<u>ed Lexical</u>	Knowled	<u>age p(H<sub>i</sub> X)</u>	
Syntactic-Semantic Evidence X	<u>pour</u>	<u>spray</u>	<u>splash</u>	<u>fill</u>	<u>empty</u>	move
pour-fill /X glipped water into glass/	.889	.008	.008	.000	.000	.093
pour-fill /X glipped glass with water/	.000	.000	.000	.990	.009	.0001
pour-fill /Glipping!/	.468	.004	.004	.468	.004	.049
pour-fill /Glipping!/ pour-empty/X glipped water from glass/ pour-none/X glipped water/	.998	.000	.000	.000	.000	.002
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pour-fill(G001, W110)Person pours water into a glass, filling itsplash-fill(G001, W120)Person splashes water into a glass, filling itspray-fill(G001, W130)Person splashes water into a glass, filling itpour-empty(G002, W110)Person pours water from a glass, emptying itpour-none(G000, W130)Person pours some water into a glassSyntactic EvidenceAttentionFeatures/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/
splash-fill(G001, W120)Person splashes water into a glass, filling itspray-fill(G001, W130)Person splashes water into a glass, filling itpour-empty(G002, W110)Person pours water from a glass, emptying itpour-none(G000, W130)Person pours some water into a glassSyntactic EvidenceAttentionFeatures/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/
spray-fill       (G001, W130)       Person splashes water into a glass, filling it         pour-empty       (G002, W110)       Person pours water from a glass, emptying it         pour-none       (G000, W130)       Person pours some water into a glass         Syntactic Evidence       Attention       Features         /X Ved water into glass/       W       1         /X Ved glass with water/       G       0         /Look, Ving!/       -          Concept       Features
pour-empty pour-none(G002, W110) (G000, W130)Person pours water from a glass, emptying it person pours some water into a glassSyntactic EvidenceAttentionFeatures/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/ConceptFeatures
pour-none(G000, W130)Person pours some water into a glassSyntactic EvidenceAttentionFeatures/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/ConceptFeatures
Syntactic EvidenceAttentionFeatures/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/ConceptFeatures
/X Ved water into glass/W1/X Ved glass with water/G0/Look, Ving!/ConceptFeatures
/X Ved glass with water/     G     0       /Look, Ving!/     - <u>Concept</u> Features     -
/Look, Ving!/ Concept Features
<u>Concept Features</u>
Hpour 11-
Hsplash 12-
Hspray 13-
Hempty 0-1
Hfill 0-2
Hmove         1         6.863J/9.611J SP04 Lecture 21

G	RAND FINALE	<u> </u>	Acquire	ed Lexical	Knowled	lge p(Hi\X)	
Scene-U	tterance Evidence X	pour	sprav	splash	fill	emptv	move
pour-fill	/X glipped water into glass/	.880	.010	.010	.000	.000	.101
pour-fill	/X glipped glass with water/	.000	.000	.000	.989	.011	.0001
pour-fill	/Glipping!/	.463	.006	.006	.463	.005	.058
none	/X glipped water into glass/	.246	.246	.246	.004	.004	.254
none	/X glipped glass with water/	.007	.007	.007	.485	.485	.007
none	/Glipping!/	.166	.166	.166	.166	.166	.170
pour-fill pour-emp pour-non	/Glipping!/ oty/X glipped water from glass/ e/X glipped water/	.998	.000	.000	.000	.000	.002
pour-fill splash-en spray-not	/Glipping!/ npty /X glipped water/ ne /X glipped water/	.061	.066	.066	.000	.000	.806
		6.863J/9.6	511J SP04 Le	ecture 21			

