Categories and Concepts
Concepts in infancy

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PSYCH-GA 2207

Why study concepts in infancy

- Our conception of the infant mind has changed dramatically in the last 35 years, showing they are much more intelligent than previously thought
- Children are the most impressive learners in the known universe

Some fundamental questions:

- Do infants have qualitatively different thought processes than adults?
- What is the origin of concepts?

Key tool in infant studies: Habituation paradigm

today we will mostly discuss infants ages 3-4 mo (months old)

+

+

+

+

Sequence of trials in a habituation task

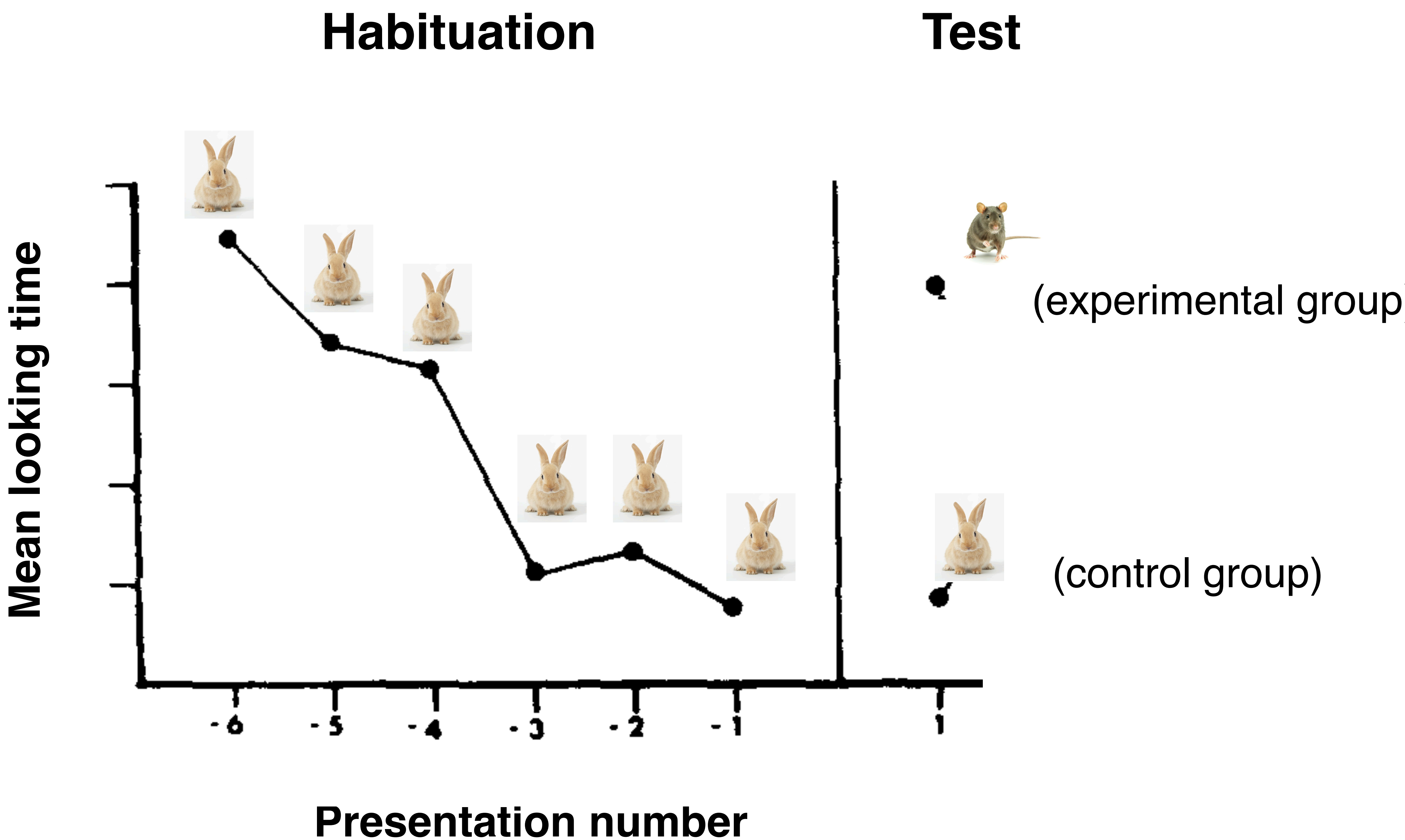
Habituation or Familiarization Trials

Trial 1	bunny1
Trial 2	bunny1
Trial 3	bunny1
Trial 4	bunny1
Trial 5	bunny1
Trial 6	bunny1

Test Trial

Trial 7 bunny1 (control group)
or rat1 (experimental group)

Hypothetical results



Concept-learning version of habituation task

<u>Habituation or Familiarization Trials</u>

Trial 1 bunny1 

Trial 2 bunny2 

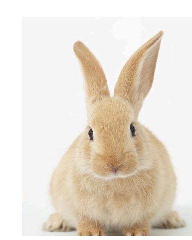
Trial 3 bunny3 

Trial 4 bunny4 

Trial 5 bunny5 

Trial 6 bunny6 

<u>Test Trial</u>



Trial 7 bunny 7 (control group)
or rat1 (experimental group)

Sequence of trials in a paired-preference procedure (habituation design)

Left half of screen   right half

Habituation or Familiarization Trials

Trial 1:	bunny 1	bunny 2
Trial 2:	bunny 3	bunny 4
Trial 3:	bunny 5	bunny 6
Trial 4:	bunny 7	bunny 8
Trial 5:	bunny 9	bunny 10

Test Trial

Trial 6:	bunny 11	rat 1

Prediction: During test, infant will look longer on the right side of the screen with the novel category

Controls added by Bomba & Siqueland (1983)

- A priori preference test between the two categories
  - do infants look more at rats than bunnies, before any in-lab exposure?

- Discriminability test within categories
  - Can infants tell the difference between individual bunnies? in a sense, the ability to discriminate between items is necessary for calling them a “category”

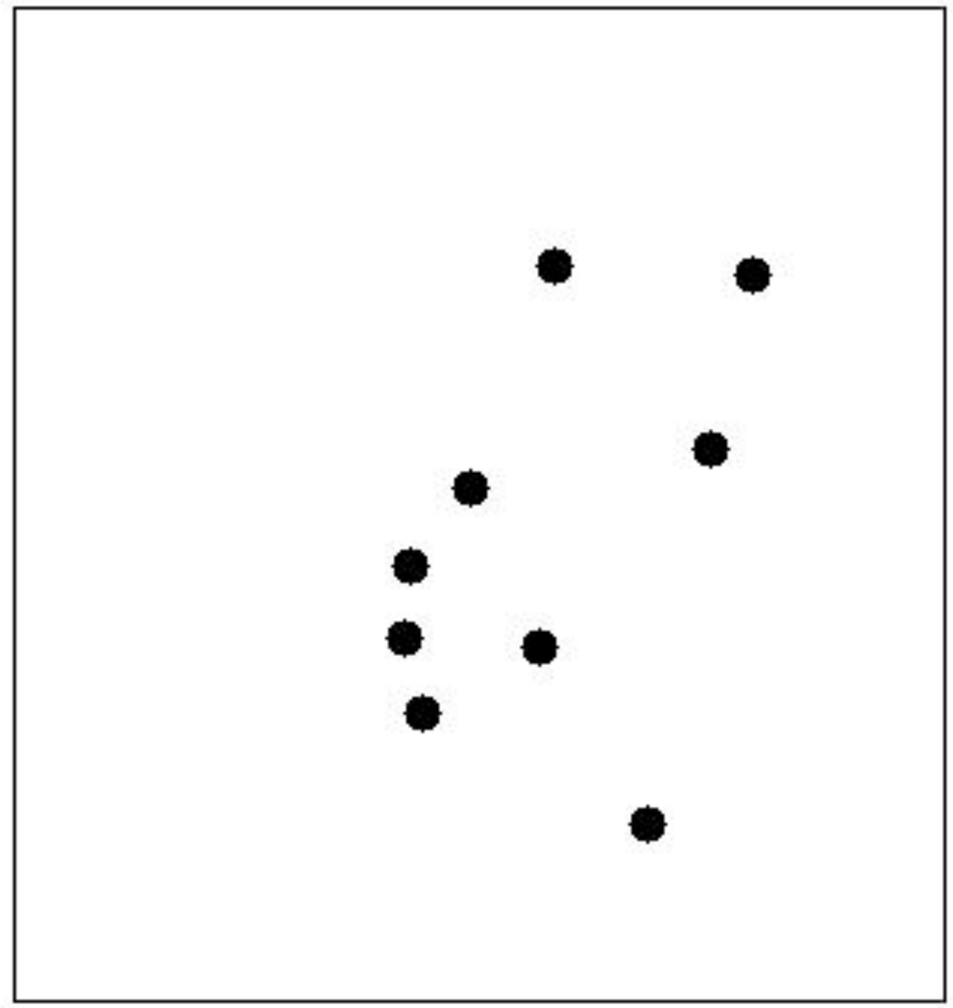
Review: Posner & Keele (1968)'s experiment on prototype formation

1. **Instructions**: You will see stimuli from Category A or B. Please indicate which category you think is correct.

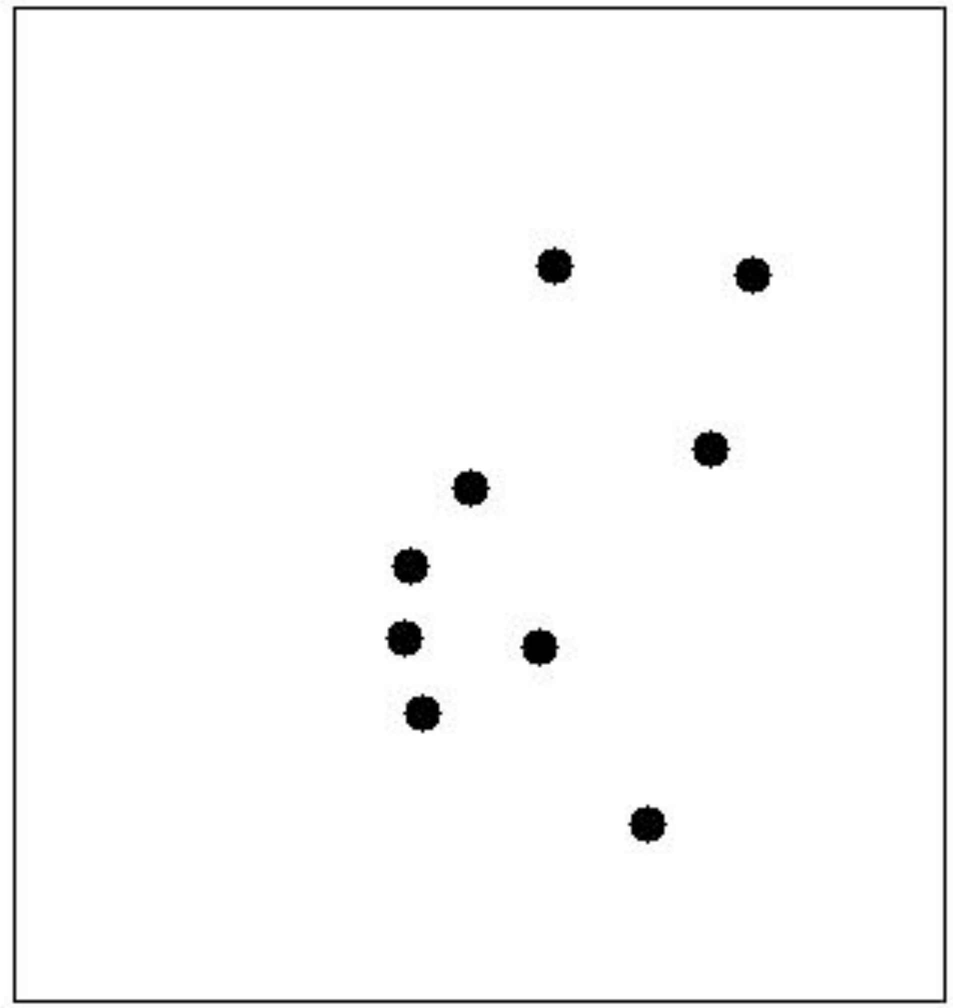
2. **Training phase**: Participants see stimuli one at a time. For each item, they respond "A" or "B". Usually, feedback (the correct answer) is received during training.

3. **Test phase (optional)**: Participants may respond to additional stimuli. No feedback is given.

Category A or B?

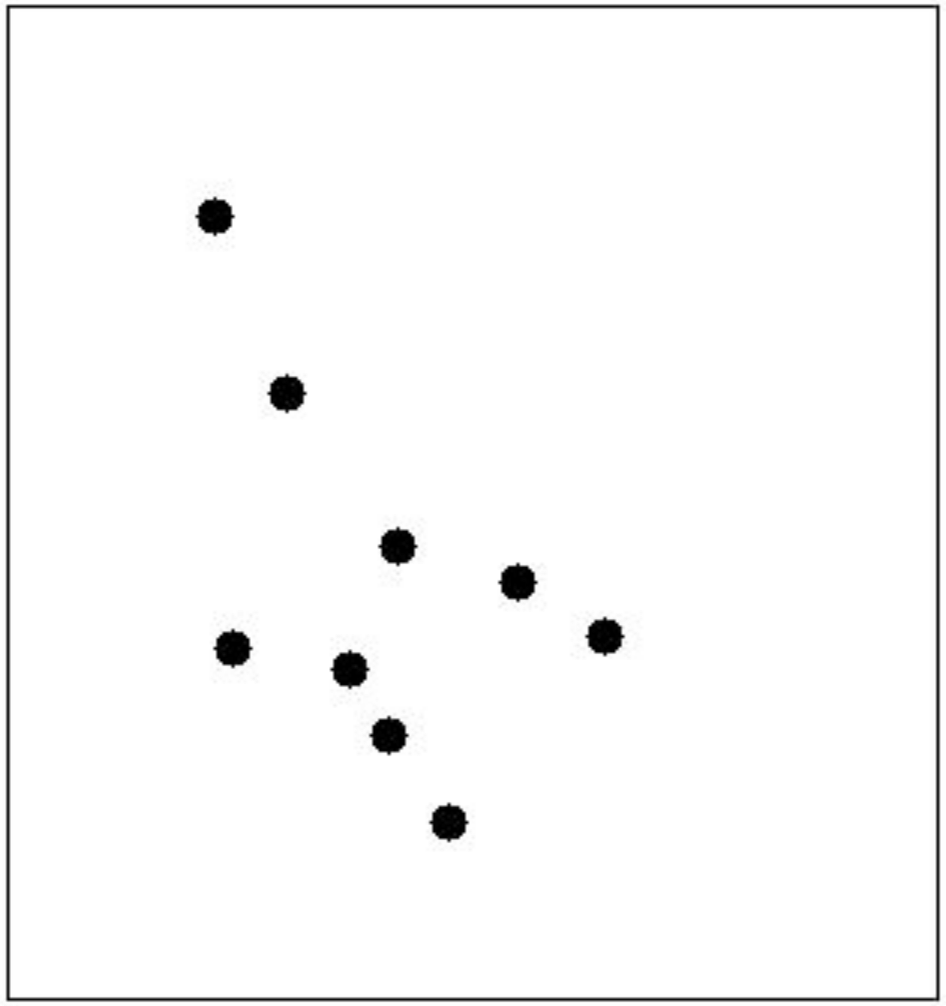


Category A or B?

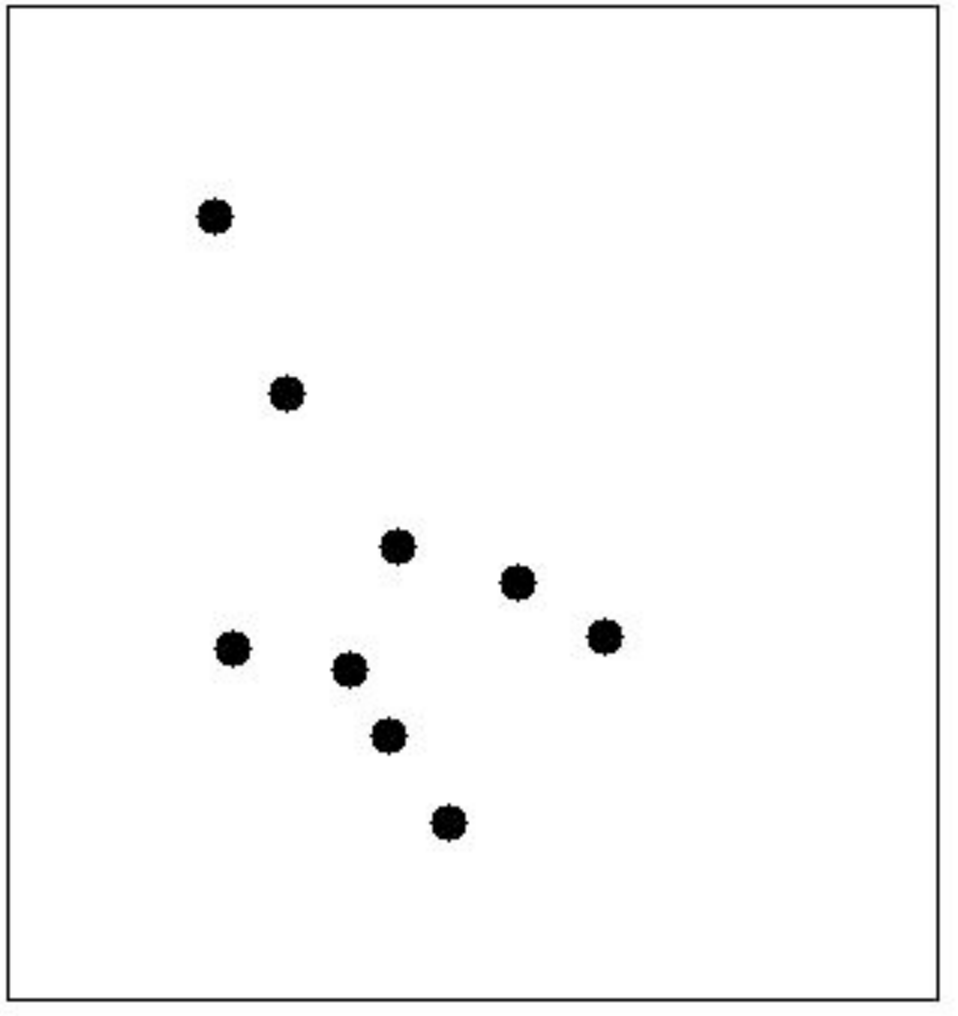


A

Category A or B?

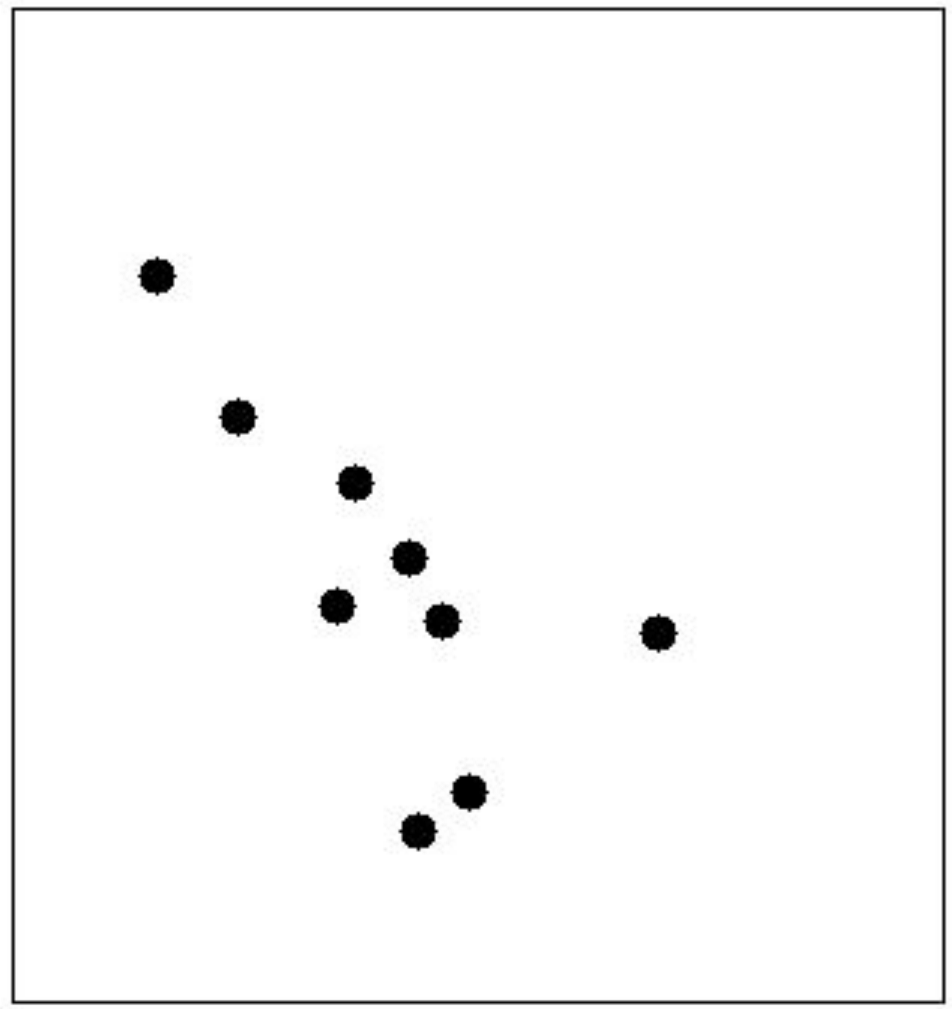


Category A or B?

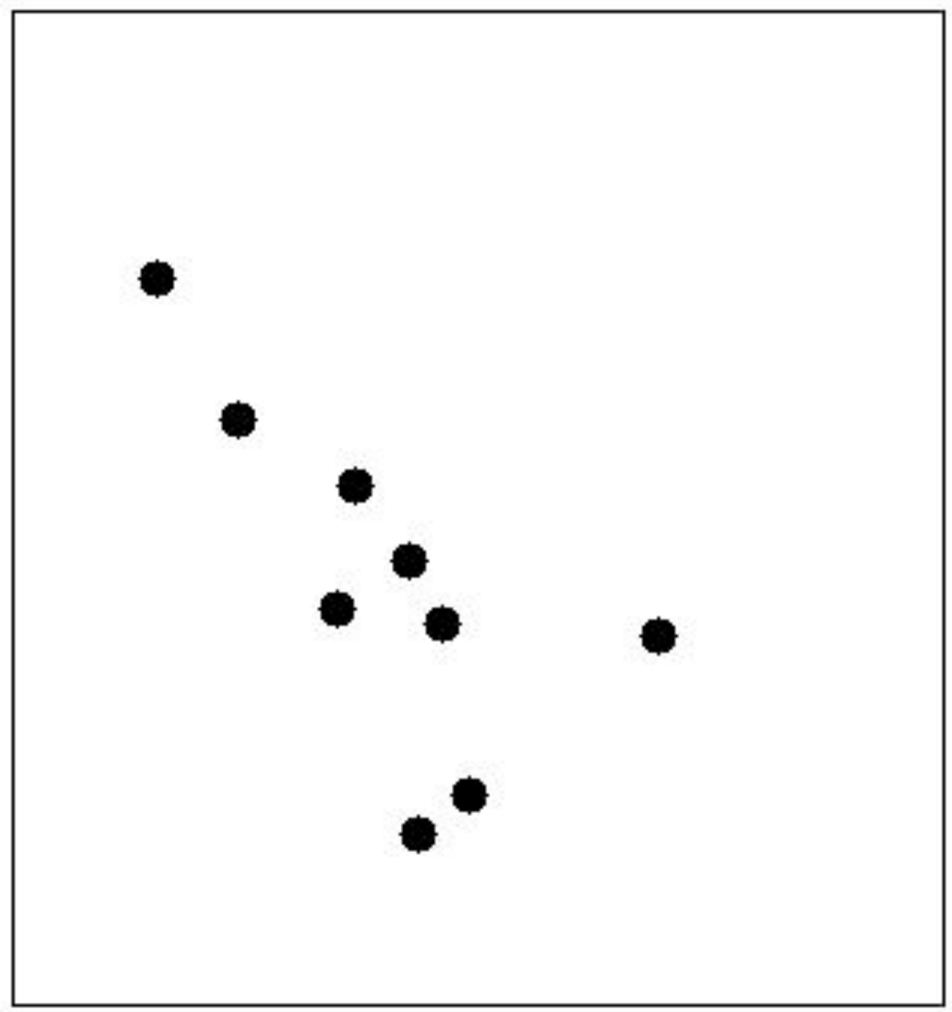


B

Category A or B?



Category A or B?



B

Review: Posner & Keele test results

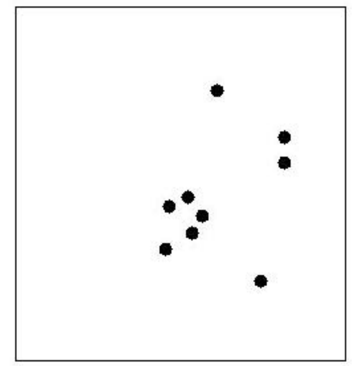
After training, participants were **tested** on:
-- the prototypes (new)
-- some pattern distortions (old)
-- some pattern distortions (new)

Result:
(Accuracy for prototype = Accuracy for old distortions)

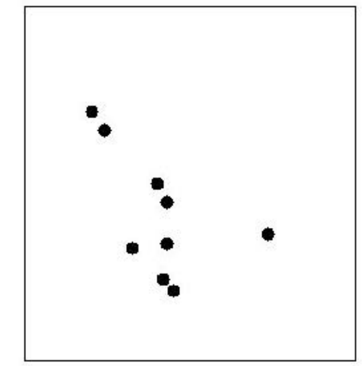
> Accuracy for new distortions

Suggests that some form of abstract representation is learned, like an “ideal image” or prototype

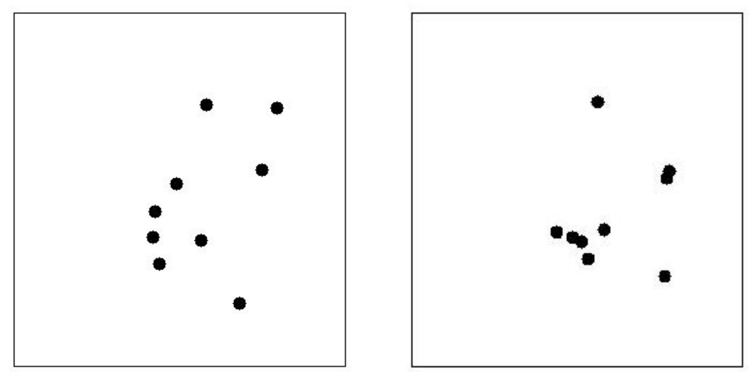
Prototype A: (not seen)



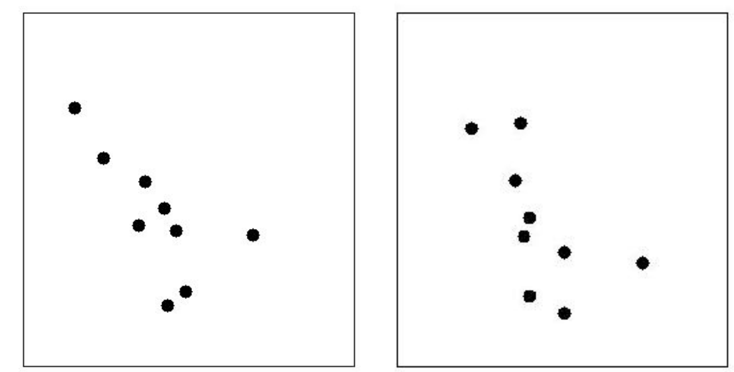
Prototype B: (not seen)



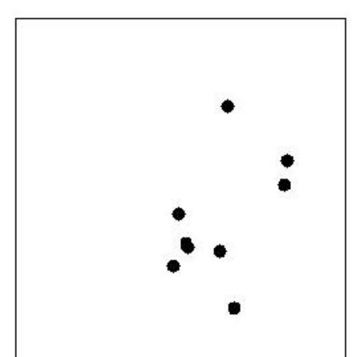
Distortions of A: Old



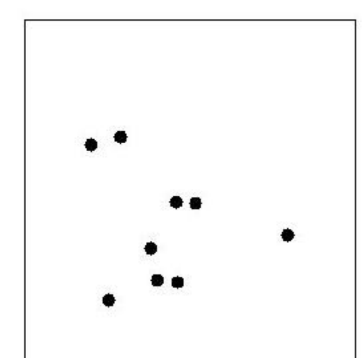
Distortions of B: Old



Distortions of A: New



Distortions of B: New



Bomba & Siqueland (1983) stimuli for 3-4 mo

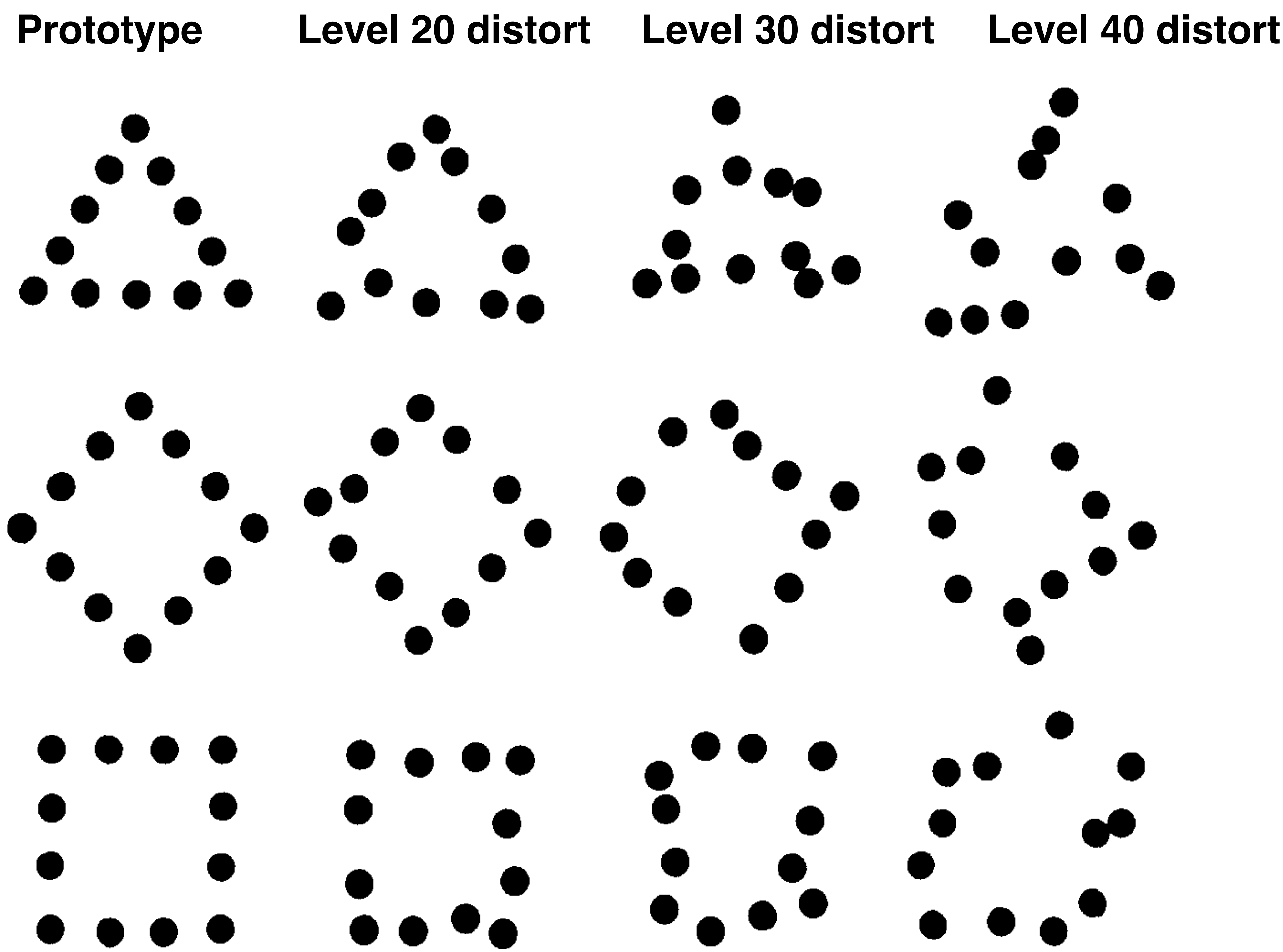


FIG. 1. From top to bottom, the prototypical triangle, diamond, and square; and from left to right, examples of Level 20, 30, and 40 distortions of each.

Bomba & Siqueland (1983) Exp 2 - category acquisition ?

Learning phase

1. triangle 1 triangle 2 (level 20 distort)
2. triangle 3 triangle 4 (level 40 distort)
3. triangle 5 triangle 6 (level 30 distort)

Test phase

triangle proto square proto

Results: Significant novelty preference of 62% of fixation time (chance is 50%)

Bomba & Siqueland (1983) Exp 4 - prototype effect?

<u>Learning phase</u>

1. triangle 1 triangle 2 (level 20 distort)
2. triangle 3 triangle 4 (level 40 distort)
3. triangle 5 triangle 6 (level 30 distort)

<u>Test phase</u>

triangle proto old exemplar (e.g. triangle 2)

<u>Prediction:</u> if infants represent the category by a prototype, you may expect paradoxical preference for the old exemplar

<u>Results:</u> no significant fixation preference; 47.4% of fixation was for old exemplar

Bomba & Siqueland (1983) Exp 5 - prototype effect after 3 min delay?

<u>Learning phase</u>

1. triangle 1 triangle 2 (level 20 distort)
2. triangle 3 triangle 4 (level 40 distort)
3. triangle 5 triangle 6 (level 30 distort)

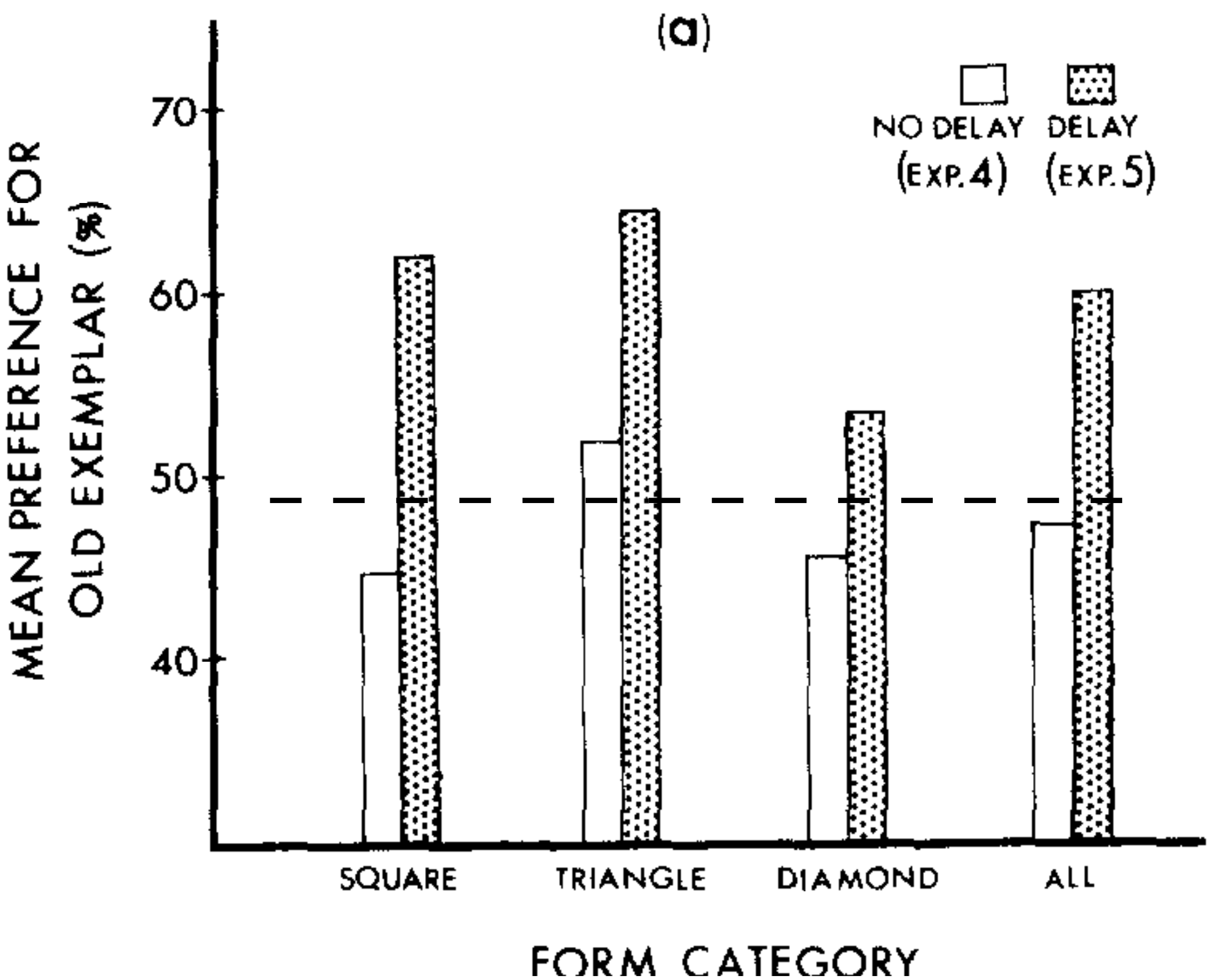
<u>Test phase</u>

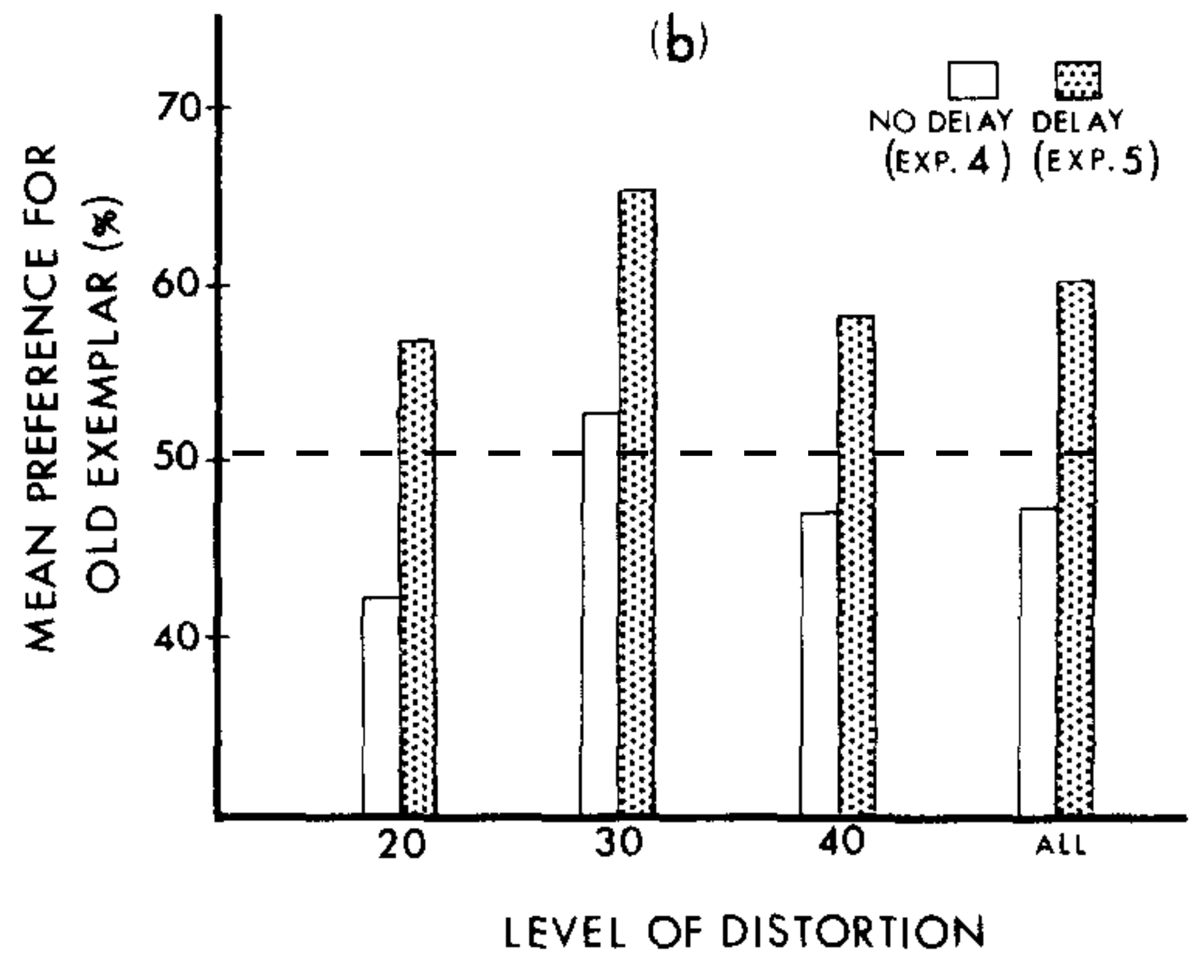
triangle proto old exemplar (e.g. triangle 2)

<u>Prediction:</u> if infants represent category by prototype, you may expect paradoxical preference for the old exemplar

<u>Results:</u> significant preference; 59.9% of fixation was for old exemplar

Preference for old exemplars after delay





Quinn (1987) - 3-4 mo infants can learn multiple categories at once

<u>Learning phase</u>

1. triangle 1	square 1
2. square 2	triangle 2
3. square 3	triangle 3
4. triangle 4	square 4
5. triangle 5	square 5
6. square 6	triangle 6

<u>Test phase</u>

square 7 diamond 1

<u>Results:</u> fixation preference for novel prototype; 69.6% preference

What is the origin of concepts? Do infants have qualitatively different categories or category learning process than adults?

So far, we have seen nothing to indicate fundamental, qualitative differences

What about more realistic categories? What about dogs vs. cats?

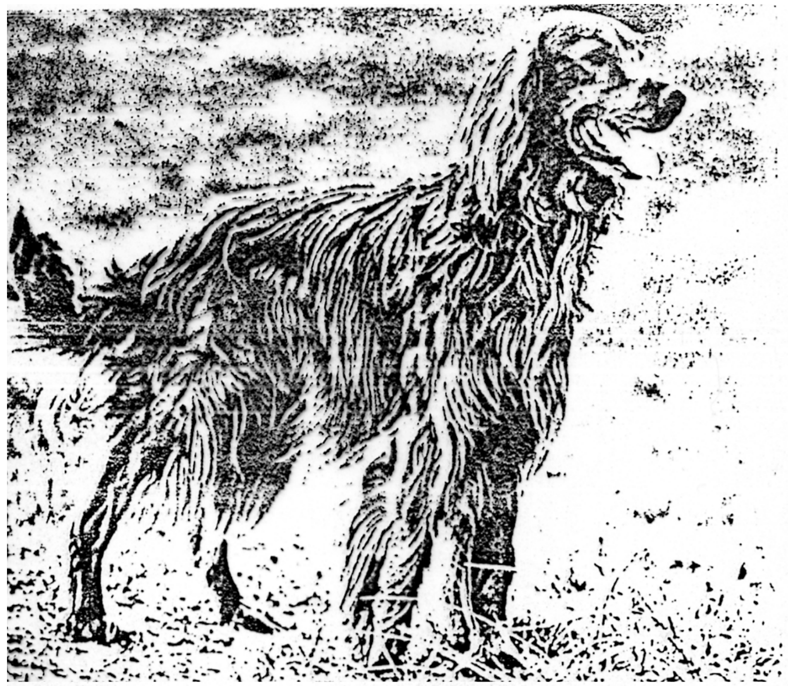
Quinn, Eimas & Rosenkrantz (1993); infants 3-4 mo

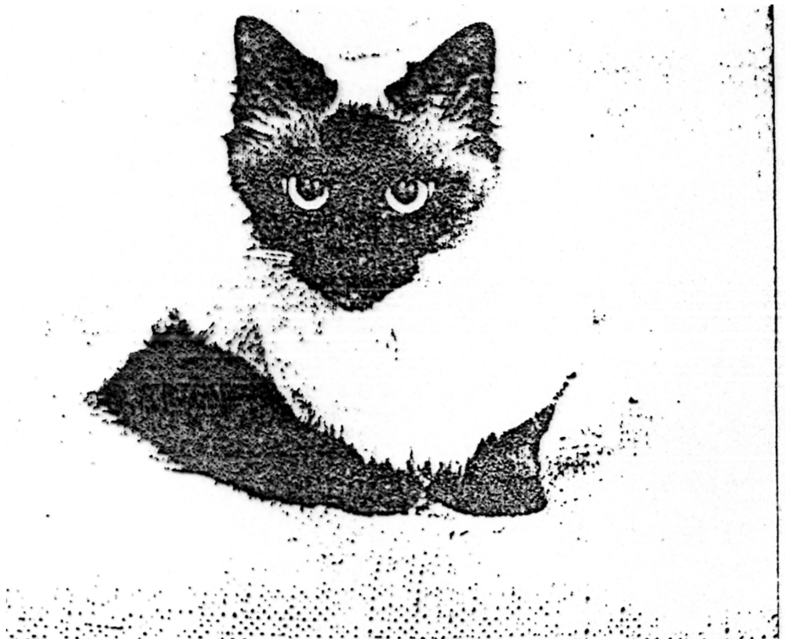
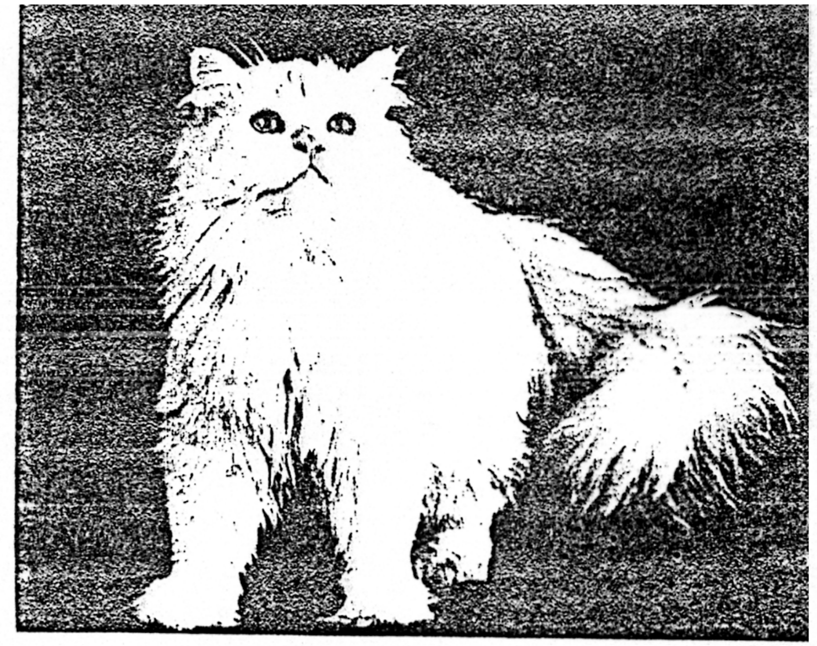
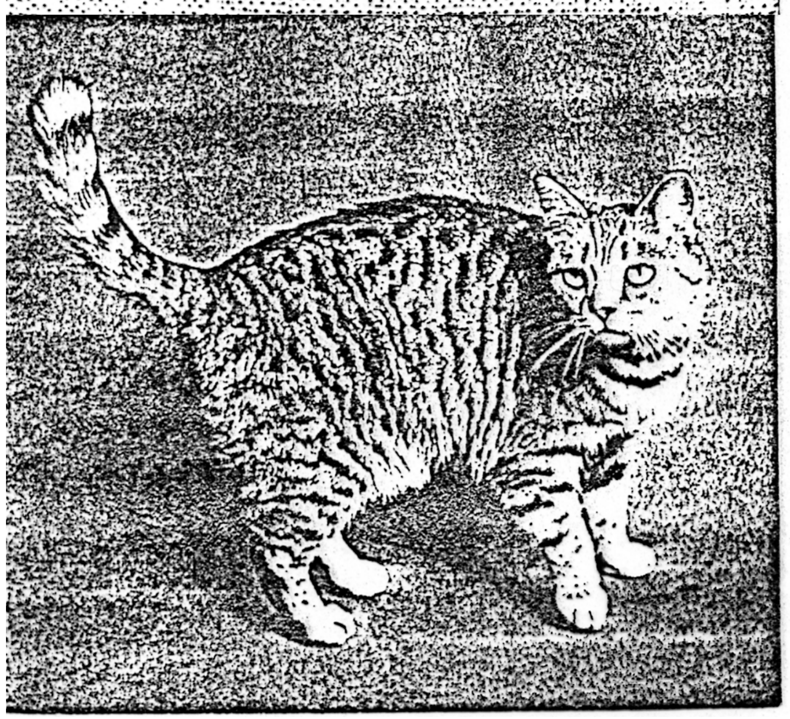
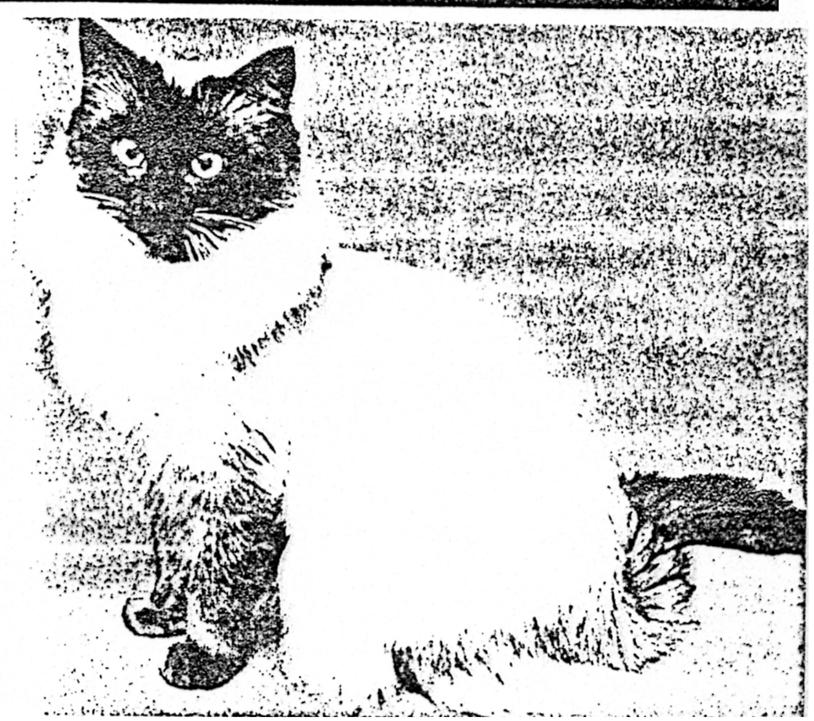
<u>Learning phase</u>
(note, not much habituation in these studies)

1. two dog photos
2. two dog photos
3. two dog photos
4. two dog photos
5. two dog photos
6. two dog photos

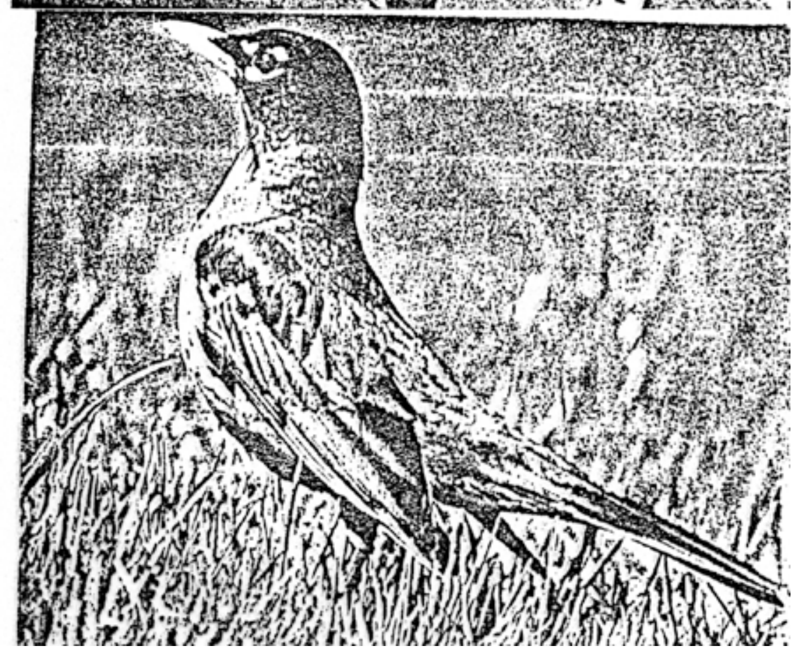
<u>Test phase</u>

new dog   new bird





When familiarized with cats or dogs, infants prefer to look at birds

Quinn, Eimas & Rosenkrantz (1993)

<u>Learning phase (cats)</u>

1. two cat photos
2. two cat photos
3. two cat photos
4. two cat photos
5. two cat photos
6. two cat photos

<u>Test phase</u>

new cat   new bird (63.6% fixation)

<u>Learning phase (dogs)</u>

1. two dog photos
2. two dog photos
3. two dog photos
4. two dog photos
5. two dog photos
6. two dog photos

<u>Test phase</u>

new dog   new bird (61.7%)

- You can’t say that infants learned the category “dog”; we can’t go beyond contrast tested (see slide title)
- Also, they measured baseline bird preference, of course

When familiarized with cats, infants prefer to look at dogs; but not vice versa!

Quinn, Eimas & Rosenkrantz (1993)

Learning phase (cats)

1. two cat photos
2. two cat photos
3. two cat photos
4. two cat photos
5. two cat photos
6. two cat photos

Learning phase (dogs)

1. two dog photos
2. two dog photos
3. two dog photos
4. two dog photos
5. two dog photos
6. two dog photos

Test phase

new dog (65%) new cat

Test phase

new cat (50%, n.s.) new dog

- Again,You can’t say that infants learned the category “dog”; we can’t go beyond contrast tested (see slide title)
- It's likely because dogs are a higher-variance category

Cognitive Development, 8, 291–318 (1993)

Concept Formation in Infancy

Jean M. Mandler
University of California, San Diego
MRC Cognitive Development Unit, London

Laraine McDonough
University of California, San Diego

Four experiments investigated conceptual categorization in 7- to 11-month-old infants. Experiments 1 and 2 showed that 9- and 11-month-olds differentiated the global domains of animals and vehicles. Within the animal domain no subcategorization was found: the infants did not differentiate dogs from fish or from rabbits. Within the vehicle domain infants differentiated cars from both airplanes and motorcycles. Experiment 3 showed similar, although weaker, categorization for 7-month-olds. Experiment 4 showed that categorization of animals and vehicles was unaffected by degree of between-category similarity. Birds and airplanes were treated as different even though the exemplars from both categories had similar shapes, including outstretched wings, and were of the same texture. These data, showing global differentiation of animals and vehicles, with lack of differentiation of "basic-level" categories within the animal domain, contrast with data from studies designed to assess perceptual categorization. Even younger infants differentiate various animal subcategories perceptually. However, the results presented here suggest that infants may not respond to such perceptual differences as being conceptually relevant.

We are concerned in this article with the process of forming concepts, or conceptual categories, in infancy. Little is known about this topic, because most of the work on infant categorization has studied the development of perceptual categories. Yet there is a considerable difference between learning to categorize objects in terms of what they look like and having concepts about the kinds of things the objects are. We know that babies learn a wide variety of perceptual categories during the first year of life (e.g., Cohen & Strauss, 1979; Eimas & Quinn, 1992; Quinn, Eimas, & Rosenkrantz, 1993; Roberts, 1988). We also know that by

Jean Mandler

UCSD

- Distinction between perceptual and conceptual categories, where conceptual means understanding objects as being “the same sort of thing.”
- In previous work, Mandler has shown that toddlers 19-30 mo distinguish global categories (animals vs. vehicles) but only some basic-level categories, in sequential touching tasks

- Here we look at 9-11 months (Mandler & McDonough, 1993), younger than Mandler’s previous studies
- Children are given 4 objects from a category to handle, twice (=8 trials)
- On trial 9, they get a new item from that category
- On trial 10, they get a new item from a new category
- So, this is a dishabituation task

Mandler & McDonough (1993)

Figure 1. The animals and vehicles used as stimuli for the global categorization task in Experiment 1.

Examination trials

1. vehicle1 
2. vehicle2 
3. vehicle3 
4. vehicle4 
5. vehicle1 
6. vehicle2 
7. vehicle3 
8. **vehicle4** 
9. **vehicle5** 
10. **animal1** 

- On trial 9, they get a new item from that category
- On trial 10, they get a new item from a new category

Potential patterns of results

evidence for categorization

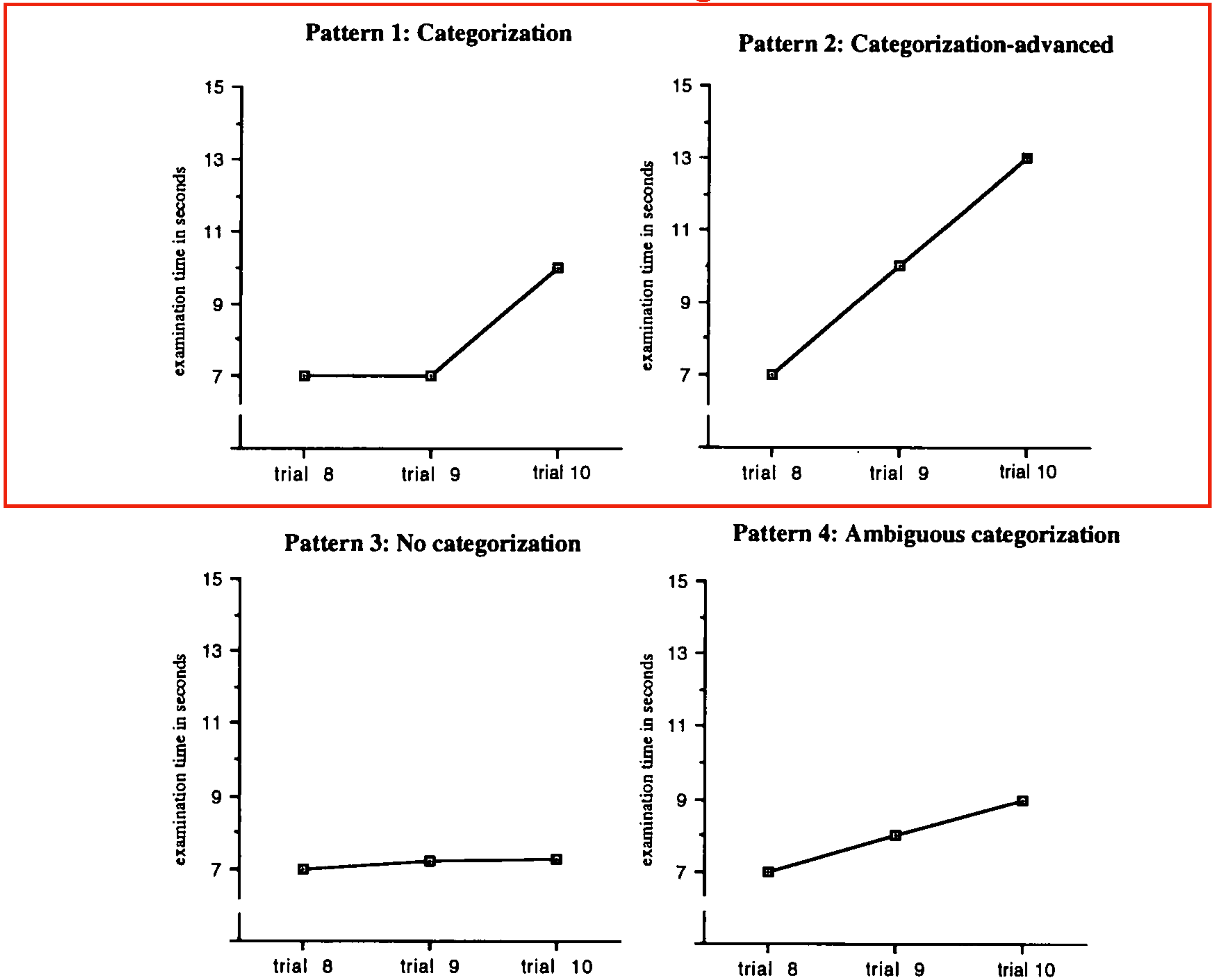
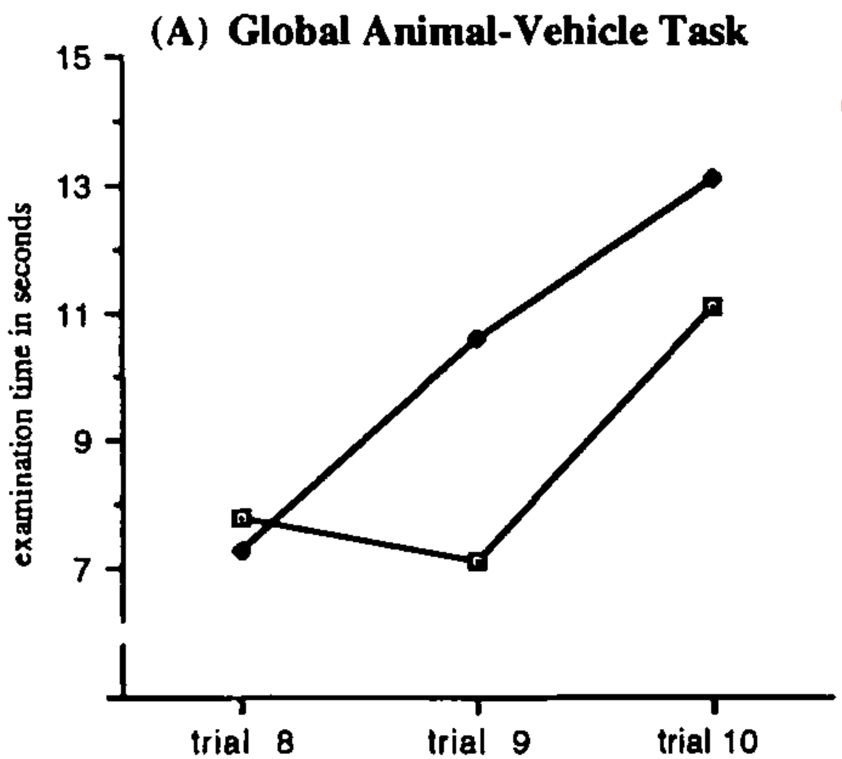


Figure 2. Idealized examples of possible patterns of examination times on the last trial of familiarization (Trial 8), on the same-category test exemplar (Trial 9), and on the contrasting-category exemplar (Trial 10).

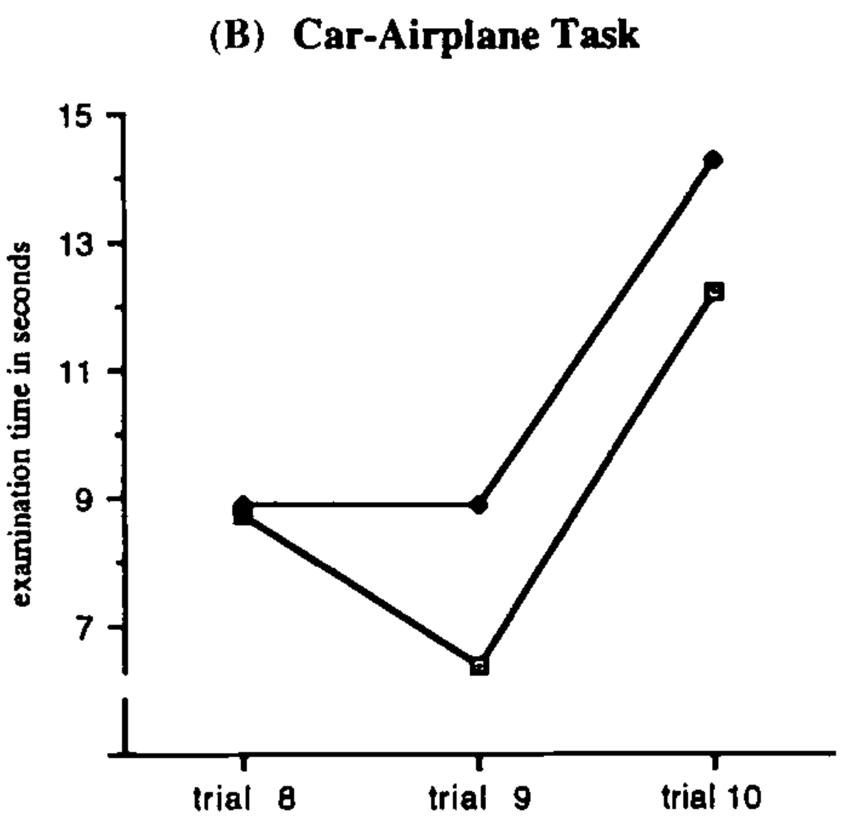
Mandler & McDonough (1993) results

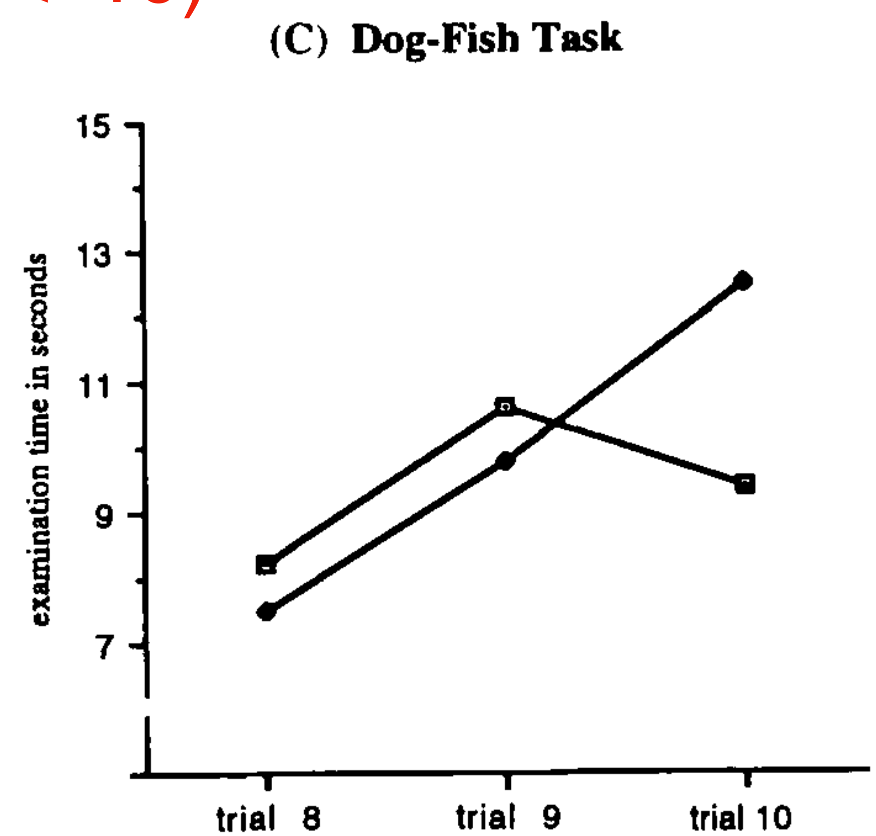


“categorization; global” (8 = 9 < 10)

“ambiguous; basic-level”
(8 < 10 only)

“categorization; basic-level” (8 = 9 < 10)





Mandler & McDonough (1993) results

Children in the task

- CAN distinguish animals from vehicles (global)
- CAN distinguish cars from airplanes (basic)
- CAN’T distinguish dogs from fish (basic) (results were actually ambiguous)

  So, children seem to form global categories first, and these are “conceptual" distinctions according to Mandler

Potential problems with conclusions

- Mandlers says we know the global contrast is conceptual because "exemplars do not look very much alike”, but Quinn asks: “what about planes have silver wheels and vertical tail fins, versus birds with texture wings and ruffled feathers?”
- What do we make of fact that children can learn some basic-level classes in these experiments?
- Heavy reliance on affirming the null hypothesis, even when there is some evidence of discrimination (e.g., 8 < 10)

Paul Quinn

U. of Delaware

- Agrees that concepts proceed from global to specific
- Doesn't agree that there is a hard distinction between conceptual and perceptual concepts
  - ✳even global concepts have a perceptual basis

- His experiments in Quinn (2004) look at subordinate categories

Child Development, May/June 2004, Volume 75, Number 3, Pages 886–899

Development of Subordinate-Level Categorization in 3- to 7-Month-Old Infants

Paul C. Quinn

Visual preference procedures were used to investigate development of perceptually based subordinate-level categorization in 3- to 7-month-old infants. Experiments 1 and 2 demonstrated that 3- to 4-month-olds did not form category representations for photographic exemplars of subordinate-level classes of cats and dogs (i.e., Siamese vs. Tabby, Beagle vs. Saint Bernard). Experiments 3 though 5 showed that 6- and 7-month-olds formed a category representation for Tabby that excluded Siamese and a category representation for Saint Bernard that excluded Beagle, but they did not form a category representation for Siamese that excluded Tabby or a category representation for Beagle that excluded Saint Bernard. The findings are consistent with a differentiation-driven view of early perceptual category development from global to basic to subordinate levels.

Categorization refers to equivalent responding to discernibly different instances from a common class (Bruner, Goodnow, & Austin, 1956). It is considered to be an adaptive mental process that allows for organized storage of information in memory, efficient retrieval of that information, and the capability of responding with familiarity to an indefinitely large number of instances from a variety of classes, most of which have not been previously encountered (Murphy, 2002). Without categorization, each experienced entity would be unrelated to all represented entities, and no represented entity would be related to any other (Smith & Medin, 1981).

Categorization must begin at some point during development, and recent evidence indicates that preverbal infants possess the ability to parse the

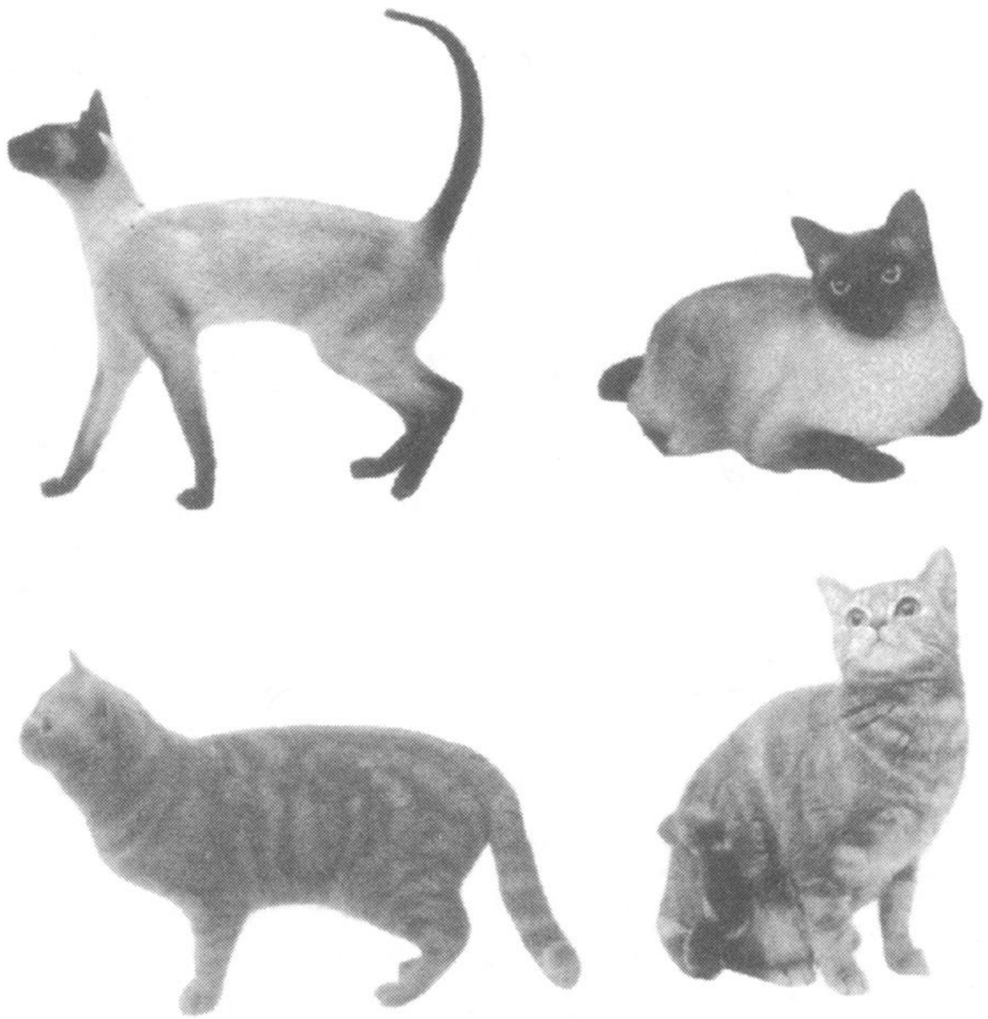
Empirical studies examining the development of category representations during the first year of life have investigated the age and means by which individuated representations can be formed for narrowly tuned basic-level and more broadly inclusive global-level classes (e.g., cat vs. dog, mammal vs. furniture; Mandler & McDonough, 1993; Quinn, Eimas, & Rosenkrantz, 1993). Of particular concern has been whether basic-level representations cohere to form global (superordinate-level) representations in accord with a constructionist perspective or whether basic-level representations evolve from original global representations in accord with a differentiation perspective. Much of this work has been in response to the theory of Rosch and Mervis, which suggested that category representations were ini-

Quinn (2004) stimuli for sub-ordinate categories

siamese

vs.

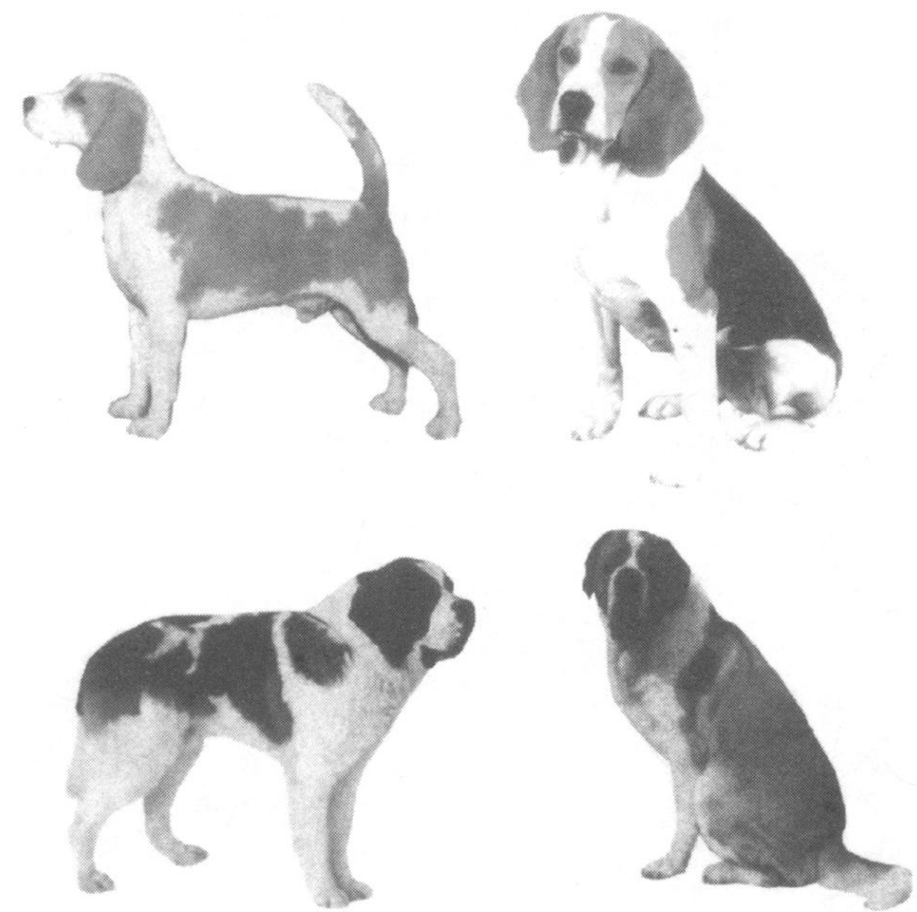
tabby



beagle

vs.

st. bernard



Quinn (2004) results - 3-4 mo (exp 1)

<u>Learning phase</u>

1. siamese 1 and siamese 2
2. siamese 3 and siamese 4
3. siamese 5 and siamese 6
4. siamese 7 and siamese 8
5. siamese 9 and siamese 10
6. siamese 11 and siamese 12

<u>Test phase</u>

siamese 13 tabby 1

Results

Familiarized	Test perf.	
Siamese	50.8%	(ns)
Tabby	**60.7**	**$p < .025$**
Beagle	58.4	(ns)
St. Bernard	**62.7**	**$p < .01$**

Results

- familiarized with tabby preferred siamese, but not vice versa
- familiarized with saint bernard prefered beagle, but not vice versa
- but results did not hold up as significant with baseline preferences (exp 2)

Quinn (2004) results - 6-7 mo (exp 3)

<u>Learning phase</u>

1. siamese 1 and siamese 2
2. siamese 3 and siamese 4
3. siamese 5 and siamese 6
4. siamese 7 and siamese 8
5. siamese 9 and siamese 10
6. siamese 11 and siamese 12

<u>Test phase</u>

siamese 12 tabby 1

Results

Familiar.	Test perf.	
Siamese	**60.8%**	**$p < .025$**
Tabby	**60.0**	**$p < .05$**
Beagle	**61.2**	**$p < .05$**
St. Bernard	**63.9**	**$p < .025$**

Results

- Differentiated sub-ordinate categories in both directions
- but one direction disappeared for each contrast, when using baseline controls (exp 5). Definitely shakier than Quinn's previous findings that basic-level contrasts learned at 3-4mo

Reminder: When familiarized with cats or dogs, 3-4 mo infants prefer to look at birds

Quinn, Eimas & Rosenkrantz (1993)

Learning phase (cats)

1. two cat photos
2. two cat photos
3. two cat photos
4. two cat photos
5. two cat photos
6. two cat photos

Test phase

new cat   new bird (63.6% fixation)

Learning phase (dogs)

1. two dog photos
2. two dog photos
3. two dog photos
4. two dog photos
5. two dog photos
6. two dog photos

Test phase

new dog   new bird (61.7%)

- You can't say that infants learned the category "dog"; we can't go beyond contrast tested (see slide title)
- Also, they measured baseline bird preference, of course

What did we learn?

- The origin of concepts is hugely important, and the order seems largely “top-down”, but..

- These kinds of results are typical of infant categorization studies
    - i.e., messy
    - probably too great a reliance on null results
- Need to compare multiple studies to make general statements about what infants can do

Contrast with: Rosch showed basic-level words learned first

Case study: Sally used primarily only basic-level words for objects, in large corpus of recorded speech.

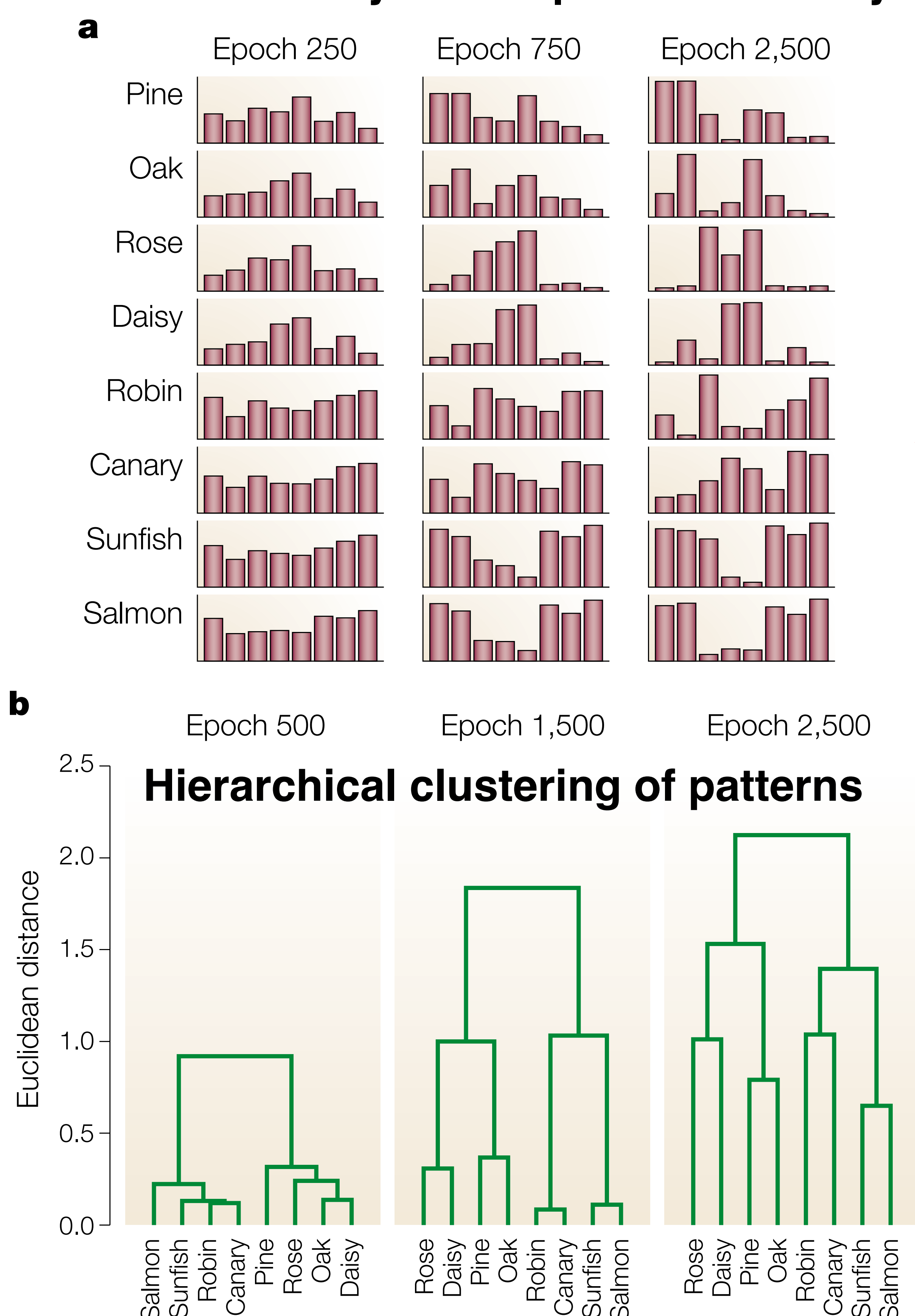
CONCRETE NOUNS USED IN STAGE I OF LANGUAGE ACQUISITION

	Taxonomic level of word used					
	Superordinate		Basic level		Subordinate	
Category	Tokens[a]	Types[a]	Tokens	Types	Tokens	Types
Nonbiological						
Musical instrument	0	0	13	6	0	0
Fruit	0	0	7	3	0	0
Tool	0	0	37	13	0	0
Clothing	2	1	91	18	4	1
Furniture	0	0	75	16	1	1
Vehicle	0	0	50	11	3	2

Biological[b]

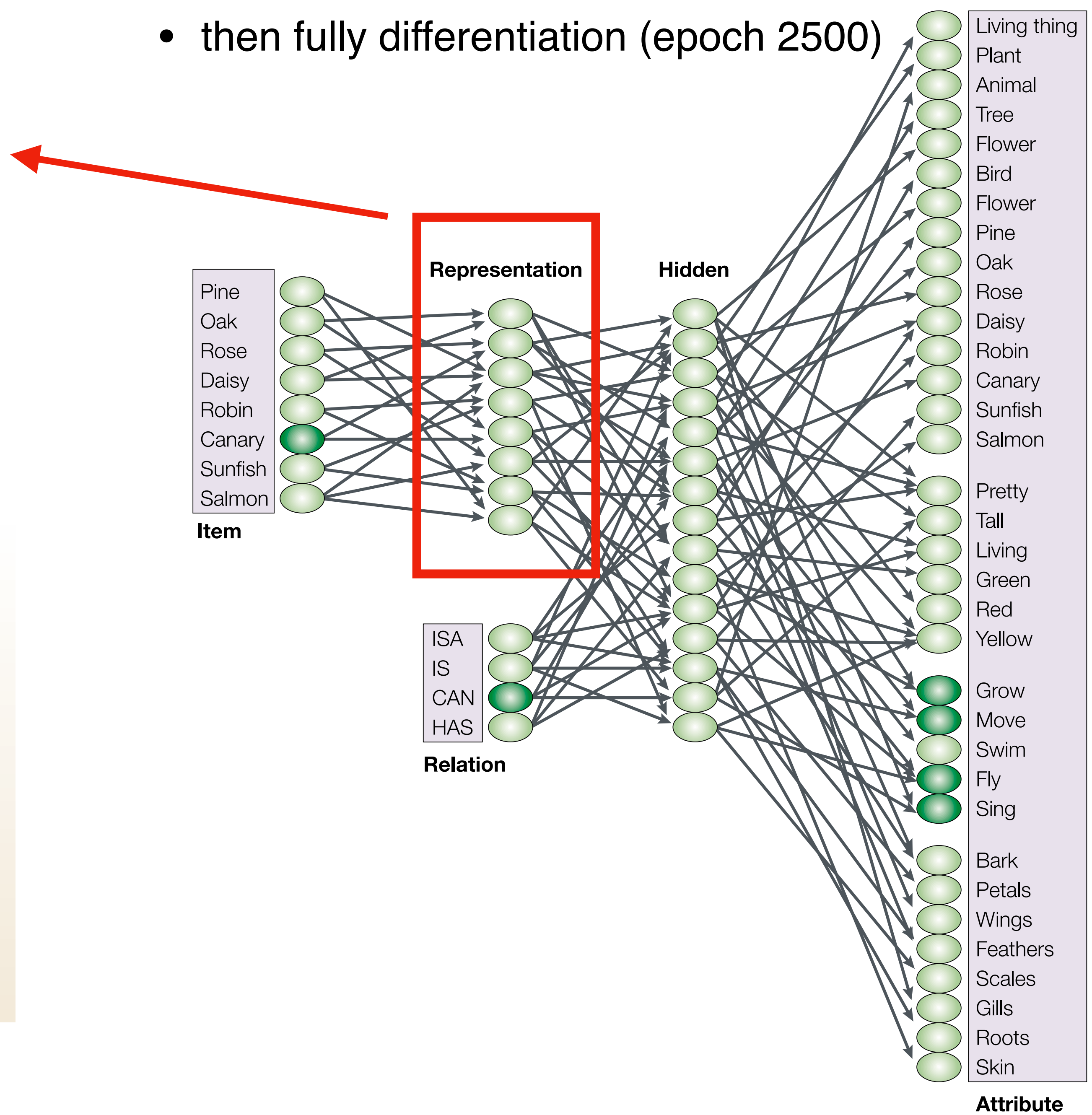
Rogers & McClelland (2003) develop model that can show broad-to-specific differentiation yet learns basic-level names first

Pattern of activity over representation layer



During training, model goes through stages that resemble broad-to-specific differentiation in children's cognitive development

- first differentiates plants vs. animals (epoch 250)
- then birds vs. fish and trees vs. flowers (epoch 750)
- then fully differentiation (epoch 2500)



COGNITIVE PSYCHOLOGY **30,** 111–153 (1996)
ARTICLE NO. 0005

Infants' Metaphysics: The Case of Numerical Identity

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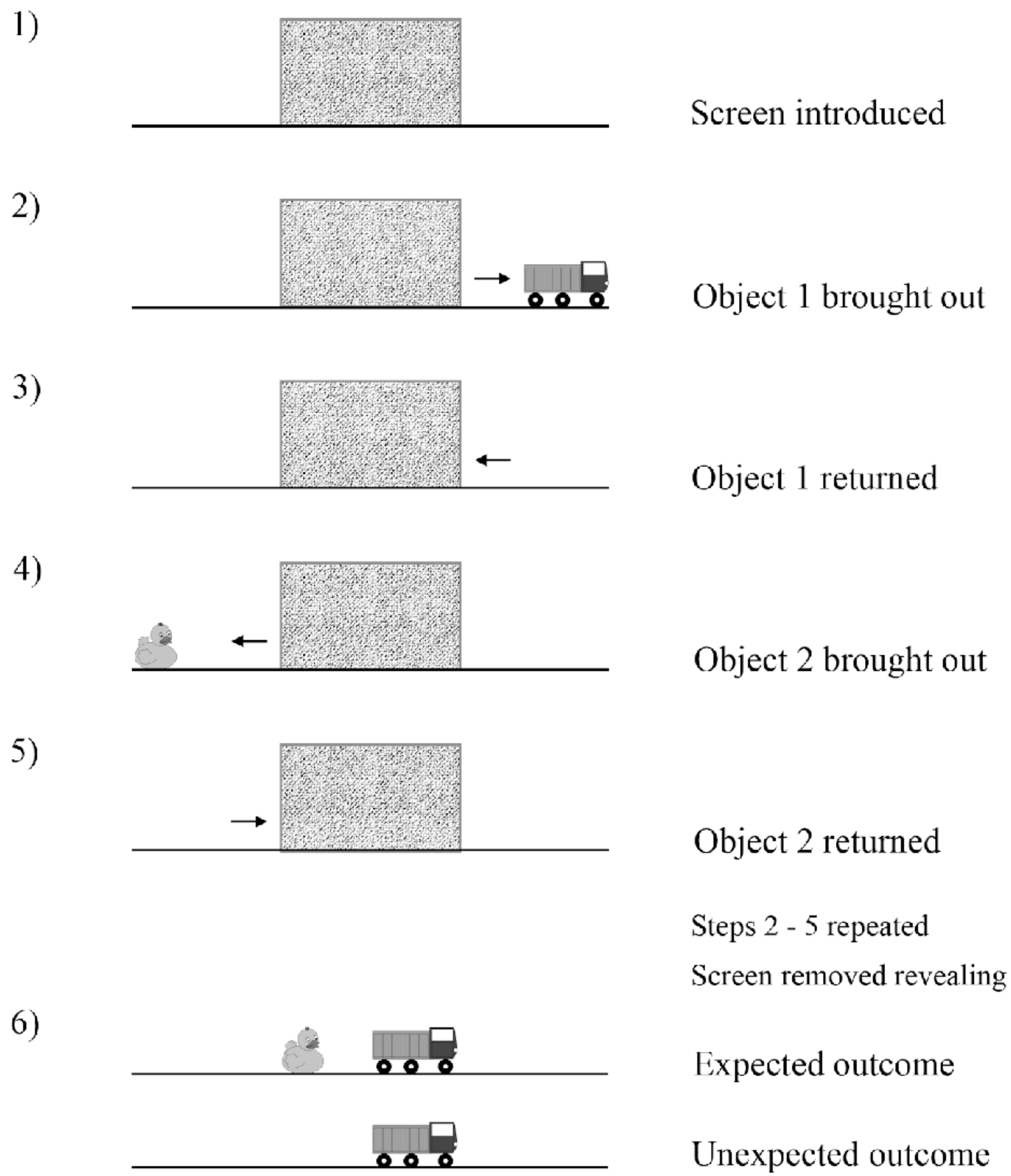
Adults conceptualize the world in terms of enduring physical objects. *Sortal concepts* provide conditions of individuation (establishing the boundaries of objects) and numerical identity (establishing whether an object is the *same one* as one encountered at some other time). In the adult conceptual system, there are two roughly hierarchical levels of object sortals. Most general is the sortal *bounded physical object* itself, for which spatiotemporal properties provide the criteria for individuation and identity. More specific sortals, such as *dog* or *car,* rely on additional types of properties to provide criteria for individuation and identity. We conjecture that young infants might represent only the general sortal, *object,* and construct more specific sortals later (the *Object*-first Hypothesis). This is closely related to Bower's (1974) conjecture that infants use spatiotemporal information to trace identity before they use property information. Five studies using the visual habituation paradigm were conducted to address the *Object*-first Hypothesis. In these studies, 10-month-old infants were able to use spatiotemporal information but failed to use property/kind information to set up representations of numerically distinct individuals, thus providing empirical evidence for the *Object*-first Hypothesis. Finally, infants succeed at object individuation in terms of more specific sortals by 12 months. The relation between success at our task and early noun comprehension is discussed.

Adults conceptualize the world in terms of enduring physical objects. We have criteria for individuation of objects (telling where one ends and another begins) and for numerical identity (telling whether an object is the *same one* as one that we encountered earlier). As philosophers are at pains to point out, these criteria are part of our conceptual system; we *could* individuate and trace identity on the basis of different criteria, or we *could* have a conceptual system that contained no criteria for individuation or identity at all (see Hirsch, 1982, for a lucid discussion of logically possible conceptual systems that

Xu & Carey's "object-first" hypothesis

Habituation



Test

- Result: 12 mo, **but not 10 mo**, expect two objects, and use object-kind information to support object individuation and numerical identity
- Control where infants of both ages expect two things to be behind occluder, if they are shown at same time

At 6–9 months, human infants know the meanings of many common nouns

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It is widely accepted that infants begin learning their native language not by learning words, but by discovering features of the speech signal: consonants, vowels, and combinations of these sounds. Learning to understand words, as opposed to just perceiving their sounds, is said to come later, between 9 and 15 mo of age, when infants develop a capacity for interpreting others' goals and intentions. Here, we demonstrate that this consensus about the developmental sequence of human language learning is flawed: in fact, infants already know the meanings of several common words from the age of 6 mo onward. We presented 6- to 9-mo-old infants with sets of pictures to view while their parent named a picture in each set. Over this entire age range, infants directed their gaze to the named pictures, indicating their understanding of spoken words. Because the words were not trained in the laboratory, the results show that even young infants learn ordinary words through daily experience with language. This surprising accomplishment indicates that, contrary to prevailing beliefs, either infants can already grasp the referential intentions of adults at 6 mo or infants can learn words before this ability emerges. The precocious discovery of word meanings suggests a perspective in which learning vocabulary and learning the sound structure of spoken language go hand in hand as language acquisition begins.

word learning | cognitive development | infant cognition

Most children do not say their first words until around their first birthday. Nonetheless, infants know some aspects of presence of dolls, and they say "Hi, I'm home!" more often than "Daddy is moving through the doorway!" (19). Furthermore, words (excepting proper names) refer to categories, not individuals, and the learner must discover each category and its boundaries. Thus, although infants can link "mommy" with films of their mother, these labels do not indicate that infants have induced the relevant category (20). Because of these complexities inherent in language understanding, the predominant view is that word learning is possible only when children can surmise the intentions of others enough to constrain the infinite range of possible word meanings, a skill believed to develop gradually after 9 mo (17). Until that age, infants' native language learning is held to be restricted to speech signal analysis (21).

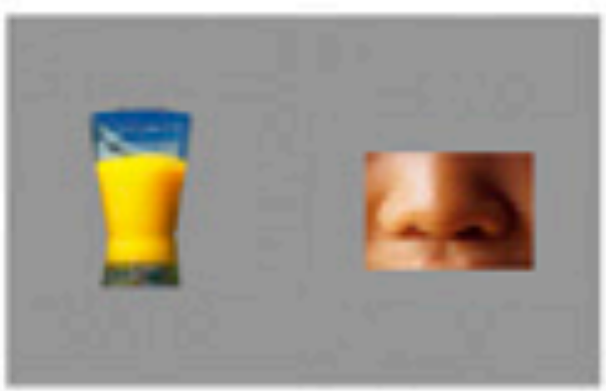
In the present research, we examined young infants' knowledge of word meaning using a variant of a task called "language-guided looking" or "looking-while-listening" (22, 23). In this method, infants' fixations to named pictures are used to measure word understanding. Infants are presented with visual displays, usually of two discrete images, one of which is labeled in a spoken sentence such as "Look at the apple" (24, 25). In our variant, the parent uttered each sentence, prompted over headphones with a prerecorded sentence, ensuring that infants (n = 33) heard the words pronounced by the familiar voice of their parent. Each infant experienced two kinds of trial: trials with two discrete images (paired-picture trials) and trials with a single complex scene (scene trials) (Materials and Methods; Fig. 1; Fig. S1; and Table 1).

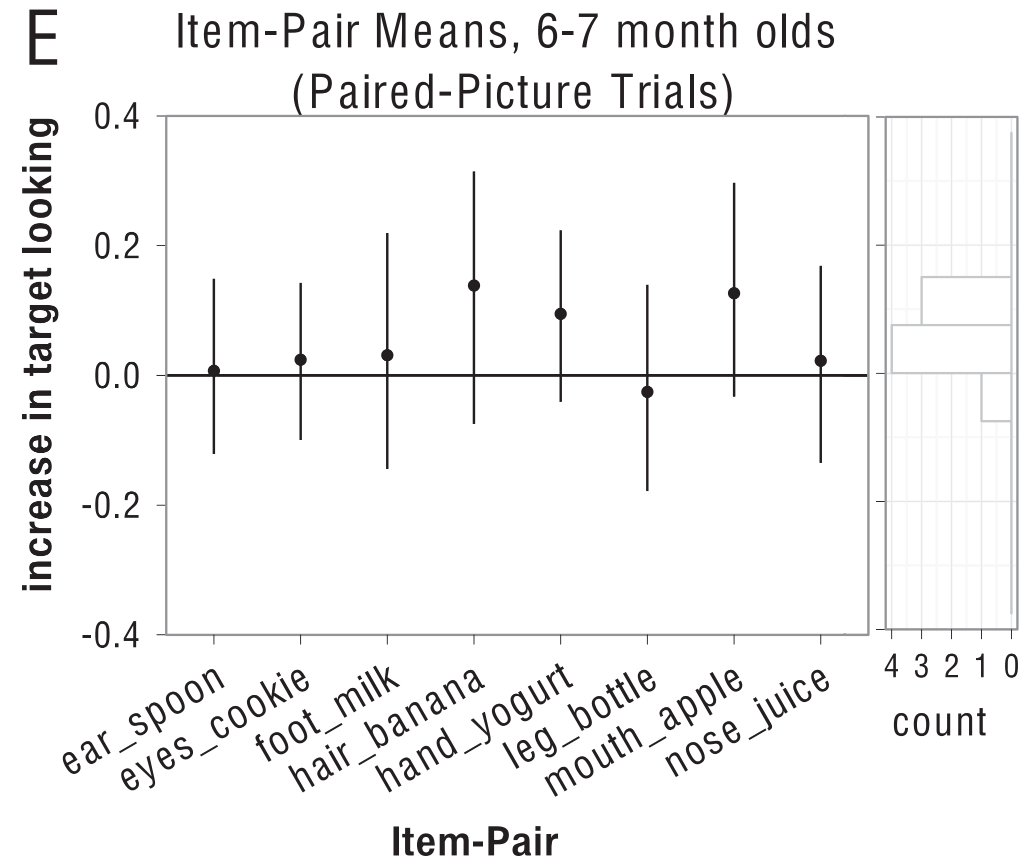
Two word categories were tested: food-related words and

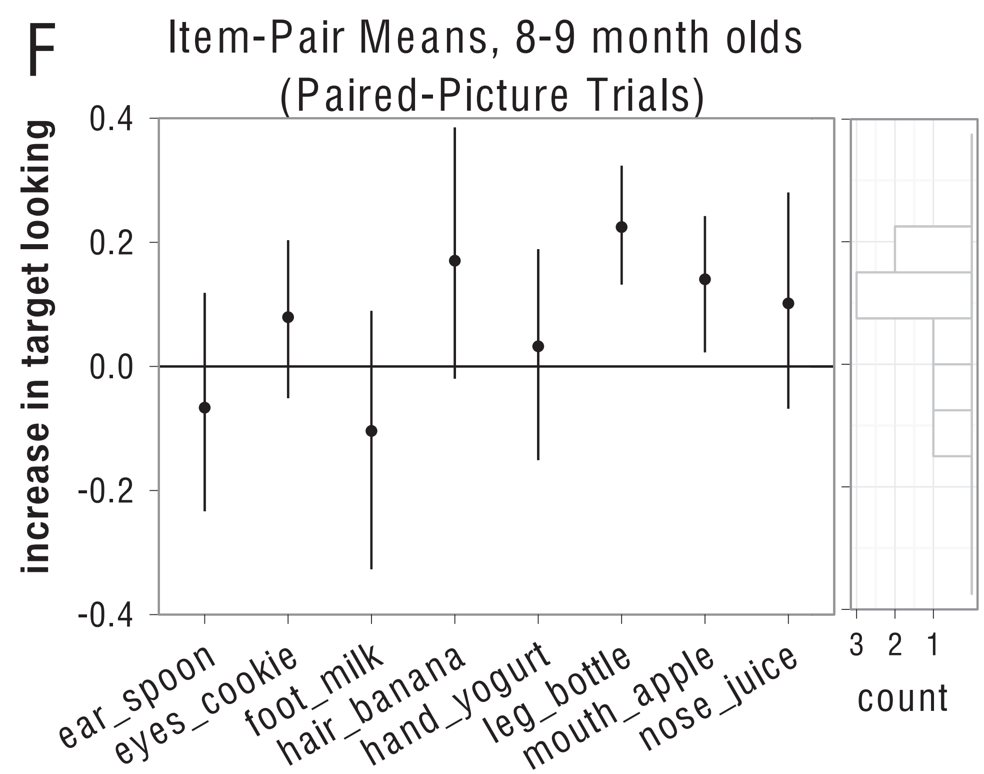
Bergelson & Swingley : Evidence that 6-9 mo infants know meanings of many common nouns

"Look at the mouth"

"Look at the juice"







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