

# Are Humans Rational?

SymSys 100  
April 14, 2011

# Anderson's Rational Approach to Cognition



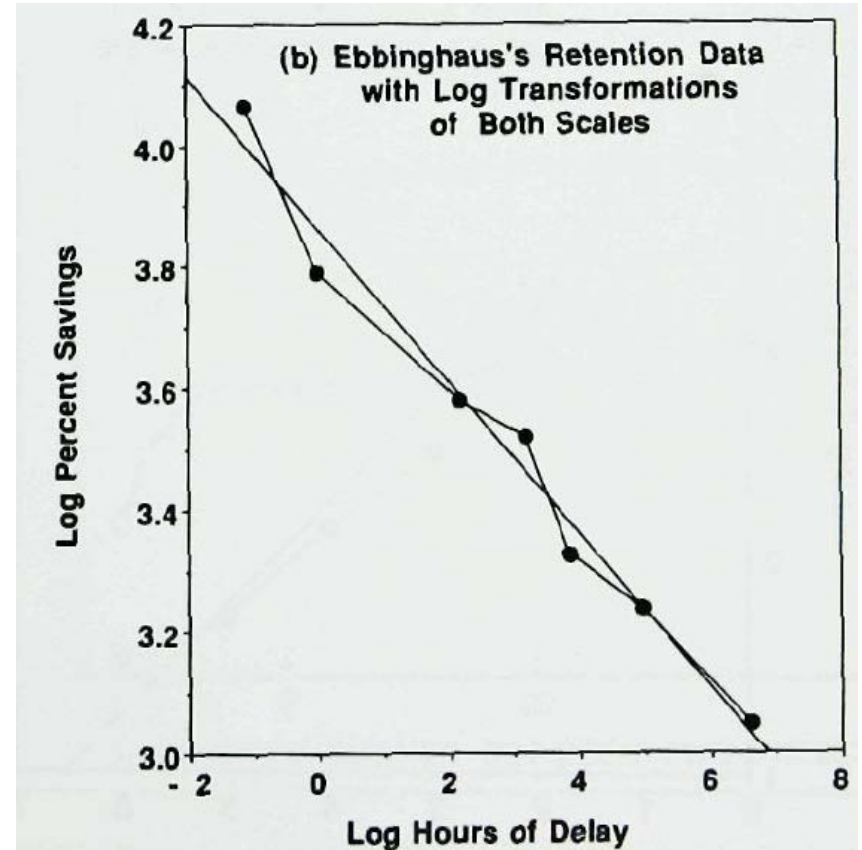
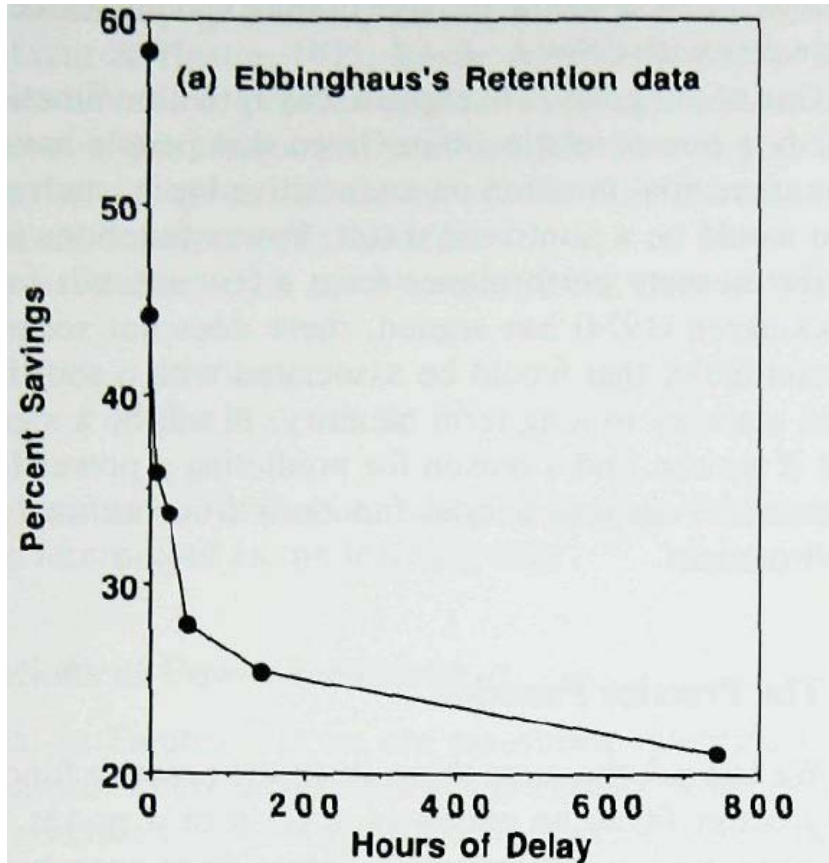
- What underlies the regularities that we see in human behavior?
- One answer:
  - Because of characteristics of the mechanisms of human thought
- Another answer:
  - Because the regularities represent the optimal response to the characteristics of the environment

# Example: Forgetting

- Why do we forget?
- Is it because:
  - our memory is imperfect
- Or is it because:
  - it costs us something to keep information around and...
  - Information from a long time ago is less likely to be useful than information we've been exposed to recently.
- If the latter, then we might predict:
  - That the form of the forgetting function should match the form of the relevance function

# Power Law of Forgetting (Anderson and Schooler, 1991)

$$P = AT^{-b} \text{ or:}$$
$$\log(P) = \log(A) - b \log(T)$$



Which topic is most likely to be in tomorrow's paper?

Two headlines from yesterday:

Man arrested in Times Square bomb plot

Rondo's 19 assists help Celtics beat Cleveland

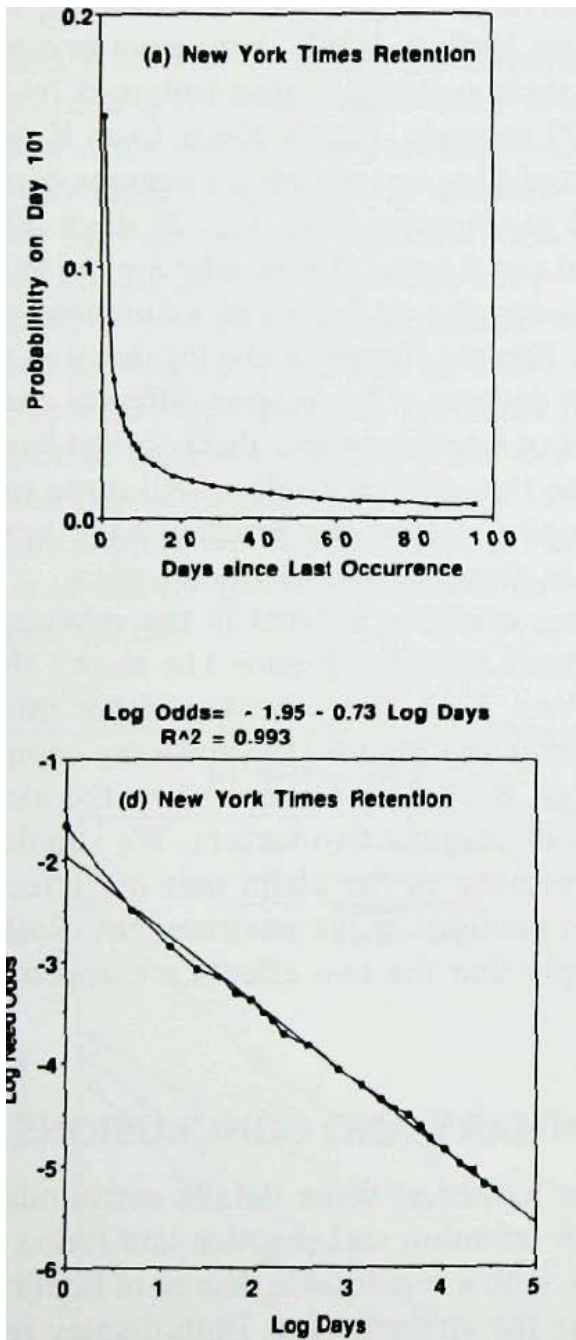
Two headlines from this morning's paper:

House passes compromise budget Bill

Bonds convicted of obstruction, not perjury

# Power Law of Recurrence

- Just like memory, recurrence of topics in the New York times obeys the power law.
- Maybe memory obeys the power law to conform to the structure of experience, not because of features of the architecture of memory.



# Rational or Irrational?

## The card selection task

“If a card has an even number on one side, then it has a vowel on the other”

Here are 4 cards, with a number on one side, and a letter on the other. Which cards should you should turn over to see if any of the cards violates the rule:

3 8 A N

“If you are drinking alcohol, then you must be over 18”.

Here are 4 cards, with the drink a student is drinking on one side, and their age on the other. Which cards should you turn over to see if any of the students are breaking the rule:

*coke beer 22 17*

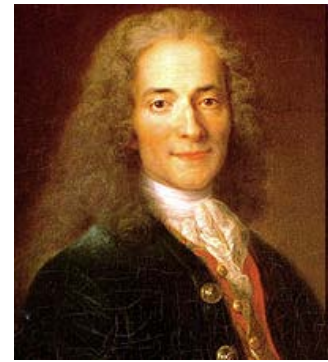
# Explanations of Card Selection Task Results

- Oaksford & Chater's Theory
  - From “A rational analysis of the selection task as optimal data selection”.
- Participants turn over cards that they expect will give them the most information
  - Premise and consequence are thought to pick out rare situations and thus to be highly informative
- Their example:
  - ‘If you eat tripe, then you will get sick’



“The purpose of a rational analysis is to show that behavior is *optimally adapted to the environment.*”

Is the Human Mind 'The Best of All Possible Minds?'  
A parable from Voltaire's *Candide*  
(Lightly adapted by jlm)

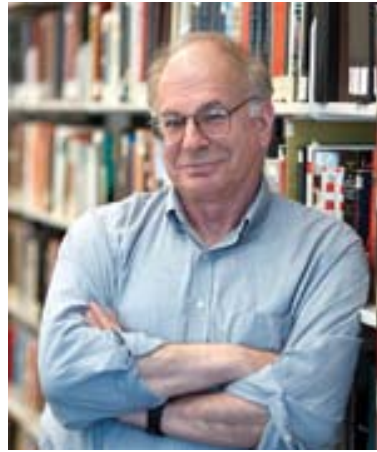


- Candide inquired into the cause that had reduced Pangloss to so miserable a condition.
- "Alas," replied the preceptor, "it was love; love, the comfort of the human species; love! tender love!"
- "Alas," cried Candide, "But how could this beautiful cause produce in you so hideous an effect?"
- Pangloss answered thus: "O my dear Candide, you remember Pacquette, that pretty wench, who waited on our noble Baroness; in her arms I tasted the pleasures of Paradise, which produced these Hell torments. She was infected with an ailment, and perhaps has since died of it; she received this present of a learned Franciscan; he was indebted for it to an old countess, who had it of a captain of horse ... who had it in a direct line from one of the fellow adventurers of Christopher Columbus."
- "O Pangloss," cried Candide, "what a strange genealogy is this! Is not the devil the root of it?"
- "Not at all," replied the great man, "it was a thing unavoidable, a necessary ingredient in the best of worlds; for if Columbus had not caught in America this disease, which contaminates the source of generation, and is evidently opposed to the great end of nature, we should have had neither chocolate nor tomatoes."

# Other Explanations of Performance in the Card Selection Task

- *Ambiguity*: People interpret 'if'... 'then' to mean different things in different contexts ("if and only if", maybe).
- *Availability*: Statement of the rule does not mention the **consonant**, thus participants don't think about it much.
- Why do people do better with the drinking example?
  - Laws and social rules bring to mind a concern about the importance of compliance, leading to a search for possible violations.
- Did evolution endow us with innate 'Cheater detectors', as proposed by Tooby and Cosmides?
  - Only some people think so!
- The one clear lesson: Reasoning does not occur strictly by structure sensitive rules: It is also sensitive to content

# Rational or Irrational? The Conjunction Fallacy Tversky & Kahneman, 1983

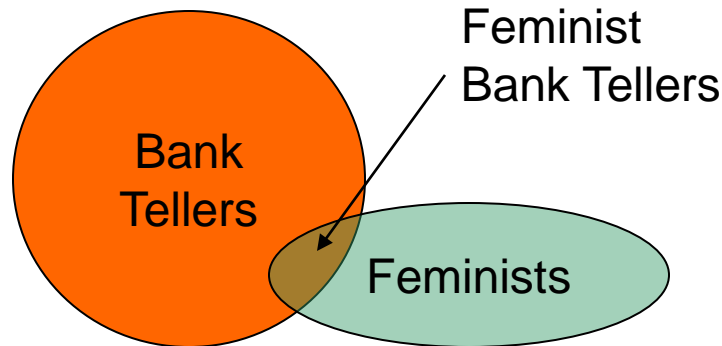


Bill is 34 years old. He is intelligent, but unimaginative, compulsive, and generally lifeless. In school, he was strong in mathematics but weak in social studies and humanities.

- Bill is a physician who plays poker for a hobby.
- Bill is an architect.
- Bill is an accountant. (A)
- Bill plays jazz for a hobby. (J)
- Bill surfs for a hobby.
- Bill is a reporter.
- Bill is an accountant who plays jazz for a hobby. (A&J)
- Bill climbs mountains for a hobby.

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

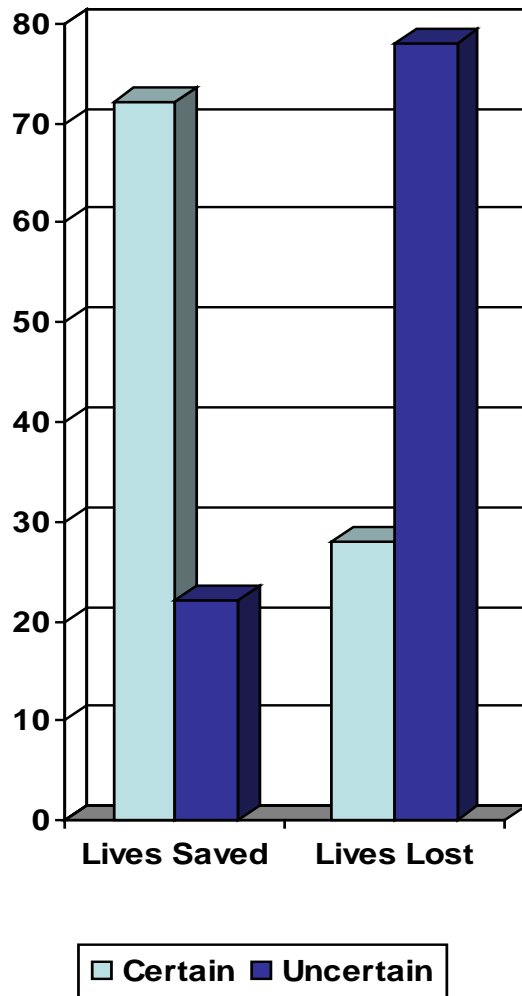
- Linda is a teacher in elementary school.
- Linda works in a bookstore and takes Yoga classes.
- Linda is active in the feminist movement. (F)
- Linda is a psychiatric social worker.
- Linda is a member of the League of Women Voters.
- Linda is a bank teller. (T)
- Linda is an insurance salesperson.
- Linda is a bank teller and is active in the feminist movement. (T&F)



# T&K's Explanation of the Conjunction Fallacy

- “We propose that a judgment of probability or frequency is commonly biased toward the natural assessment that the problem evokes. Thus, the request to estimate the frequency of a class elicits a search for exemplars, the task of predicting vocational choice from a personality sketch evokes a comparison of features, and a question about the co-occurrence of events induces an assessment of their causal connection. These assessments are not constrained by the extension rule.
- 
- Although an arbitrary reduction in the extension of an event typically reduces its availability, representativeness, or causal coherence, there are numerous occasions in which these assessments are higher for the restricted than for the inclusive event.”
-

# Framing Effects



Problem 1 [ $N = 152$ ]: Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is  $1/3$  probability that 600 people will be saved, and  $2/3$  probability that no people will be saved.

Which of the two programs would you favor?

*Or after the same cover story...*

If Program C is adopted 400 people will die.

If Program D is adopted there is  $1/3$  probability that nobody will die, and  $2/3$  probability that 600 people will die.

Which of the two programs would you favor?

# Why does this happen?

- We evaluate outcomes relative to a baseline or neutral point.
- Losses loom larger than gains.
- Both gains and losses show a *diminishing returns* effect.
- Thus the subjective utility of a larger gain or loss is less than it 'should' be, relative to smaller gains and losses.

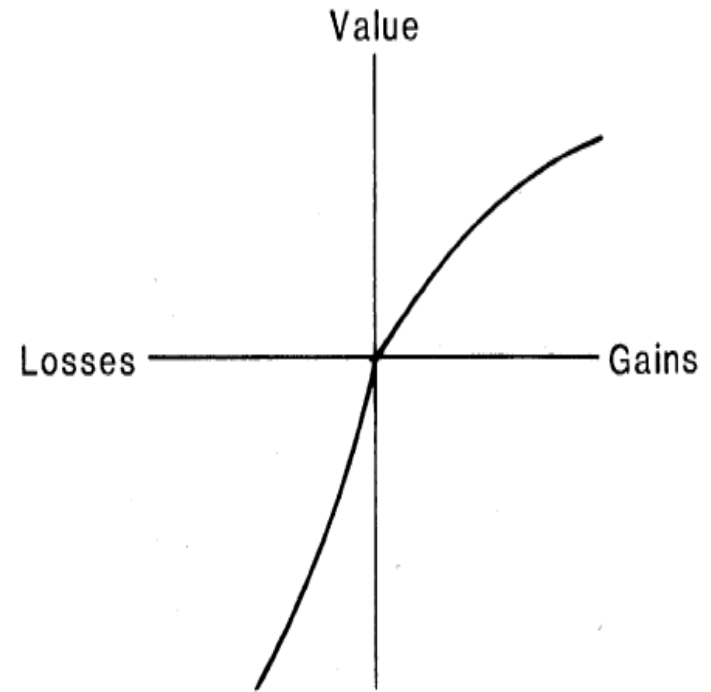
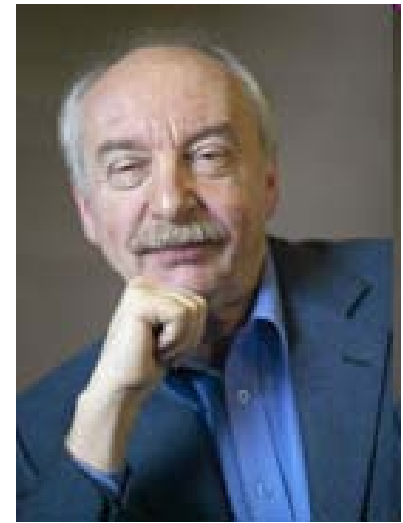


Fig. 1. A hypothetical value function.

# Are T&K Overplaying the Laws of Probability?

Chase, Hertwig & Gigerenzer, 1998



- “Proponents of [competing views] agree on one critical point: rationality requires reasoning in accordance with the rules of probability theory. ... [But] no single conception of probability is shared by all statisticians and philosophers... In our view, wherever a norm’s applicability depends on our interpretation of probability in this way, we are not justified in treating it as an unequivocal norm of sound reasoning.”

# Visions of Rationality



- ‘Bounded Rationality’ (Simon, 1957)
  - People don’t have the resources it would take to be rational; they are always working under constraints.
    - “Expecting people’s inferences to conform to classical rational norms in such complex environments requires believing that the human mind is a ‘Laplacean demon’: a supercalculator with unlimited time, knowledge, and computational power.”  
(Chase et al., *TiCS*, 1998)
  - Instead of optimizing, says Simon, they ‘satisfice’.
    - A satisficing strategy may often be (near) optimal if the costs of the decision-making process itself, such as the cost of obtaining complete information, are considered in the outcome calculus.

# Failure of Bayesian Inference, and how to reduce them

The probability of breast cancer is 1% for a woman at age 40 who participates in routine screening. If a woman has breast cancer, the probability is 80% that she will have a positive mammography. If a woman does not have breast cancer, the probability is 9.6% that she will also have a positive mammography.

A woman in this age group had a positive mammography in a routine screening. What is the probability that she actually has breast cancer? (Answer: \_\_\_\_%)

Ten out of every 1000 women at age 40 who participate in routine screening have breast cancer. Eight out of these ten women with breast cancer will get a positive mammography. Of the 990 women without breast cancer, 95 will also get a positive mammography.

Here is a new representative sample of women at age 40 who got a positive mammography in routine screening. How many of these women do you expect actually to have breast cancer? (Answer: \_\_\_\_ out of \_\_\_\_)

- Even doctors do badly on problems stated with probabilities.
  - This is called ‘Base Rate Neglect’
- Both undergrads and doctors do much better on problems stated with ‘natural frequencies’.
- What causes base rate neglect, according to Chase et al?

# Fast and Frugal Heuristics

- Which has the largest population:  
Graz or Salzburg?

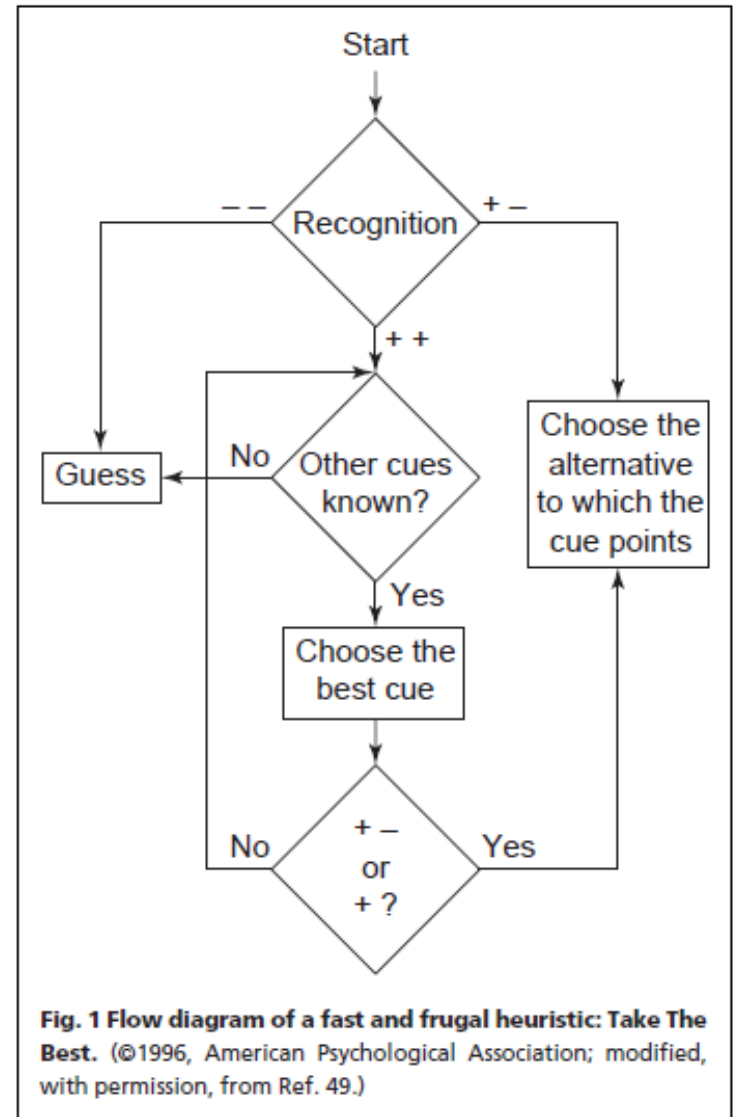
Graz: 223,000

Salzburg: 145,200

- The ‘recognition heuristic’:
  - if you recognize one object and not the other, then infer that the recognized object has the higher value on the target variable; if you do not recognize either object, then guess.

# “Take the best”

- What happens if you recognize both cities?
  - Use ‘Take the Best’
- Search for facts about each city, starting with those most likely to be good predictors of the answer.
  - How many professional sports teams?
  - How many universities?
  - How many people from there have you heard of?
- When you find a variable where you know the answer for both cities, you stop, and choose on that basis.
- Often this is more accurate than considering all available sources of information.



# Are Humans Rational?

- Yes
  - Anderson, Chater
- No
  - Tversky, Kahneman, Voltaire
- They do pretty well with limited resources
  - Simon, Gigerenzer
- Your opinion?