## Language development in infancy

attention to sound structure in infancy

word recognition and phonological encoding

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## What's going on in the first year

innate auditory abilities govern categorization of speech

then, infants start sorting out which sounds of a particular language are meaningfully different

at the same time, infants begin building a vocabulary of words (mainly sound-forms only, no meanings)

by 10-12 months, infants say their first words

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## What ARE they thinking?
### (A Q&D tutorial on infant language methods)

What do kids say (sounds, words)?

But what if they can't talk?

Have to ask what they *pay attention* to.
   What seems **interesting**?
   What seems **new**?
   What means something's going to **happen**?
   What did a spoken word **refer to**?

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## What ARE they thinking?
### (A Q&D tutorial on infant methods)

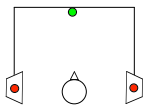**H**eadturn **P**reference **P**rocedure: What seems **interesting**?

Play sounds out of a speaker

Some sounds of Type 1, some of Type 2

Does infant look at speaker longer (indicating more interest) for Type 1, or is there no difference?

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## What ARE they thinking?
### (A Q&D tutorial on infant methods)

**H**eadturn **P**reference **P**rocedure: What seems **interesting**?

1. trial starts with green light
2. once baby's ready, flash one side light
3. when baby turns to light, start playing sounds from speaker
4. when baby turns away, stop sounds and start new trial

**dependent measure: listening time to a given kind of auditory material**

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## What ARE they thinking?
### (A Q&D tutorial on infant methods)

Habituation: What seems **new**?

Version 1: **high-amplitude sucking** (HAS)--good if v. young
      kid gets to hear sound with each HA suck
      after hearing the same sound, suck rate declines
      present slightly-changed sound:
            does sucking rate perk up again?
            (= renewed interest)
Version 2: **visual** habituation
      hear sound whenever kid looks at visual stimulus
      gradually, look length declines
      change sound: do looks get longer again?

## What ARE they thinking?
(A Q&D tutorial on infant methods)

What means something's going to **happen**?

Conditioned Head-Turn Procedure

    teach kid that whenever sound Y happens, reward
        usually a toy drumming bear

    then present X, X, X, Y, X…
        do they look for reward at Y?
        I.e., can they detect Y (is it different from X?)

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## What ARE they thinking?
(A Q&D tutorial on infant methods)

Picture fixation: What did a spoken word **refer to**?

Show pictures of a ball and an apple.

Sound: "Look at the **ball**! Isn't it nice?"

Videotape eyes as word is heard.

Code **eye movements** to given picture.
    Do they look more at the ball than the apple?
    (=know the word?)

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# Early speech development

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## *innate auditory abilities*

case study: Eimas et al., 1971, on [p] vs [b]--**HAS**
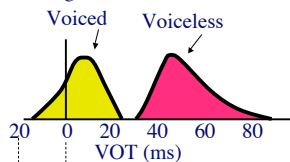
   the sound [p] in, say, "a pack":

        1. stop vocal fold vibration

        2. put lips together

        3. release lips and let air through

        4. start vocal fold vibration

   time between #3 and #4: **Voice Onset Time (VOT)**

   VOT is a primary cue listeners use to distinguish
   [p] from [b] at syllable onset.
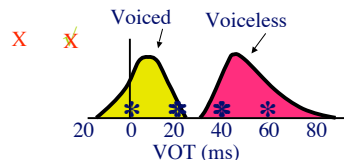
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VOT variation in English

Voiced     Voiceless

20  0  20  40  60  80
VOT (ms)

Voicing **lead**    **Short** lag     **Long** lag
like Spanish /b/

    like Eng. /b/    like Eng. /p/
    or Spanish /p/

Thai uses all three: ba: 'crazy'; pa: 'aunt'; pʰaa: 'cloth'

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X  x

Voiced    Voiceless

20  0  20  40  60  80
VOT (ms)

English speakers can distinguish synthesized b/p sounds
differing only in VOT, if tested using 20 and 40 msec.

But they can't (or perform poorly) if tested using 0 and 20 or
40 and 60.

*Categorical perception* (strict definition): listeners can only
discriminate sound pairs they can give different labels.

*Categorical perception* (loose definition): listeners are much better
at discriminating between categories than within categories.

## How do infants perceive speech sounds?

Eimas et al.: 1- and 4-month-olds; habituation procedure.

VOT:  +20/+40  0/+20,  Control
      (ba/pa)   +60/+80  (ba…ba…ba…ba…)



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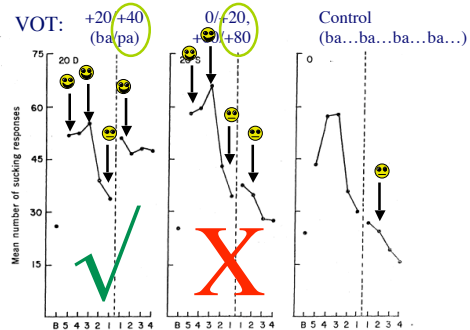
Uniquely human genetic innate language capacity!…or not



chinchilla
macaque
J. quail

*Basic auditory ability*

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Further study: replications testing discrimination of many speech sounds.

Under ideal conditions, young infants can tell apart **any two speech sounds** that are used in any language for conveying different meanings.

| some contrasts | some contrasts infants discriminated in studies | | |
|---|---|---|---|
| big/pig | b/p | s/z | a/ã |
| shed/said | b/d | s/θ | E/æ |
| dumb/numb | r/l | f/θ | i/ɪ |
| | b/w | d/g | |
| ñora/nora | b/m | a/i | |
| | w/j | u/y | |

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### *language-specific refinement*

Werker & Tees 1984: test discrimination of Hindi dental and retroflex /t/, and discrimination of Nthlakampx velar and uvular consonants [k'] and [q'], using CHT.

🔊 velar     🔊 uvular

Canadian babies     discriminated at 6-8 months
                    only some did at 8-10 months
                    almost none at 10-12 months

**Infants get *worse* at discriminating sounds that aren't contrastive in their language.**

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### *language-specific refinement: vowels*

similar results, perhaps even earlier development

Polka & Werker 1994, using visual habituation procedure

German /u/ vs /y/     4 months discriminate
                      6 months don't
                      10-12 months don't

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### *language-specific refinement: vowels*

Catalan and Spanish
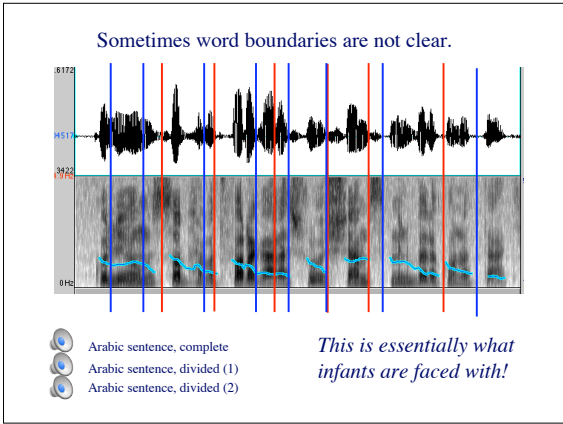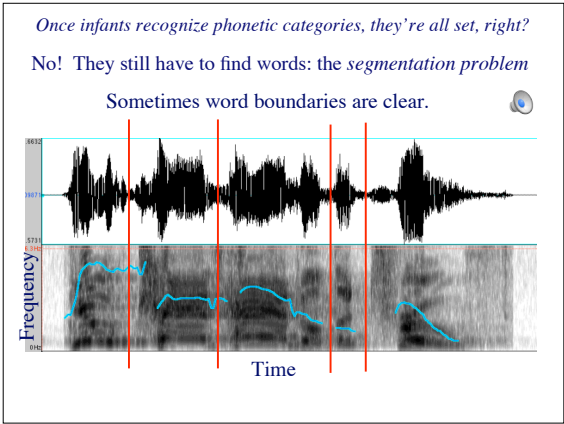
Catalan: has /e/ and /E/  (like "bait" and "bet")
Spanish: just something in between, near /e/

Bosch & Sebastian-Gallés, using habituation procedure:

   all 4.5 month olds discriminate /e/ and /E/;
Catalan 8.0 month olds discriminate them too;
Spanish 8.0 month olds don't.

*Once infants recognize phonetic categories, they're all set, right?*

No!  They still have to find words: the *segmentation problem*

Sometimes word boundaries are clear. 🔊



Frequency

Time

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Sometimes word boundaries are not clear.



🔊 Arabic sentence, complete
🔊 Arabic sentence, divided (1)
🔊 Arabic sentence, divided (2)

*This is essentially what infants are faced with!*

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## What about actual speech to infants?

In general, parents don't do much to mark where linguistic units (words, phrases) begin and end.  The baby has to figure that out.

Start by learning words in isolation?

Word-teaching experiment (see Aslin, 1993)
Get parents to teach word (e.g. "rist") to infants
Parents rarely produced in isolation…
*Even though trying to teach kids the word!*

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## How do infants know which things might be words?

**Distributional analysis**: which things tend to go together. Sound sequences that appear together in various environments are more likely to be words.

thatsaprettybabyisntit
doyoulikeyourbabybrother
thebabyspitupagain

**Transitional probability:**
ba-->by   100%
ty-->ba    33%
by-->is    33%

Saffran, Newport & Aslin 1996, 8-mo-olds (HPP):
bidakupadotigolabubidakugolabu…

likely
not likely

Listened longer to "novel" (low transitional probability) sequences ku.pado than to bidaku

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Saffran, Newport & Aslin 1996, 8-mo-olds (HPP)

**Also works with tones, sequences of visual objects--*not a language-specific learning mechanism***

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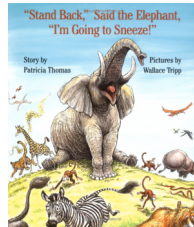## infants' learning of word-forms from speech

Infants remember words from stories after two weeks. Shown by preference for hearing those words rather than other words.                    (Jusczyk & Hohne 1997)

## Jusczyk & Hohne (1997)

1. Visit home of 8-month-olds 10 times over 2 weeks.

On each visit, sit infant in a seat, and play a tape-recording of someone reading a story. Meanwhile flip through a book with pictures relating to story.

3 stories total, 30 min. per visit, 5 talkers each story.



"Stand Back," Said the Elephant, "I'm Going to Sneeze!"
Story by Patricia Thomas
Pictures by Wallace Tripp

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## Jusczyk & Hohne (1997)

2. Wait 2 more weeks.



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## Jusczyk & Hohne (1997)

3. Use headturn-preference procedure to test word lists.

| In stories | Foils |
|------------|---------|
| sneeze | aches |
| elephant | apricot |
| ants | sloth |
| gray | jaunt |
| python | lanterns |
| [...] | [...] |

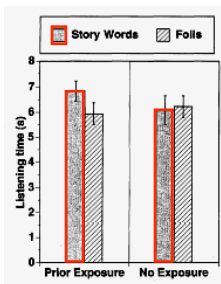*in-stories* words occurred ~13 times per story visit.

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## Jusczyk & Hohne (1997)

Results (HPP): Infants preferred the familiar-word lists.



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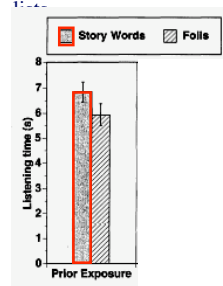
## Jusczyk & Hohne (1997)

Results: Infants preferred the familiar-word lists.



But not in a control study of infants with the same test, but no familiarity with the stories.

8-month-olds remember at least some words they've heard (even if they don't know what the words mean yet)

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## *infants' learning of word-forms from speech*

Similar results are found with shorter training and testing just after the training.

These studies show that children are *biased* in what words they extract and remember.

-- extract strong-weak (berry), not weak-strong (beret)
  [French infants do the reverse.]

-- don't extract words crossing prosodic phrase boundaries

  CHT: 10 mos. trained to turn to "paper", then tested:
  50% *The church with the **paper** spires is heavenly.*
  15% *The man with the least **pay per**spires constantly.*
  Gout, Christophe, & Morgan 2004

12-month-olds know a stock of word-forms, possibly quite large (150-350 words), some of which are connected to some meaning.

These words, first learned only as sounds, form the basis of the early vocabulary.

around 6-8 weeks: cooing (contented vowel sounds)

around 2-3 months: some consonantlike sounds, often *velars* like [g] and [k]

around 6 months: other consonantlike sounds with *labial* or *alveolar* constriction ([m], [n], [b], [p], [d])

around 6-9 months: *canonical babbling* (dadada or nanana)

around 11 months: *variegated babbling* (dababi with prosody)

Also, throughout (and beyond) the first year, words gradually approach adult pronunciation

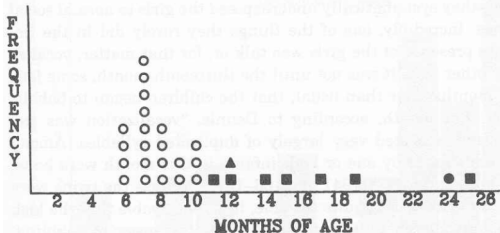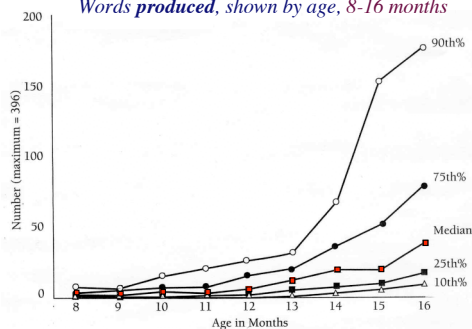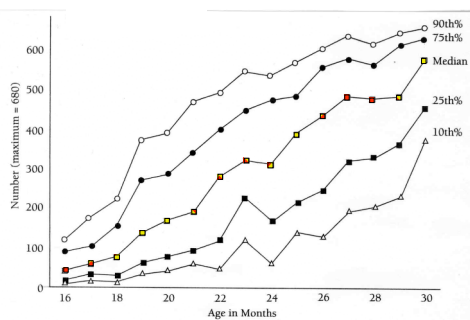*onset of canonical babbling: age distribution*



*Figure 5.7.* Age of onset of babbling in nine hearing-impaired (filled symbols) and twenty-one normally hearing (open symbols) infants.

Oller & Eilers, 1988

*Acquisition of the vocabulary:*
*Words **produced**, shown by age, 8-16 months*



*Words produced, shown by age, 16-30 months*



# Word learning

## Are children's word meanings fundamentally like ours?

Maybe not: some words may be *context bound*

   Bloom: *car* only for particular viewpoint
   Barrett: *duck* only for duck bath game
   Bates: words used only in the presence of their referent

But this phase is limited (only children's very first words), and may refer only to *production* tendencies, not weird denotations.

Mostly, children's words refer to categories, where the sorts of categories are comprehensible (even if they're not quite the right meanings).

## What do children talk about?

Why are children talking? -- Not only requests; many comments too.

Which words? -- a variety:

   proper nouns (Mommy);
   common nouns and pronouns (dog, this)
   action words (go, up, look)
   modifiers (all-gone, mine, big)
   social words (no, want,)
   function words (what, for, is)
                                        --K. Nelson 1973

As vocabulary expands, the proportion of nouns balloons.

## Why so many nouns?

Some crosslinguistic variation; noun bias not universal

   *Mandarin*: children produce more verbs than nouns.
   (a) verbs more likely to be sentence-final
   (b) verbs vary less in their realization in M. than in Eng.
   (c) parents simply say more verbs in M.

But the general pattern favors nouns, and in particular object labels.

   *Why*?
      - maybe the concepts are simpler
      - maybe the concepts are easier to identify

# Problems in word learning

## Problems in word learning

**phonological encoding**: what sounds did you say?

**present-referent identification**: what are you talking about now?

**category identification**: how can a word be extended?

## Phonological encoding: production

Children's speech: often hard to understand
      "squirrel" --> /ga/

   -**simplify** consonant cluster skw -> k  ("cluster reduction")
   -liquids /l/ and /r/ often **omitted**
   -voiceless stop consonants often **voiced**
   -vowels often **undifferentiated**

Does children's speech reflect their knowledge of words, or just what they can do with their vocal apparatus?

### *Phonological encoding*: *perception*

To find out what children know about sound forms, try testing their word recognition with correct pronunciations and mispronunciations.
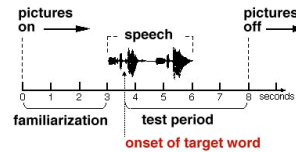
If children know how words should sound, mispronunciations should be **harder to understand** than correct pronunciations.

If children only have a vague idea how words should sound, they **shouldn't care** how words are said.

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one simple word recognition task: picture fixation
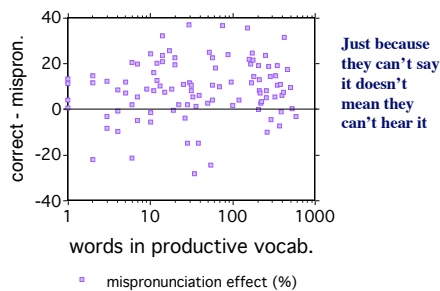
Swingley & Aslin, 2000, 2002

pictures on → --- speech --- pictures off →

familiarization    test period

**onset of target word**

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Where's the ball?    Correct
Where's the gall?    Mispron.

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Target fixation given correct pronunciation and mispron., plotted by child's age



proportion to target

<- 50% = can't tell

Age (days)

● correct pronunciations
□ mispronunciations

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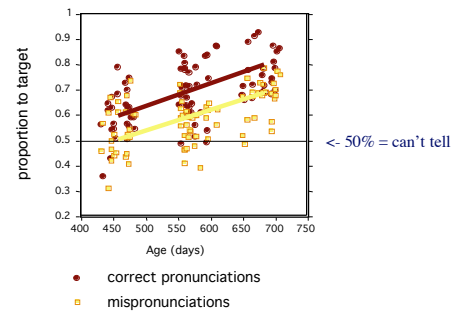
% better on correct pron. than on mispronunciation, shown by child's production vocabulary (14-23 months)



correct - mispron.

words in productive vocab.

□ mispronunciation effect (%)

**Just because they can't say it doesn't mean they can't hear it**

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A small caveat: doesn't work so well for *new* words

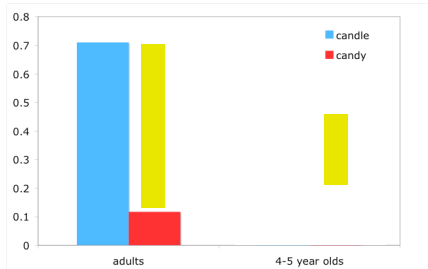Stager & Werker, 1997, habituation w/14-m-o



"bih"            "dih"

Test: "dih"
No dishabituation!
Fine with lif/neem

Kids have less precise representations of new word-object pairings

## My work: long time to get to adult performance



## Problems in word learning

*phonological encoding*: what sounds did you say?

→ *present-referent identification*: what are you talking about now?

*category identification*: how can a word be extended?

---

## *present referent identification*

Saint Augustine, bishop of Hippo, AD 397
They say, I look: "the natural language of all nations"

W.V.O. Quine
    but you never know -- "gavagai" problem

How can you really know what someone else is talking about? Even if they point and say a single word, they could mean many different things.

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## *3 views on Quine's problem*

1. just store a correlation matrix

2. linguistic constraints on hypothesis space

3. St. Augustine was right: intention reading carries the day

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### 1. just store a correlation matrix

|  | | | |
|---|---|---|---|
| brown | 1 | 1 | 0 |
| huge | 1 | 0 | 0 |
| animal | 1 | ? | ? |
| right-here | 0 | 1 | 1 |
| long-nose | 1 | 1 | 1 |
| big-ears | 1 | 0 | 1 |
| scary | 1 | 0 | 0 |
| wrinkles | 1 | 0 | 0 |
| edible | 0 | 1 | 0 |
| yummy | 0 | 1 | 0 |

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### Just store a correlation matrix--but what about…

• What are the features in the matrix?
    okay for object labels, but what about "all-gone" or "think"
• Lots of things are present when a word is heard (for example, the child), yet children home in on the right meaning
• What about *fast mapping*?
    relatively error free learning, w/few trials

*Fast mapping example:*
"Give me the maroon one, not the green one, the maroon one."
(for colors, shapes, or textures)
2, 3, and 4 year olds better than chance in later choosing the right color/shape/texture from a set of 4.
    Carey & Bartlett, 1978; Heibeck & Markman, 1987

Success in fast mapping suggests that "brute-force correlation"--gathering lots of information over lots of different exposures--is not the way children learn words.

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*2. linguistic constraints on hypothesis space*

Maybe children are **biased** against certain word meanings, simplifying the learning problem.

Ellen Markman: constraints on object labels
*whole object* assumption
*mutual exclusivity* constraint

Experiments:
"Where's the mido?"

More complex situation:
"Hold the handle."

Here, mutual exclusivity outranks whole-object assumption

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*2. linguistic constraints on hypothesis space*

**Linguistic context** as an aid in word learning

Roger Brown (1957), 3-4 year olds
"sibbing" *vs.* "some sib"

       *sibbing* --> verb interpretation
       *some sib* --> substance interpretation

Katz, Baker, & Macnamara (1974), 17 month olds
"a dax" *vs.* "Dax"
       object
       animate critter

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*2. linguistic constraints on hypothesis space*

Naigles (1990), 2-year-olds

1. rabbit pushing duck down; rabbit and duck twirl arms
   "The rabbit is *gorping* the duck." *or*
   "The duck and the rabbit are *gorping*."

2. rabbit pushing duck *vs.* rabbit and duck arm-twirling
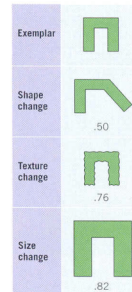   "Find *gorping*!"

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*3. St. Augustine was right*

That is, maybe children are really good at figuring out what their parents are probably talking about, so word learning isn't so hard after all.

    Lots of social cues--joint attention

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*category identification: how should a word be extended?*

Often, shape most important

| | |
|---|---|
| Exemplar | "This is a *dax*." (i.e. this has the non-obvious property of being called a dax.) |
| Shape change .50 | "Is *this* a *dax*?" |
| Texture change .76 | "Is *this* a *dax*?" |
| Size change .82 | "Is *this* a *dax*?" |

Landau, Smith, & Jones 1988
(2- and 3-year-olds)

*category identification: how should a word be extended?*

Shape not always the most important factor

Soja, Carey, & Spelke 1991, 2-year-olds

Show children  (a) novel object, like honey dipper;  or
                        (b) heap of substance, like blob of gel
*"This is a blicket."*

Test: *"Find another blicket."*

(a) group:  wood honey dipper *vs.* bits of honey-dipper plastic
     Picked same **shape**

(b) group:  similar heap of cream *vs.* little blobs of gel
     Picked same **substance**

---

*category identification: how should a word be extended?*

In general, children use whatever information they think
is most relevant for identifying the *category* denoted by
a word.

*for object labels:*
shape
material composition
function
intended category or intended function