

# The Philosophical Baby

*What Children's Minds Tell Us About  
Truth, Love, and the Meaning of Life*

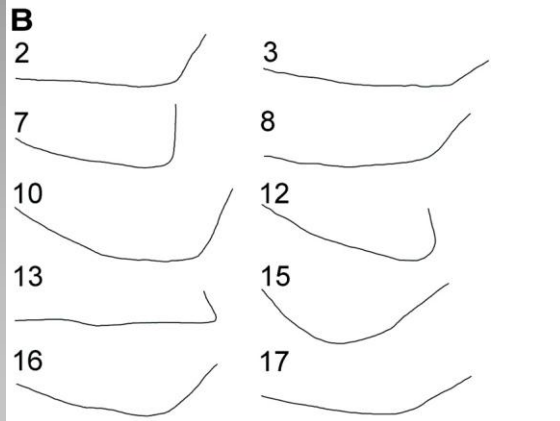


Alison Gopnik

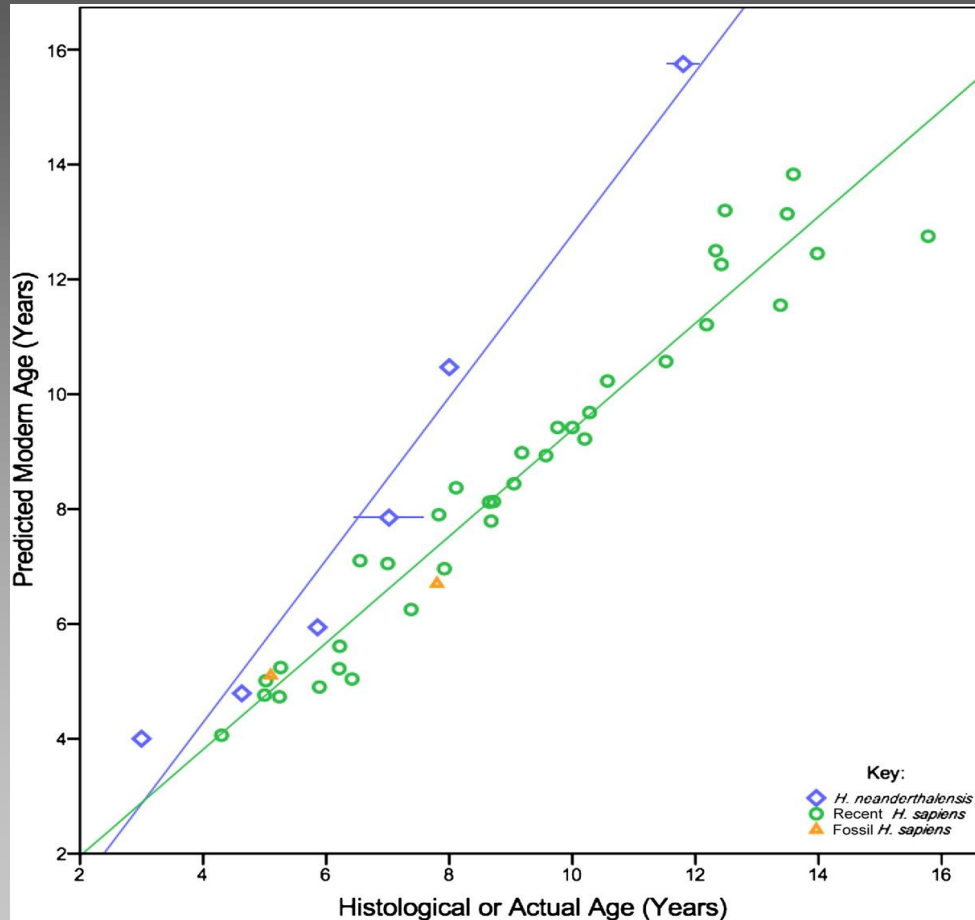
# The Problem of Knowledge

- Abstract Structured Hierarchical Representations
- Learned From Concrete Variable Contingent Evidence
- The Nativist Solution
- The Empiricist Solution

# Evolution: The Uses of Immaturity

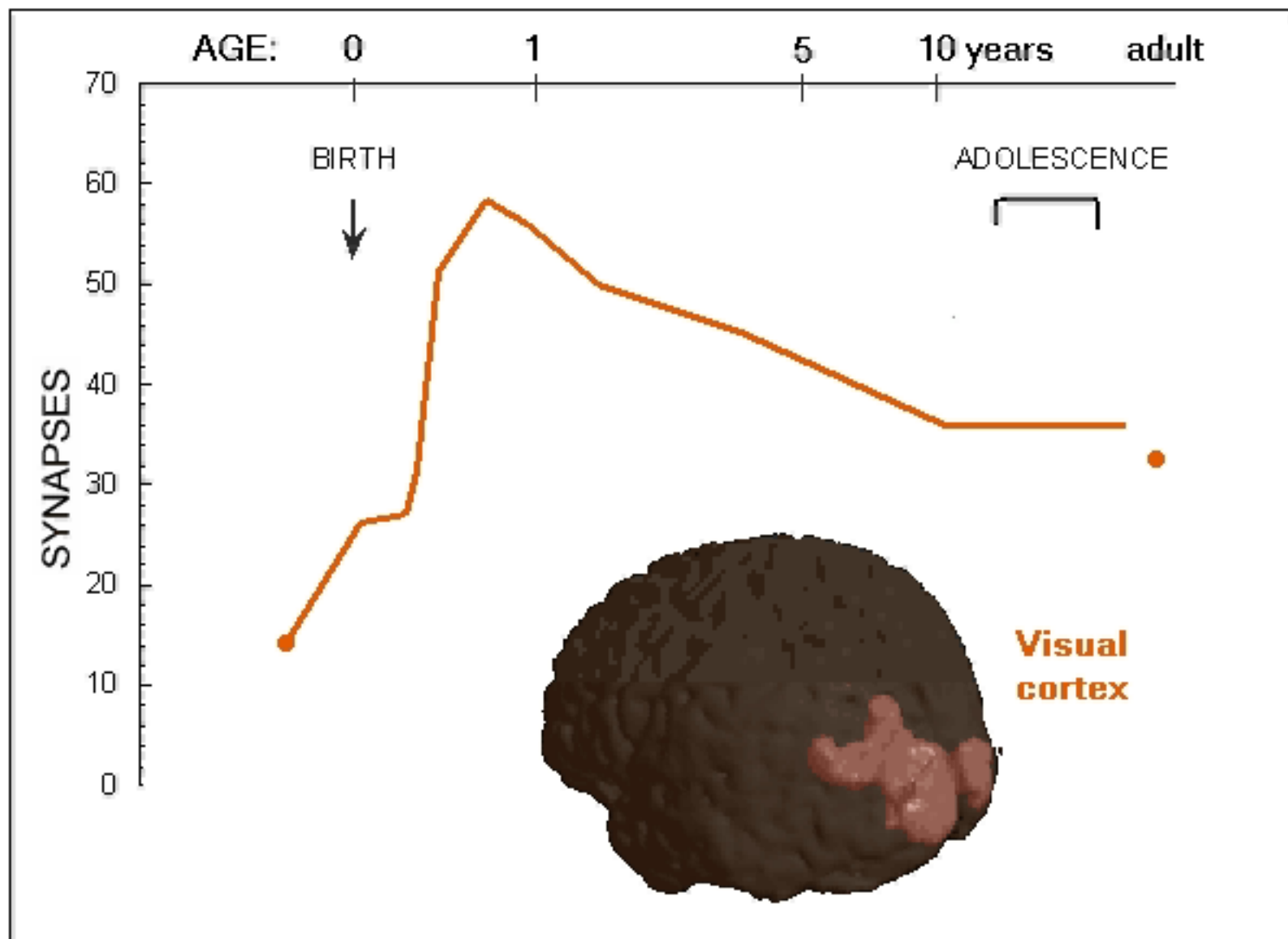


# Fossil Dental Evidence For Immaturity In Homo Sapiens vs Neanderthal



Smith T M et al. PNAS 2010;107:20923-20928

# Human Brain Development of Connections (Synapses)



Adapted from P. Huttenlocher et. al. (1979-1997)

# Bayesian Babies



Alison Gopnik

# The Blicket Detector



# Kushnir & Gopnik, 2007

81% make contact between block and toy when asked to “make it go”

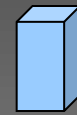




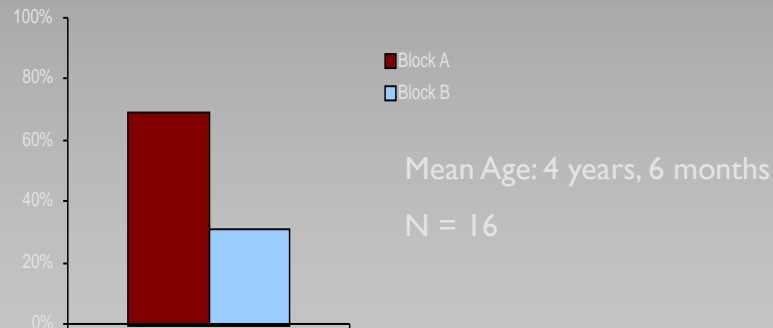
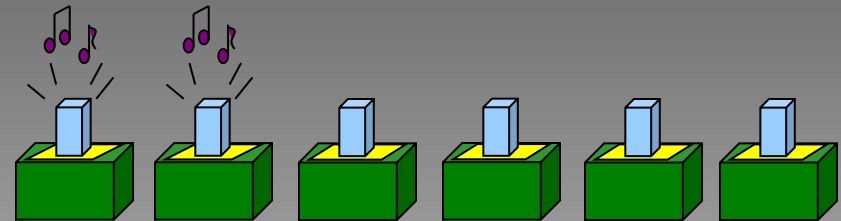
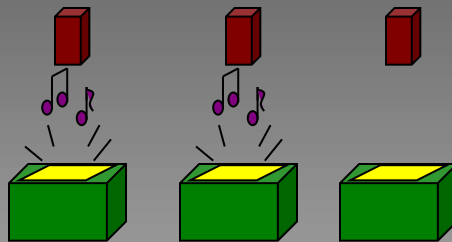
# Probabilistic Strength = Causal Strength?



Block A:  $P=2/3$



Block B:  $P=1/3$



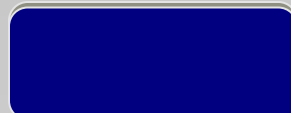
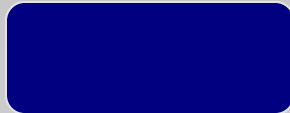
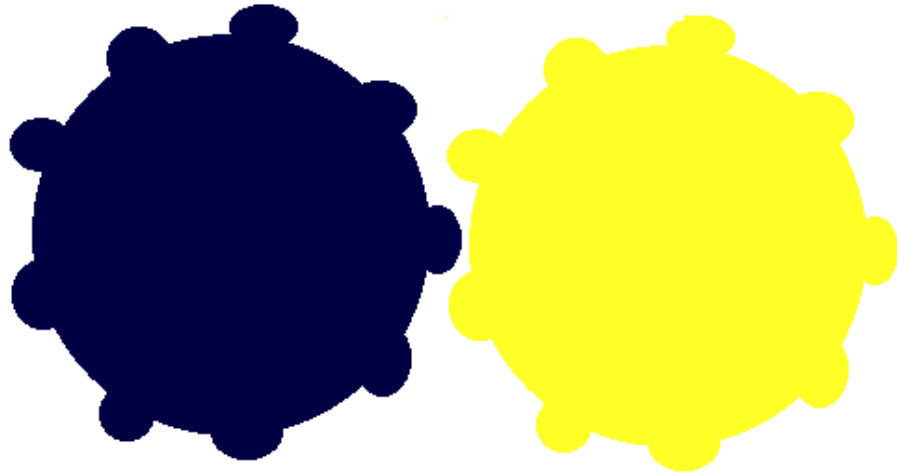
Causal Strength Question: "Make it go"

# Le Gare: Play as Experiment

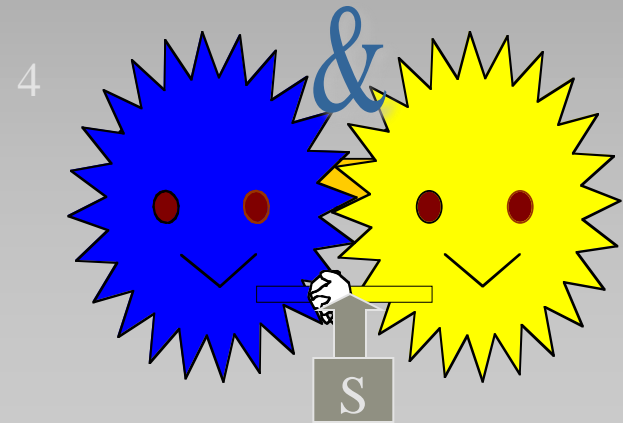
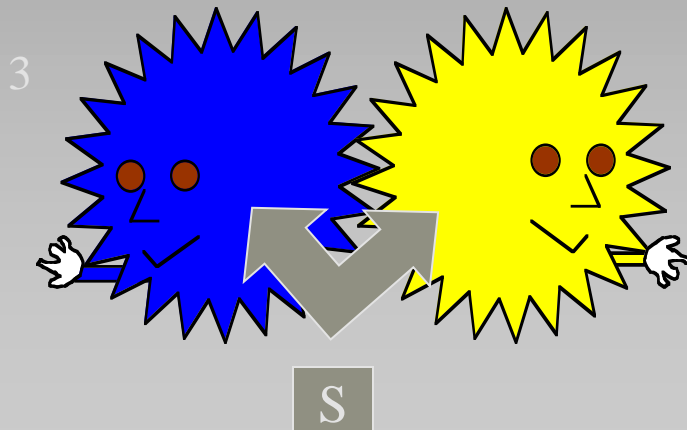
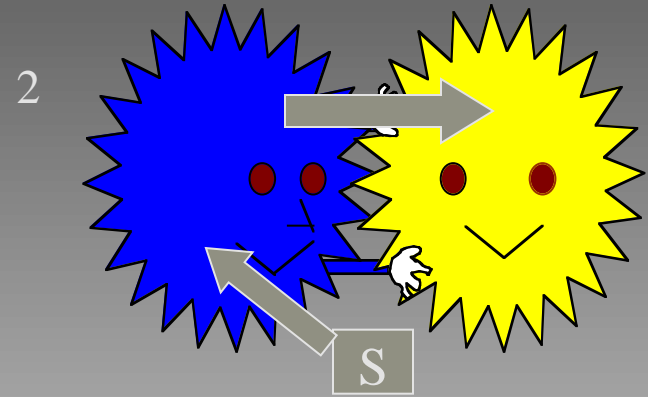
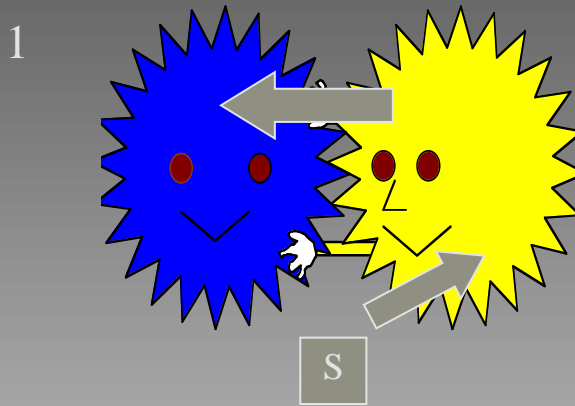


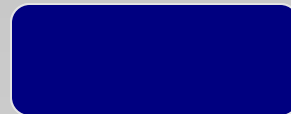
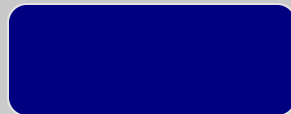
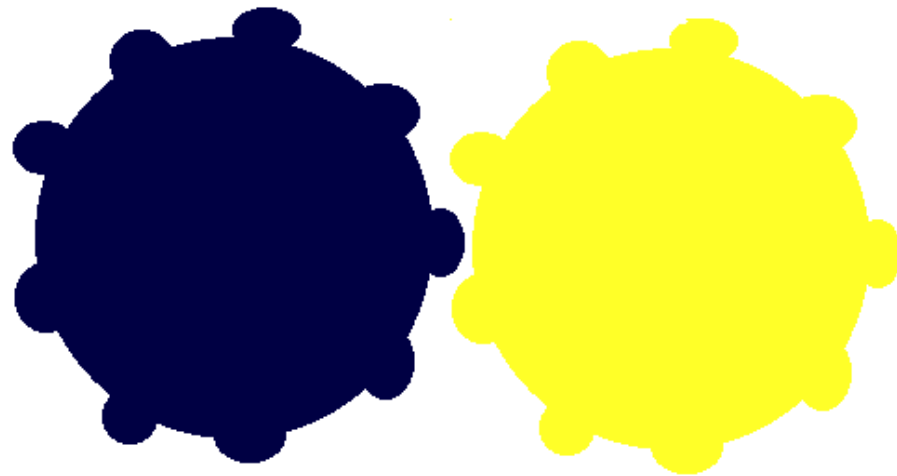
# Schulz, Gopnik, and Glymour 2007

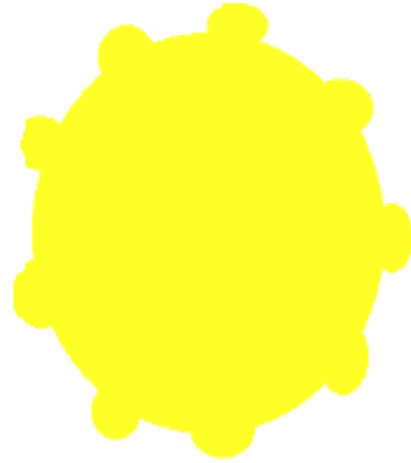
- More complex causal structure

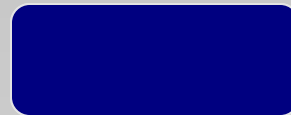
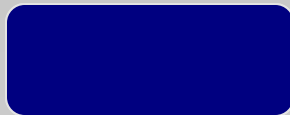


# The Causal Possibilities



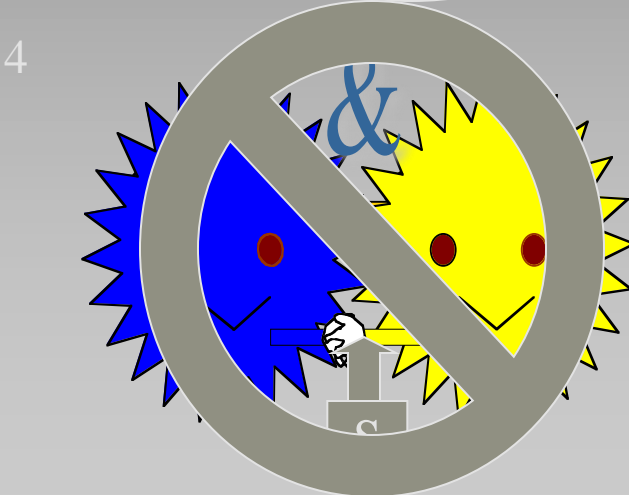
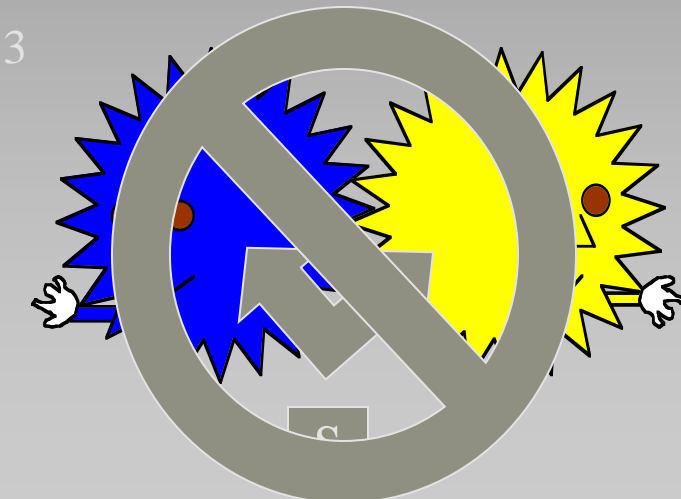
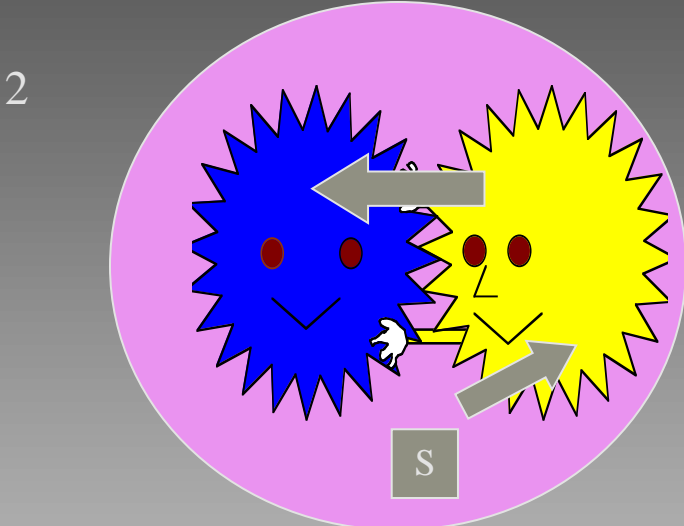
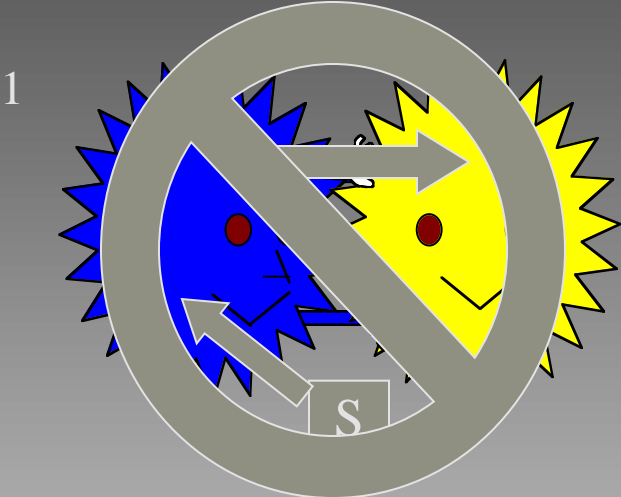






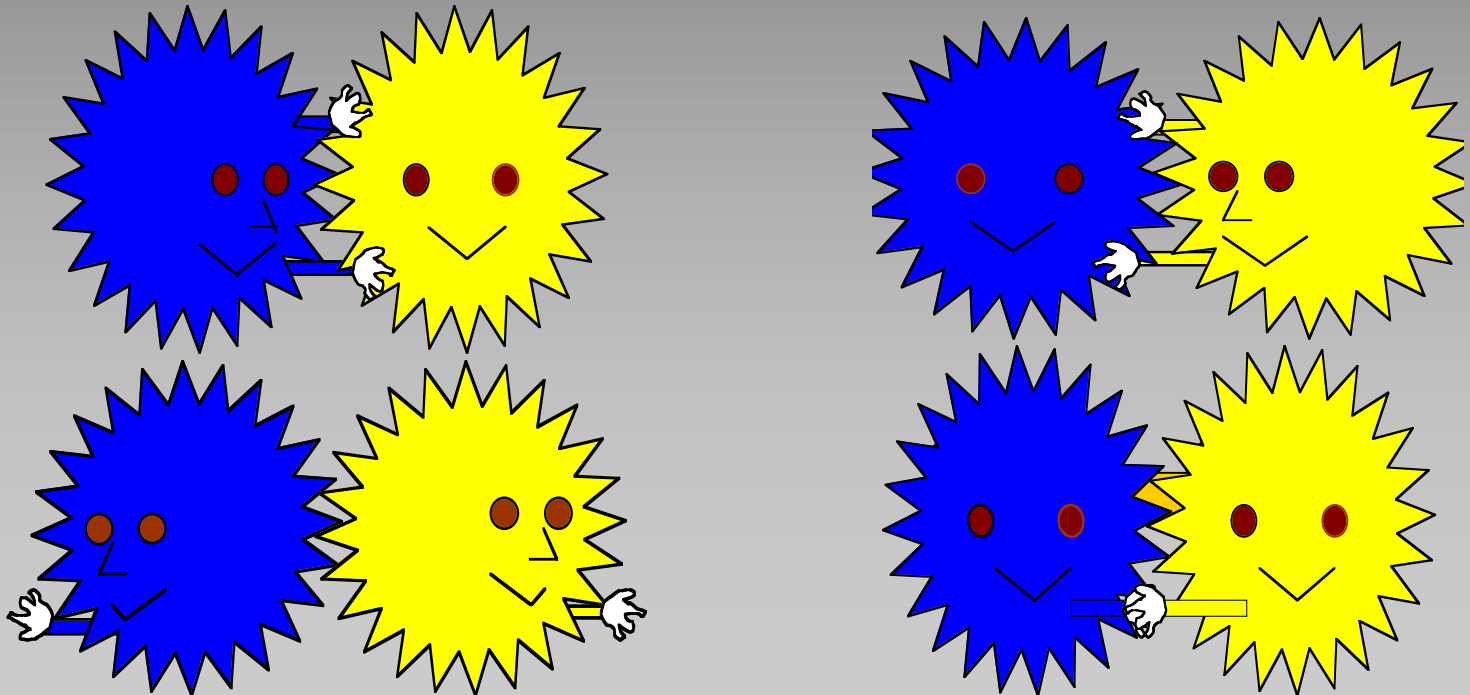


Interventions on each causal structure will produce different patterns of evidence.

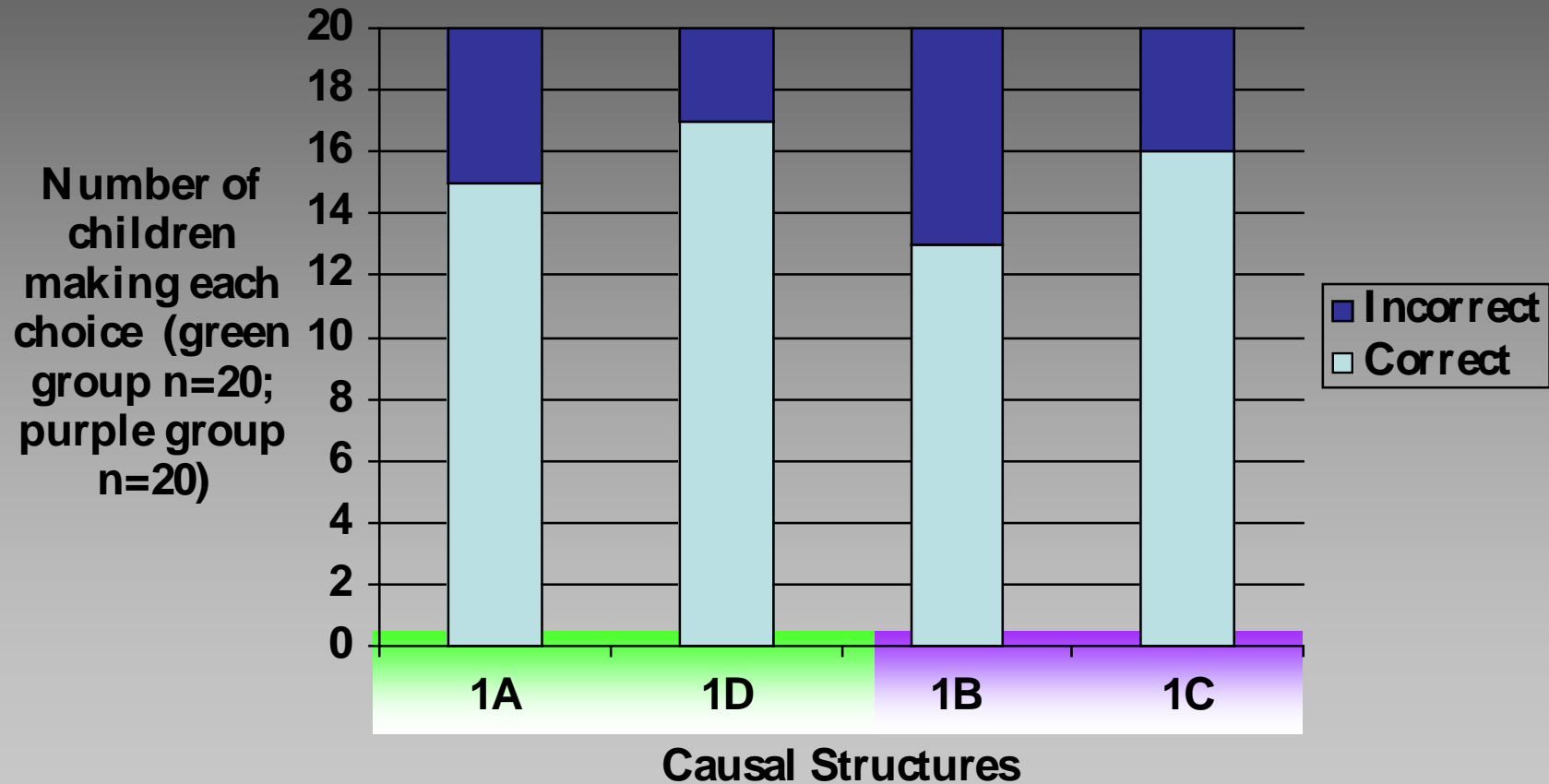


# Conditional interventions . . .

Knowing each gears' relationship to the switch let you determine the gears' relationship to one another . . .



# Predicting the structure from patterns of evidence



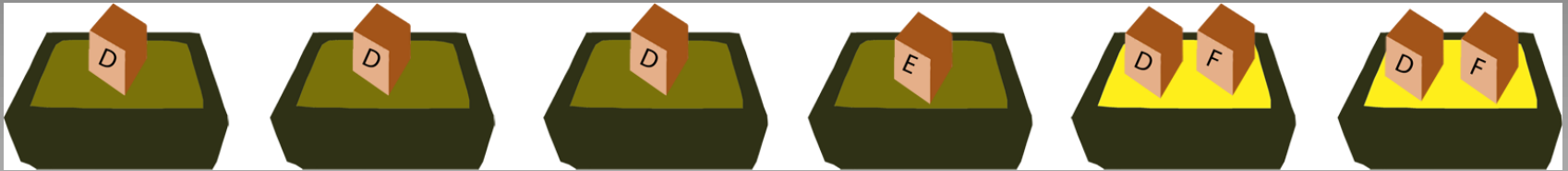




# Inferring Abstract Laws: Lucas, Gopnik & Griffiths

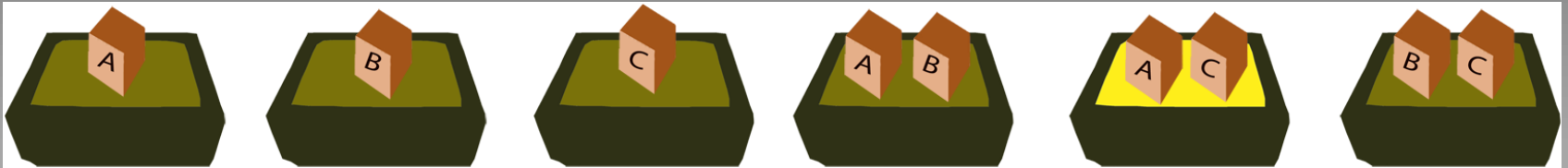
- Framework theories
- Hierarchical Bayes-nets (Griffiths & Tenenbaum)
- The blessing of abstraction (Goodman)

# Which objects are blickets?

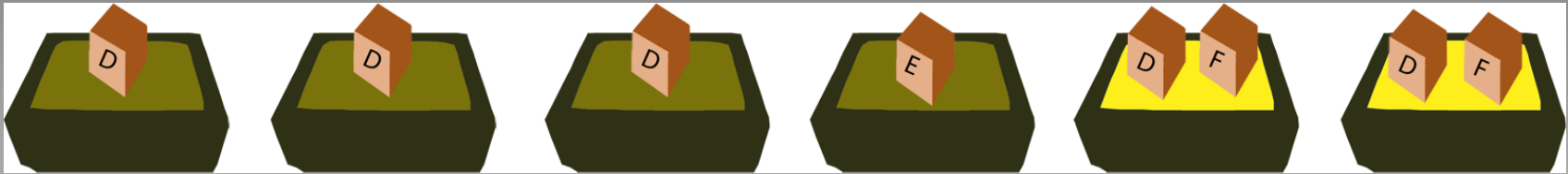


Is D a blicket? Is E a blicket? Is F a blicket?

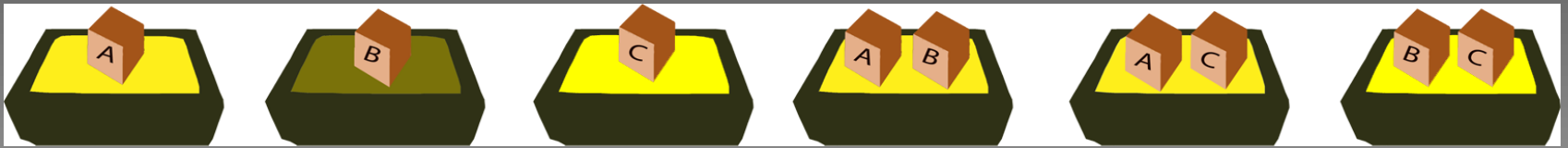
# What if you also saw these events?



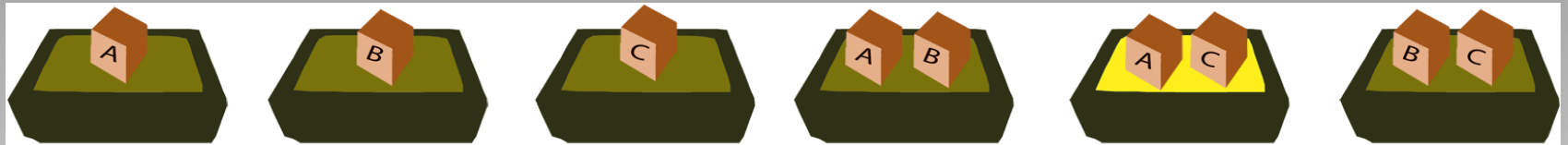




## “Or” Training

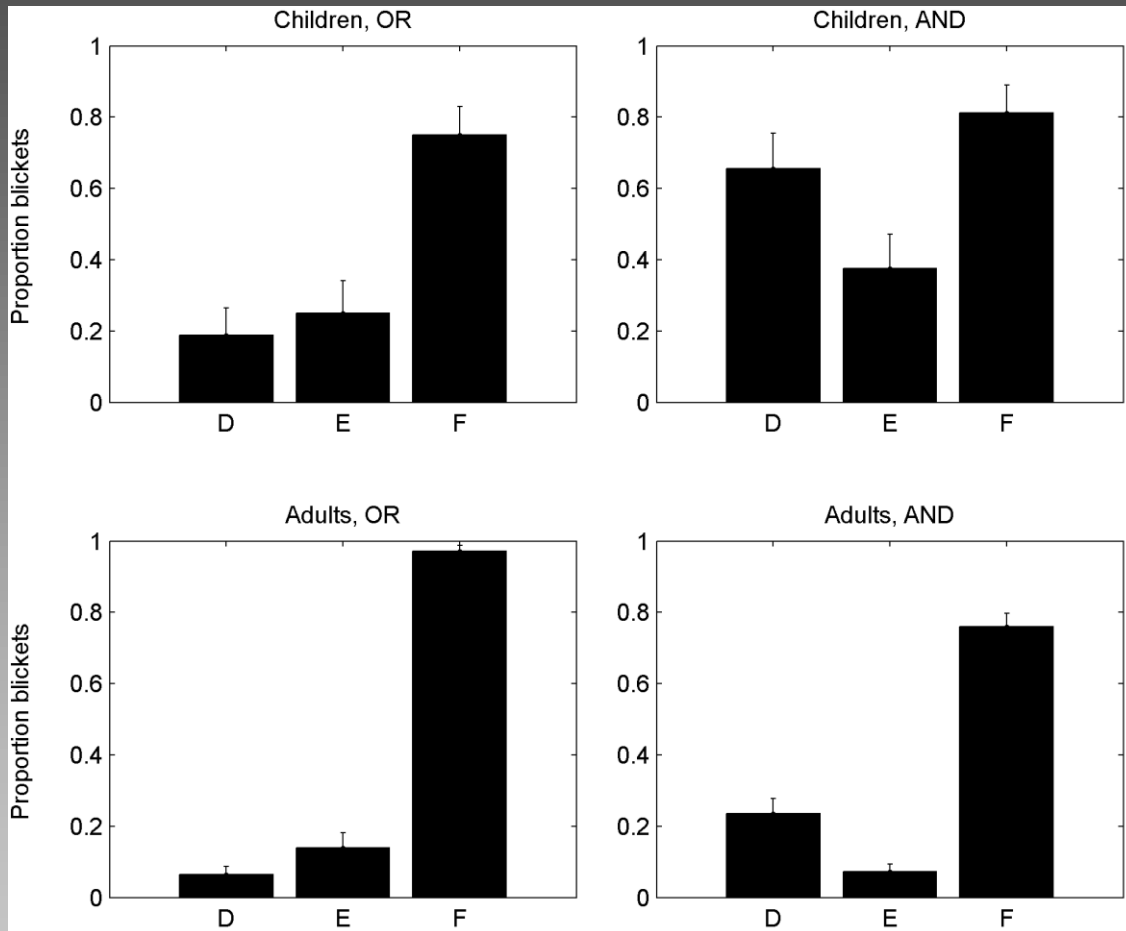


## “And” Training



## Test





# Gopnik & Wellman Psychological Bulletin, Gopnik, Science

Four year olds (and younger) can rationally

- Infer complex causal structure from conditional probabilities
- Integrate and override prior knowledge in the face of new evidence
- Infer unobserved structure
- Infer abstract hierarchical over-hypotheses
- Infer theories of the physical, biological and psychological domains
- Etc. etc. etc.

# The Algorithm Problem

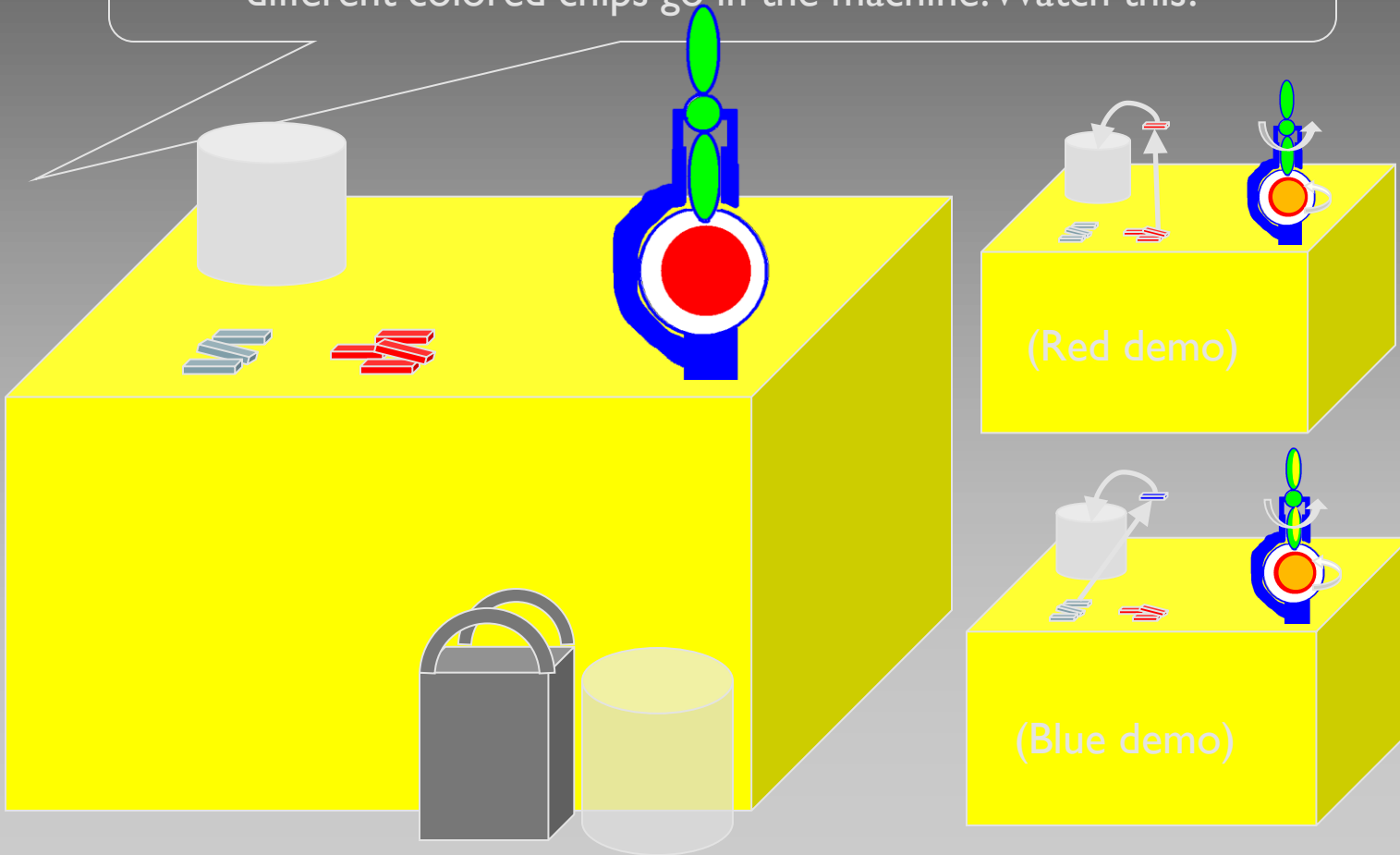
## Sampling Solutions

- Particle Filters
- Markov Monte Carlo Processes
- The Signature of Sampling: Variability that reflects probability distributions

# General Method of Sampling

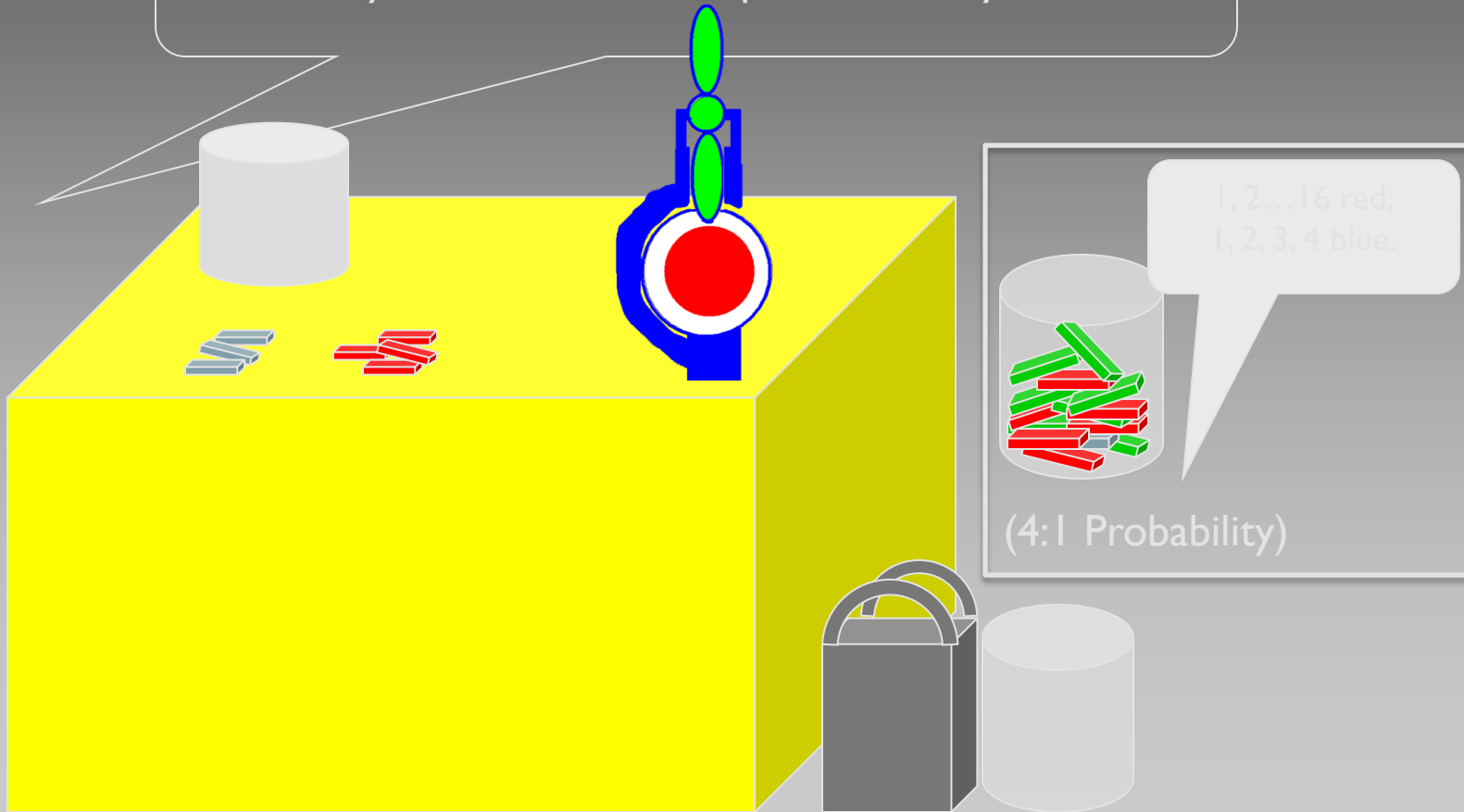
## Expts

Look, I've got a toy here that lights up and spins around when different colored chips go in the machine. Watch this!



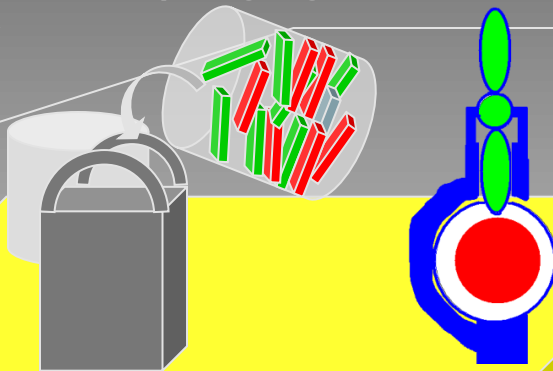
# General Method of Sampling Expts

Can you help remind me? What happens when...  
...Okay, now let's count chips out into my bucket.



# General Method of Sampling Expts

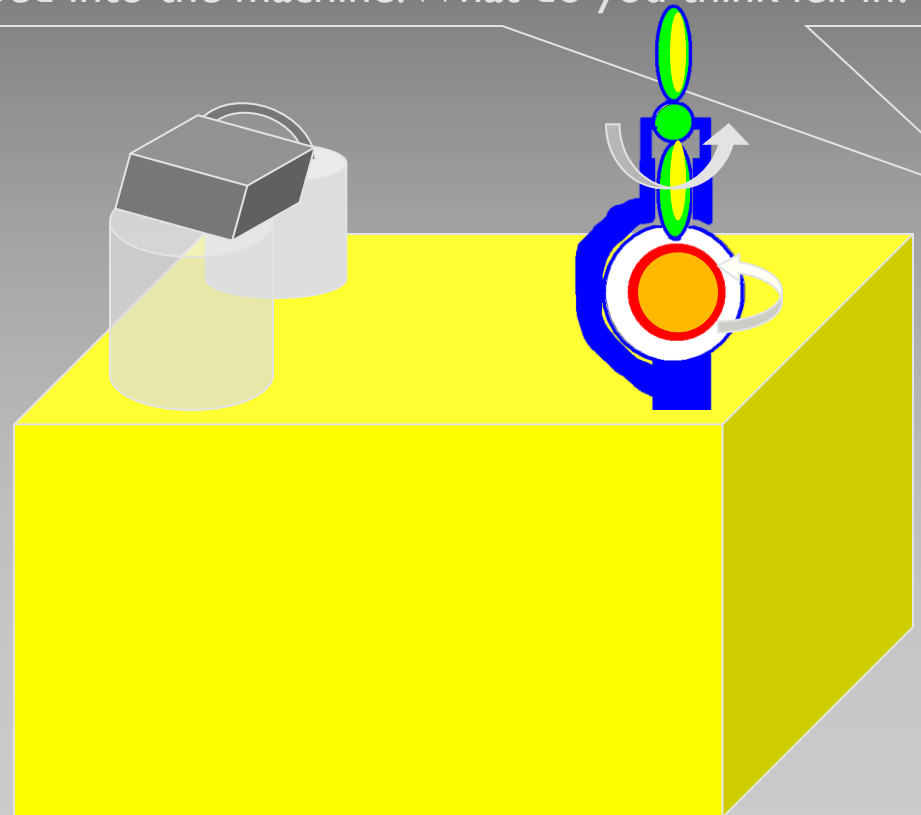
Now I'm going to mix up my chips, pour them into my bag and set my bag right here on top of the bucket.





# General Method of Sampling Expts

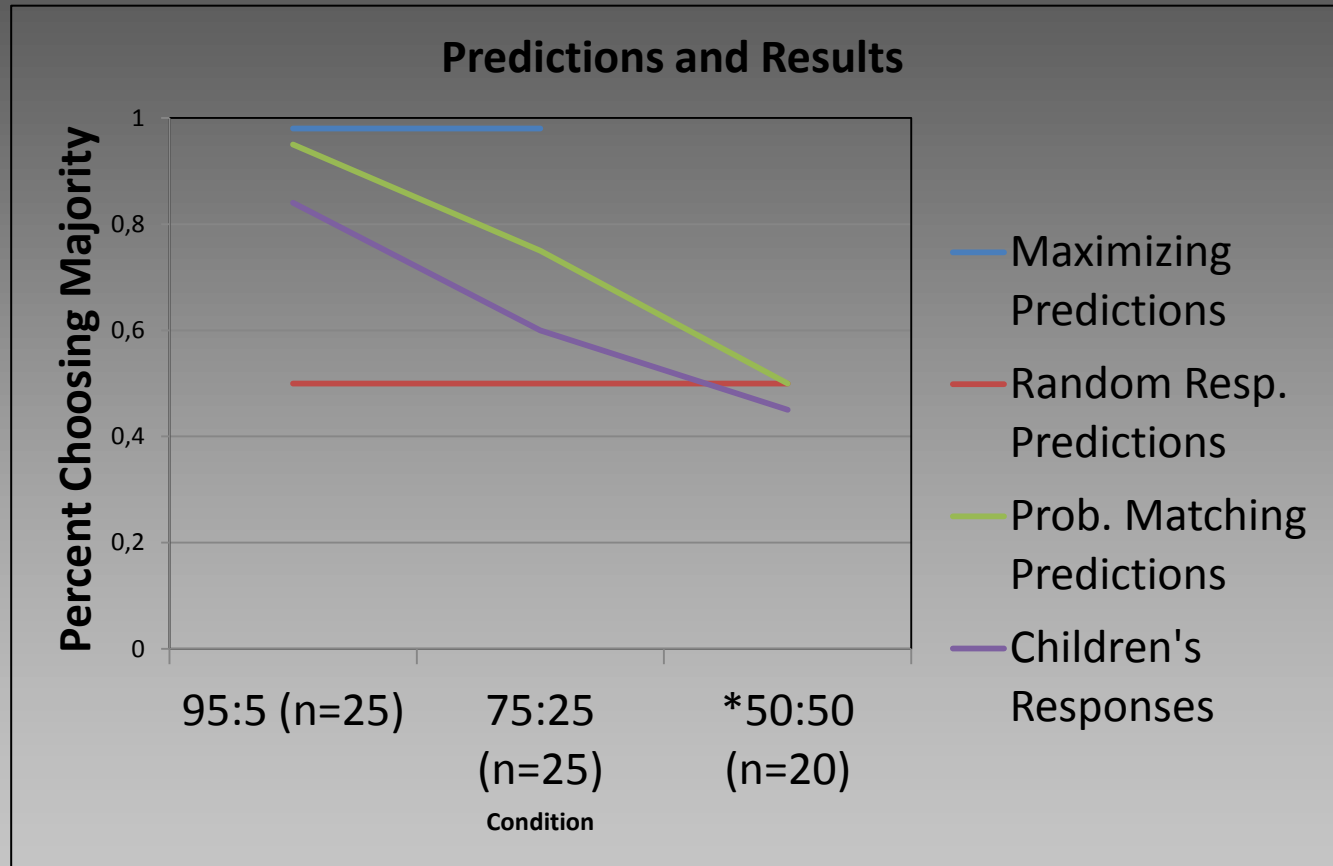
Oh! My bag tipped over and the toy is going off! A chip dropped into the machine. What do you think fell in?



# Expt. 1: 3 Conditions

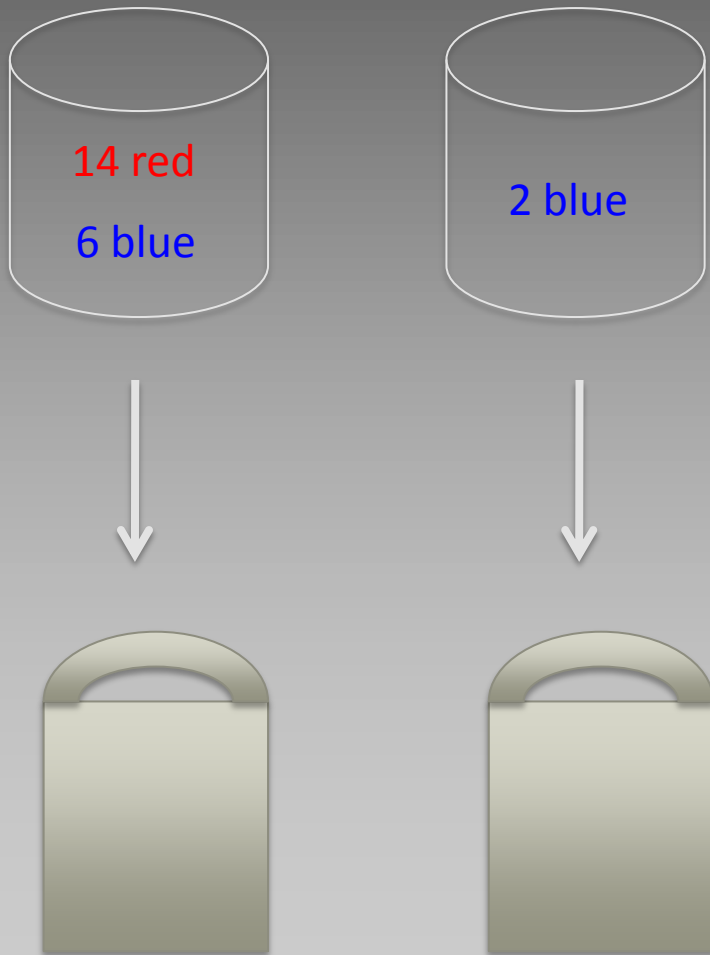
- Condition 1: count 19 red and 1 blue block (n=25)
- Condition 2: count 15 red and 5 blue blocks (n=25)
- Condition 3: count 10 red and 10 blue blocks (n=25)
- Participants: 4- and 5-year-olds

# Expt. I: Results



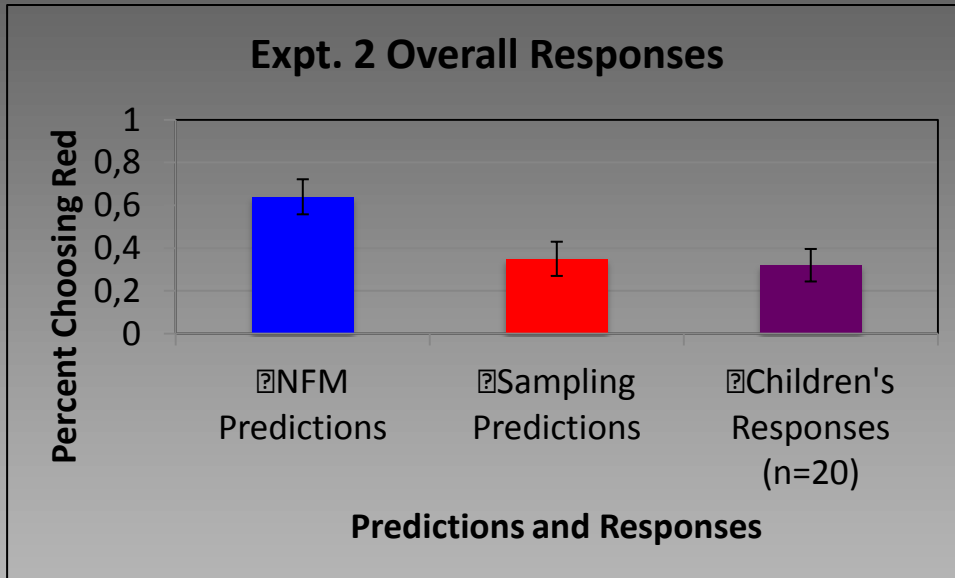
- Children appear to be following the predictions of probability matching more closely than other predictions.

# Expt. 2A: Method



1. Two transparent buckets.
2. Two identical opaque bags.
3. Switch the bags around so child could no longer tell which bag contained which distribution.
4. Chose a bag at random, placed on top of toy and knocked it over
5. What color?
6. What bag?
7. Trials 2 and 3: Identical to T1 except new toys, new stimuli for distributions (Lego & poker chips), new bags used.

# Expt. 2A: Results



Children (n = 20; Mean age = 56mo.s) behaved in accord with S. H. Children chose “red” chip on only 32% of trials (not different from sampling prediction).

# Developmental Differences in Sampling

- Flatter Priors
- Higher Temperature Search
- Childhood is evolution's way of performing simulated annealing

# Collaborators and Support

- Clark Glymour
- Laura Schulz
- Tamar Kushnir
- Chris Lucas
- Tom Griffiths
- Stephanie Denison
- Elizabeth Bonawitz
- NSF
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