Psych 156A/ Ling 150: Psychology of Language Learning

Lecture 10
Grammatical Categories

Announcements

Homework 3 will be returned on Tuesday

Homework 4 will be assigned today, and due next Thursday (5/8/08)

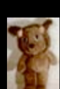
Quiz 4 will be on Tuesday (5/6/08)

Grammatical Categorization

Computational Problem: Identify grammatical categories

These will tell you how words are used in the language.

"This is a DAX."



"He is sibbing."

DAX = noun

SIB = verb

Categorization: How?

How might children initially learn what categories words belong to?

Deriving Categories from Semantic Information
Semantic Bootstrapping Hypothesis (Pinker 1984)

Children can initially determine a word's category by observing what kind of entity in the world it refers to.

objects, substance = noun
(*goblins, glitter*)

action = verb
(*steal, sing*)

Word's semantic category (meaning) is then linked to innate grammatical category knowledge (noun, verb)

Categorization: How?

How might children initially learn what categories words belong to?

Deriving Categories from Semantic Information
Semantic Bootstrapping Hypothesis (Pinker 1984)

Children can initially determine a word's category by observing what kind of entity in the world it refers to.

Slight problem: hard to identify the referent in the world for words sometimes (like verbs)

"Look! He's *frepping*!"

frep = climb, perch, glower, grab, yell, …?

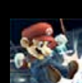
Categorization: How?

How might children initially learn what categories words belong to?

Deriving Categories from Semantic Information
Semantic Bootstrapping Hypothesis (Pinker 1984)

Children can initially determine a word's category by observing what kind of entity in the world it refers to.

Another problem: mapping rules are not perfect
Ex: not all action-like words are verbs



"active", "action"
action-like meaning, but they're not verbs

Categorization: How?

How might children initially learn what categories words belong to?

Distributional Learning

Children can initially determine a word's category by observing the linguistic environments in which words appear:

relative location of words in an utterance: "He likes to SIB."

phonological regularities within classes of words: *the, a, an*
= short (monosyllabic) words, simple syllables

co-occurrence relations between grammatical categories:
Determiner Noun (the goblin)
= Determiners (a, the, an, …) precede Nouns (goblin)

Categorization: How?

How might children initially learn what categories words belong to?

Distributional Learning (Evidence)

Children are sensitive to the distributional properties of their native language when they're born (Shi, Werker, & Morgan 1999).

7 month olds can recognize and track specific *functor* words (*a, the, to, will*…) in fluent speech (Höhle & Weissenborn 2003)

15-16 month German infants can determine novel words are nouns, based on the distributional information around the novel words (Höhle et al. 2004)

18 month English infants can track distributional information like *"is…-ing"* to signal that a word is a verb (Santelmann & Jusczyk 1998)

Categorization: How?

How might children initially learn what categories words belong to?

Idea (Gómez & Lakusta 2004)

(1) Sound properties of certain words can be tracked distributionally (monosyllabic, simple syllables = noticeable to infants).

(2) Infants can group words together into categories based on these properties.

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

data missing

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

“the” goes with these words

“the” behavior = precedes “king”, “girl”, “baby”, etc.

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

"a" goes with almost all the same words

Inference: "a" has almost the same distribution as "the", so "a" is the same category as "the"

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

Prediction:
"a" acts like "the",
"a" goes with "dwarf"

Conclusion:
"a dwarf" is in language

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

"will" goes with these words

"will" behavior =
precedes "sing", "laugh", "steal", etc.

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

"can" goes with almost all the same words

Inference: "can" has almost the same distribution as "will", so "can" is the same category as "will"

About Categorization

Data Observed

	X1	X2	X3	X4	X5
A1 = the	king	girl	baby	goblin	dwarf
A2 = a	king	girl	baby	goblin	
	Y1	Y2	Y3	Y4	Y5
B1 = will	sing	laugh	steal	run	sneeze
B2 = can	sing	laugh	steal	run	

Prediction:
"can" acts like "will" so "can" goes with "sneeze"

Conclusion: "can sneeze" is in language

Gómez & Lakusta 2004: Categorization Experiment

Testing 12 month olds, using artificial language paradigm (so children couldn't have any experience with the categories beforehand)

General procedure:
Infants exposed to one of two training languages (L1 or L2).
Used same set of vocabulary (all novel words).

L1 generalization: a goes with X, b goes with Y (aX, bY language)
L2 generalization: a goes with Y, b goes with X (aY, bX language)

Gómez & Lakusta 2004: Categorization Experiment

L1

	X1	X2	X3	X4	X5	X6
A1 = alt	coomo	fengle	kicey	loga	paylig	wazil
A2 = ush	coomo	fengle	kicey	loga	paylig	wazil
	Y1	Y2	Y3	Y4	Y5	Y6
B1 = ong	deech	ghope	jic	skige	vabe	tam
B2 = erd	deech	ghope	jic	skige	vabe	tam

Gómez & Lakusta 2004: Categorization Experiment

L1

	X1	X2	X3	X4	X5	X6	
A1 = alt	coomo	fengle	kicey	loga	paylig	wazil	Disyllabic words
A2 = ush	coomo	fengle	kicey	loga	paylig	wazil	
	Y1	Y2	Y3	Y4	Y5	Y6	
B1 = ong	deech	ghope	jic	skige	vabe	tam	Monosyllabic words
B2 = erd	deech	ghope	jic	skige	vabe	tam	

Gómez & Lakusta 2004: Categorization Experiment

L1

	X1	X2	X3	X4	X5	X6	
A1 = alt	coomo	fengle	kicey	loga	paylig	wazil	Disyllabic words
A2 = ush	coomo	fengle	kicey	loga	paylig	wazil	
	Y1	Y2	Y3	Y4	Y5	Y6	
B1 = ong	deech	ghope	jic	skige	vabe	tam	Monosyllabic words
B2 = erd	deech	ghope	jic	skige	vabe	tam	

Association: alt/ush (a1,a2) go with these words (X1-X6)
Abstraction: alt/ush (a1,a2) go with disyllabic words
Categorization: alt/ush are a category whose behavior is to go with disyllabic words

Gómez & Lakusta 2004: Categorization Experiment

L1

	X1	X2	X3	X4	X5	X6	
A1 = alt	coomo	fengle	kicey	loga	paylig	wazil	Disyllabic words
A2 = ush	coomo	fengle	kicey	loga	paylig	wazil	
	Y1	Y2	Y3	Y4	Y5	Y6	
B1 = ong	deech	ghope	jic	skige	vabe	tam	Monosyllabic words
B2 = erd	deech	ghope	jic	skige	vabe	tam	

Association: ong/erd (b1,b2) go with these words (Y1-Y6)
Abstraction: ong/erd (b1,b2) go with monosyllabic words
Categorization: ong/erd are a category whose behavior is to go with monosyllabic words

Gómez & Lakusta 2004: Categorization Experiment

L2

	X1	X2	X3	X4	X5	X6	
A1 = alt	deech	ghope	jic	skige	vabe	tam	Monosyllabic words
A2 = ush	deech	ghope	jic	skige	vabe	tam	
	Y1	Y2	Y3	Y4	Y5	Y6	
B1 = ong	coomo	fengle	kicey	loga	paylig	wazil	Disyllabic words
B2 = erd	coomo	fengle	kicey	loga	paylig	wazil	

Gómez & Lakusta 2004: Categorization Experiment

General procedure:
Infants exposed to one of two training languages (L1 or L2).
Used same set of vocabulary (all novel words).

L1 generalization: a goes with X, b goes with Y (aX, bY language)
L2 generalization: a goes with Y, b goes with X (aY, bX language)

Test phase:
Infants exposed to *new* phrases from their training language
L1 children: new aX, bY examples
L2 children: new aY, bX examples

Gómez & Lakusta 2004: Categorization Experiment

L1 test

	X1	X2	X3	X4	X5	X6	
A1 = alt	beevit	meeper	gackle	roosa	nawlup	binnow	Disyllabic words
A2 = ush	beevit	meeper	gackle	roosa	nawlup	binnow	
	Y1	Y2	Y3	Y4	Y5	Y6	
B1 = ong	vot	pel	tood	rud	biff	foge	Monosyllabic words
B2 = erd	vot	pel	tood	rud	biff	foge	

The point: Children needed to complete association, abstraction, and categorization in order to realize that these new instances of aX and bY were part of the artificial language L1.

Gómez & Lakusta 2004: Categorization Experiment

L1 process

	X1	X2	… X6
A1 = alt	coomo	fengle	…. wazil
A2 = ush	coomo	fengle	…. wazil
	Y1	Y2	…Y6
B1 = ong	deech	ghope	…tam
B2 = erd	deech	ghope	…tam

Gómez & Lakusta 2004: Categorization Experiment

L1 process

	X1	X2	… X6	
A1 = alt	coomo	fengle	…. wazil	Association
A2 = ush	coomo	fengle	…. wazil	Association
	Y1	Y2	…Y6	
B1 = ong	deech	ghope	…tam	Association
B2 = erd	deech	ghope	…tam	Association

Gómez & Lakusta 2004: Categorization Experiment

L1 process

	X1	X2	… X6	
A1 = alt	coomo	fengle	…. wazil	Abstraction: disyllabic words
A2 = ush	coomo	fengle	…. wazil	Abstraction: disyllabic words
	Y1	Y2	…Y6	
B1 = ong	deech	ghope	…tam	Abstraction: monosyllabic words
B2 = erd	deech	ghope	…tam	Abstraction: monosyllabic words

Gómez & Lakusta 2004: Categorization Experiment

L1 process

	X1	X2	… X6
A1 = alt	coomo	fengle	…. wazil
A2 = ush	coomo	fengle	…. wazil
	Y1	Y2	…Y6
B1 = ong	deech	ghope	…tam
B2 = erd	deech	ghope	…tam

Categorization based on similar distribution: disyllabic words

Categorization based on similar distribution: monosyllabic words

Gómez & Lakusta 2004: Categorization Experiment

L1 process

	X1	X2	… X6
A1 = alt	coomo	fengle	…. wazil
A2 = ush	coomo	fengle	…. wazil
	Y1	Y2	…Y6
B1 = ong	deech	ghope	…tam
B2 = erd	deech	ghope	…tam

Extension to new examples: alt beevit

Extension to new examples: ong pel

Gómez & Lakusta 2004: Categorization Experiment

Results:
12 month olds listened longer to the test items that obeyed the categorizations of the language they were trained on, even though the words in the test items were ones they had never heard before.

This suggests that 12 month olds were able to complete association, abstraction, and categorization for this artificial language - based only on the distributional information available.

Specifically, the distributional information was the occurrence of one item next to another one in the training phase (L1: aX, bY).

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Idea: Children may be attending to other kinds of distributional information available in the linguistic environment

There is evidence that children can track information that is non-adjacent in the speech stream (Santelmann & Jusczyk 1998, Gómez 2002)

he *is* run*ning*

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Idea: What categorization information is available if children track frequent frames?

Frequent frame: X___Y
where X and Y are words that frame another word
and appear frequently in the child's linguistic environment

Examples:	the__is	can___him
	the king is…	can trick him…
	the goblin is…	can help him…
	the girl is…	can hug him…

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Data representing child's linguistic environment:
6 corpora of child-directed speech from the CHILDES database

CHILDES Child Language Data Exchange System

Definition of "frequent" for frequent frames:
Frames appearing a certain number of times in a give corpus (ex: 45 times).

Meant to represent the idea that the child will encounter these frames often enough to recognize them and use them for categorization.

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Trying out frequent frames on a corpus of child-directed speech.

Frame: the ___ is
"the radio is in the way…but the doll is…and the teddy is…"

radio, doll, teddy = Category1 (similar to Noun)

Frame: you ___ it
"you draw it so that he can see it… you dropped it on purpose!…so he hit you with it…"

draw, dropped, with = Category 2 (similar-ish to Verb)

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Determining success with frequent frames:

Precision = # of words identified correctly as Category within frame / # of words identified as Category within frame

Recall = # of words identified correctly as Category within frame / # of words that should have been identified as Category

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Determining success with frequent frames:

Precision = # of words identified correctly as Category within frame / # of words identified as Category within frame

Recall = # of words identified correctly as Category within frame / # of words that should have been identified as Category

Frame: you ___ it
draw, dropped, with = Category 2 (similar-ish to Verb)

# of words correctly identified as Verb = 2
# of words identified as Verb = 3
Precision = 2/3

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Determining success with frequent frames:

Precision = # of words identified correctly as Category within frame / # of words identified as Category within frame

Recall = # of words identified correctly as Category within frame / # of words that should have been identified as Category

Frame: you ___ it
draw, dropped, with = Category 2 (similar-ish to Verb)

# of words correctly identified as Verb = 2
# of words should be identified as Verb = many (all verbs in corpus)
Recall = 2/many = small number

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Some actual results of frequent frames

Frame: you ___ it
put, want, do, see, take, turn, taking, said, sure, lost, like, leave, got, find, throw, threw, think, sing, reach, picked, get, dropped, seen, lose, know, knocked, hold, help, had, gave, found, fit, enjoy, eat, chose, catch, with, wind, wear, use, took, told, throwing, stick, share, sang, roll, ride, recognize, reading, ran, pulled, pull, press, pouring, pick, on, need, move, manage, make, load, liked, lift, licking, let, left, hit, hear, give, flapped, fix, finished, drop, driving, done, did, cut, crashed, change, calling, bring, break, because, banged

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Some actual results of frequent frames

Frame: the ___ is
moon, sun, truck, smoke, kitty, fish, dog, baby, tray, radio, powder, paper, man, lock, lipstick, lamb, kangaroo, juice, ice, flower, elbow, egg, door, donkey, doggie, crumb, cord, clip, chicken, bug, brush, book, blanket, Mommy

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Precision & Recall of frequent frames across corpora

Precision: Above 90% for all corpora (high)

Interpretation: When a frequent frame clustered words together into category, they often did belong together. (Nouns together, verbs together, etc.)

Recall: Around 10% for all corpora (very low)

Interpretation: A frequent frame made lots of little clusters, rather than being able to cluster all the verbs together and all the nouns together.

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Getting better recall (forming one category of Verb, Noun, etc.)

Many frames overlap in the words they identify.

the__is	the__was	a___is	that___is …
dog	dog	dog	cat
cat	cat	goblin	goblin
king	king	king	king
girl	teddy	girl	teddy

What about putting clusters together that have a certain number of words in common?

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Getting better recall (forming one category of Verb, Noun, etc.)

Many frames overlap in the words they identify.

the/a/that__is/was

dog	teddy
cat	goblin
king	
girl	

Recall goes up to 91% (very high).
Precision stays above 90% (very high)

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Summary

Frequent frames are non-adjacent co-occurring words with one word in between them.

They are likely to be information young children are able to track, based on experimental evidence.

When tested on realistic child-directed speech, frequent frames do very well at grouping words into clusters which are very similar to actual grammatical categories like Noun and Verb.

Frequent frames could be a very good strategy for children to use.

Questions?