9.85 Cognition in Infancy and Early Childhood

Lecture 22: Causal reasoning Part One

Today

- Why care about causal reasoning?
- Philosophical issues in causal reasoning.
  - Regularity
  - Logic
  - Probability
  - Mechanisms
  - Interventions

Causal reasoning from spatiotemporal relations

- Michottean launching (perceptual causality)
- http://cogweb.ucla.edu/Discourse/Narrative/michotte-demo.swf

- **Direct launching**
- Delayed launching (500 ms)
- Launching without collision (6 cm)
- Delayed reaction without collision (500 ms and 6 cm)

Causal reasoning from spatiotemporal relations

- Infants should dishabituate most to reversals in the Direct Launching condition …

- Why?
- Because both trajectories and agent/patient relationship are reversed.

Spatiotemporal regularity and developmental psychology

- Note however, that a strict Humean would argue that all of these:

- Direct launching
- Delayed launching (500 ms)
- Launching without collision (6 cm)
- Delayed reaction without collision (500 ms and 6 cm)

- … as causal --- they are all instances of regularity.

Spatiotemporal regularity and developmental psychology

- Open questions:
- Is perceptual causality the same as ‘real’ causality?
- Do babies use perceptual causality as a way into ‘real’ causality?
- How do spatiotemporal regularities map onto mechanism knowledge?

Mechanisms and developmental psychology

- Piaget believed infants started only with an undifferentiated feeling of effort …
- “Nursling at the age of one or two months … must experience …without his knowing how a certain action leads to a result, that a certain complex of efforts, tension, expectation, desire, etc. is charged with **efficacy**.” (1954)
- No separation of action and outcome.

Mechanisms and causal learning

- Differentiation resulted in **phenomenalism**
- Whenever infants experience efficacy, they infer that they a causal relationship between their action and the subsequent (or simultaneous) phenomena.
- Like operant learning except for emphasis on internal experience; no understanding of mechanism required.

Mechanisms and causal learning

- Piaget described a total of 17 stages in the development of causal reasoning.
- Believed children were “precausal” for years.

Mechanisms and causal reasoning

- Precausal reasoning characterized by "a confusion between psychological activity and physical mechanism."
- **Artificialistic**: river moves because of boats
- **Animistic**: string unwinds because it wants to.

Mechanisms and causal learning

- 50 years ago: infants and young children are “precausal”. Why?
  - “confusion between psychological activity and physical mechanism”
- 50 years later: infants and young children are much smarter. Why?
  - understand domain-specific causal mechanisms.

Mechanisms and causal learning

- Early constraints on object motion
- Early understanding of goal-directed action
  - Babies expect objects to move through contact, but expect agents to move spontaneously.
  - Babies expect hands to move objects
  - Babies treat agent actions but not object actions as goal-directed.

Mechanisms and causal learning

- Additional evidence from children's spontaneous explanations:
- I talking very quiet because I don't want somebody to wake up.
- He'll eat his food because to be alive.
- He got a bad tooth because he fell of his bike.

Mechanisms and causal learning

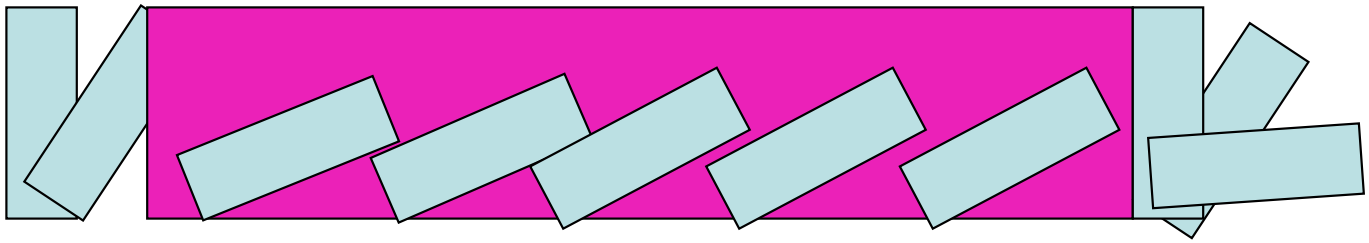
- What happens if you pit an understanding of mechanisms of generative transmission against simple Humean covariation?
- How would you do it?
- Jack-in-the-boxes with gaps
- Flashlights and tuning forks

Mechanisms and causal learning

- So perhaps the causal reasoning of young children is characterized by an understanding of the way that causes generate their effects …
- Domain-appropriate, spatiotemporally continuous processes for transmission of force or energy …

A problem?

- Do children really understand domain-appropriate, spatiotemporally continuous mechanisms for transmission of force or energy?



- Do you?

Illusion of explanatory depth

- Keil's experiment …

A problem?

- An impoverished understanding of causal mechanisms even in adults.

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Please see:
Fig 1 in Keil, F. C. "Folkscience: coarse interpretations of a complex reality." *Trends Cogn Sci* 7, no. 8 (Aug 2003): 368-373.

Mechanisms and causal learning

- Specific to causal knowledge (no illusions about knowledge of movie plots, capitols of countries, etc.)

- "The rise of appeals to intuitive theories in many areas of cognitive science must cope with a powerful fact. People understand the workings of the world around them in far less detail than they think" (Keil, 2003).

The importance of mechanism understanding . . .

Still, prior knowledge about causal mechanisms might help constrain children's interpretation of evidence.

Or the importance of patterns of evidence?

1) Mechanism knowledge helps distinguish between causes and spurious associations.

2) But so might patterns of evidence. In which case, mechanism knowledge should be defeasible.

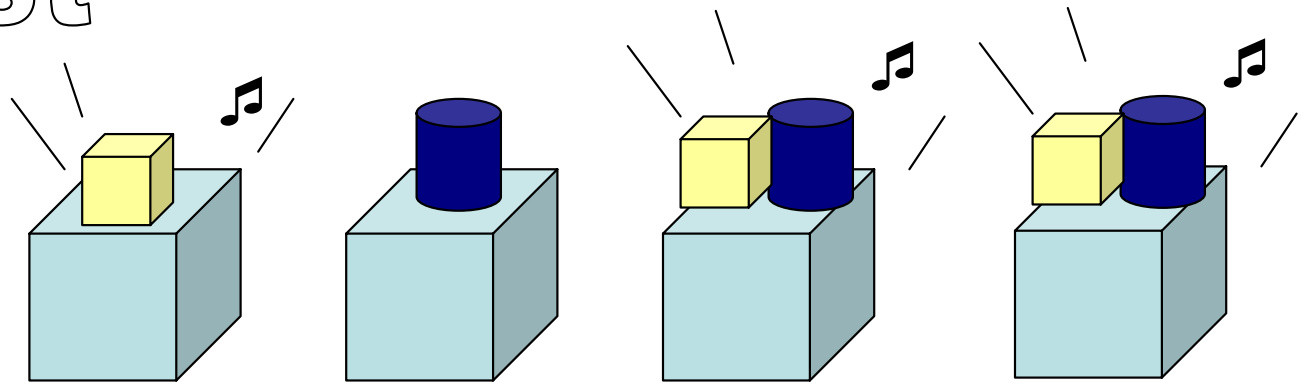
Snoopy and patterns of evidence

- Snoopy and Woodstock observe a correlation between kicking snowmen and snow falling.
- But Snoopy knows that kicking snowmen and snow falling are also correlated with snow clouds.
  - If you don't kick snowmen, the dependence between snow clouds and snow falling still holds.
  - But if there are no snow clouds, kicking snowmen and snow falling become independent.
- Therefore clouds ***screen-off*** kicking as a cause of snow.

Formally:

- If C1, C2, and E covary
- C1 and E covary in the absence of C2.
- But C2 and E are independent in the absence of C1.
- Then C1 screens-off C2 from the effect.

Test



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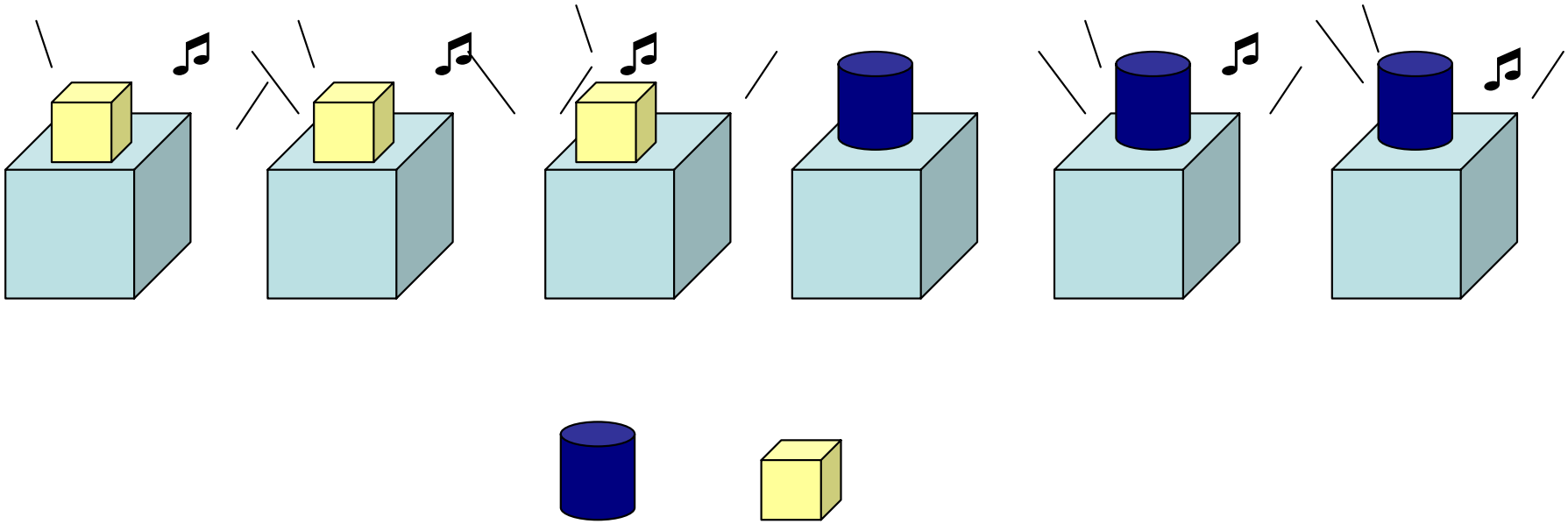

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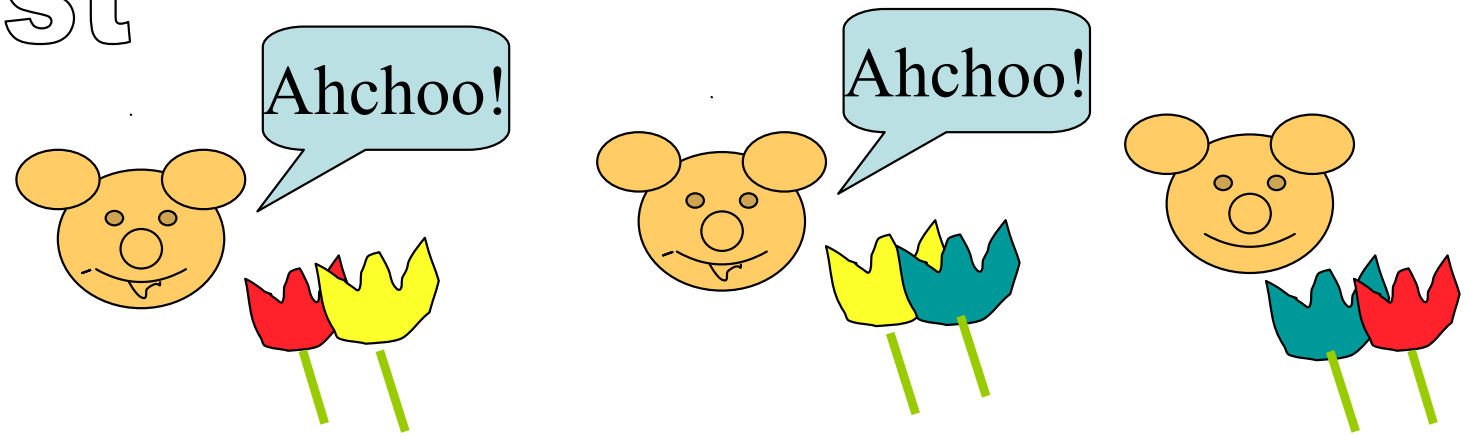

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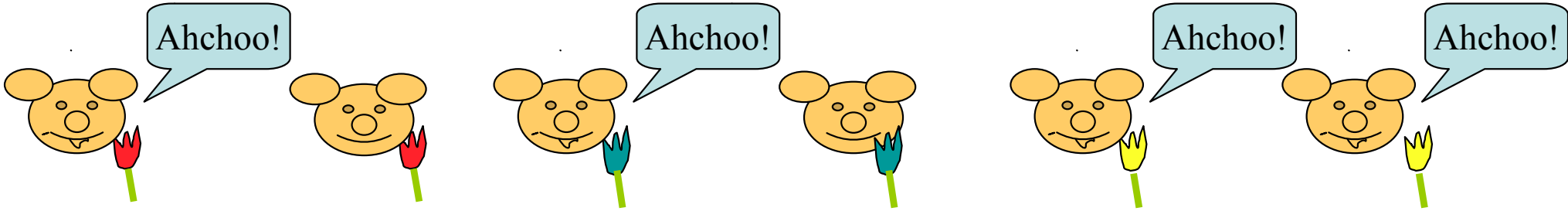
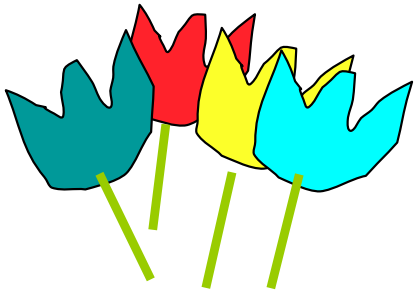
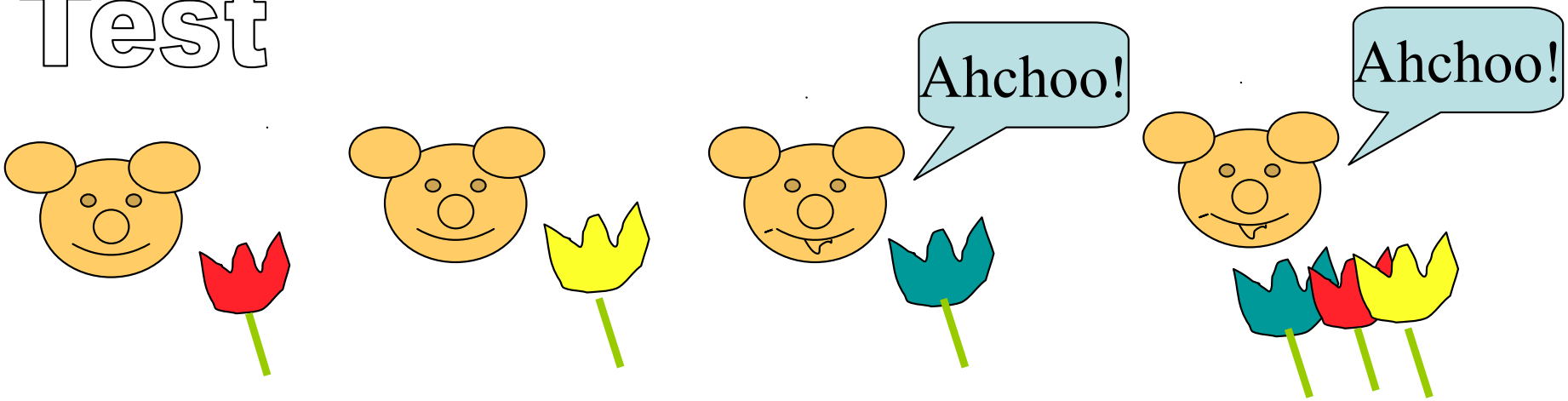




Can you give me the one that makes Monkey sneeze?

Test



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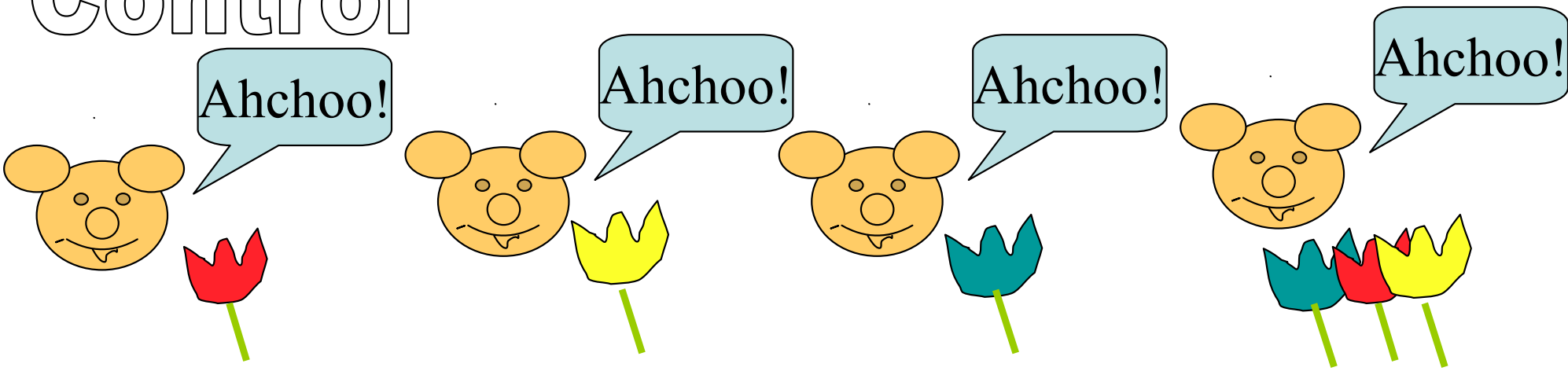
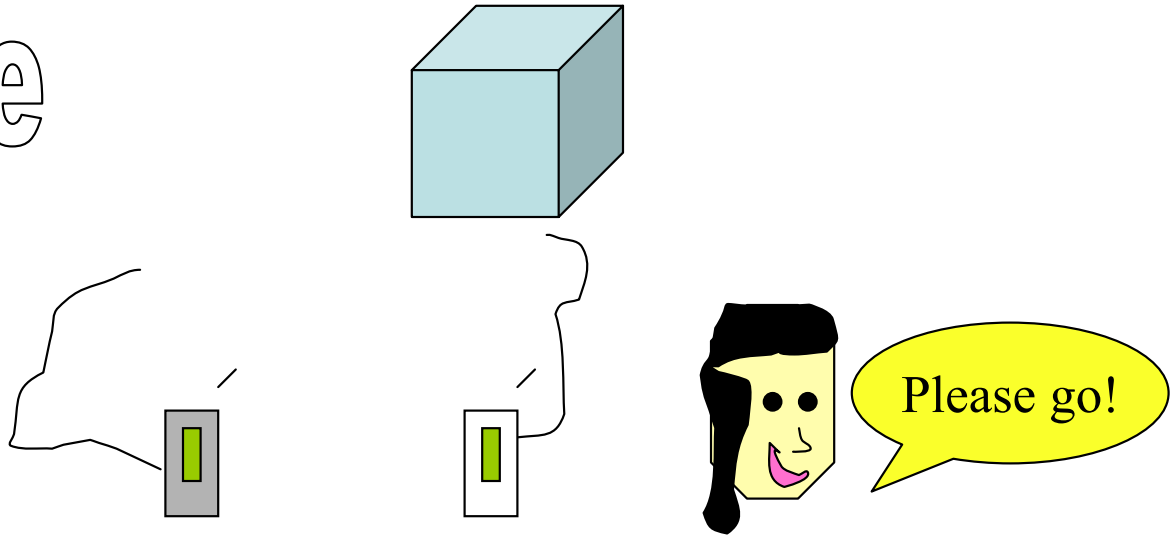


Can you make it so Monkey won't sneeze?

Baseline



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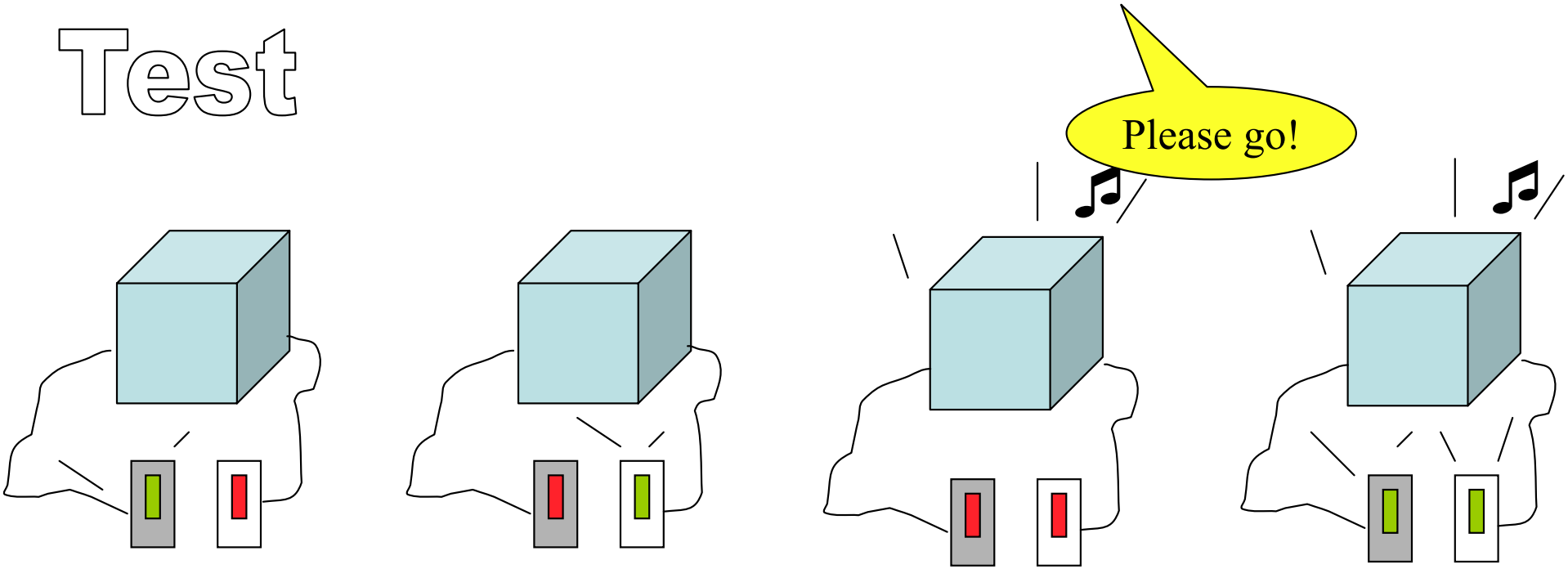
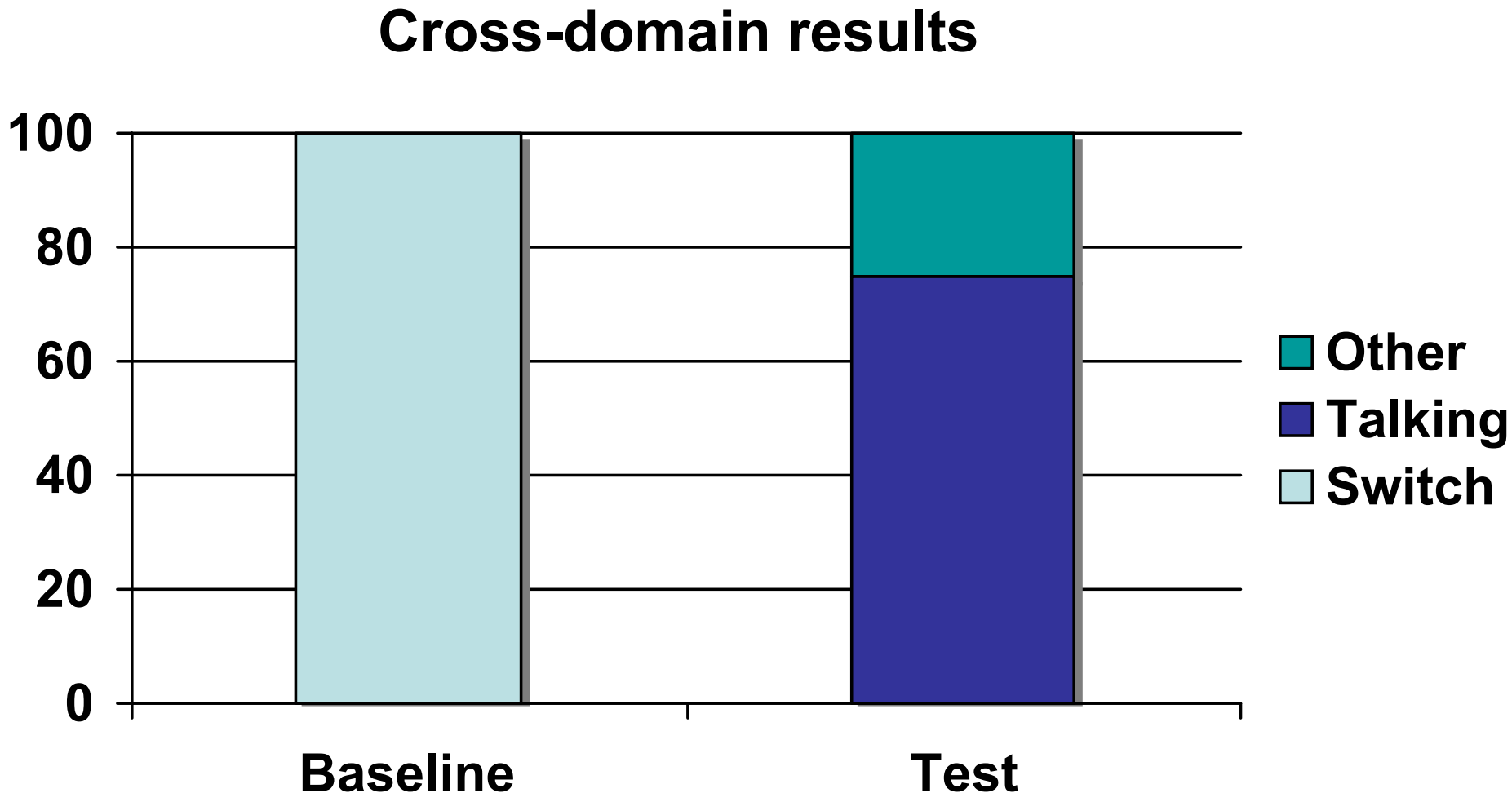
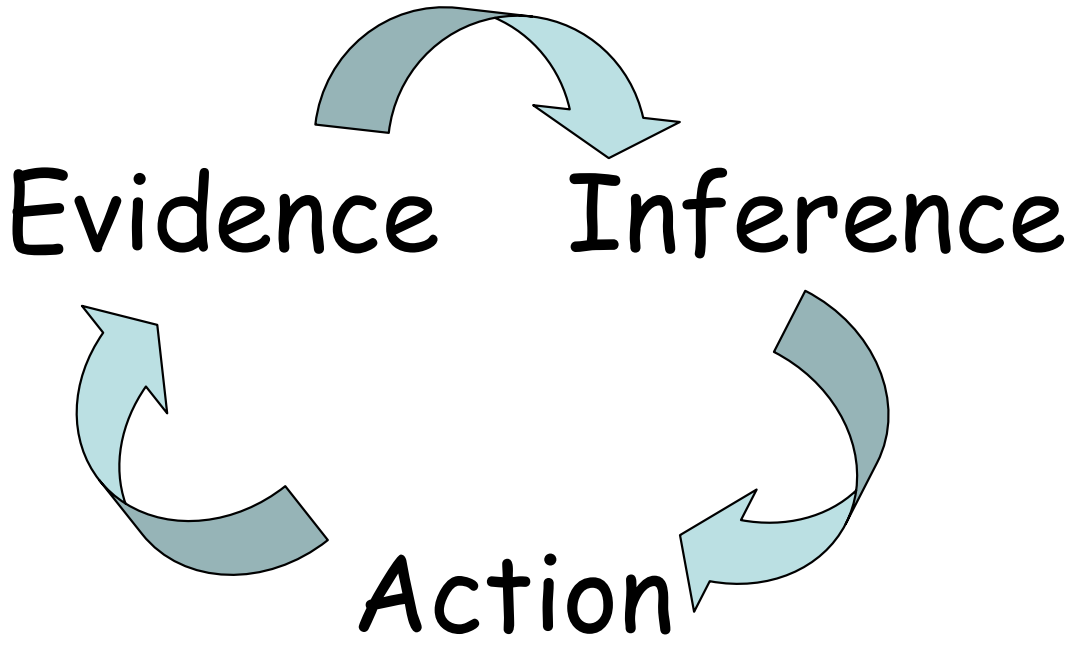



Cross-domain results
100
80
60
40
20
0
Baseline
Test
Other
Talking
Switch

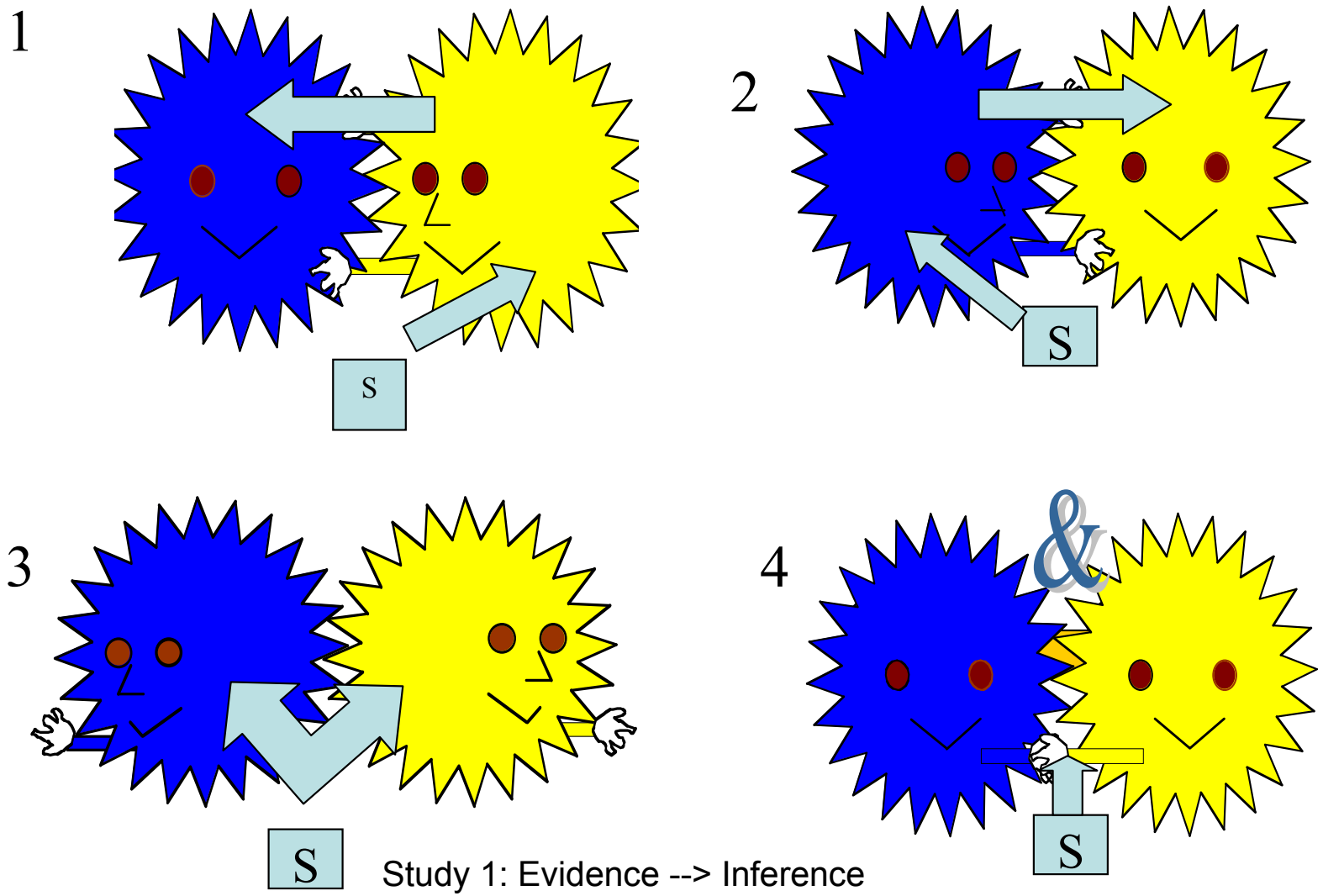
Interventions, evidence, and causal inference

Evidence → Inference

Interventions, evidence, and causal inference: Constructivism revisited



The Causal Possibilities

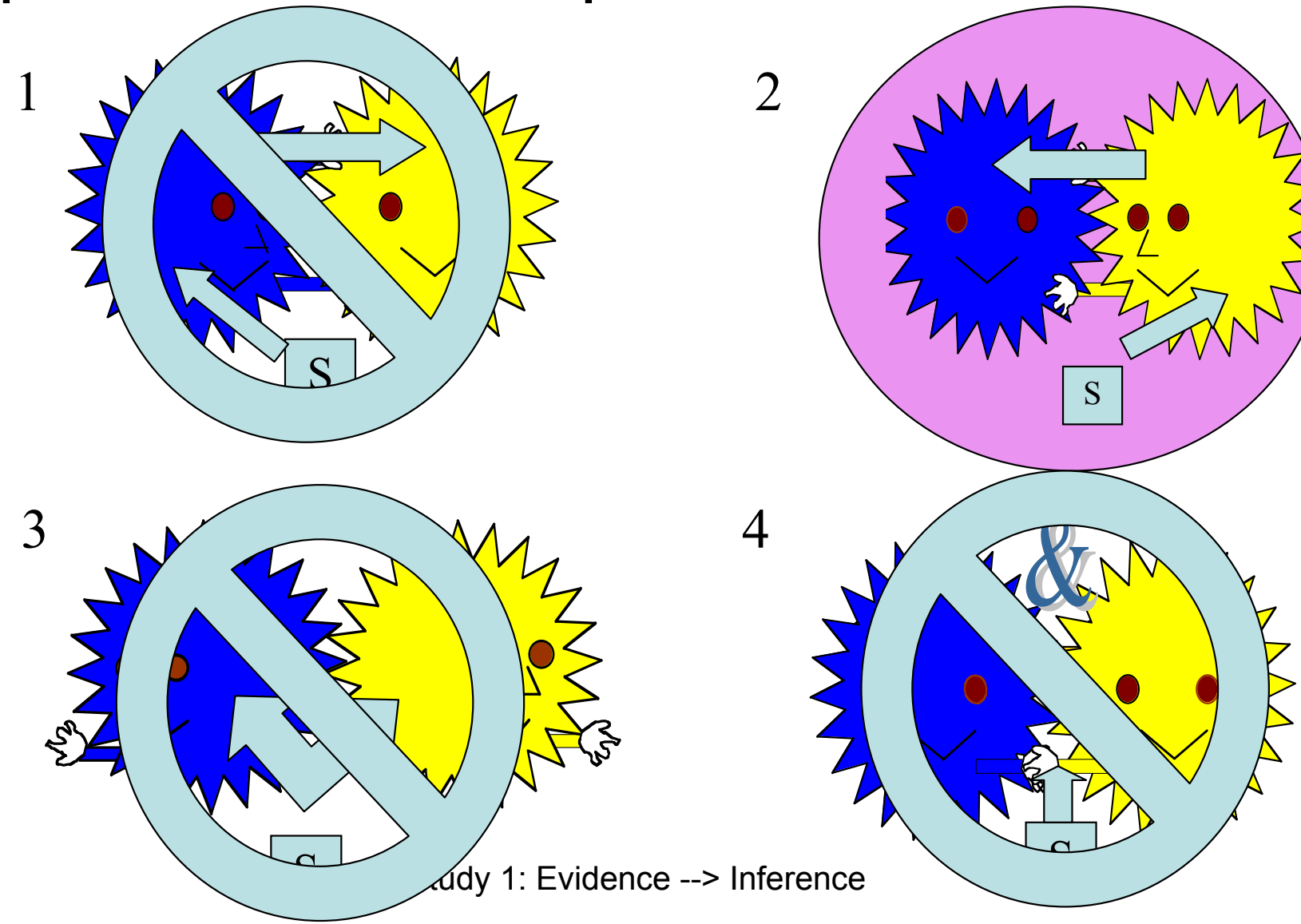


Study 1: Evidence --> Inference

The usual suspects

- Mechanism knowledge
- Direct interventions
- Spatiotemporal information
- Covariation information

Interventions on each causal structure will produce different patterns of evidence.



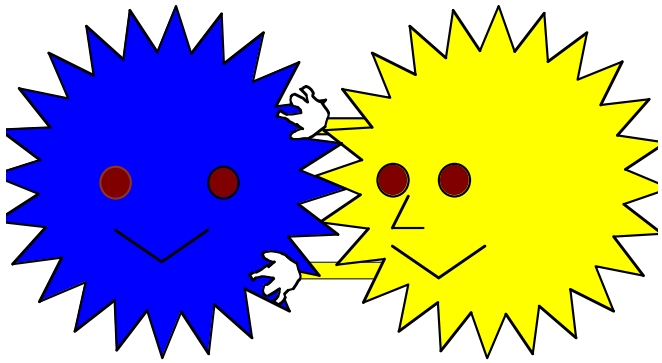
Conditional intervention principle

- X is a cause of Y iff:
- holding other causes of Y constant, an intervention to change the value or probability distribution of X changes the value or probability distribution of Y.

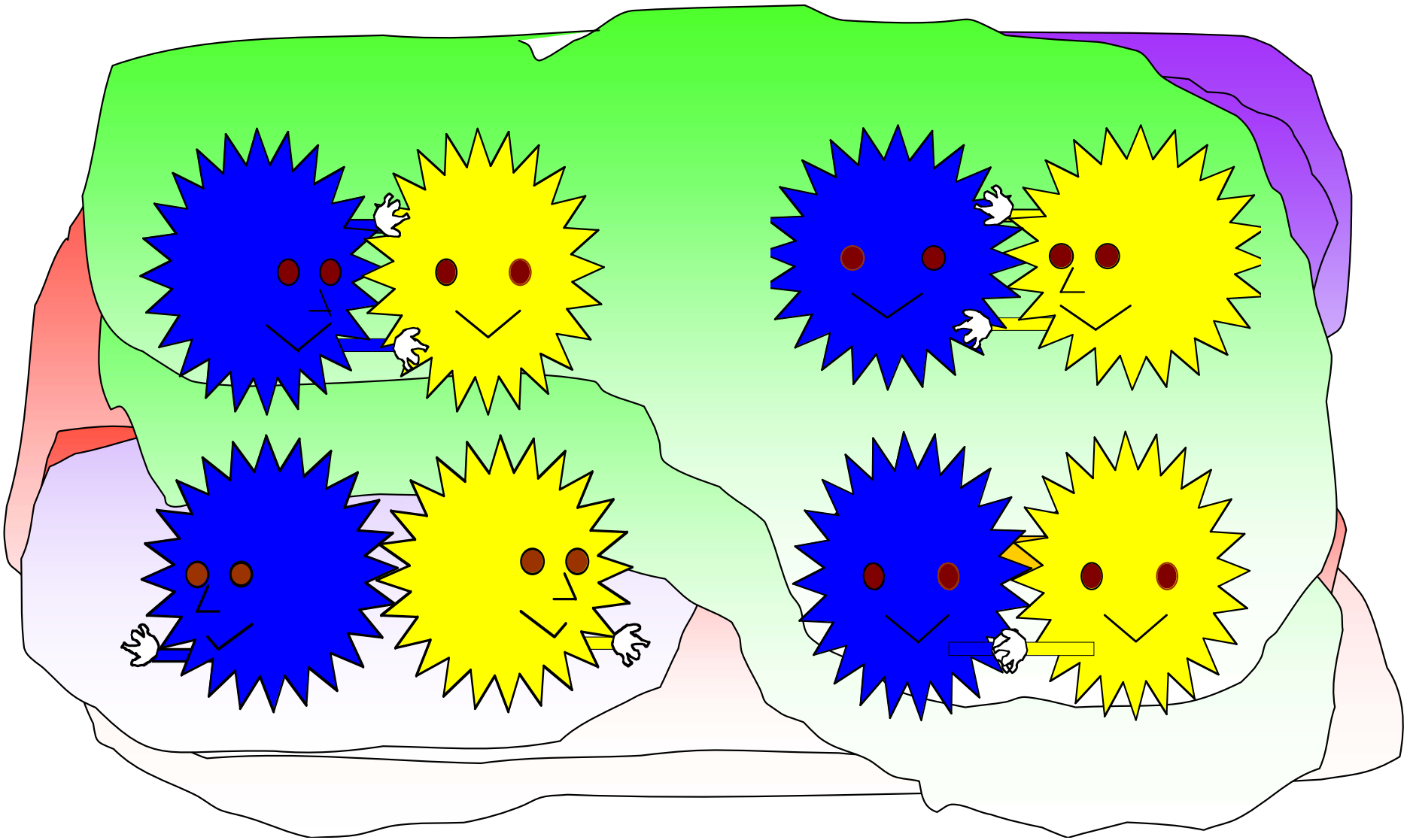
- "Interventionist" account of causation (Pearl, 2000; Woodward, 2003)

The principle in practice . . .

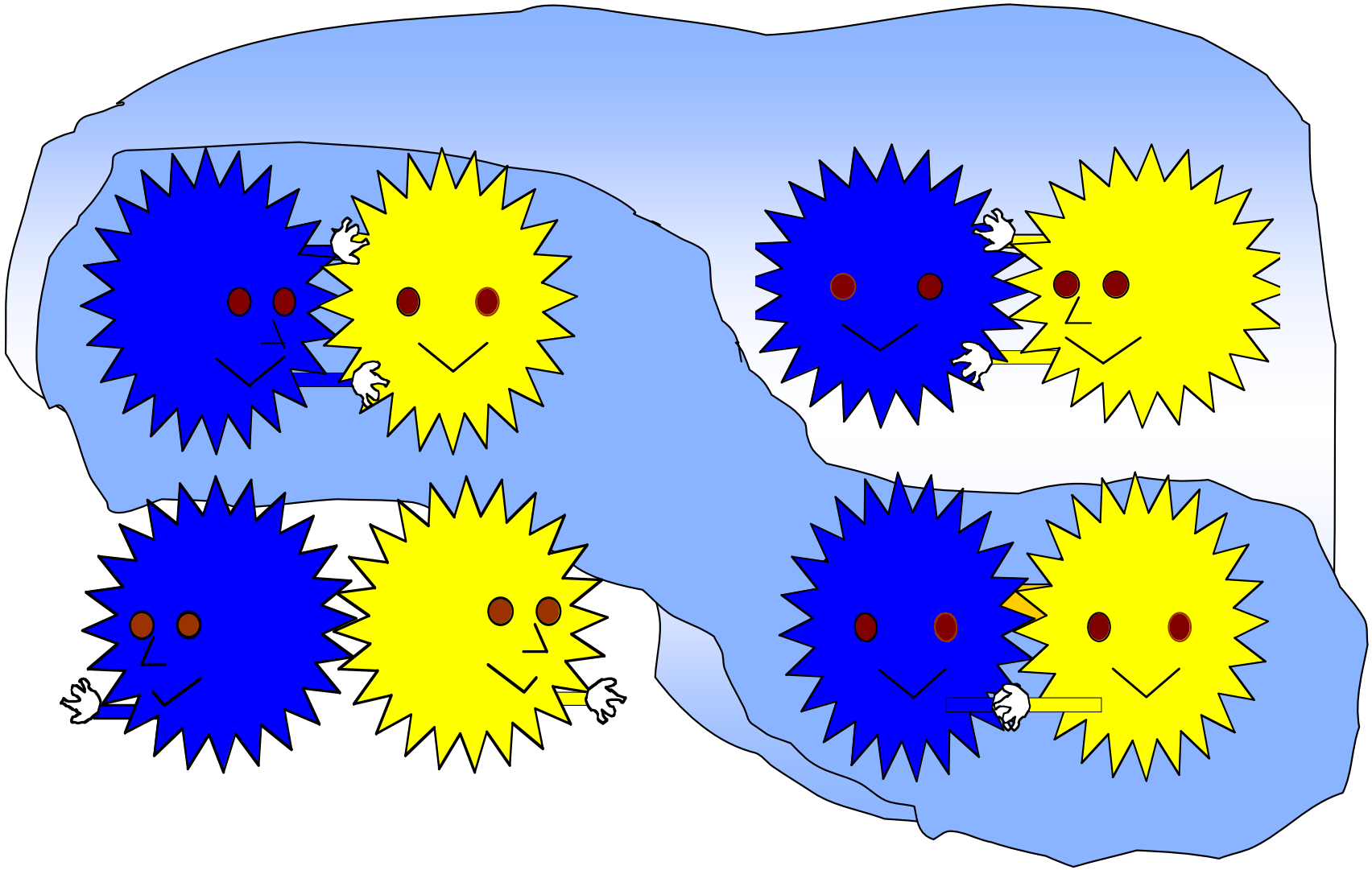
	Interventions		Outcome
1	SOff	Yon	Bstill
2	SOff	Yoff	Bstill
3	*SOff*	*Bon*	*Ystill*
4	*SOff*	*Boff*	*Ystill*
5	**SOn**	**Yon**	**Bspins**
6	**SOn**	**Yoff**	**Bstill**
7	*SOn*	*Bon*	*Yspins*
8	*SOn*	*Boff*	*Yspins*



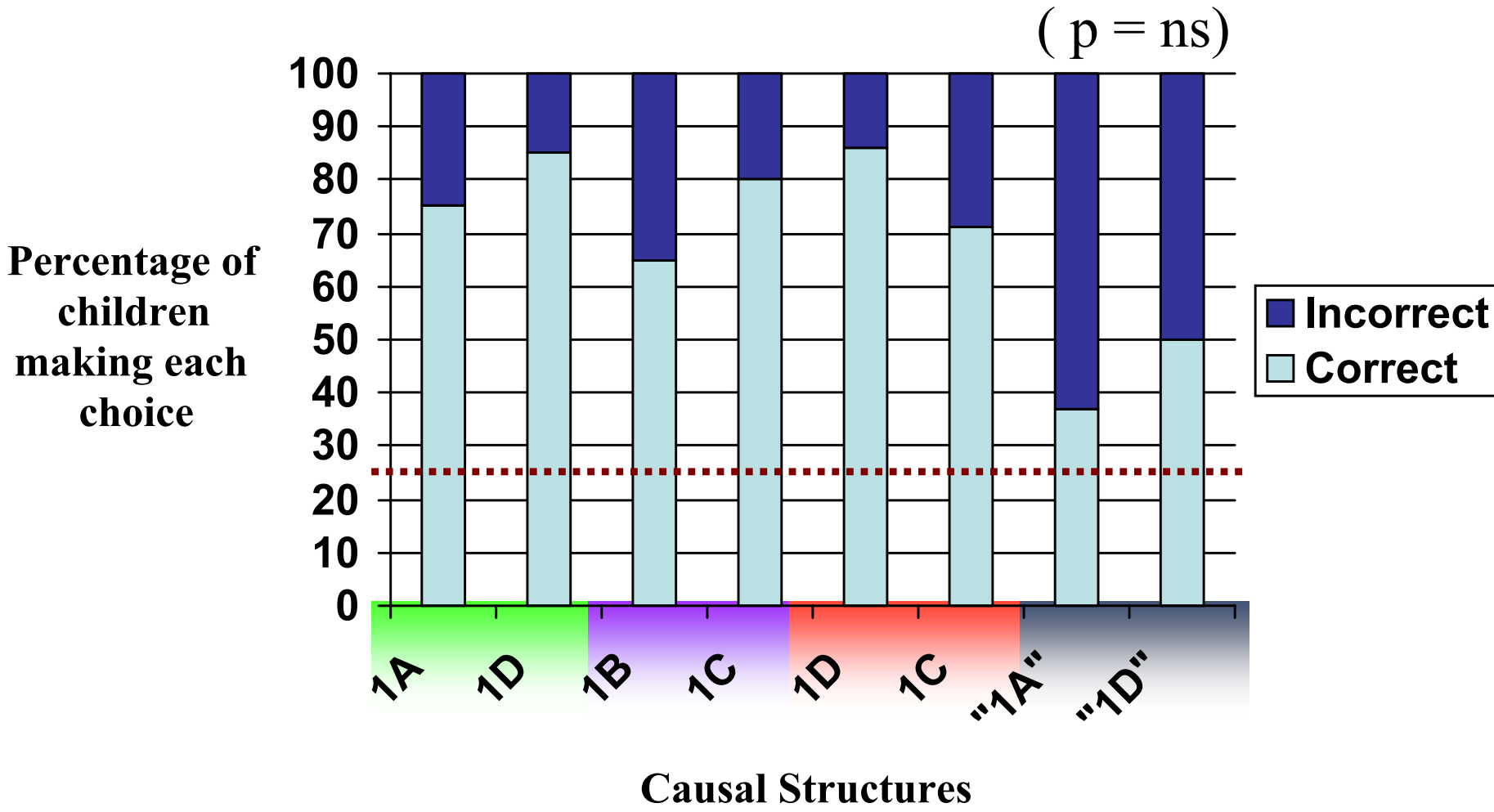
Can children distinguish all four causal structures?



“Switchless” control condition

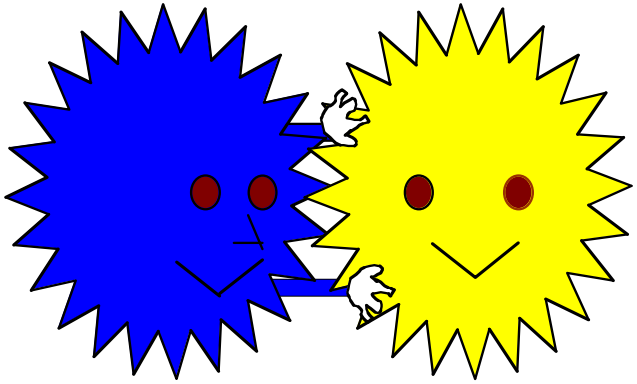


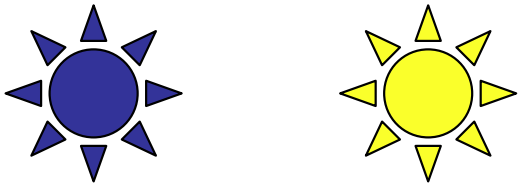
Predicting the structure from patterns of evidence



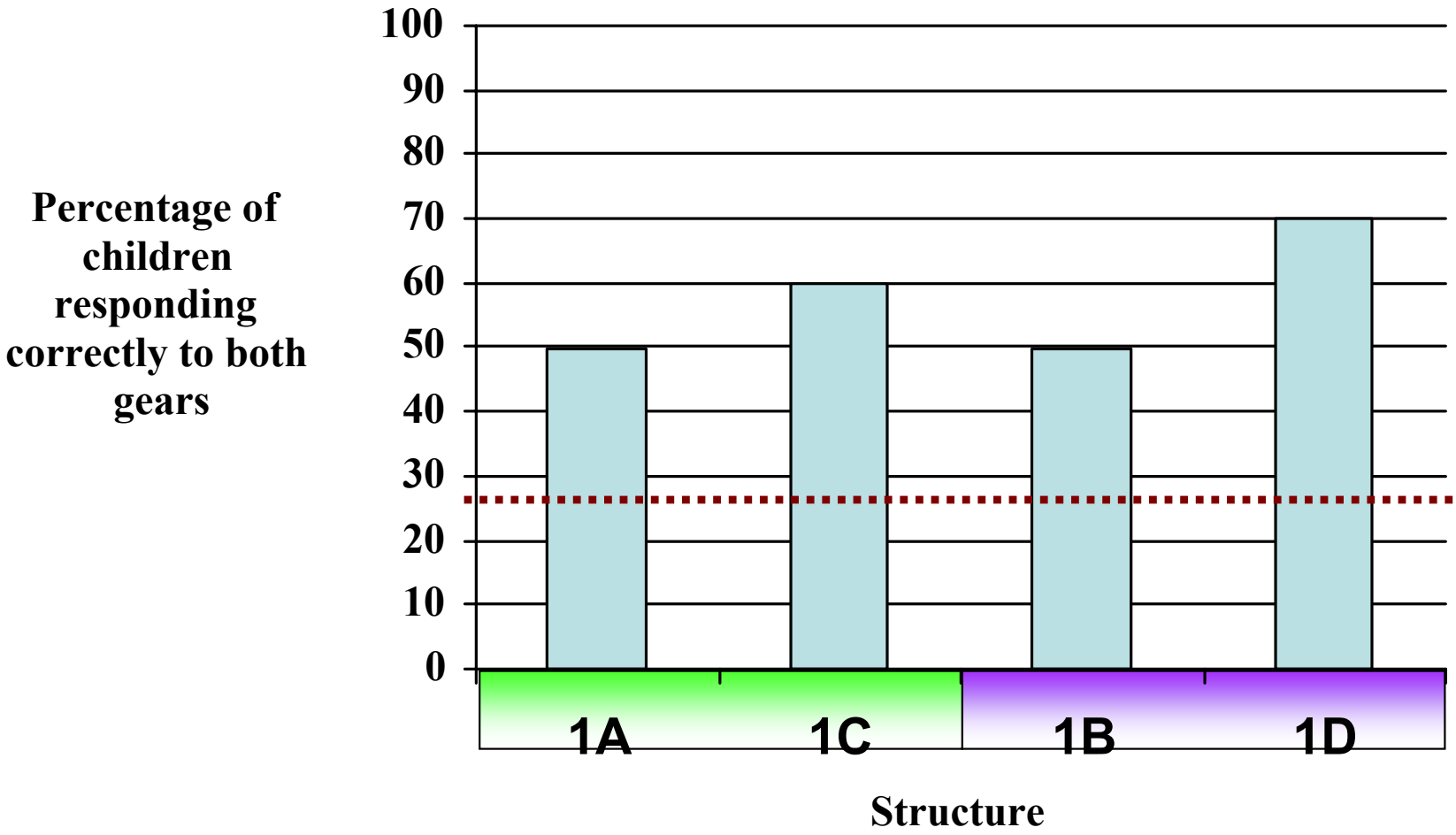
Study 1: Evidence --> Inference

Predicting evidence from structure





Predicting patterns of evidence from the structure



Study 1: Evidence --> Inference

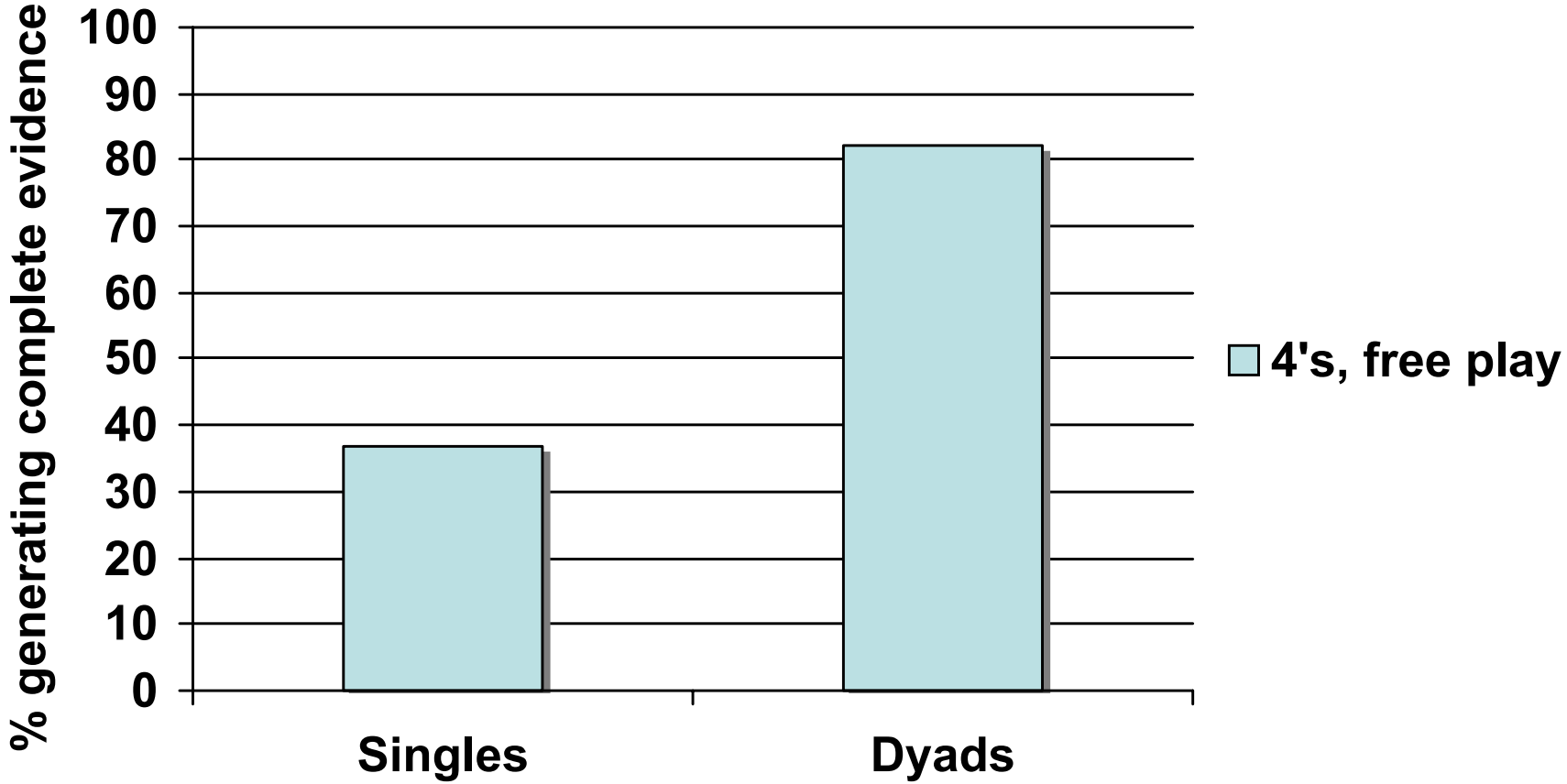
Conclusions: Study 1

- Children can use interventions and patterns of outcomes to infer causal structure and …
- Can use knowledge of causal structure to predict the outcome of interventions.

The problem

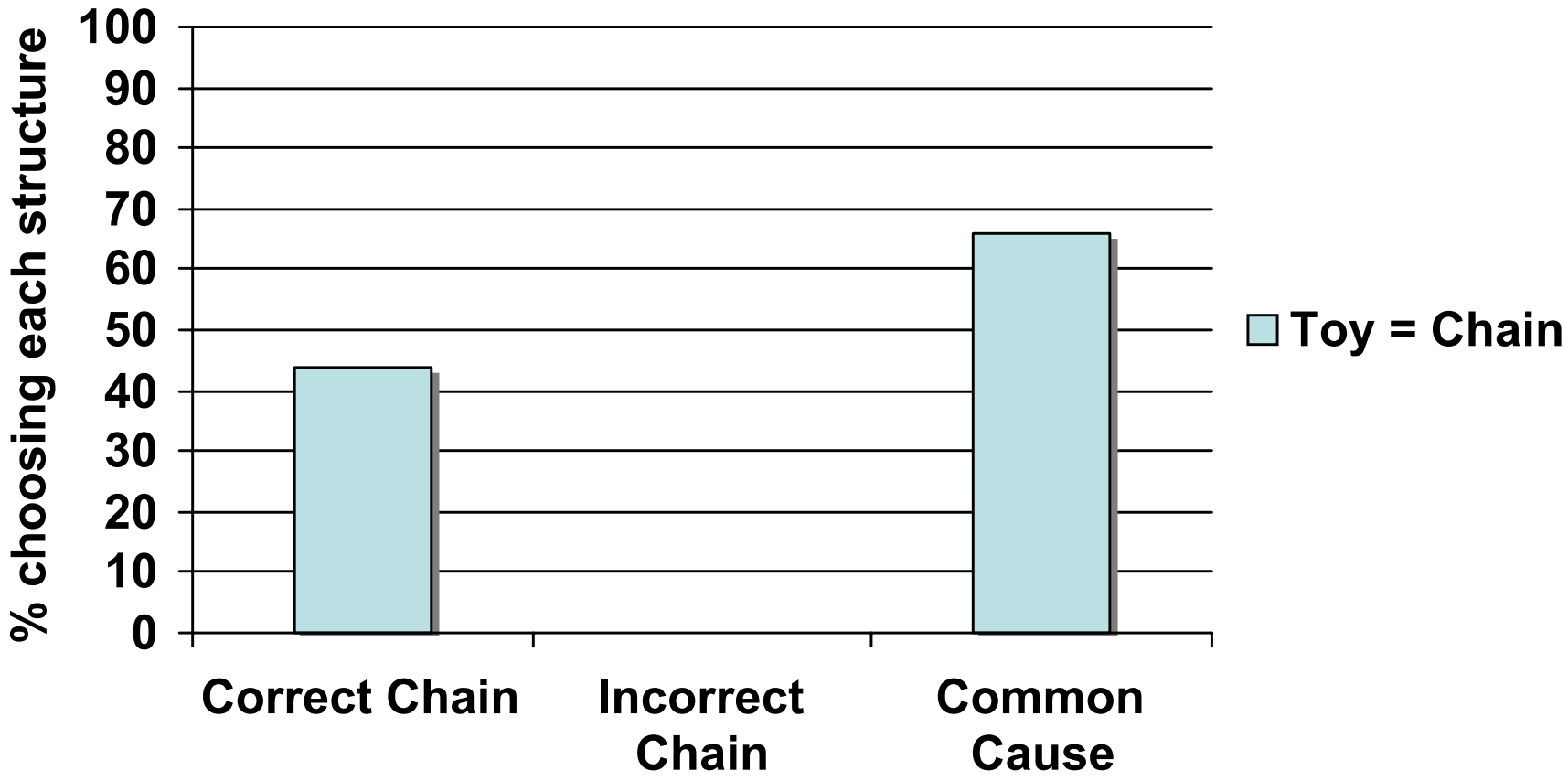
- Children are very bad at designing controlled experiments.
- What happens if you just let them play?

Free play: Generating evidence



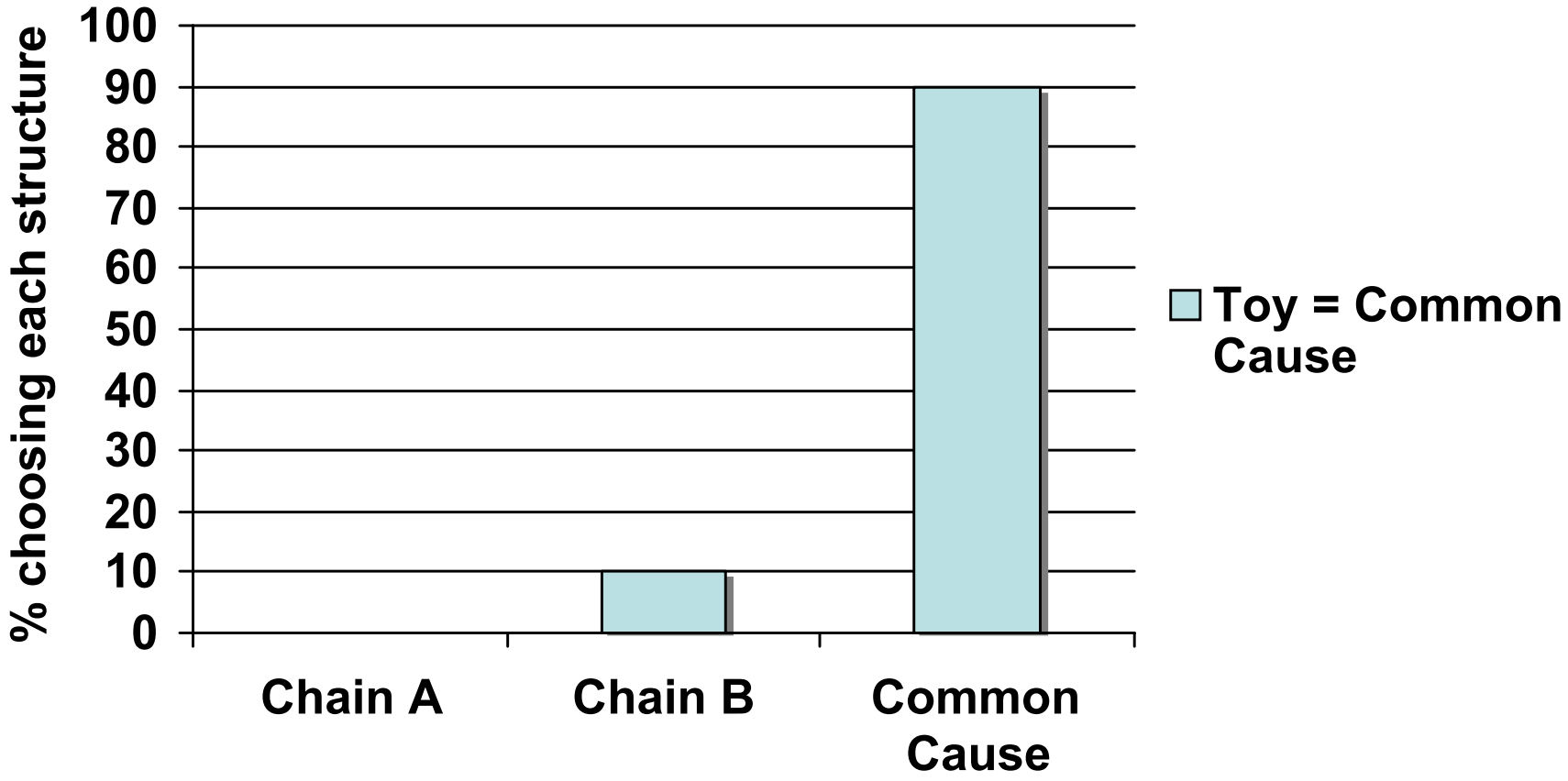
Study 2: Action --> Evidence --> Inference

Free play: Accuracy



Study 2: Action --> Evidence --> Inference

Free play: Accuracy



Study 2: Action --> Evidence --> Inference

Interventions, evidence and causal learning

- Children can use the pattern of interventions and outcomes to:
  - Learn causal structure from patterns of evidence.
  - Predict patterns of evidence from knowledge of causal structure.

  - Children's spontaneous play might generate the type of evidence that could support these inferences.

Some questions for next time

- Is it true that we can learn that anything can cause anything -- or are there constraints on the causal relations we can learn?
- How do we integrate new knowledge with old beliefs? Are younger children more flexible learners or more conservative learners?
- How could children reason about unobserved and unobservable causes?
- What are candidate mechanisms of conceptual change?