Abstract Relational Concepts

Relational Learning Beyond Infancy

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The Natural Partitions Hypothesis

Gentner (1982)

- We parse the world into objects and relations among the objects
- Objects are perceptually cohesive: Relations are perhaps harder, dynamic/unstable, indefinite number of options
- Hypothesis: children will form categories of objects before they form categories of relations between objects *universally*
- This means early vocabularies will be filled with simple object nouns, like, *dog* & *chair*, before prepositions *of*, verbs *throw*,and even relational nouns like *guest*.

The Natural Partitions Hypothesis

Gentner (1982)

Early predominance of nouns over verbs found in:

- Chintang (Stoll, et al., 2011)
- English (e.g., Gentner, 1982; Goldin-Meadow, Seligman, & Gelman, 1976)
- Italian (e.g., Caselli, Bates, Casadio, Fenson, Fenson, Sanderl, & Weir, 1995)
- Japanese (e.g., Imai, Haryu, & Okada, 2005)
- Korean (e.g., Au, Dapretto, & Song, 1994; but see Choi & Gopnik, 1995)
- Mandarin (e.g., Liu, Zhau, & Li, 2008; Tardif, Gelman, & Xu, 1999; but see Tardif, 1996)
- Navajo (Gentner & Boroditsky, 2009)
- Tzeltal (Brown, Gentner, & Braun, 2005)

How are abstract relational concepts learned?

- Last time we talked about identity relations (same/different) and causal perception in infancy

Today, abstracting and generalizing
- Spatial relations
- Causal relations
- Number concepts

- Less time on social relations, but a lot of work on that

Analogical comparison highlights relations

Gentner (1983)

- Rutherford model of the atom
- The atom is like the solar system

Sun is more massive than the planets which causes the planets to revolve around the sun.

Nucleus is more massive than electrons which causes the electrons to revolve around the nucleus.

- aspirin:pain::muffler:noise

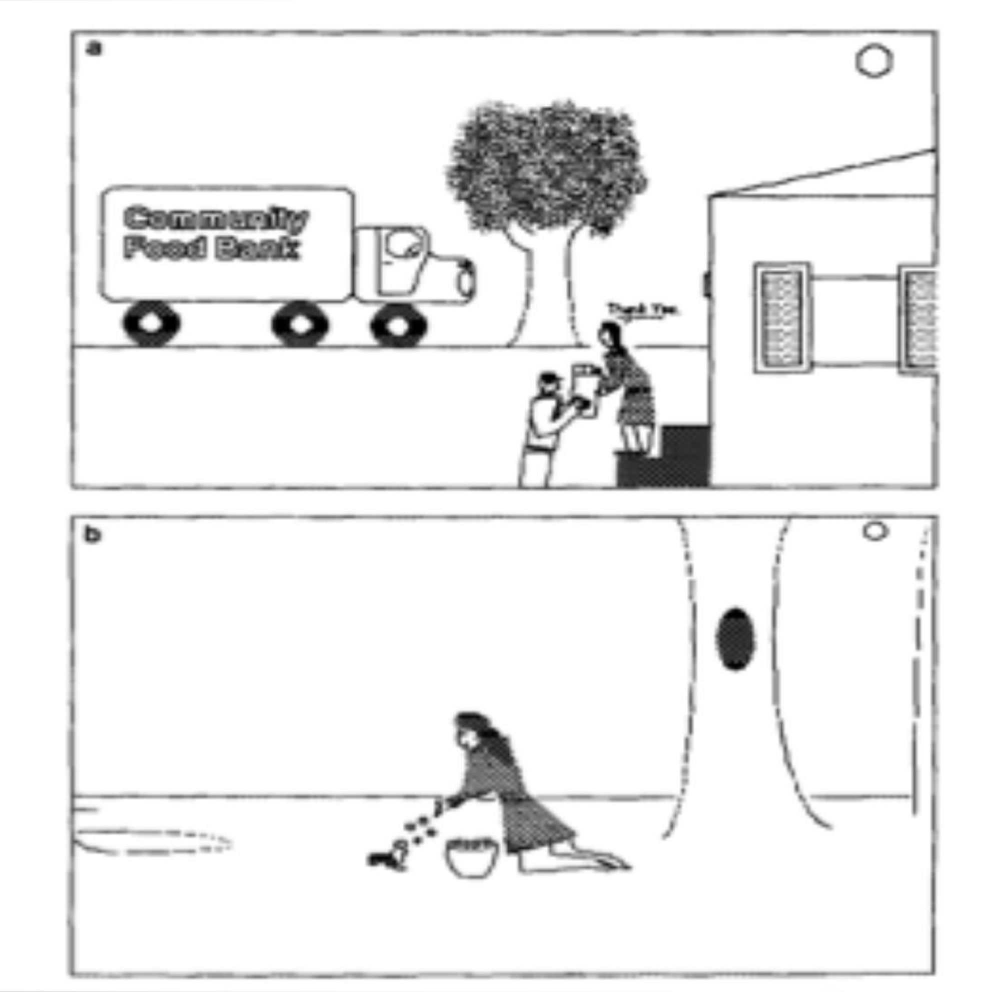
Even mundane comparisons highlights relations

- Markman & Gentner (1993)

What goes with this woman from the top picture in the second picture?

Even mundane comparisons highlights relations

- Markman & Gentner (1993)

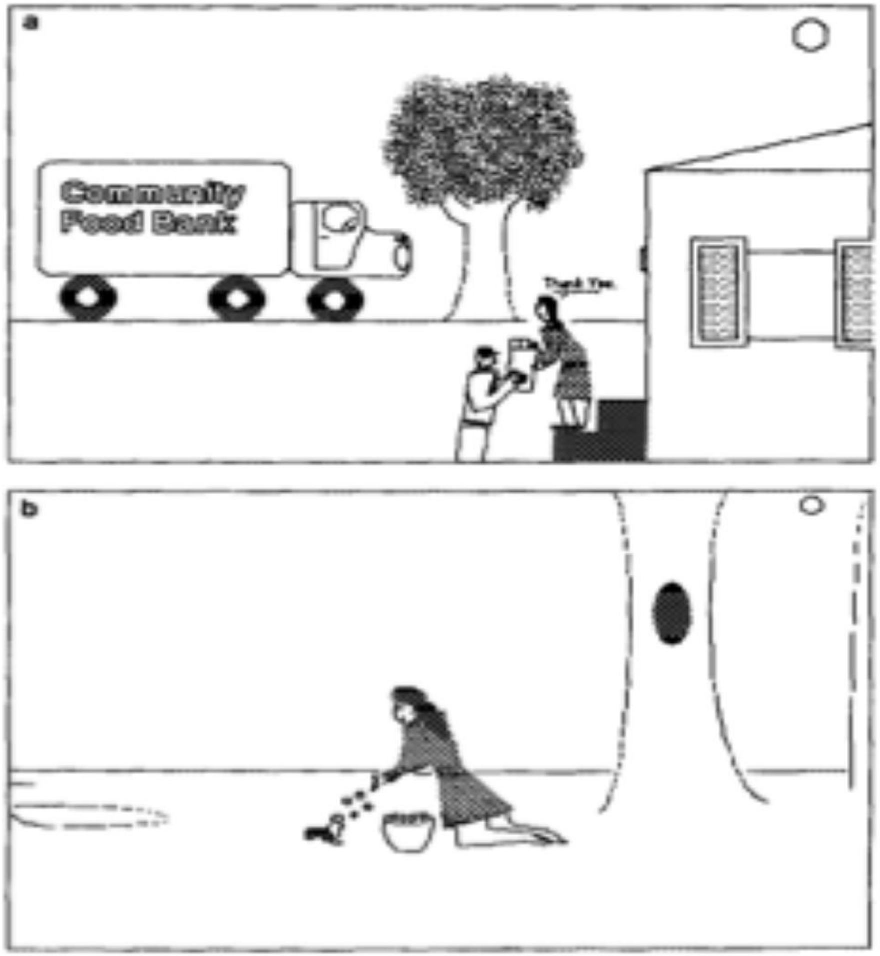


What goes with this woman from the top picture in the second picture?

Most people say the other woman

Even mundane comparisons highlights relations

- Markman & Gentner (1993)

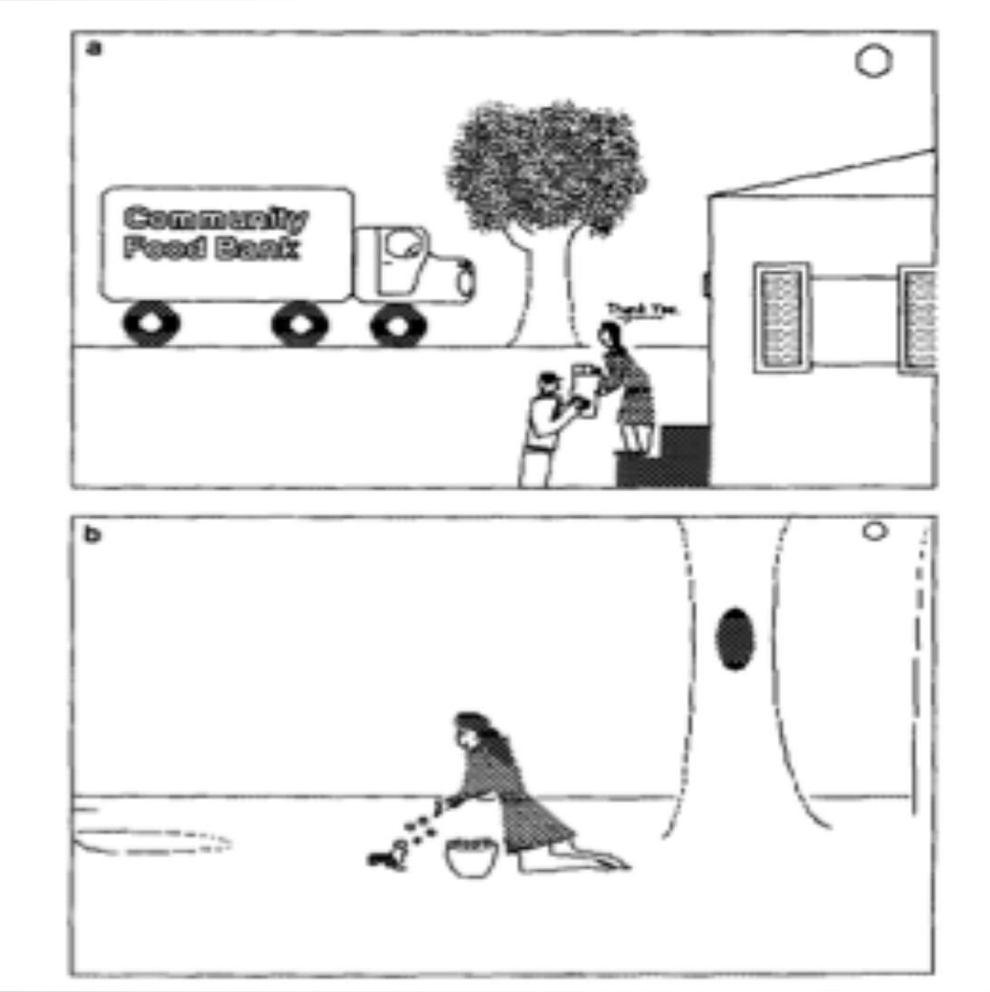


What goes with this woman from the top picture in the second picture?

But, if they compare the the two scenes first, they pick the squirrel (each are in the receiving food role).

Even mundane comparisons highlights relations

- Markman & Gentner (1993)



Even simple comparison of simple scenes, shifts focus to relational structure. Similar to more “sophisticated” analogical reasoning

Learning relational concepts

- The relational shift in “the career of similarity”
  - Gentner & Ratterman (1991)
- Consequences for word learning:
- Relational words are learned later
  - e.g., Gentner & Boroditsky (2001)
- Relational words are often assumed to be featural at first
  - Keil & Batterman (1984)
  - *uncle* = beardy guy → uncle = a parents’ brother
  - *island* = place with beaches and palm trees → *island* = land surrounded by water

Comparison and the relational shift

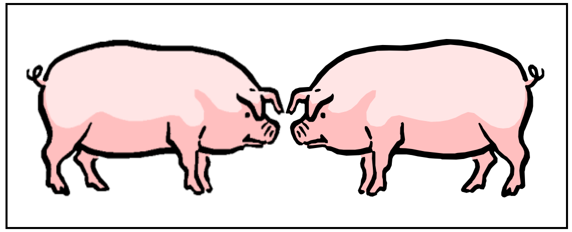
(Christie & Gentner, 2010)

Triad word extension task for a novel relational word

3 year olds
4 year olds

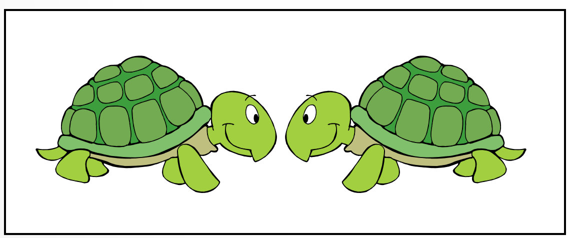
Three conditions: 1 solo example vs. 2 examples presented in sequence vs. Comparison of 2 examples

Solo

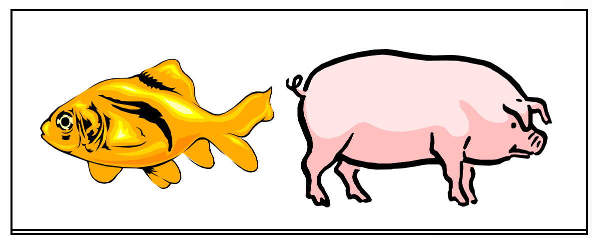


“This is a Toma”

standard 1



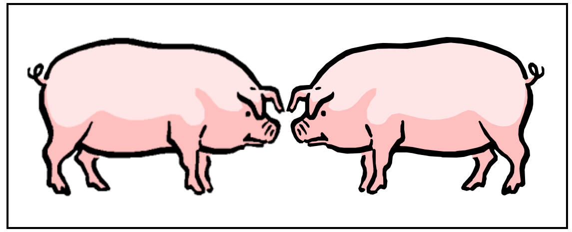
Relational match



Object match

“Which one of these two is also a Toma?”

Comparison



“This is a Toma”

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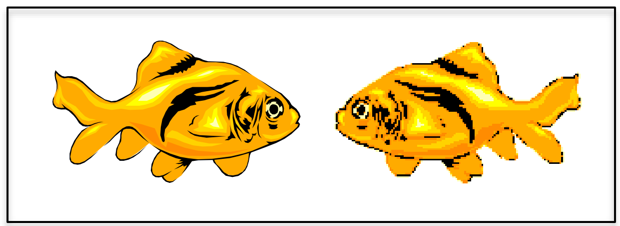
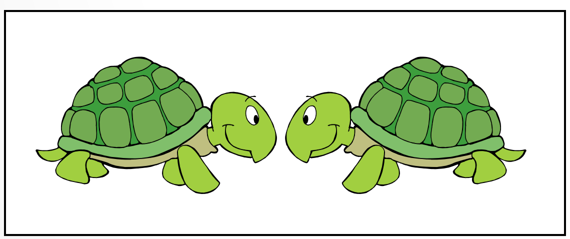


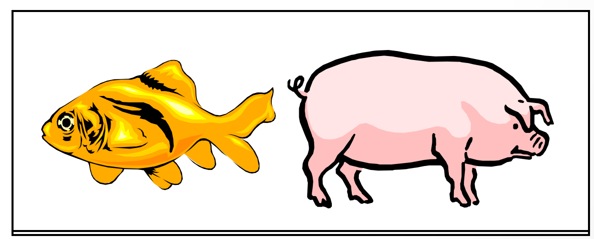
“And this is also a Toma”

“Can you see why they’re both Tomas?”

standard 2



Relational match

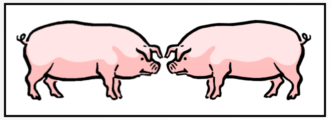


Object match

“Which one of these two is also a Toma?”

Solo

"This is a Toma"



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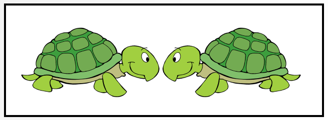
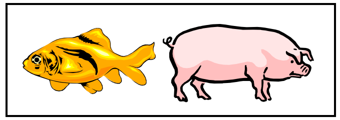


Relational match



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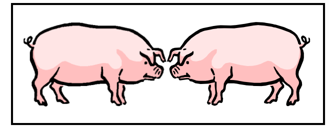

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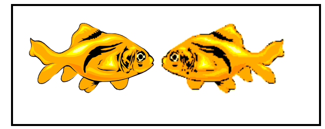
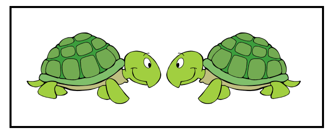
"This is a Toma"



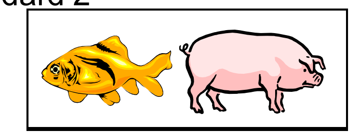
Standard 2

"And this is also a Toma"

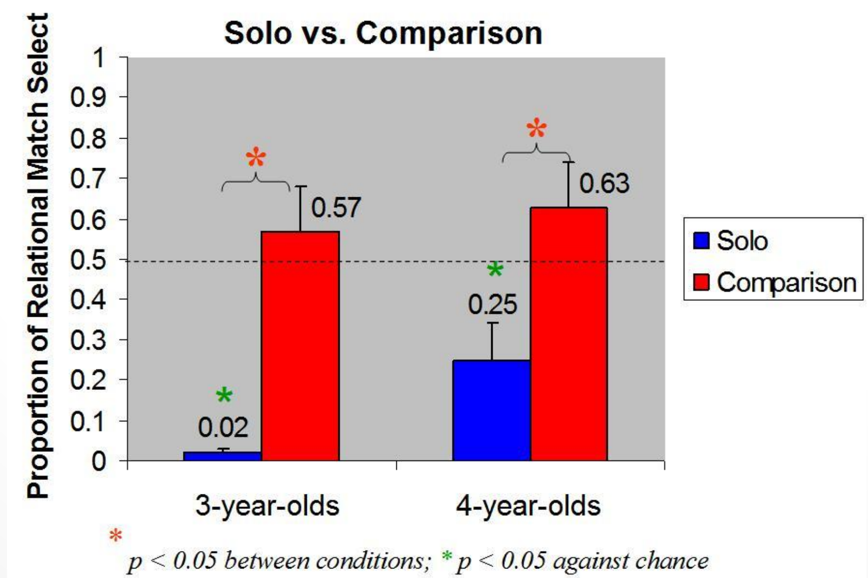
"Can you see why they' re both Tomas?"



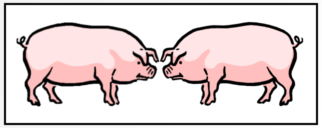
Relational match



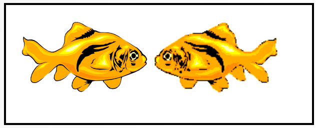
Object match



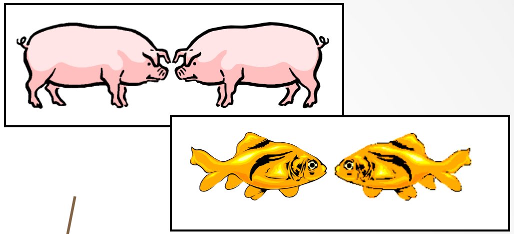
Comparison versus Multiple exemplars

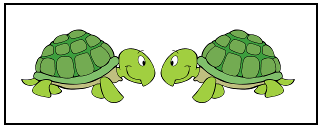

Standard 1

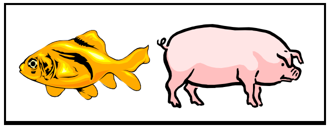
“This is a toma”


Standard 2

“This is a toma”

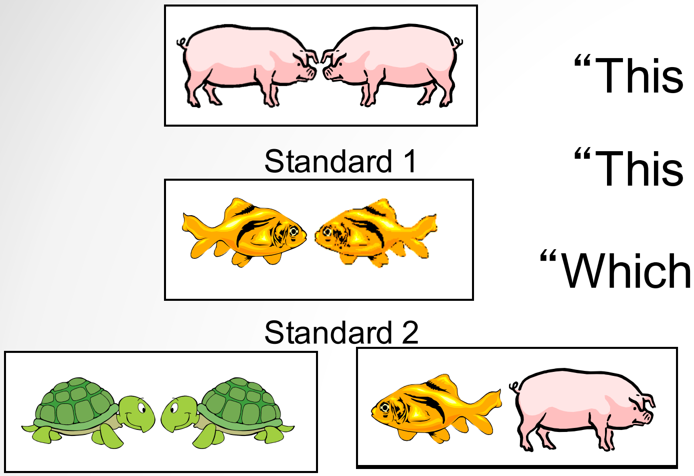



Relational match


Object match

“Which one of these is also a toma”

Comparison vs. Multiple exemplars



Standard 1

Standard 2

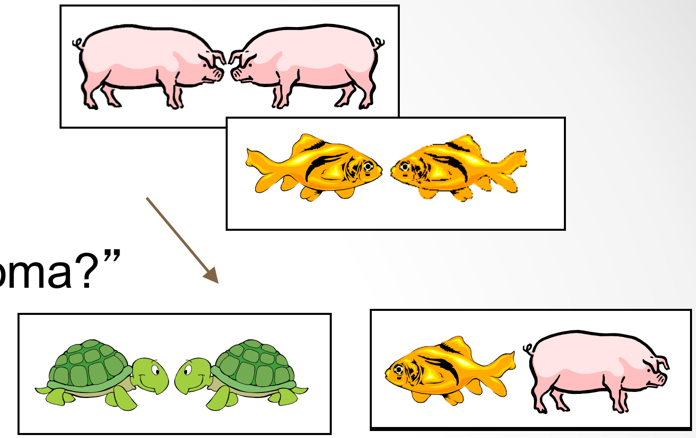
Relational match

Object match

"This is a toma"

"This is a toma"

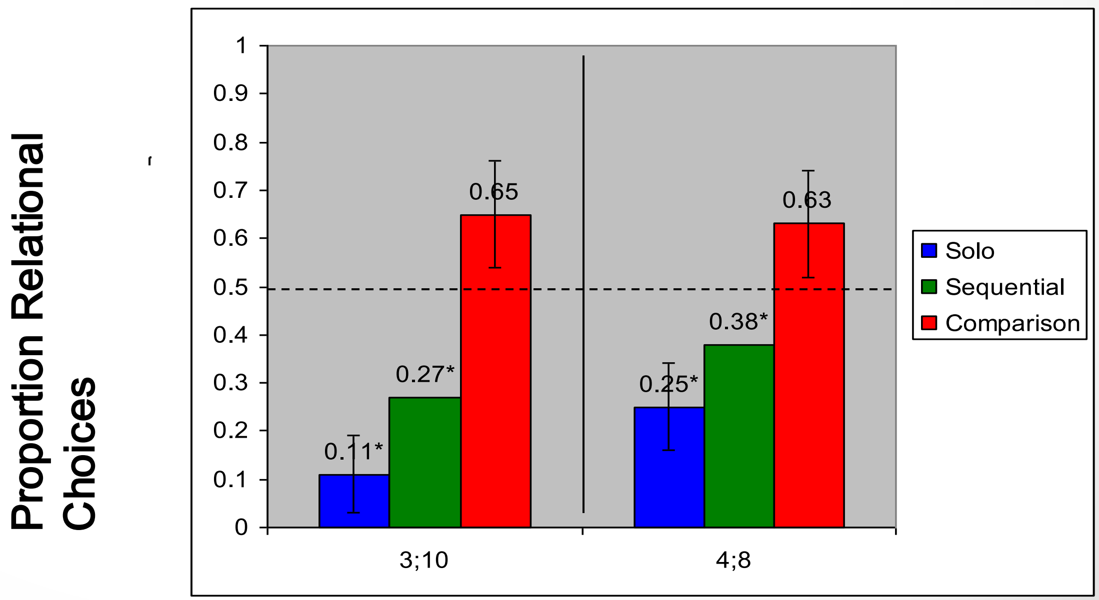
"Which one of these is a toma?"



Relational match

Object match

This is a similar to pattern to infant relational learning It doesn't matter the age, when learning an entirely novel relation –> comparison helps!



How language fosters relational thinking

- Giving two things a common label is a powerful invitation to compare them, abstract their commonalities
  - Understand their relational structure

- Reify relational systems
- Recall that relations are perceptually ill defined. Systematic relational labeling is critically for having stable relational representations.
  - Homesigners without spatial language have poor spatial skills.
  - Builds on the seedlings of our non-linguistic relational abilities.

Homesign

How language fosters relational thinking

- Gentner, Ozyurek, Gurcanli, Goldin-Meadow (2013)

D. Gentner et al./Cognition 127 (2013) 318–330

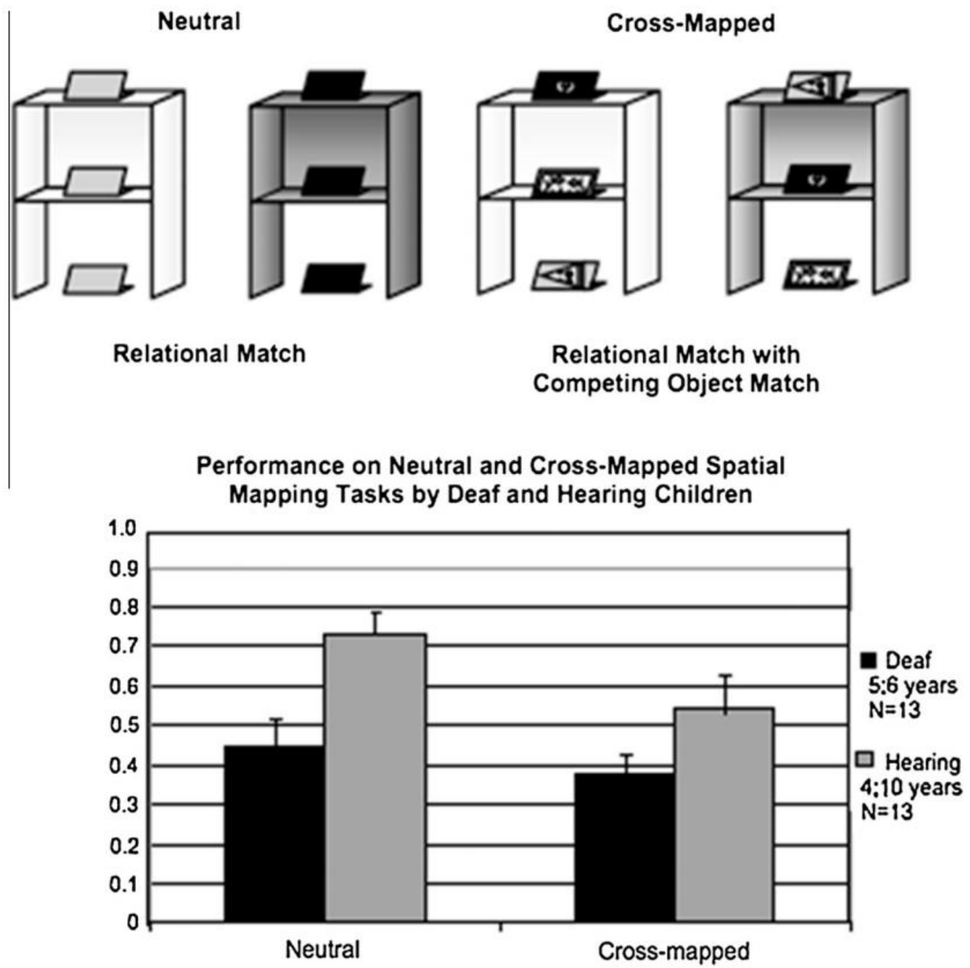


Fig. 4. Examples of the shapes and choice cards shown to the deaf and hearing children in the Mental Transformation Task.

Abstract causal reasoning

- Learning novel spatial relations seem to need a lot of support.
- On the other hand..
- Alison Gopnik (and colleagues) show abstract causal learning during a similar age range
- That is, when children are attempting to figure out what causes what else in the world
  - They are like little scientists who test abstract hypotheses

Abstract causal reasoning

Abstract causal reasoning

- Lucas, Bridgers, Griffiths, & Gopnik (2014)
- 4 year-olds and adults learned about 2 different “blicket” machines
- The first machine would either work with one specific block, or only with a specific combination of blocks
  - Not just any 1 or 2, but specific 1 or 2
- Then the 2nd machine (with a new set of blocks) was presented such that it would be ambiguous between working from 1 specific block, or from 2 specific blocks

Abstract causal reasoning

- Lucas, Bridgers, Griffiths, & Gopnik (2014)
- Adults assumed 1 block for 2nd machine regardless of how the first machine worked
- 4 year-olds interpreted the 2nd in line with the first
- Adults were biased to single-object explanations due to prior experience
- So, kids at least, seem ready to interpret the relations between a new sets of object in terms of just learned causal relations
    - (But next time, we go into some limits on this)

Language and abstract thought: the case of number.

- Carey posits a core knowledge system for number
- However, core knowledge is often qualitatively different than mature conceptual knowledge
- Language plays a key role making this transition

The role of language in Carey's "The Origin of Concepts"

- Core knowledge for number:
- Two systems

1: precise number of small sets

can distinguish 2 dots from 3 dots

2: analog magnitude scale

can distinguish large quantities from others, vaguely

350 dots from 500 dots, not 350 dots from 352 dots

- To learn maths, clearly something needs to change.

The role of language in Carey's "The Origin of Concepts"

- 2 year olds often can count to 10 and beyond, but this doesn't mean they know what those words mean

The role of language in Carey's "The Origin of Concepts"

As suggested by CS2's being qualitatively different from each of the CS1s that contain symbols with numerical content, it is indeed difficult to learn. American middle-class children learn to recite the count list and to carry out the count routine in response to the probe "how many," shortly after their second birthday. They do not learn how counting represents number for another $1\frac{1}{2}$ or 2 years. Young 2-year-olds first assign a cardinal meaning to "one," treating other numerals as equivalent plural markers that contrast in meaning with "one." Some 7 to 9 months later they assign cardinal meaning to "two," but still take all other numerals to mean essential "some," contrasting only with "one" and "two." They then work out the cardinal meaning of "three" and then of "four." This protracted period of development is called the "subset"-knower stage, for children have worked out cardinal meanings for only a subset of the numerals in their count list.

The role of language in Carey's "The Origin of Concepts"

- How does language support the transition from subset knowers to knowing the general principle that the next number in the count list means that previous number + 1?
- For this situation, Gentner's analogical learning view & Carey's core knowledge view give language the same role
- Systematic structure in language can be the basis of an analogy for systematic conceptual structure

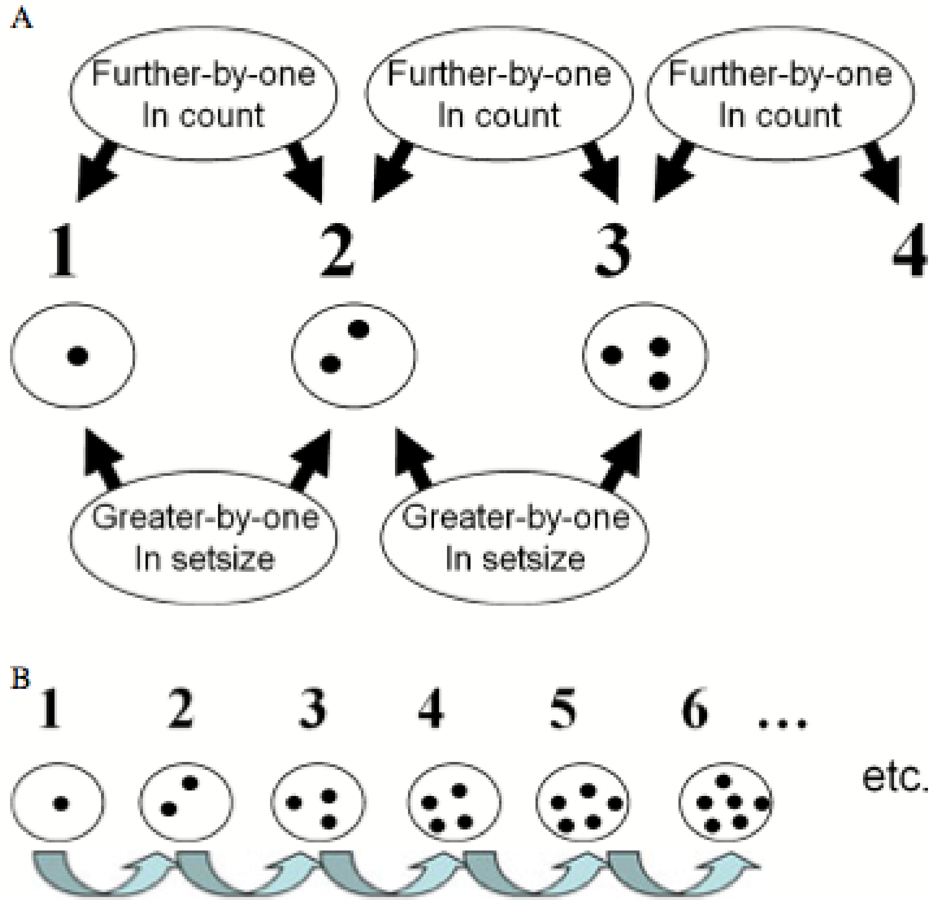


Fig. 4. The analogy linking count sequence and numerical order [based on Carey's (2001, 2004, 2009) proposal]. (A) When the child has ''2'' connected to set size 2, and ''3'' to set size 3, this makes two instances of the same relational pattern—permitting an analogy. This analogy invites the inference (not shown here) that the same relational pattern will hold for ''4'': that is, that its set size will be one greater than the set size of ''3.'' (B) The analogy also invites the abstraction IMPLIES {FURTHER-BY-ONE (count list) → GREATER-BY-ONE (setsize)}, suggesting that the sequence continues indefinitely.

The role of language in Carey's "The Origin of Concepts"

The role of language in Carey's "The Origin of Concepts"

- Evidence that Piraha tribe in Brazil have no numerical language and never leave core knowledge state of numerical cognition
  - See work by Peter Gordon & Mike Frank
  - Sometimes language may support abstract concept learning, but people may still learn these concepts without language. Other abstract concepts seem perhaps unlearnable without language.

Summary of different approaches

Abstract/ Relational Concept

- Infancy: constructivist pattern of building relational representations as a higher-level over object representations
- Gentner's Analogical learner view: the world is naturally partitioned into objects and the relations among them. Our perceptual systems readily process objects, but relations are less perceptually constrained, and so is facilitated with language/comparison. This pattern is common across age groups.
- Carey- Core Knowledge: we are born with core knowledge, but this is inadequate for mature cognition. Language is needed for the conceptual shift to mature cognition (e.g., numbers to do maths).
- Gopnik's hypothesis-testing view: Causal exploration in action reveals abstract thought from early age.