9.85 Cognition in Infancy and Early Childhood

Lecture 9: Concepts, categories and induction

Housekeeping

- Sign-up for a meeting time if you haven't already.

- We are on lecture 9.

- On Wednesday we will be on lecture 10: Identity, Essences and Transformation.

- Next Monday I'm out of town -- Kate Hooppell will guest lecture on children's understanding of spatial relationships. Office hours are on Thursday next week.

When object knowledge isn't enough …

- Spatiotemporal features, Spelke principles, support relations, number …

- But how do you know a banana is a banana?

Two (intersecting) problems of inductive inference

- How do you go from a small sample of instances to a general category? (How do you learn the "sense" of a concept?)
- Given that you have a general category, how do you recognize an instance of it? (How do you identify the "reference" of a concept?)

Are children's concepts like adult concepts?

- Over-extensions (dogs, buttons)
- Under-extensions (dogs, butterflies)
- Wrong extensions (ethnicity)

Incommensurability?

- Fodor: if children's concepts weren't like adult concepts we couldn't talk to each other.

- Concepts change historically as well as ontogenetically -- concept of heat …

- How can we read 17th century chemistry books? Or Dante?

Ways concepts can change

- By collapsing (moving and sitting butterflies)
- By dividing (dog; heat; ethnicity)
- By eliminating (phlogiston; ether)
- By creating (quantum mechanics)

How can you learn a concept?

- By definition … learn this definition, decide if these examples fit the definition.

- "Classical view" of concepts (since Aristotle)

- Applied to everything: causality, truth, justice, dogs.

- Want to capture everything that is an instance of causality, justice, truth and dogs and nothing that is not an instance of these.

Classical theory of concepts

- Captures necessary and sufficient features.
- Useful in logical deduction.
    - All bachelors are unmarried men.
    - John is an unmarried man
    - John is a bachelor

    - If you're a bachelor then you're an unmarried man.
    - John is a bachelor.
    - Then John is an unmarried man.

Classical theory of concepts

- Piaget's view as well …
- "The 'intension' of a class is the set of properties common to the members of that class, together with the set of differences, which distinguish them from another class"
- (Necessary and sufficient features)

Classical theory of concepts

- Children's failures at deductive logic suggested to Piaget that they had an immature understanding of most concepts until school-age.

- But I suggested that the problems of conceptual development were problems of inductive logic …

- Hints at the demise of the classical theory.

Implications of the classical theory

- Everything is or is not a member of a definable category.
  - (We may not know whether Fred is a wildebeest or not, but there's a fact of the matter: Fred really is either a wildebeest or he is not a wildebeest.)
- All members of the category are equally good members of the category.

Demise of the classical view

- Theoretical problems:
  - Wittgenstein
- Empirical problems
  - Fails to explain effects of typicality
  - And intransitivity

Failures of definition

- List the necessary and sufficient features of a "game" …

- You might think at least scientific concepts are an exception but …

Failures of definition

- "There's a big group of people who don't know what a metal is. Do you know what we call them? Metallurgists! Here's why metallurgists don't know what metal is. We know that a metal is an element that has metallic properties …

- So we start to enumerate all these properties: electrical conductivity, thermal conductivity, ductility, malleability, strength, high density. How many of these properties does an element have to have to classify as a metal? We can't get the metallurgists to agree …"

Failures to explain typicality effects

- What's a bachelor pad look like?
- What do bachelors do for dinner?
- What do they do for fun?

- Is Mark Morris a bachelor?
- Is Pope Benedict?

Typicality

- This is an issue for preschoolers and grandmothers just like it's an issue for you and bachelors.

- Preschoolers emphasize characteristic features

  – grandmothers have white hair and bake cookies

- Over defining features

  – Grandmothers are women with grandchildren.

Characteristic v. defining features

- What's an island?
    - You dance
- Who lives on an island?
    - People … yup, people without clothes on…
- Is there an island in Ithaca?
    - No
- Why not?
    - Cause it's not summertime there yet.

Characteristic v. defining features

- ## What's a princess?
  - In a castle
- ## If I live in a castle am I a princess?
  - And kings live in castles!
- ## Can a princess be ugly?
  - No
- ## Can a princess be old?
  - No

Characteristic v. defining features

- Maybe it's just due to familiarity. When children have to generate a response, they generate the most accessible examples

- But preschoolers show the preference for characteristic over defining features even given forced choices (lies, robbers, uncles)

Prototype effects

- Found in every conceivable area.
- There are more and less prototypical birds (robins -- chickens -- ostriches -- penguins)
- Kitchen utensils (knives -- toasters -- sinks -- sponges)
- Even odd numbers (7 -- 43)

Prototype effects

- Generate a range of phenomena …
  - Reaction time (agree that robin is a bird faster than penguin is a bird)
  - Production
    - Naming
      - Name a fish
      - How many of you named an eel?
    - Word ordering (apples and limes)
  - Cognitive reference points (dark reds are reddish; true red isn't marrooonish; 101 is close to 100; 100 isn't close to 101).

Prototype effects

- Prototype effects are not explained by simple frequency (we see more chickens than catbirds but a catbird is still more typical.)
- We can extract prototypes even if we've never seen them at all.
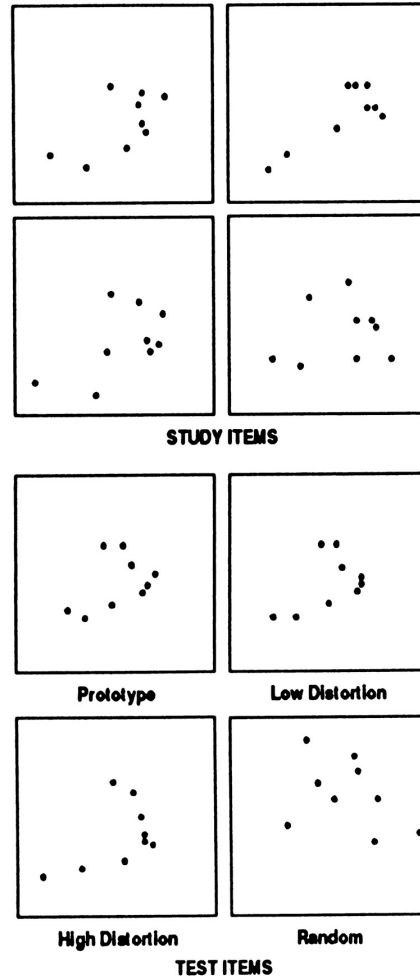
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STUDY ITEMS

Prototype   Low Distortion

High Distortion   Random

TEST ITEMS

Fig 5 in Squire L. R., and S. M. Zola. "Structure and function of declarative and nondeclarative memory systems." *Proc Natl Acad Sci U.S.A.* 93, no. 24 (November 26 1996): 13515-22. (Copyright 1996 National Academy of Sciences, U.S.A. Used with permission.)

Prototype effects

- 3-month-old infants can do this as well …

- When habituated to distortions of a triangle or square as dots, they preferred the prototype of the one they've never seen … suggesting that they'd extracted the prototype from the distortions.

Prototype effects

- Like Wittgenstein's idea of family resemblance. We extract a summary representation of the different exemplars.
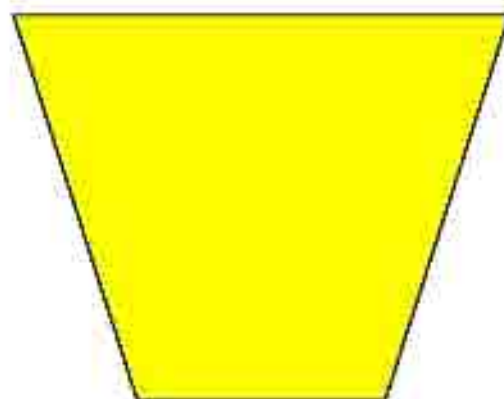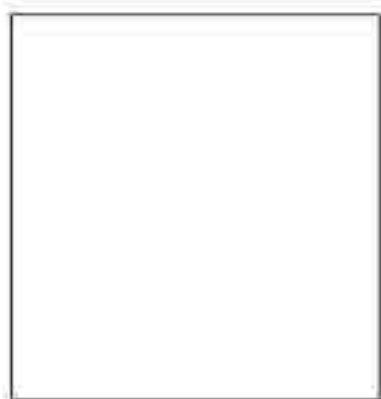
Extracting features for concept learning
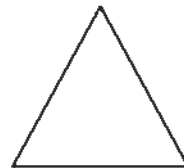
Extracting features

- Surprisingly, the contrast seems to aid the infants in extracting the relevant features.
- And infants can handle many distractors
  - Feather-tails + Giraffe bodies + Web feet
  - Fluffy-tails + Cow bodies + Club feet
  - Eyes, nose, legs, changed, but babies tracked correlation between feather-tails and giraffe bodies and were surprised at fluffy tails.
- Initial variance is important. Young infants habituated to cats dishabituate dogs; infants habituated to dogs don't dishabituate to cats.

Classical view and prototypes

- Failures of classical view:
- Typicality effects
- Intransitivity
  - According to the classical view, inclusion relatoinships (IS-A relatoinships) are transitive.
  - If A is a B and B is a C, then A is a C.
  - If dogs are mammals and mammals are animals then dogs are animals.

Classical view and prototypes

- But Big Ben is a clock.
- Clocks are furniture.
- And Big Ben isn't furniture.

Transitivity

- But people think that all chairs are furniture and that a car seat is a chair but they don't think a car seat is furniture.
- Classical view can't explain intransitivity.

Classical view and prototypes

- Prototype view aimed to address failures of classical view.

- Some instances are better instances of a category than others because exemplars can have different numbers of features and can have features of different weights.

- Transitivity can fail because the features common to Big Ben and clocks might be different than the features common to clocks and furniture. No necessary and sufficient features.

Challenges to the prototype view

- If you store weighted features, quickly have a combinatorial explosion.
    - Prompted "exemplar" theories -- that you just remember a few exemplars and compare new instances to them.
    - But doesn't explain why a novel prototype should be more "familiar" than an actually-observed stimulus.

Challenges to the prototype view

- Features used for categorizatoin are context-sensitive.
  - Children extend category labels on the basis of shape.
  - But not if the objects have eyes.
  - And not if one object is used as a container for another.

Challenges to the prototype view

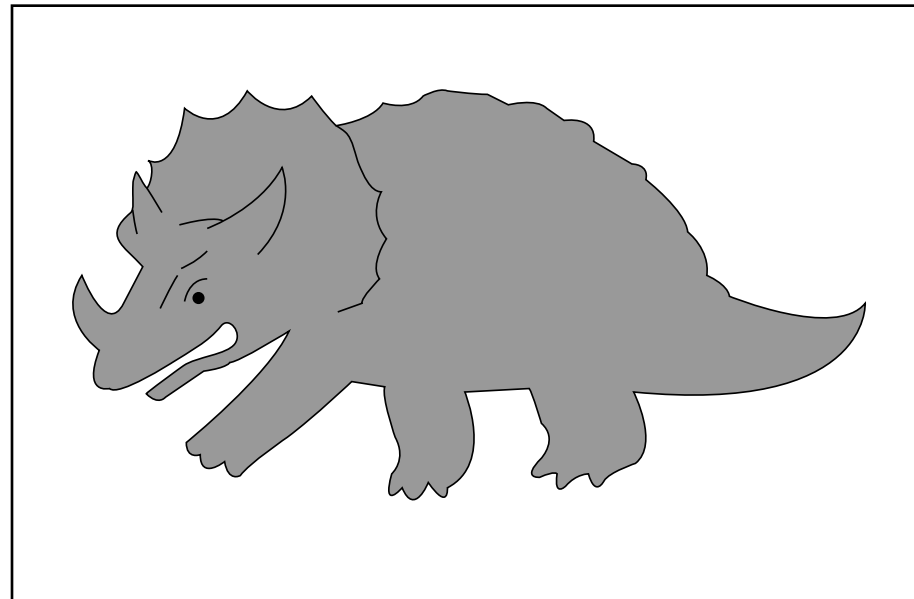- How do you know which features to weight more heavily than others?

Illustration courtesy of MIT OCW.

Challenges to the prototype view

- Many category inferences from legs, eyes, horn.
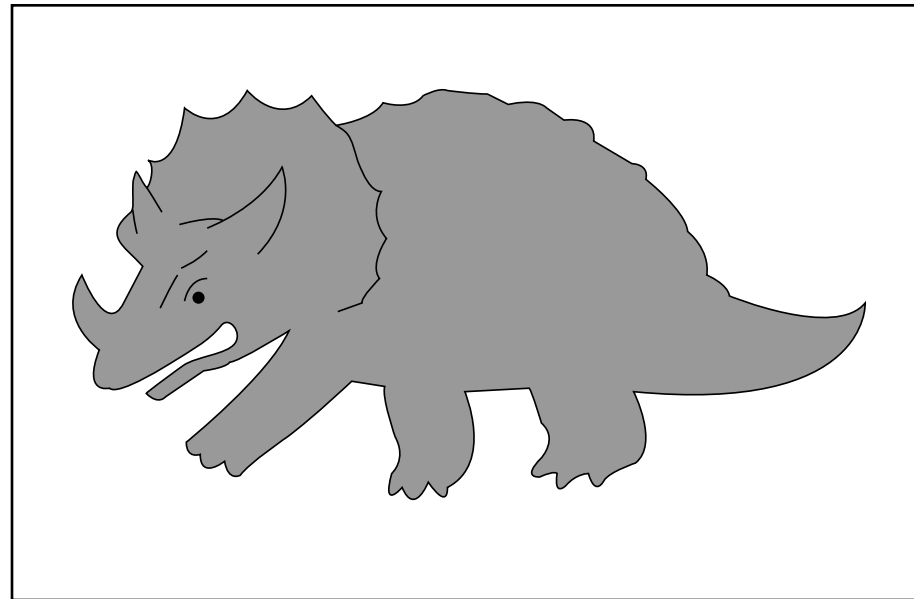- Very few from being in a living room.

Illustration courtesy of MIT OCW.

Challenges to the prototype view

- – If you see a new animal you pay attention to how many legs it has, what it eats, where it lives, not where it happens to be standing.
- – If you see a fuzzy, grey thing paddling after a goose you may categorize it also as a goose … even though it looks nothing like prototypical goose -- because you know something about babies in general.

Challenges to the prototype view

- Why are some feature combinations easier to learn than others?

Test

- Category A
  - Green
  - Air bags
  - Vinyl seats
  - Stick shift

- Category B
  - White
  - Seatbelts
  - Cloth seats
  - Automatic transmission

- Category A
  - Made in Africa
  - Lightly insulated
  - Green
  - Has wheels

- Category B
  - Made in Norway
  - Heavily insulated
  - White
  - Has treads

Concepts as embedded in theories?

- Features are context-sensitive
- Some features are weighted more heavily than others
- Some feature lists are easier to learn than others …

- Suggests our theories inform our inductive inferences about concepts.

Evidence for effects of theories

- The same category can prompt different inferences depending on the properties involved.

Category-based induction

- <u>Robins have high potassium in their blood.</u>
- All birds have high potassium in their blood.
- V.
- <u>Penguins have high potassium in their blood.</u>
- All birds have high potassium in their blood.

- **Premise-typicality matters.**

Category-based induction

- Hippos require Vitamin K
- <u>Rhinos require Vitamin K.</u>
- All animals require Vitamin K.
- V.
- Hippos require Vitamin K
- <u>Bats require Vitamin K.</u>
- All animals require Vitamin K.
- **Premise diversity matters.**

Category-based induction

- Hippos require Vitamin K
- <u>Bats require Vitamin K.</u>
- All animals require Vitamin K.
- V.
- Hippos require Vitamin K
- Rhinos require Vitamin K
- <u>Bats require Vitamin K.</u>
- All animals require Vitamin K.
- **Amount of evidence matters.**

Category-based induction

- <u>Robins have an ulnar artery</u>
- Birds have an ulnar artery.
- V.
- <u>Robins have an ulnar artery</u>
- Ostriches have an ulnar artery.

- Inclusion fallacy
- **Similarity of premise to concluding exemplar matters.**

Category-based induction

- However, it also turns out that background knowledge affects category-based induction.

Theories and concepts

- Target food: cereal
- Cereal has blick inside. Which of the following has blick inside?
- The Blick people of New Guinea eat cereal for lunch. What else do they eat for lunch?
  - Taxonomic food: pasta (for biochemical properties)
  - Thematic food: milk (for sociocultural behaviors)

Theories and concepts

- "This bird has semasoid bones". What else has semasoid bones?"
  - Sparrow
  - Bug
- Usually extended to taxonomic choices (other birds)
- But "This bird caught a flu germ. What else has a flu germ?"

Theories and concepts

- Both children and adults can override taxonomic choices to make inductive inferences on the basis of causal connections (ecological relatoinships -- like food webs).

- Background knowledge has an effect: "Experts" -- rural children, ecologists, often do this better than novices, urban children, university undergraduates.

Inferences about natural kinds and artifacts

- This is a pig.
  - Does it have the same insides as this cow?
  - Or as this piggy bank?
- If I take the insides out of this dog and left the outside, would it still bark and eat food?
- If I take the insides out of this peanut butter jar and leave the outside, would it still be a peanut butter jar and hold things?

Inferences about natural kinds

- "This baby animal looks like a horse, goes neigh, people ride it …"
- "But scientists have discovered that it has cow parts inside, cow blood, its parents are cows and its children are cows."
- Is it a cow or a horse?

Inferences about artifacts

- "This object looks like a key and if fits in doors and opens them …"
- "But scientists have discovered that it's full of penny metal, it was made out of pennies and it will be melted back into pennies."
- "Is it a key or a penny?"

Theories and concepts

- Children believe that natural kind concepts are much more stable than artifact concepts.
- Children also believe that "insides" or "essences" are much more important for natural kinds than for artifacts.

Concepts and theories

- In particular, both adults and children think that properties that cause other properties are more critical for category membership than other properties.

Theories and concepts

- Children's inductive inferences change depending on the domain involved.
- Suggesting that there's no single "prototypical" concept that determines category inferences, rather the inferences are embedded in children's background knowledge.