Ping Pong in Church

Productive use of concepts in human probabilistic inference

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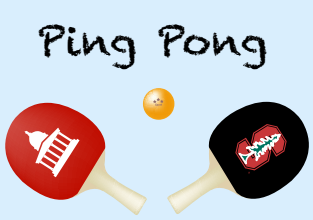
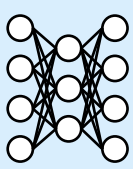
1 How do people make inferences from complex patterns of evidence across diverse situations?

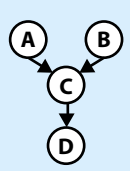
What does a computational model need in order to capture the abstract knowledge people use for everyday reasoning?



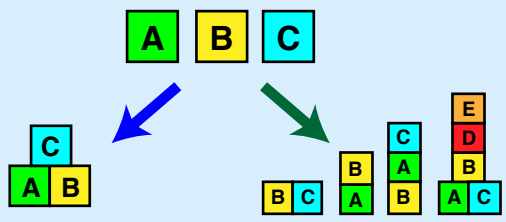
Logic

$$\frac{A \quad A \rightarrow B}{B}$$





Thinking is compositional and productive.



Thinking = probabilistic inference over compositionally structured representations

2

Model

```
(mh-query 1000 100 ;Monte Carlo Inference
  ;CONCEPTS
  (define personstrength (mem (lambda (person) (gaussian 10 3))))
  (define lazy (mem (lambda (person game) (flip 0.1))))
  (define (teamstrength team game)
    (sum (map (lambda (person)
                (if (lazy person game)
                   (/ (personstrength person) 2)
                   (personstrength person)))
              team)))
  (define (winner team1 team2 game)
    (if (< (teamstrength team1 game)
        (teamstrength team2 game))
        'team2 'team1))
  ;QUERY
  (personstrength 'A)
  ;EVIDENCE
  (and
    (= 'team1 (winner '(TG) '(NG) 1))
    (= 'team1 (winner '(NG) '(AS) 2))
    (= 'team1 (winner '(NG) '(BL) 3))
    (lazy '(NG) 1) ;additional evidence, used in Experiment 2
  )
)
```

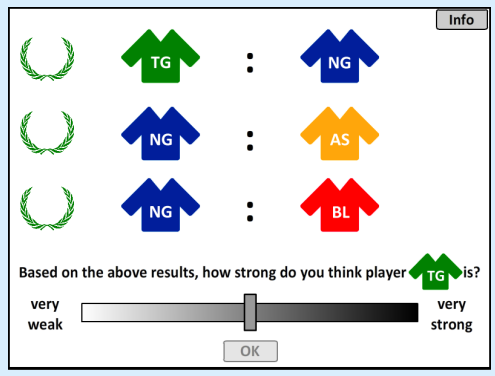

personstrength
normally distributed persistent property

lazy
p(lazy) = 10%
not persistent

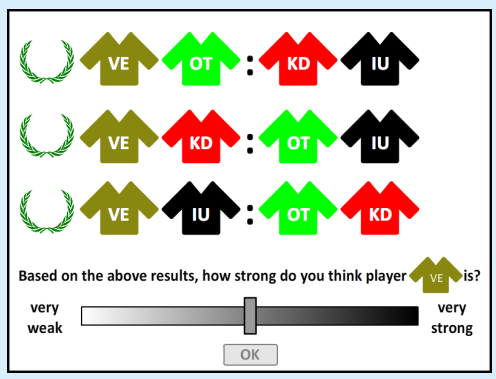
teamstrength
individual strengths combine additively

winner
team with greater strength wins

Singles



Doubles



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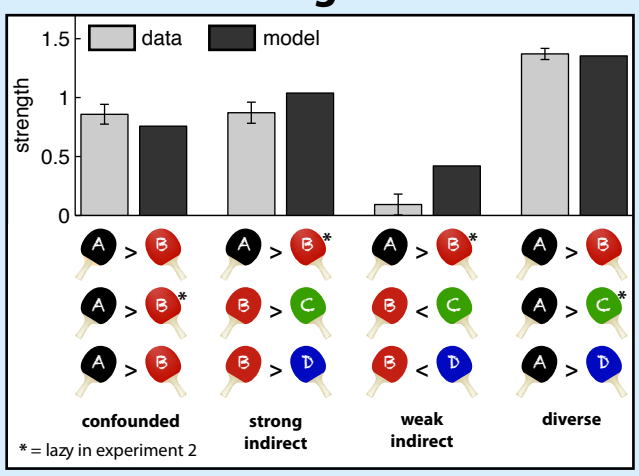
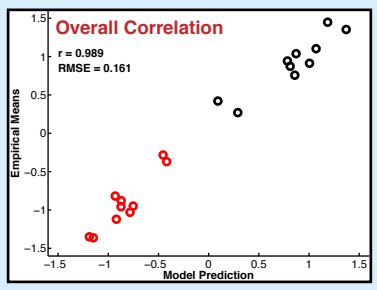
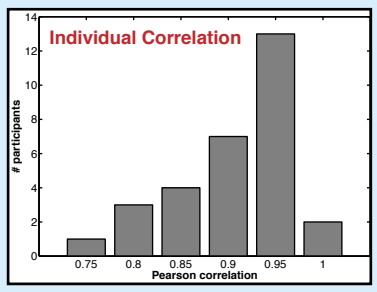
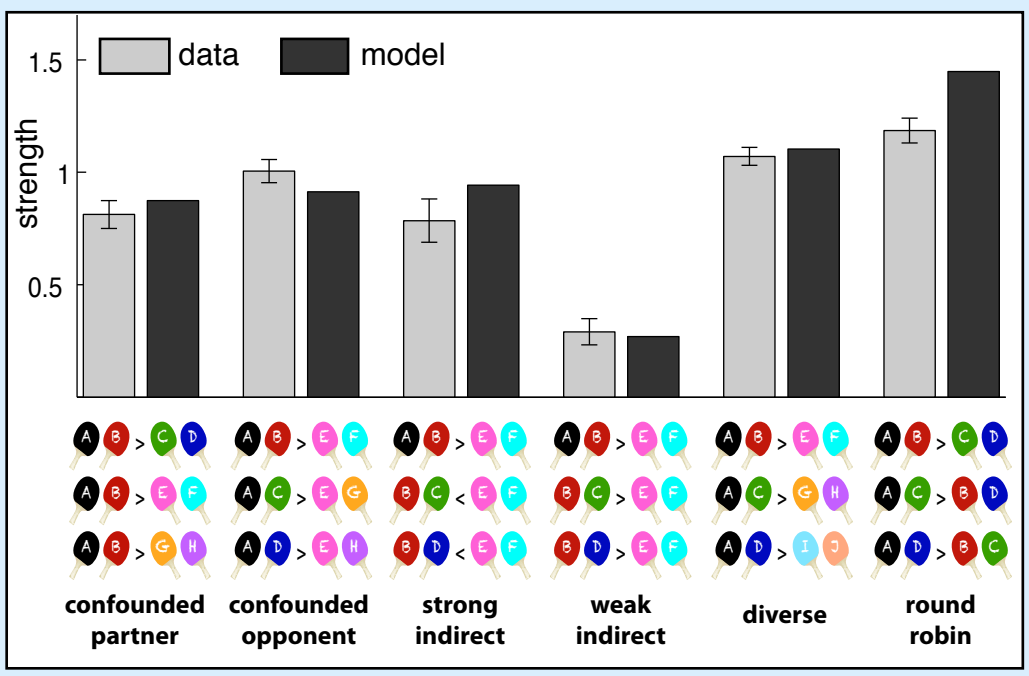
Singles







Doubles



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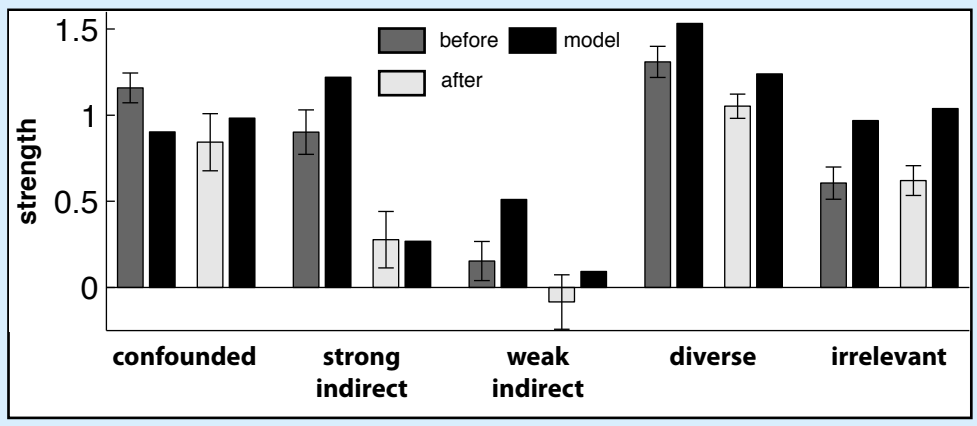
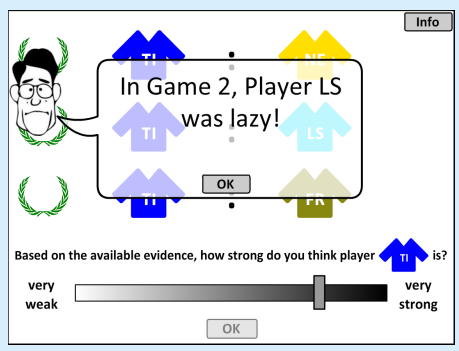
Commentator



- people can reason flexibly based on different patterns and sources of evidence
- compositional concepts support productive extensions over novel situations and objects



- only a handful of concepts required to predict inferences in fourty different situations
- understanding people's intuitive theories through models based on probabilistic programs

Gerstenberg, T. G., Goodman, N. D., Lagnado, D. A., & Tenenbaum, J. B. (2012). Noisy Newtons: Unifying process and dependency accounts of causal attribution. *Cognitive Science Proceedings*

Goodman, N. D., Mansinghka, V. K., Roy, D., Bonawitz, K., & Tenenbaum, J. B. (2008). Church: A language for generative models. *Uncertainty in Artificial Intelligence*

Goodman, N. D., & Tenenbaum, J. B. (in prep). The probabilistic language of thought.