9.85 Cognition in Infancy and Early Childhood

Word learning

Today

- What are words? What are children's first words?
- Word learning and the problem of induction.
- Lexical constraints on interpretation of word meanings.
    - Whole object bias/shape bias
    - Thematic vs. taxonomic groupings
    - Basic level bias
    - Mutual exclusivity
- Referential intent and interpretation of word meanings

What are words? What are children's first words?
Word learning

- First words: 12 months

- 10,000 words by age six.

- Average adult probably knows 60,000 words; highly educated (you) probably know 120,000 words.

- Double it if you speak two languages.

- No evident upper limit ... (reported fluency from 56-115 languages)

- Children learning a signed language like ASL do so at exactly the same pace as hearing children; age of first word, first 50 words, etc. is identical (Petitto, 1992).

- Blind children too (Landau & Gleitman, 1985).

What are words? What are children's first words?
What's a word?

- "John stayed in the poker game until he got cleaned out" (Bloom, 2000)

- Microsoft word count says 11 words.

- But arguably it's psychologically misleading to count words this way.
  - We might want to count 'stayed', 'stay' and 'staying' all as one word (children don't need to learn their meanings separately).
  - The word 'poker' can be two words semantically.
  - And 'cleaned out' is its own idiomatic semantic unit (you have to learn its meaning separately from 'clean' and 'out')

What are words? What are children's first words?
In word counts ...

- Usual use is dictionary entries (lemmas). Advantage is that stay, stayed and staying count as a single word; disadvantage is that poker counts as one word.

- From the perspective of language acquisition, words are "Saussurian signs": arbitrary entities consisting of concepts + forms.

- dog, clean out, soccer, hat trick, capital gains, and Citizen Kane are each words.

Word learning and the problem of induction
Word learning

- Previous lectures on concepts gave you some idea of how hard it was to define what meaning a word had (definitional? prototypical? theory-based?)

- Might want to say children only know the meaning of the word gold when they can tell all and any instance of gold from non-gold ... but if so, then none of us knows the meaning of words ...

- Today we'll focus on how children learn knowledge associated with a word that captures psychological intuitions about the sense (meaning) and reference (things in the world it applies to) of words.

How do we learn words?

- Associative learning.
- "It looks simple. A 14-month-old toddles after the family dog, smacking it whenever she gets close. The dog wearily moves under the table. 'Dog,' the child's mother tells her. 'You're chasing the dog. That's the dog.' The child stops, points a pudgy hand the dog, and shrieks 'Daw!' The mother smiles: 'Yes, dog.'" (Bloom, 2000)

What are words? What are children's first words?
First words

- In general, what are they?
- Adele (16 months): mama, baby, eyes, duck, bear, book, ball, cracker, turkey, water, bubbles, light
- Adele (16 months): uhoh, more, no, up, hi, bye, yay, wow, wedditgo,
- Adele (20 months): Mommy go up; hold my hand; baby go swimming; off my sack; more Raffi; where'd she go?; other one; pick me up; no smock

What are words? What are children's first words?
First words

- Adele -- 23 months
  - Ring around the rosie, pocket full of posy, ashes, ashes all fall down; want to draw on paper; mommy come play over here; what's Sophia doing?; want more Raisin Bran ... please.

What are words? What are children's first words?
First words

- In general, what are they?
- Includes "mommy" "daddy" "doggy"
- But also "allgone" "more" "uh oh"

What are words? What are children's first words?
First words

- Nouns are neither all nor most of children's first words (typically fewer than half of first 50 words).

- However, much larger proportion of toddler's vocabulary than vocabularies of older children and adults …

- …for every language studied: English, Italian, Japanese, Kaluli, Mandarin, Navajo, Turkish, and Tzetzal.

Ostensive labeling?

- Common among us (See the doggy?)
- but not cross-culturally universal. In some cultures, children are spoken **about** but not **to** until they can produce full sentences.
- A brief pause for baby talk ...

Ostensive labeling isn't universal

- Children learning Kaluli in Papua New Guinea are explicitly taught assertive language -- "Elema" (say it like that) -- for teasing, shaming, asking ... but there is no ostensive labeling.
- She "holds her infant so that it faces another child [and] moves the infant as one might a ventriloquist's dummy, speaking for it in a nasalized falsetto voice [with] speech... well formed and clearly articulated"

Word learning and the problem of induction
Moreover ...

- Associative learning doesn't answer the question of what to associate with the word ...

- Question 1 for you. What's a gavagi?

Image: Wikimedia. Public Domain.

Word learning and the problem of induction
Gavagi

- Word learning is a paradigm case of more general problem of induction
  - Infinite number of equally logical generalizations one can make from any pattern or exemplar (Nelson Goodman)
- But we prefer some generalizations to others.

Word learning and the problem of induction
Quine

- "Gavagi"
  - Dinner?
  - Something cute?
  - An animal?
  - A thing that hops?
  - A rabbit in the Fall?
  - Not to be confused with Thumper and Bugs
  - A rabbit plus grass?
  - Disconnected rabbit parts?
  - A rabbit but only to the year 2011, then carrots.

Image: Wikimedia. Public Domain.

Word learning and the problem of induction

- In fact, we solve these problems so easily it takes philosophers like Quine and Goodman even to point out that there's a problem.

- Suggests that there are some biases or constraints on how we interpret the meaning of words.

Constraints on interpreting the meaning of words

- Lexical constraints
- Referential constraints
- Syntactic cues

Lexical constraints on the meaning of words

- Possibly we first privilege the interpretation of words as referring to whole objects because we process the world as containing objects.

- "Spelke" objects (objects that are solid, cohesive and move on continuous paths) might help constrain induction about word meanings.

Image: Wikimedia. Public Domain.

Lexical constraints on the meaning of words

- If sensitivity to Spelke-objects affects children's interpretation of word meanings …

- Two predictions:
  - Children will generalize a label to the object and not a part of the object or a property of the object.
  - Children will generalize according to object itself as opposed to object + other relationships.

- Rules out disconnected rabbit parts, nose of rabbit, rabbit + grass ...

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Lexical constraints on the meaning of words: Whole object bias

Question 2

- This is a fep
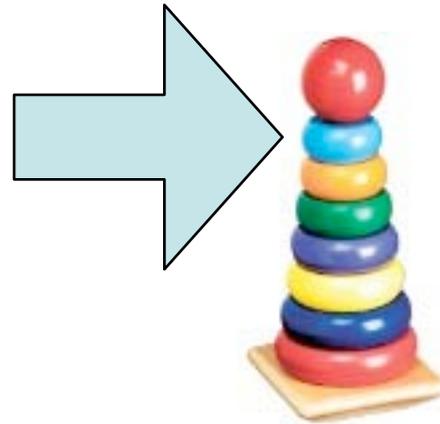
Lexical constraints on the meaning of words: Whole object bias
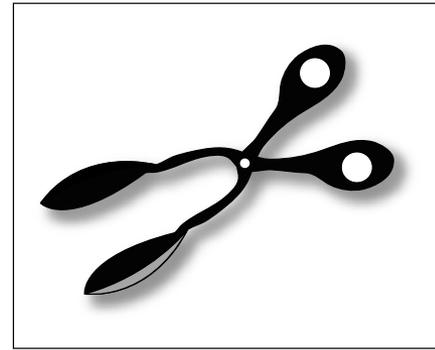
- "Look at this pewter."

Image by MIT OpenCourseWare.

- "Which one is pewter?"
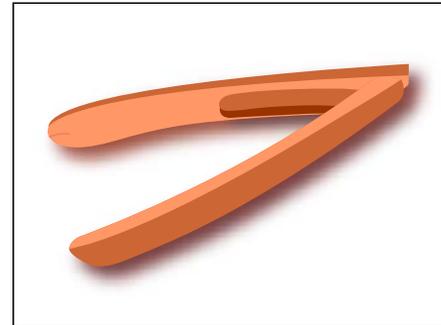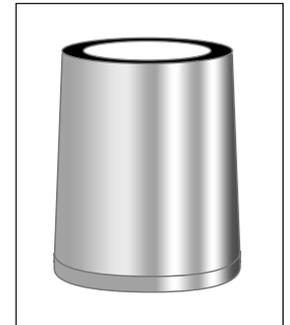
Image by MIT OpenCourseWare.

Image by MIT OpenCourseWare.

Lexical constraints on the meaning of words: Whole object bias

- "Look at this pewter."
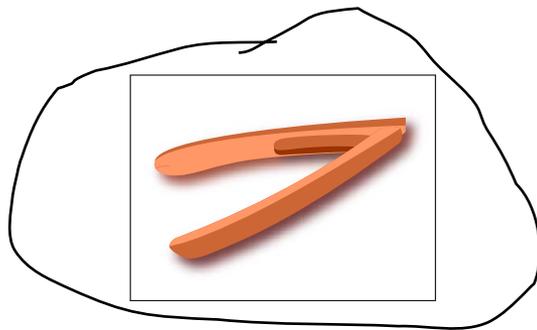
Image by MIT OpenCourseWare.
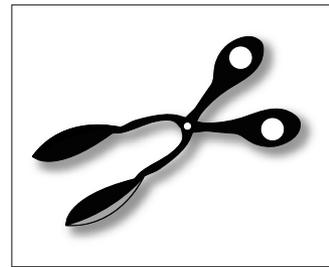
Image by MIT OpenCourseWare.
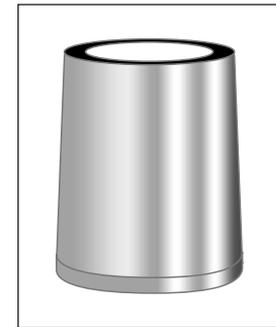
Image by MIT OpenCourseWare.

- Suggests that children generalize to whole objects and not object properties.

Lexical constraints on the meaning of words: Whole object bias

- Children generalize a novel word to a novel object, not an object's properties.
  - But what makes wooden tongs the "same" object as metal tongs and a metal cup a "different" object?
- "Sameness" often seems to be determined by overall shape rather than properties like texture and color.

Lexical constraints on the meaning of words: Shape bias

"This is a dax."
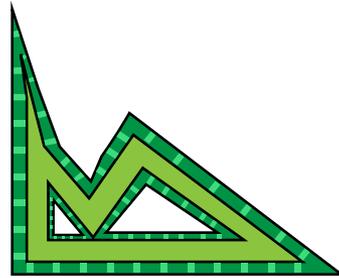
"Show me the dax."
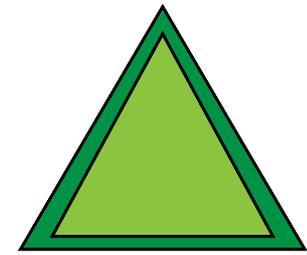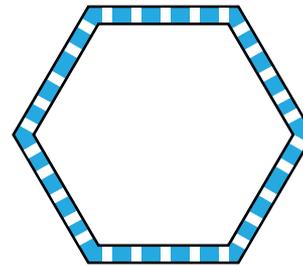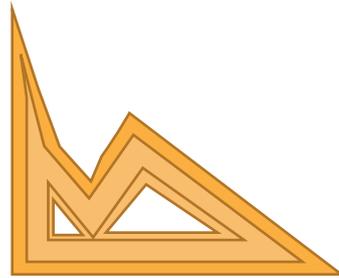
Shape   Texture   Color

Image by MIT OpenCourseWare.

Lexical constraints on the meaning of words: Shape bias

- Shape bias emerges for words only when productive vocabulary is between 50-150 words ... and shape bias seems to support rapid addition of new words.

Image by MIT OpenCourseWare.
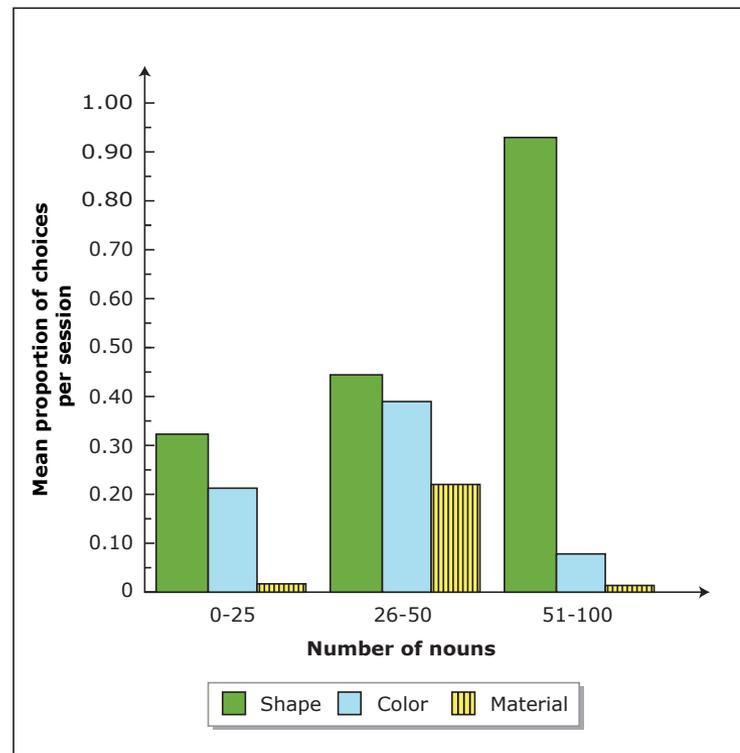
Lexical constraints on the meaning of words: Shape bias
-- a soft constraint
"This is my blicket"
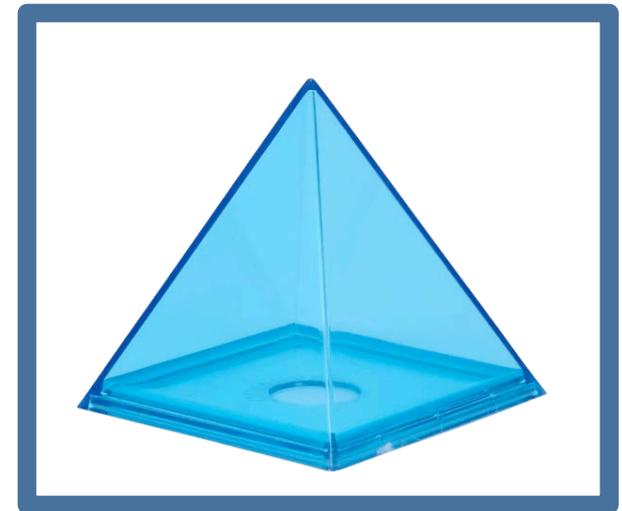
Soja (1991)

"This is my blicket"
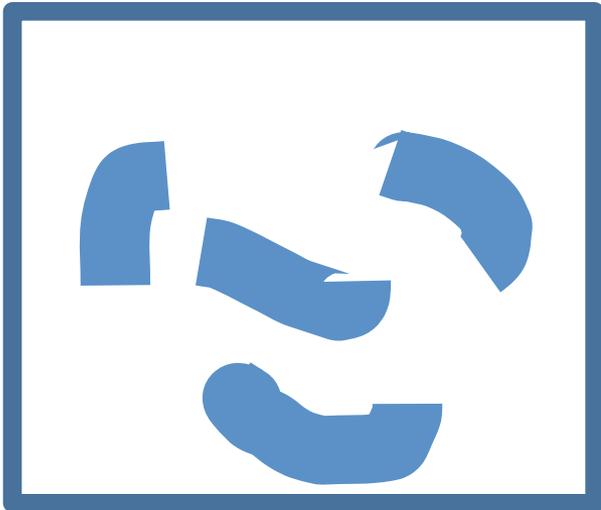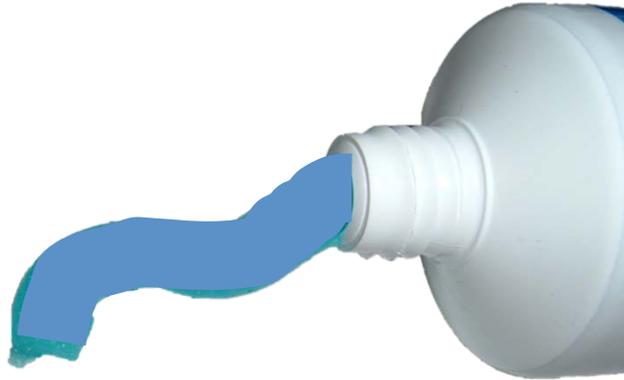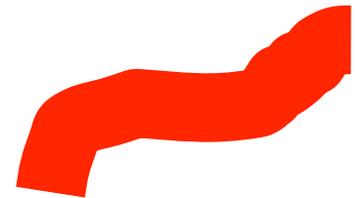
Soja (1992)

"This is a/some blicket"
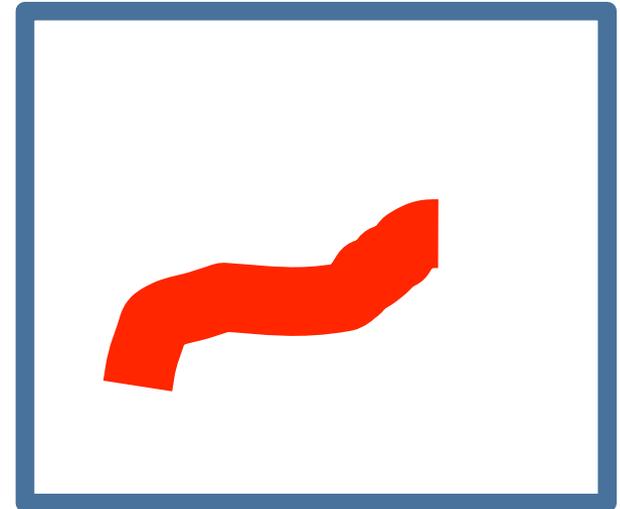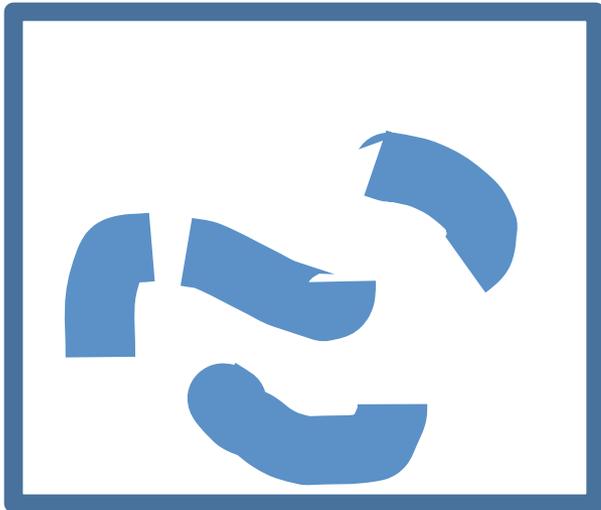
Japanese syntax

Identical syntax for count and mass nouns

Kenji-wa booru-o motteiru.
Kenji-Top ball-Acc have1

''Kenji has a/some balls''

Kenji-wa mizu-o motteiru.
Kenji-Top mizu-Acc have

''Kenji has water''

"Look at this dax!"/Kore-wa *dax* to iimasu

complex objects: both English and Japanese kids have a shape bias
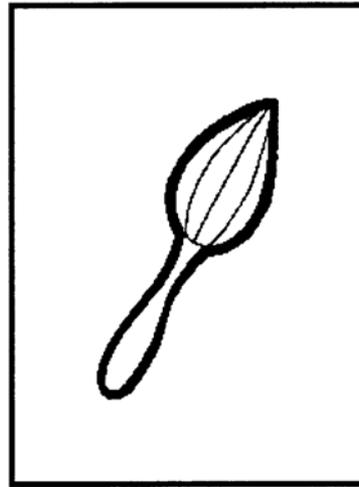
Porcelain Lemon Juicer
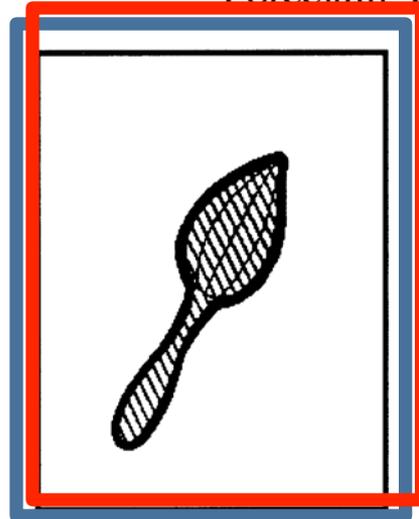
Wooden Lemon Juicer
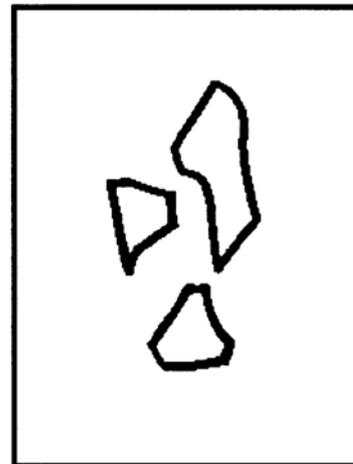
Porcelain Pieces

Imai & Gentner (1997)

"Look at this dax!"/Kore-wa *dax to iimasu*

simple objects:
English has a
shape bias;
Japanese kids at
chance
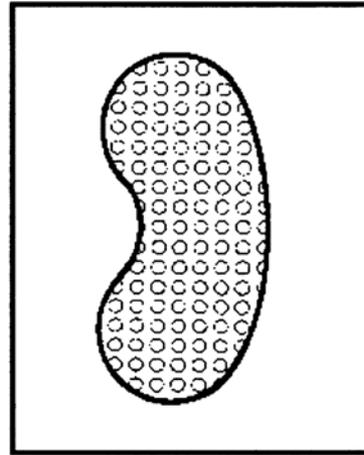
Kidney-Shaped Wax
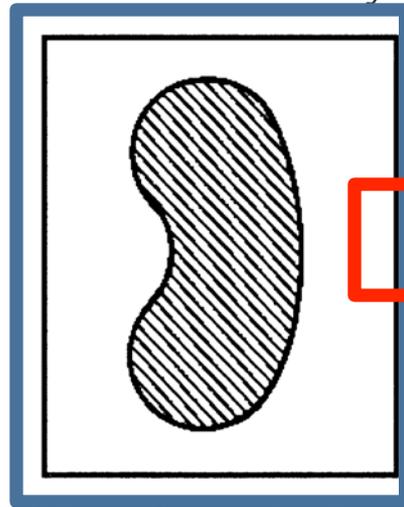
Kidney-Shaped Plaster
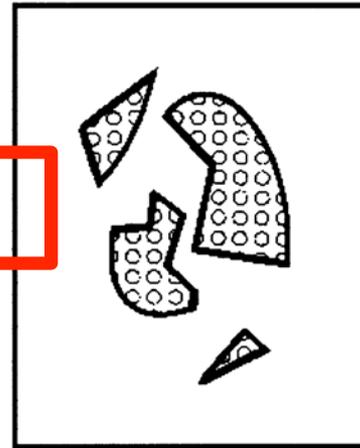
Wax Pieces

"Look at this dax!"/Kore-wa *dax* to iimasu

substances objects: English kids at chance, Japanese kids show a substance bias
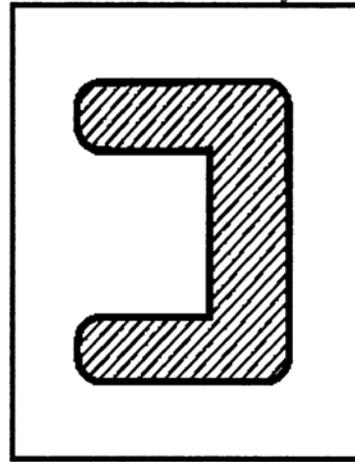
Nivea
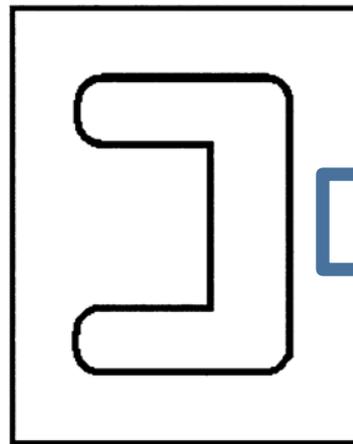
Dippity-Do
(hair-setting gel)
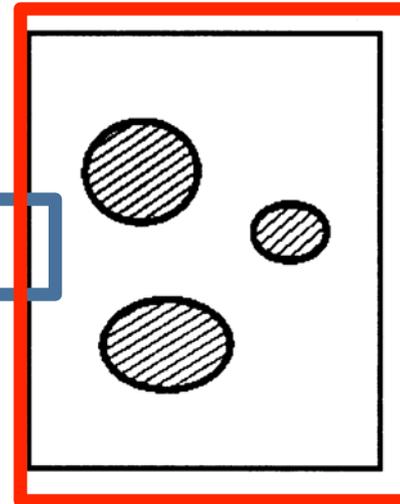
Nivea Piles

Does language change how we think?

" We suggest that the results of our word-extension task are relevant to the issue of what the speakers of the language consider 'another entity of like kind'…. [our findings are] consistent with the claim that linguistic structure affects the weighting of dimensions and the way in which speakers classify entities into different categories" (Imai & Gentner)

Alternatively "Thinking for speaking" (Slobin): the act of using language calls up different representations; all of which are available pre-linguistically

Barner, Inagaki & Li (2009, Cognition)
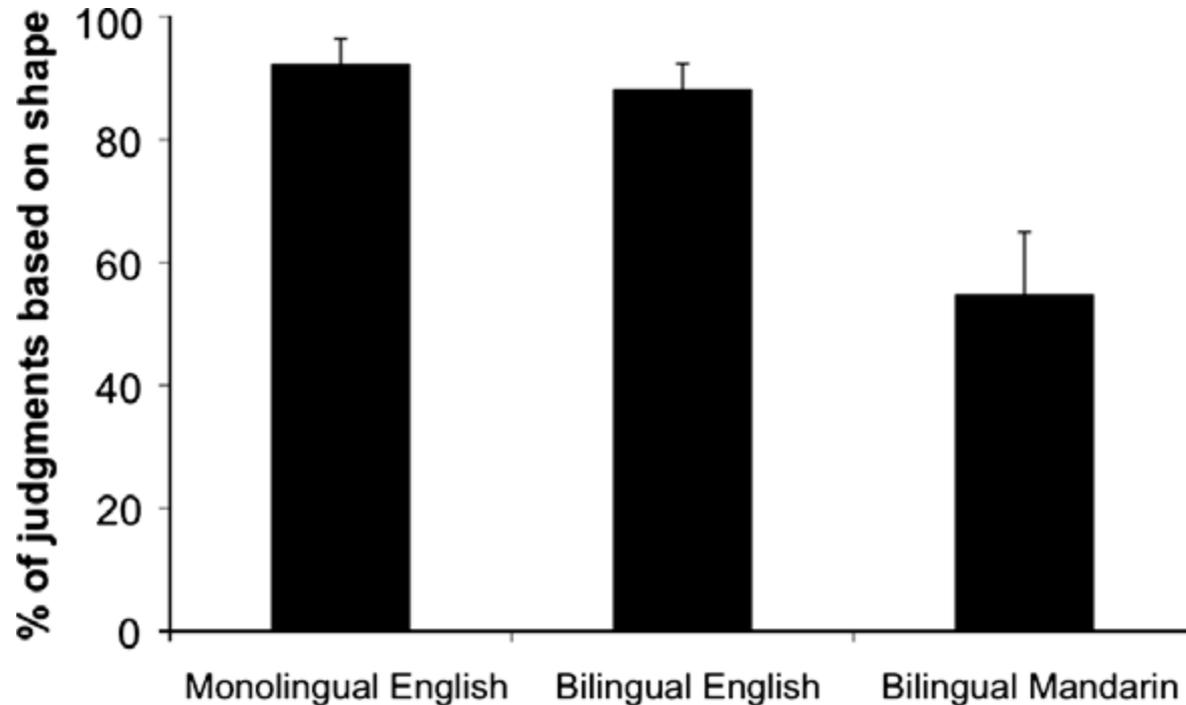
Courtesy of Elsevier, Inc., http://www.sciencedirect.com. Used with permission.

English monlinguals are biased towards shape; so are Mandarin/English speakers when tested in English … but not when tested in Mandarin. Consistent with "thinking for speaking".

Lexical constraints on the meaning of words

- If sensitivity to Spelke-objects affects children's interpretation of word meanings …

- Two predictions:
  - Children will generalize a label to the object and not a part of the object or a property of the object.
  - **Children will generalize according to object itself as opposed to object + other relationships.**

- Rules out disconnected rabbit parts, nose of rabbit, rabbit + grass ...
  - **TAXONOMIC as opposed to THEMATIC groupings**

Lexical constraints on the meaning of words: Thematic groupings vs. taxonomic groupings

In the absence of an object label -- may sometimes group thematically

Can you find another one?
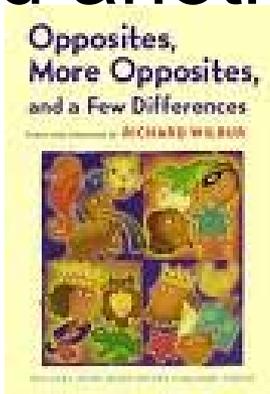
Opposites,
More Opposites,
and a Few Differences

The Knight at Dawn
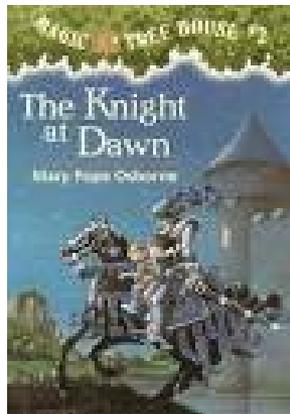
Question 3

Lexical constraints on the meaning of words: Thematic groupings vs. taxonomic groupings

In the presence of an object label -- more likely to group by kind (taxonomically)

- See the reedle? Can you find another reedle?
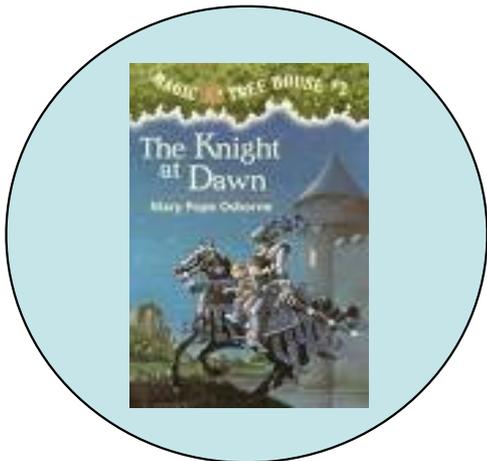
Question 3
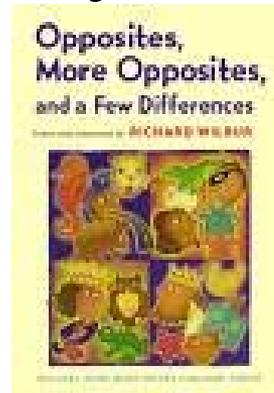
Lexical constraints on the meaning of words: Thematic groupings vs. taxonomic groupings

Same for preschoolers, in the absence of an object label -- may sometimes group thematically

- "See this? Can you find another one?"
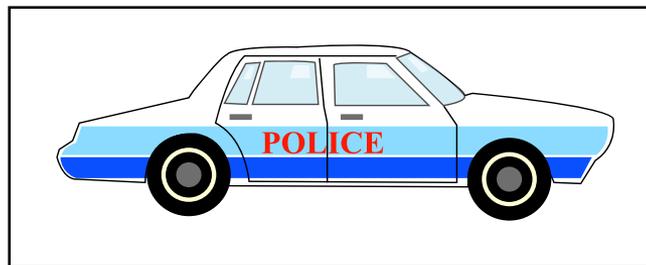
Image by MIT OpenCourseWare.
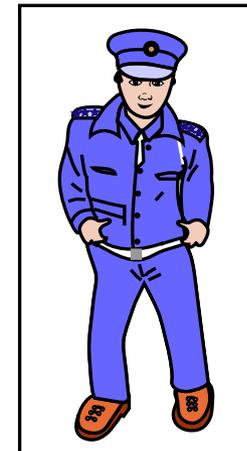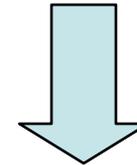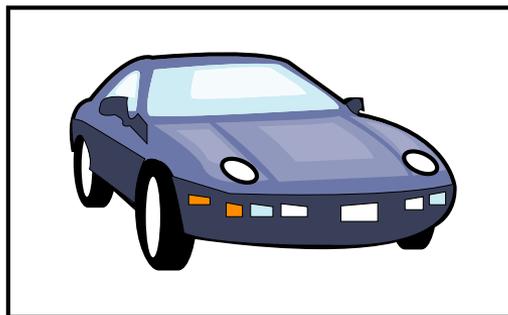
Image by MIT OpenCourseWare.

Image by MIT OpenCourseWare.

Taxonomic groupings

- But given an object label ("This is a dax, can you find another one") children make taxonomic groupings
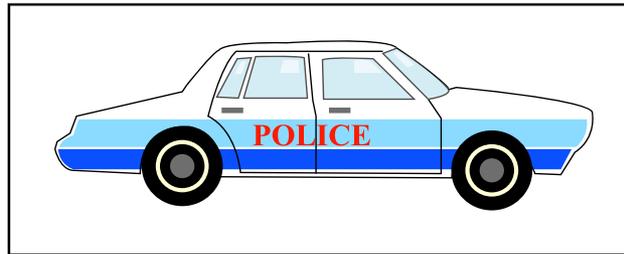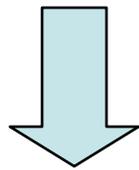
Image by MIT OpenCourseWare.
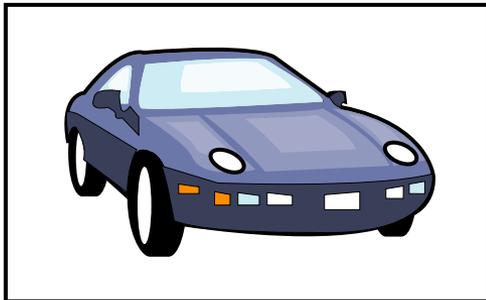
Image by MIT OpenCourseWare.
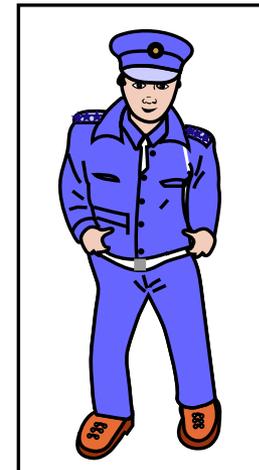
Image by MIT OpenCourseWare.

Constraints on word learning so far ...

- Children don't consider all the hypotheses in Quine's problem of induction …
  - Bias towards interpreting words as referring to whole objects.
  - Objects are often identified by shape.
  - And labels influence children to group taxonomically rather than thematically ...

Lexical constraints on the meaning of words: Basic level bias

- Children don't consider all the hypotheses in Quine's problem of induction …

- And not just whole objects -- but objects at the "basic level".

Lexical constraints on the meaning of words: Basic level bias

- Can call the same object a
  - rabbit
  - Mammal
  - Animal
  - Brush rabbit, Sylvilagus bachmani
  - Bugs

Image: Wikimedia. Public Domain.

Lexical constraints on the meaning of words: Basic level bias
Hierarchical categories

- Animal (superordinate)

- Rabbit (basic)

- Brush rabbit (subordinate)

Hierarchical categories

- What's special about basic level categories?

- They may optimize
  - informativeness
  - and distinctiveness

Hierarchical categories

- What's special about basic level categories?
- They may optimize
  - **informativeness**
  - and distinctiveness

Hierarchical categories

- If you know something is a dog, it's very informative -- you get a lot of inductive power:
    - subject to leash laws, eats dog food, barks ...

- The superordinate level is less informative (knowing something is an animal tells you something, but not as much ...)

- And the subordinate level is less generalizable (Jessup, the golden retriever, is friendly and sheds a lot. But Rover the pit bull?)

Hierarchical categories

- What's special about basic level categories?

- They may optimize
  - informativeness
  - and **distinctiveness**

Hierarchical categories

- Distinctiveness optimized at the basic level:

  - Cats (basic level) look more like other cats than they look like butterflies ...

  - But animals (superordinate level) don't look like each other.

  - And Siamese cats (subordinate level) might be hard to tell from Tabby cats.

Hierarchical categories

- That is, the basic level arguably optimizes two demands of distinctiveness
  - **within-category similarities**
  - Superordinate categories may be hard to learn because there are fewer within-category similarities.
  - And **between-category differences**
  - Subordinate categories may be hard to learn because there are fewer between-category differences.

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Lexical constraints on the meaning of words: Basic level bias

- But of course, children must also *overcome* a whole-object and basic-level bias.

  – To learn subordinate and superordinate categories
  – To learn parts
  – To learn properties
  – To learn synonyms
  – To learn names for objects in other languages

- How do they do this?
  – **mutual exclusivity** assumption
  – syntactic/contextual cues

Lexical constraints on the meaning of words: Mutual exclusivity

- Novel labels pick out novel referents
- "Point to the dax" (**question 4** for you)

Image by MIT OpenCourseWare.

Image by MIT OpenCourseWare.
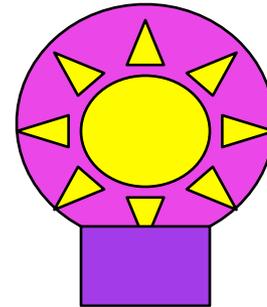
Lexical constraints on the meaning of words: Mutual exclusivity

- Works for adjectives too.
- "Get me the chromium one"
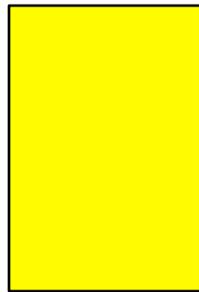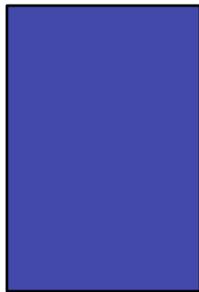
How might mutual exclusivity let you learn object parts?

- **Question 5**: What's a fendle?

Image of light-up toy with a handle and many components removed due to copyright restrictions

Lexical constraints on the meaning of words: Mutual exclusivity

This is a skich. What's a skich?

- **Question 6 for you.**

Image of light-up toy with a handle and many components removed due to copyright restrictions

Lexical constraints on the meaning of words: Mutual exclusivity

- "This is a finial"
- "Which one is the finial -- this part here or the whole thing?"

Image by MIT OpenCourseWare.

- "This is a dorsal fin"
- "Which one is the dorsal fin -- this part here or the whole thing?"
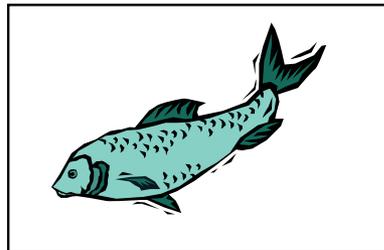
Image by MIT OpenCourseWare.

Lexical constraints on the meaning of words: Mutual exclusivity

- "This is a finial"
- "Which one is the finial -- this part here or the whole thing?"

Image by MIT OpenCourseWare.

- "This is a dorsal fin"
- "Which one is the dorsal fin -- this part here or the whole thing?"

Image by MIT OpenCourseWare.

Lexical constraints on the meaning of words: Mutual exclusivity

- "This is pewter."
- (Novel label; novel object)
- "Which one is pewter?"
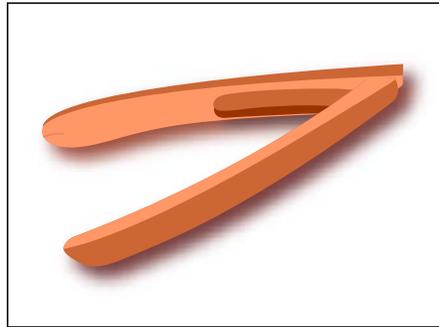
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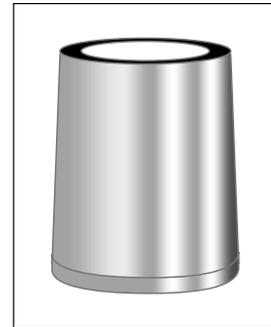
Image by MIT OpenCourseWare.

- Whole-object inference

Lexical constraints on the meaning of words: Mutual exclusivity

Image by MIT OpenCourseWare.

- "This is pewter."
- (Novel label; familiar object)
- "Which one is pewter?"
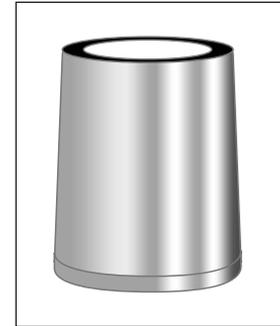
Image by MIT OpenCourseWare.
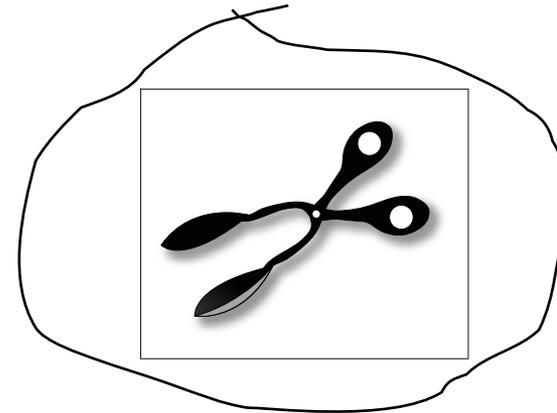
Image by MIT OpenCourseWare.

- Property inference

Lexical constraints on the meaning of words: Mutual exclusivity

- If there's a novel label for a novel object, assume it applies to the whole object. (**Whole-object bias**)

- If there's a novel label for a familiar referent, assume it applies to a novel referent (e.g., a part or a property). (**Mutual-exclusivity)**

- The constraints can work in opposing directions ...

Today

- What are words? What are children's first words?
- Word learning and the problem of induction.
- Lexical constraints on interpretation of word meanings.
  - Whole object bias/shape bias
  - Thematic vs. taxonomic groupings
  - Basic level bias
  - Mutual exclusivity
- Referential intent and interpretation of word meanings

By the way, what's this?

- FAST MAPPING

- (10,000 words by age 6)
- Not specific to words however ...
- Seems to hold for unobservable properties (this is the one my uncle gave me; this one lights up)
- But not for observable ones (this one had a sticker on it)

Interpreting action as referential

Ten-month-old revolution

• the ability to follow the gaze and attention of another

• understanding the referential function of pointing or showing

• the coordination of these processes

Interpreting action as referential

- Social referencing

Interpreting action as referential

St. Augustine

- "When my elders named any thing, and as they spoke turned towards it, I saw and remembered that they called what they would point out by the name they uttered. And that they meant this thing and no other was plain from the motion of their body …expressed by the countenance, glances of the eye, gestures of the limbs, and tones of the voice, indicating the affections of the mind …"

Interpreting action as referential

- Social cues might act as another type of constraint on the meaning of words …

- helping us avoid errors we might make if we learned associatively.

- A few clever studies ... Dare Baldwin, Mike Tomasello ...

Referential constraints on the meaning of words: eye gaze

- **Discrepant labeling task**

- Babies learn labels for object of adults' attention, not their own.

- Babies monitor more in ambiguous contexts (e.g., don't look at face if there's only one object; do if there are 2 or more).

Interpreting action as referential: intentionality

- **Discrepant retrieval task**
- Babies learn labels for what adult intends to label.
- Not just the first object they see.
- And not just the most perceptually salient object.

Referential constraints on the meaning of words: intentionality

- **Intention task**

- Babies assume labels map onto intended rather than accidental actions.

- (Even if accidental action happens immediately after the label).

Referential constraints on the meaning of words: discourse novelty

- **Discourse novelty task**

- Babies can use social cues to disambiguate referents.

Referential constraints on the meaning of words

- Referential intent and word learning
- So how good are these extra-linguistic cues?
- Adult simulation
  - 40 seconds of videotape of mom playing with her toddler.
  - Six most commonly used nouns and verbs were identified.
  - For each word, observers watched 6 tapes with the sound turned off and a beep inserted when the word was uttered.

The extra-linguistic context

- "To test for such effects of information change independent of conceptual change, we used Human College Sophomore as the experimental population. While we would not want to exaggerate the conceptual sophistication of these subjects, we can be quite confident of their competence and stability with respect to the ideas labeled by the words that are the stimuli in these experiments; namely, 24 nouns and 24 verbs that are among the most frequently encountered by the average English-learning child during the first 2 years of life."

Gillette, Gleitman, Gleitman, & Lederer, Cognition, 1999

Table 1
Correct identification of target, final conjecture in Experiment 1 (targets listed from most to least frequent)

Noun targets	Final conjecture	Verb targets	Final conjecture
Piggy	89.3	Go	3.6
Ball	78.6	Do	3.6
Mommy	3.6	Put	35.7
Hat	28.6	Come	75.0
Elephant	89.3	Want	3.6
Plane	100	See	10.7
Bag	85.7	Look	42.9
Kiss	7.1	Get	7.1
Toy	25.0	Turn	3.6
Drum	89.3	Play	21.4
People	39.3	Hammer	14.3
Nose	67.9	Have	0
Hole	57.1	Push	42.9
Daddy	3.6	Say	0
Music	39.3	Throw	85.7
Hand	14.3	Pop	0
Tail	25.0	Like	0
Hammer	71.4	Stand	3.6
Thing	3.6	Think	0
Camera	46.4	Know	0
Peg	10.7	Make	0
Pilot	3.6	Wait	3.6
Shoes	3.6	Fell	10.7
Swing	96.4	Love	0
Mean	44.9	Mean	15.3

Mystery Verb	Syntax and Selectional Information:
GORP means....?	Why don't you GORP gramma? GORP Daddy, GORP Daddy. You gonna GORP Daddy? I'm gonna GORP Markie. Can you GORP Markie on the phone? GORP Mark. GORP Mark.

Fig. 7. The maternal sentences with a nonsense word (capitalized) substituted for the verb *call*. In Condition 5, subjects saw these lists only. In Condition 6, they were accompanied by the matching video (Fig. 4).

Table 5
Correct identification (in %) of target verb in Experiment 3 (targets listed most to least frequent)

Target	Cross-situational observation Condition 1	Noun co-occurrence Condition 2	Observation + nouns Condition 3	Syntactic frames Condition 4	Syntax + selection Condition 5	Full information Condition 6
Go	0	20	15	60	65	100
See	0	25	5	90	95	100
Come	0	0	15	40	60	100
Say	0	35	20	85	90	100
Do	0	5	0	15	35	100
Put	5	15	50	75	95	100
Get	10	0	30	40	65	100
Look	25	45	30	95	100	100
Want	0	30	55	90	100	100
Have	0	0	30	30	45	100
Know	0	0	0	90	100	100
Like	0	0	0	80	90	100
Think	0	0	0	90	90	100
Take	15	35	20	60	85	100
Find	10	5	35	45	65	80
Play	5	45	75	50	85	100
Push	50	30	70	15	90	90
Show	0	10	50	90	100	100
Sit	5	5	25	15	55	100
Catch	35	5	15	10	45	40
Call	5	30	50	20	65	60
Make	0	35	50	25	70	80
Eat	15	0	5	5	35	30
Pull	S	20	50	25	85	90
Mean	7.7	16.5	29.0	51.7	75.4	90.4

Referential constraints on the meaning of words

- Chomsky: Poverty of the stimulus
- Slobin: Poverty of the imagination

Referential constraints on the meaning of words

- Language acquisition happens in a rich context with multiple overlapping cues and lots of background knowledge.

- Stimulus may not be so impoverished after all.

Interim summary

- Word learning is a paradigmatic problem of induction: the possible interpretations of word meanings are infinite. The inference is vastly underdetermined by the evidence.

- Nonetheless, children converge on accurately the conventional meanings of 10,000 words in five years ...

- Evidence suggests their learning is supported by a combination of soft lexical constraints

  – whole object bias, shape bias, taxonomic bias, basic level bias, mutual exclusivity ...

- And cues from the referential context.

Learning words is a problem of inductive inference -- but having words constrains many problems of induction

Image by MIT OpenCourseWare.

Object labels help object individuation:

How does having a word constrain other problems of inductive inference?

Image by MIT OpenCourseWare.
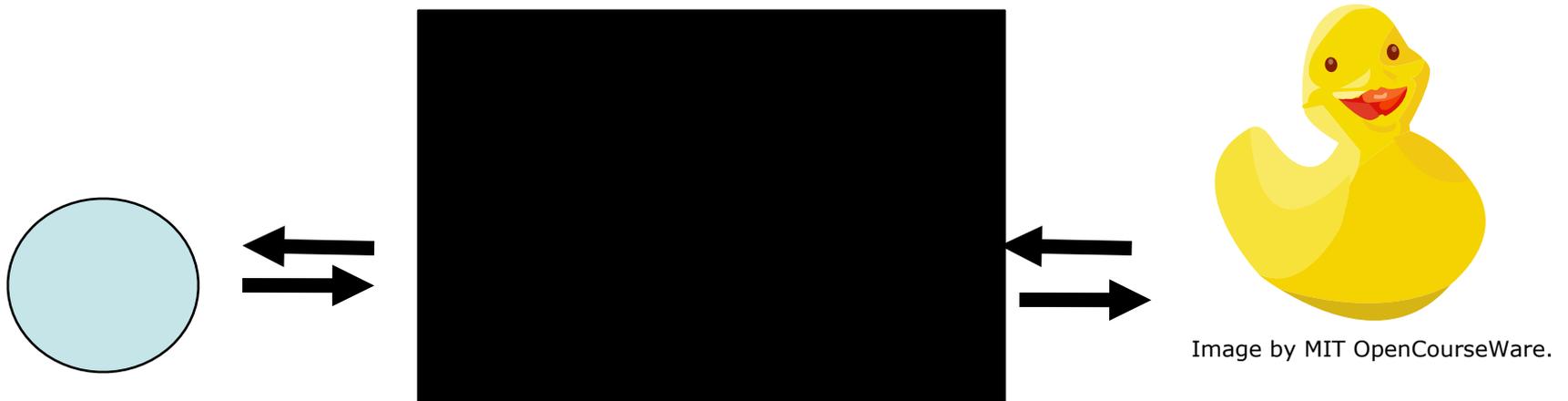
Object labels support object individuation: "Look at the toy!" "See the toy!"

How does having a word constrain other problems of inductive inference?

"Look at the toy"; "look at the toy"
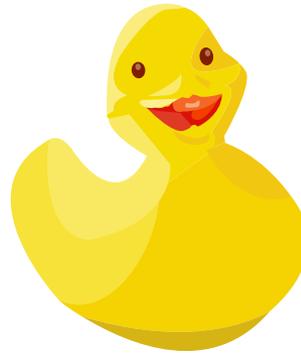
Image by MIT OpenCourseWare.

How does having a word constrain other problems of inductive inference?

"Look at the duck" "See the ball!"
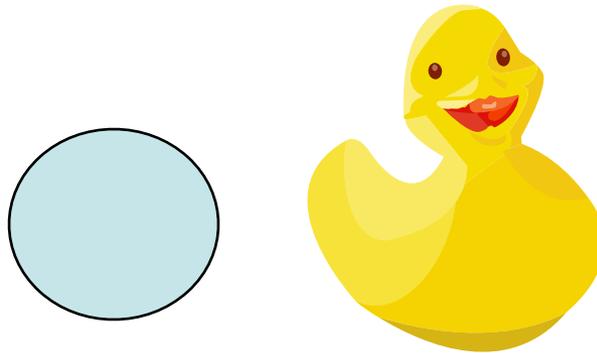
Image by MIT OpenCourseWare.

Learning words is a problem of inductive inference -- but having words constrains many problems of induction

- In the absence of objects labels, children extend inferences about unobserved properties on the basis of appearance.

- "This bears live young"

- "What else bears live young?"

How does having a word constrain other problems of inductive inference?

- However, children can use object labels to override information about appearances.

- "This is a bat. It bears live young"

- "What else bears live young?"

- "This bat?"   "Or this bird?"

How does having a word constrain other problems of inductive inference?
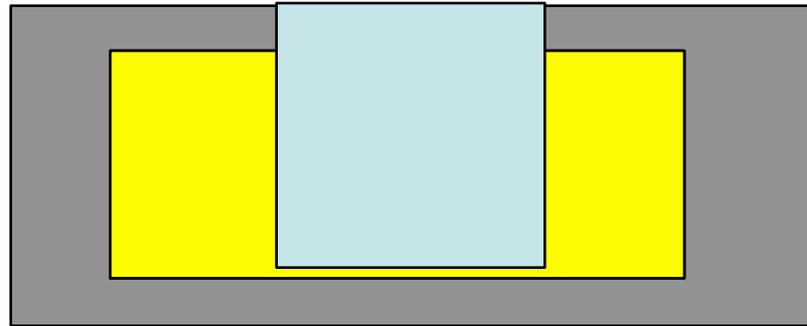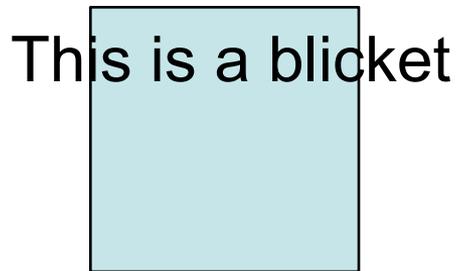
This is a blicket

This is a fep   This is a blicket
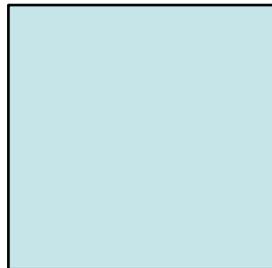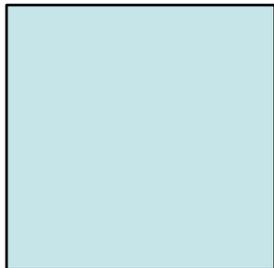
Inductive inferences from categories to causal properties

- Abundant evidence that children can use category labels to make inferences about an entity's unobserved properties.

  - if 'blickets' activate a toy, a new object called a 'blicket' is likely to activate the toy

- Inductive inferences from kinds to their causal properties eliminate the need for trial and error learning ...

  - can infer that new members of the category will have properties common to the category without testing each of them.

Inductive inferences from categories to causal properties

- In specifying conditions in which we can avoid trial and error learning, principles of inductive inference also provide an account of the conditions under which exploration is rational.

- For instance, if children assume that members of a kind will share unobserved causal properties ...

- ... they should engage in more exploration when causal properties vary within a kind

- ... then when causal properties vary between kinds.

This is a Blicket
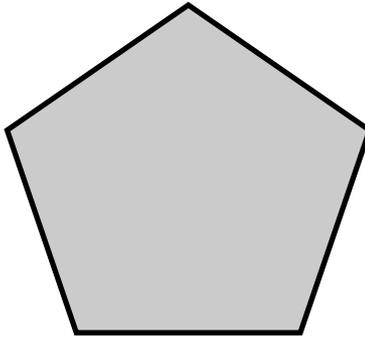
The Blicket is magnetic
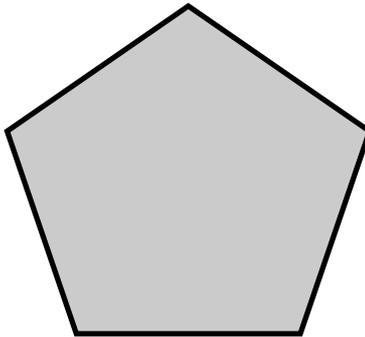
Look at these!
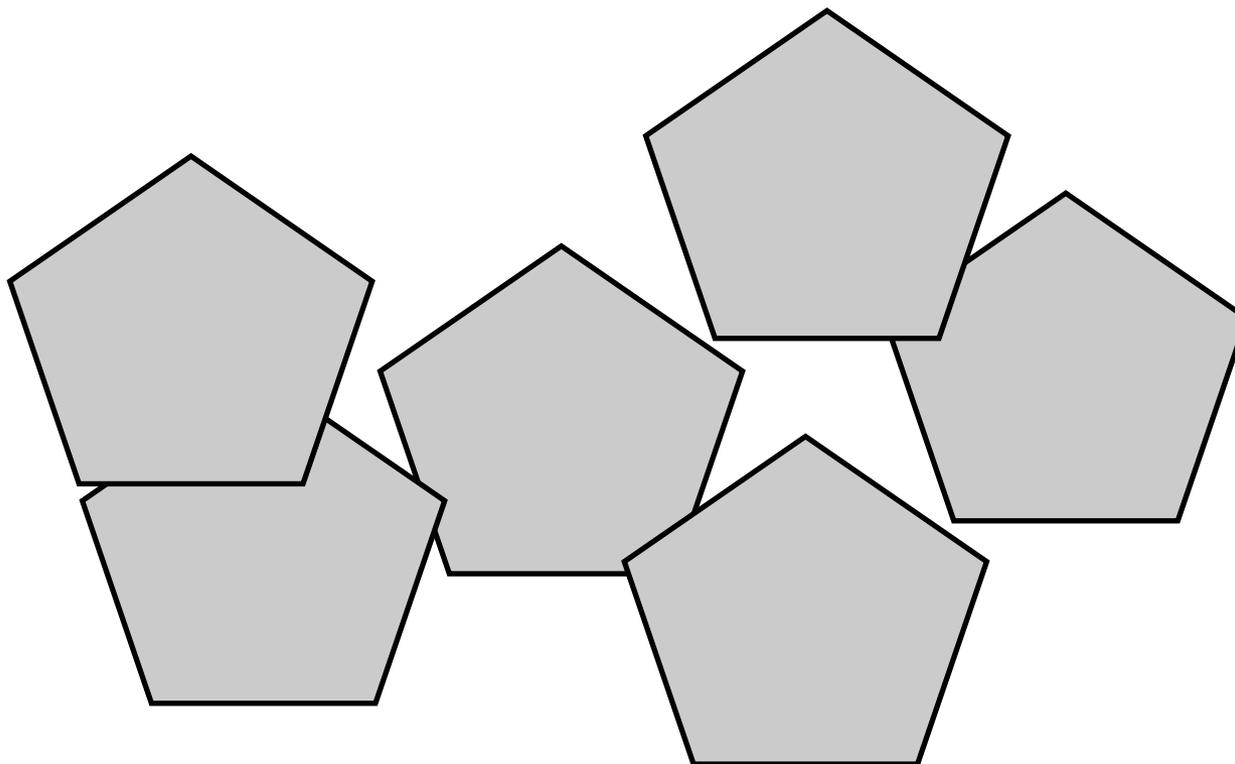
These are Blickets.
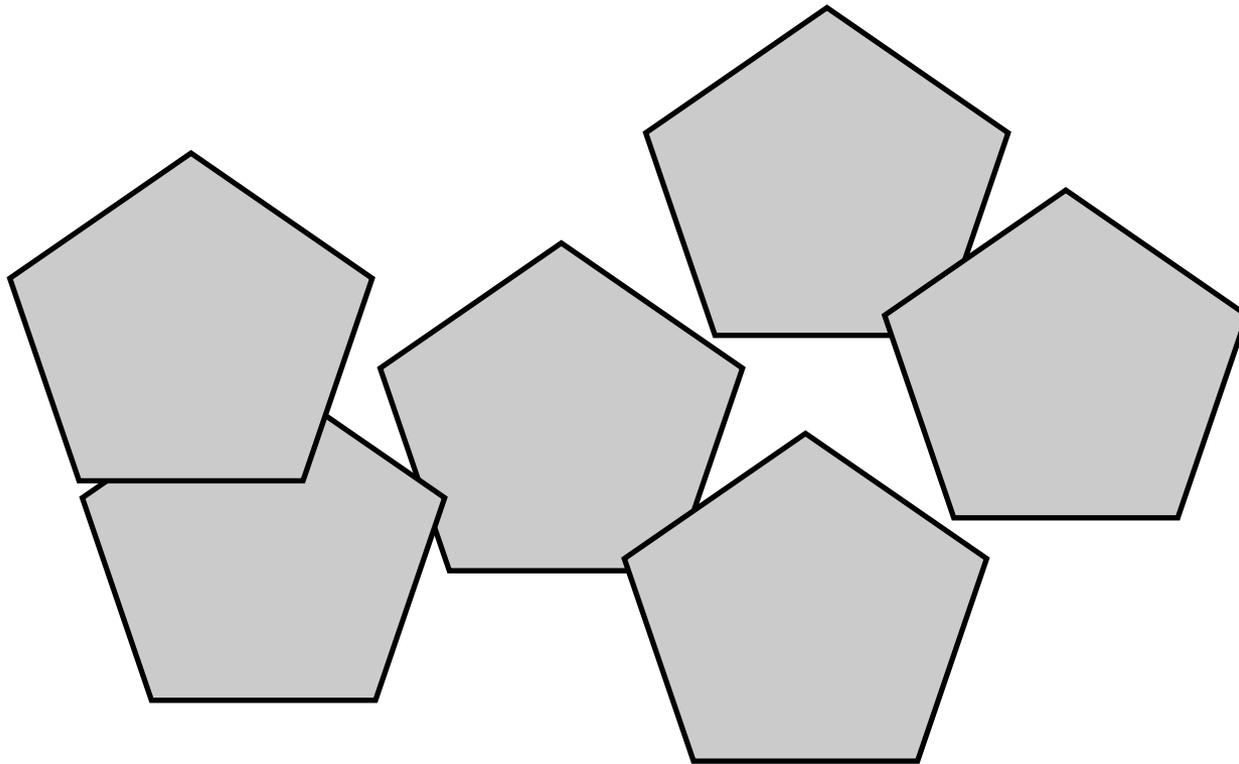
These are Dacks.
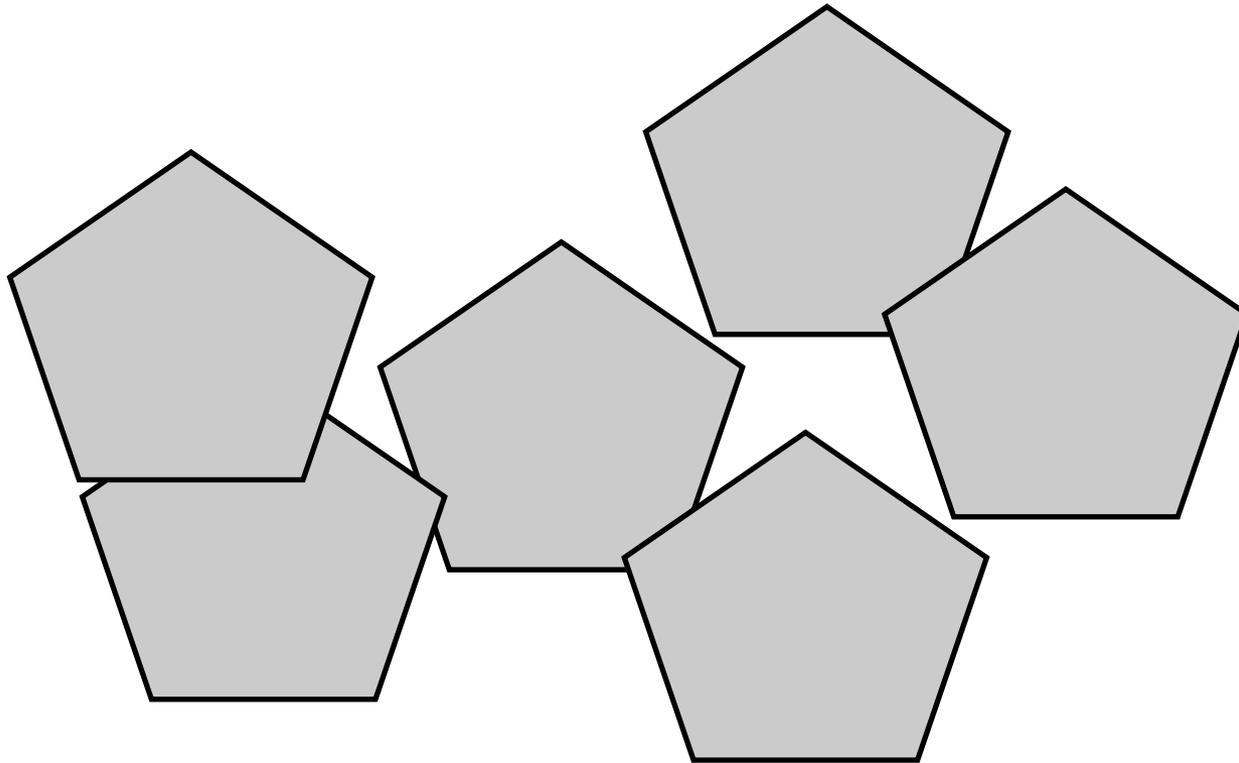
Many possible process-level accounts of why children differentially explore in the one kind and two kind conditions ...

- Evidence of inert blocks in the one kind condition is insufficient to overturn their expectation that the new members of the kind will have the causal property.

- Evidence of inert blocks in the one kind condition indicates that the causal status of each token of the type is uncertain. They want to discover the causal status of each token of the type -- or the factors that distinguish magnetic "blickets" from inert ones.

- Evidence in the two-kind condition of a single inert "dack" is sufficient for them to infer that all "dacks" are inert.

All accounts result in an equivalent adaptive outcome ...

- If children spontaneously explore more individual objects when objects' causal properties vary within categories than between categories ...

- children will be likely to discover the causal properties of individual objects in cases where they cannot otherwise be inferred.

9.85 Infant and Early Childhood Cognition
Fall 2012