

Reasoning

- Do we always make the best possible decisions?
 - Normative account of judgment: What we SHOULD do
 - Descriptive account: What we DO do
 - People are irrational: normative and descriptive accounts do not always agree –
 - Behavior deviates from normative account in systematic ways
- How can we think better?

Normative Accounts of Judgment

- Statistics and probability theory
- Bayes' theorem
 - $P(A|B) = P(B|A) * P(A) / P(B)$

Normative Accounts of Judgment

$$\text{Value} = \sum (P(X) * V(X))$$

Expected Utility Theory

– P(X) = Probability of Outcome X

– V(X) = Value of Outcome X

– Gamble: If you roll a 6, you get \$4. Otherwise, you give me \$1

– Value = P(win)*V(win)+P(lose)*V(lose)

– Value = (1/6)*4+(5/6)*-1 = -1/6, so don't take bet

Normative Accounts of Judgment

$$\text{Value} = \sum (P(X) * V(X))$$

P(X) = Importance, V(X) = Value

	Larry	Curly	Moe	Importance
IQ	4	2	1	4
Money	2	2	7	2
Sense of humor	7	7	9	9
Expected value	4*4 + 2*2 + 7*9=83	2*4 + 2*2 + 7*9=75	1*4 + 7*2 + 9*9=99	

Judgment Heuristics

- Rules of thumb
- “Satisfice” rather than optimize
- Irrationality is beneficial, because it allows us to make reasonable decisions in a reasonable amount of time
- Heuristics and fallacies: Representativeness, availability, counterfactual reasoning, confirmation bias, anchoring and adjustment, framing, sunk cost, overconfidence, hindsight bias, causal reasoning

Representativeness

- The tendency to judge the probability of an object/event O belonging to a Category C by evaluating how typical/representative O is of C
- Base-rate neglect
 - Answer $P(C|O)$ by using $P(O|C)$
 - $P(C|O)$ also depends on $P(C)$. $P(C)$ is the base rate.
 - People do use base rates if there is no information about representativeness
 - But base rates are ignored even if representativeness information is completely nondiagnostic
- Conjunctive fallacy
 - People sometimes judge $P(A\&B)$ to be greater than $P(A)$
 - $P(\text{hearts \& queen})$ must be less than $P(\text{queen})$
 - Linda, the feminist bankteller
- The use of similarity in reasoning
 - Assume that cause and effect should be similar

John is a graduate student at a large midwestern University. John is solitary, smart, studious, likes reading, likes to have a quiet working environment, and enjoys helping people with their work.

Estimate the likelihood (from 0% to 100%) of John being in the following fields:

- A. Computer science graduate student _____
- B. Library sciences graduate student _____
- C. Law student _____
- D. Psychology graduate student _____

Law students are much more frequent (they have a higher base rate) than library science graduate students. People ignore this fact because the description is more representative of a librarian.

People judge $P(\text{Librarian} | \text{Description})$ is high because $P(\text{Description} | \text{Librarian})$ is high, ignoring that $P(\text{Librarian})$ is low.

Imagine that some psychologists have administered personality tests to 30 engineers and 70 lawyers, all people successful in their fields. Brief descriptions were written for each of the 30 engineers and 70 lawyers. A sample description follows. Judge that description by indicating the probability that the person described is an engineer. Use a scale from 0 to 100.

Jack is a 45-year-old man. He is married and has four children. He is generally conservative, careful, and ambitious. He shows no interest in political and social issue and spends most of his free time on his many hobbies which include home carpentry, sailing, and mathematical puzzles.

The probability that the man is one of the 30 engineers in the sample of 100 is _____?

Imagine that some psychologists have administered personality tests to 70 engineers and 30 lawyers, all people successful in their fields. Brief descriptions were written for each of the 70 engineers and 30 lawyers. A sample description follows. Judge that description by indicating the probability that the person described is an engineer. Use a scale from 0 to 100.

Jack is a 45-year-old man. He is married and has four children. He is generally conservative, careful, and ambitious. He shows no interest in political and social issue and spends most of his free time on his many hobbies which include home carpentry, sailing, and mathematical puzzles.

The probability that the man is one of the 70 engineers in the sample of 100 is _____?

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75% in both cases – people ignore base rate

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The probability that the man is one of the 30 engineers in the sample of 100 is _____?

Imagine that some psychologists have administered personality tests to 30 engineers and 70 lawyers, all people successful in their fields. Brief descriptions were written for each of the 30 engineers and 70 lawyers. A sample description follows. Judge that description by indicating the probability that the person described is an engineer. Use a scale from 0 to 100.

The probability that the man is one of the 30 engineers in the sample of 100 is _____?

Correct use of base rates when no description is given – 30%

Imagine that some psychologists have administered personality tests to 30 engineers and 70 lawyers, all people successful in their fields. Brief descriptions were written for each of the 30 engineers and 70 lawyers. A sample description follows. Judge that description by indicating the probability that the person described is an engineer. Use a scale from 0 to 100.

Jack is a 45-year-old man. He is from Cleveland, is 5'11", likes dogs, and has brown eyes.

The probability that the man is one of the 30 engineers in the sample of 100 is _____?

Imagine that some psychologists have administered personality tests to 30 engineers and 70 lawyers, all people successful in their fields. Brief descriptions were written for each of the 30 engineers and 70 lawyers. A sample description follows. Judge that description by indicating the probability that the person described is an engineer. Use a scale from 0 to 100.

Jack is a 45-year-old man. He is from Cleveland, is 5'11", likes dogs, and has brown eyes.

The probability that the man is one of the 30 engineers in the sample of 100 is _____?

Even a completely nondiagnostic description makes people ignore base rates – 50%

A coin is flipped randomly ten times. Which of the following patterns is more likely to occur, or are they equally likely?

- A. tails tails tails tails tails heads heads heads heads heads ____
- B. tails heads tails heads heads heads tails tails heads tails ____

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- A. tails tails tails tails tails heads heads heads heads heads ____
- B. tails heads tails heads heads heads tails tails heads tails ____

Any specific pattern of heads and tails is equally likely. 1 out of 2^{10}

A. seems unlikely because it is not REPRESENTATIVE of a random process.

A town has a large hospital (45 babies a day are born there) and a small hospital (15 babies a day are born there). For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such days?

The larger hospital _____

The smaller hospital _____

About the same (within 5 percent of each other) _____

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The larger hospital _____

The smaller hospital _____

About the same (within 5 percent of each other) _____

The smaller hospital is far more likely to have more days where >60% of the babies are boys.

Central limit theorem: the more random samples you take, the more closely your average will approximate the expected average (50%).

Small hospitals are not more representative of the kind of hospital that makes boy babies, so people think the two hospitals will be about the same.

Linda is 32 years old, outspoken, pro-choice, socialist, went to a small liberal arts school, and is a participant in a weekly woman's discussion group. Rank order the following, in terms of how likely you think they are (put a 1 by the most likely, a 2 by the second most likely, etc.)

- A. Linda is a feminist ____
- B. Linda is a teacher ____
- C. Linda is feminist bank teller ____
- D. Linda is a writer ____
- E. Linda is a bank teller ____
- F. Linda is a woman's studies teacher ____

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P(Feminist & Bank teller) cannot be greater than P(Bank teller)

P(Woman's studies teacher) cannot be greater than P(Teacher)

The description is representative of a feminist bank teller, but not of a bank teller.

Sampras is currently rated as the best men's tennis player in the world. Sampras is playing the 40th best player, Gulickson. Sampras is not expecting much of a challenge, and begins the match with a somewhat cocky attitude. Estimate how likely each of the following events are (give percentages between 0 and 100%. 100% means that you absolutely know for sure that the event will happen):

- A. Sampras wins the match _____
- B. Sampras loses the match _____
- C. Sampras loses the first set, but wins the match _____
- D. Sampras wins the first set, but loses the match _____

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- C. Sampras loses the first set, but wins the match _____
- D. Sampras wins the first set, but loses the match _____

P(Sampras loses first & wins match) cannot be greater than P(wins match)

But losing first set and winning the match is representative of being cocky, and so it is thought to be likely

Availability

- The tendency to evaluate the probability of an event by assessing the ease with which instances come to mind
- A good heuristic, but salient cases will influence judgments too much

Do more words A) begin with the letter "R" or B) do more words have the letter "R" as the third letter in the word? _____

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More words have "R" as the third letter, but it is easier to generate words that begin with "R" - they are highly available

A. Approximately how many words in the English language do you think fit the pattern ___ I N G ? (example TAKING) _____

B. Approximately how many words in the English language do you think fit the pattern ___ _ N _ ? (example SHRINK) _____

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B. Approximately how many words in the English language do you think fit the pattern _ _ _ _ _ N _ ? (example SHRINK) _____

The answer to B. must be more than A., but it is easy to think of words for A..

Out of 200 million people, 902 die of appendicitis, 24,600 die of suicide, 75,850 die of lung cancer, 48 die of venomous bites, and 31,160 die of breast cancer. Estimate how many people die of the following:

Tornadoes
Strokes
Homicide
Botulism
Asthma
Diabetes
Emphysema
Motor vehicle accidents

Out of 200 million people, 902 die of appendicitis, 24,600 die of suicide, 75,850 die of lung cancer, 48 die of venomous bites, and 31,160 die of breast cancer. Estimate how many people die of the following:

Tornadoes 90 over
 Strokes 209,160 under
 Homicide 18,860 over
 Botulism 2 over
 Asthma 1,886 under
 Diabetes 38,950 under
 Emphysema 21,730 under
 Motor vehicle accidents 55,350 over

Counterfactual reasoning

- Simulation heuristic
 - Related to availability: Think of highly available alternatives when evaluating an event
 - Counterfactual reasoning: If only it had been different
 - Ease of converting unusual conditions determines people's decisions
- Constraints on counterfactual reasoning
 - Change events so that atypical event is replaced with a more typical event
 - More likely to change element that is focused upon
 - Not "anything goes"

- Mr. Crane and Mr. Tees were scheduled to leave the airport on different flights, at the same time. They traveled from town in the same limousine, were caught in a traffic jam, and arrived at the airport 30 minutes after the scheduled departure time of their flights.
 - Mr. Crane is told that his flight left on time.
 - Mr. Tees is told that his flight was delayed, and just left five minutes ago.
 - Who is more upset? Mr. Crane or Mr. Tees?
- 96% of participants said that Mr. Tees would be more upset
- They both missed the flight but it was more possible for Mr. Tees to reach his flight.
- Simulation exercise – how close they came to reaching their flight in time
 - Mr. Tees is more disappointed because it is easier for him to imagine how he could have arrived 5 minutes earlier than it is for Mr. Crane to imagine how the 30 minutes delay could have been avoided.
 - Constraints on simulation – why difficult to imagine avoiding 30 minutes delay?

- Mr. Jones was 47 years old, the father of three and a successful banking executive. His wife has been ill at home for several months.
 - Route version: On the day of the accident, Mr. Jones left his office at the regular time. He sometimes left early to take care of home chores at his wife's request, but this was not necessary on that day. Mr. Jones did not drive home by his regular route. The day was exceptionally clear and Mr. Jones told his friends at the office that he would drive along the shore to enjoy the view.
 - Time version: On the day of the accident, Mr. Jones left the office earlier than usual, to attend to some household chores at his wife's request. He drove home along his regular route. Mr. Jones occasionally chose to drive along the shore, to enjoy the view on exceptionally clear days, but that day was just average.
- The accident occurred at a major intersection. The light turned amber as Mr. Jones approached. Witness noted that he braked hard to stop at the crossing, although he could easily have gone through. His family recognized this as a common occurrence in Mr. Jones' driving. As he began to cross after the light changed, a light truck charged into the intersection at top speed, and rammed Mr. Jones' car from the left. Mr. Jones was killed instantly.
- It was later ascertained that the truck was driven by a teenage boy, who was under the influence of drugs.
- As commonly happens in such situations, the Jones family and their friends often thought and often said, "If only ...", during the days that followed the accident. How did they continue this thought? Please write one or more likely completions.

Table 1. Analysis of first completion of the "if only" stem

Response categories	Time version	Route version
(i) Route	8	33
(ii) Time	16	2
(iii) Crossing	19	14
(iv) Boy	18	13
(v) Other	1	3

- Events are not mentally undone by arbitrary alterations.
- Downhill change in mental simulation
 - Removes an unexpected aspect of the story
 - Subjects were more likely to undo the accident by restoring a normal value than by introducing an exception (uphill change)
 - Subjects did not replace an arbitrary value with another arbitrary value (horizontal change) – no subject mentioned that if Mr. Jones had come to the intersection two or three seconds earlier he would have gone through safely.
- Focus rule
 - Stories are altered by changing some property of the main object of concern and attention
 - Subjects were told to empathize with Mr. Jones' family
 - Mr. Jones behavior was changed in simulation
 - In another experiment, Mr. Jones was the focus for one group, and the boy was the focus for another group
 - Changing the insane behavior of the drugged boy was less frequent when Mr. Jones was the focus (28%) than when the boy was the focus (68%)

Confirmation Bias

- A tendency for people to look for evidence that confirms their hypothesis. The tendency not to look for falsifying evidence.
- Wason 246 task, Wason selection task
- Illusory correlations
 - A tendency for people to see correlations between variables when the correlations do not really exist
 - People tend to see correlations that are consistent with their hypotheses

I'm thinking of a rule for generating sequences of 3 numbers. I'll give you a hint: "2 4 6" fits the rule. If you ask me about a sequence of three numbers, I'll tell you whether it fits the rule. You'll be able to guess the rule after awhile. What sequence do you want to try out first?

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People often test sequences like "8 10 12," expecting the answer to be "Yes, it fits the rule"

Sequences like "10 5 12" are seldom tested, even though they provide useful disconfirmatory evidence.

You are given four pieces of paper. On each paper, there is a letter (B or W) on one side, and a number (9 or 12) on the other side. Which two pieces of paper would you turn over to verify that the rule "If a paper has a double digit number on one side, then it must have a B on the other side" is being followed?



Suppose you were shown four checks that were either for greater than 10 dollars or less than 10 dollars and were initialed on the back by the boss (B) or by one of the workers (W). The rule is that if a check is for 10 or more dollars, it must be initialed by the boss. Which two checks would you turn over to verify that the rule "If a check is a double digit number, then it must have a B on the other side (be initialed by the boss)" is being followed?



Suppose you were shown four checks that were either for greater than 10 dollars or less than 10 dollars and were initialed on the back by the boss (B) or by one of the workers (W). The rule is that if a check is for 10 or more dollars, it must be initialed by the boss. Which two checks would you turn over to verify that the rule “If a check is a double digit number, then it must have a B on the other side (be initialed by the boss)” is being followed?



- B → 9 or 12 on other side. Neither would falsify/test rule.
- W → 9 or 12 on other side. If 12, then rule is wrong, so must turn over
- 9 → B or W on other side. Neither would falsify rule
- 12 → B or W on other side. If W, then rule is wrong, so must turn over

People often turn over 12
 People often turn over B to CONFIRM rule

People reason better with the concrete version of this problem

People pay most attention to confirmatory evidence

	Get Better	Stay Sick
Treat	80	20
Don't treat	60	200

Tend to ignore

Illusory Correlation experiment

- Rorschach ink blots
- Subjects are psychologists providing diagnoses from ink blot interpretations
- Stimuli are cards with picture, interpretation, and diagnosis
- Subjects see false correlations consistent with their hypotheses, and miss true correlations that are not consistent with their hypotheses

Anchoring and adjustment

- When making an estimate, people start with a figure, and adjust this figure up or down to obtain their estimate
- Insufficient adjustment, so estimate is close to anchor

- (A) Provide an estimate (don't try to work it out) for the following product:

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 \quad \underline{\hspace{2cm}}$$

- (B) Provide an estimate (don't try to work it out) for the following product:

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \quad \underline{\hspace{2cm}}$$

- People tend to give higher estimates in (A) than (B), because the first couple of products provides an anchor.

- (A) I just asked my computer to come up with a random number between 1 and 100. It came up with 87. Do you think that percentage of African countries that belong to the United Nations is greater than or less than 87%? _____. Estimate the percentage of African countries that belong to the United Nations _____.

- (B) I just asked my computer to come up with a random number between 1 and 100. It came up with 23. Do you think that percentage of African countries that belong to the United Nations is greater than or less than 23%? _____. Estimate the percentage of African countries that belong to the United Nations _____.

- People tend to give a higher estimate in (A) than (B) because anchor is higher in (A), even though it is irrelevant.

Framing

- The same information, expressed in different forms, can lead to different judgments

- (A) 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 have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows: If Program A is adopted, exactly 200 people will be saved. If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no people will be saved. Which of the two programs would you favor?

- (B) Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. If Program A is adopted, exactly 400 people will die. If Program B is adopted, there is a 1/3 probability that no people will die, and a 2/3 probability that 600 people will die. Which of the two programs would you favor? _____
- 70% Program A in (A), 78% Program B in (B)
- When framed in terms of lives SAVED, people are risk averse
- When framed in terms of lives LOST, people are risk seeking

- (A) Imagine that you have decided to see a play and paid the admission price of \$10 per ticket. As you enter the theater you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered. Would you pay \$10 for another ticket? _____
- (B) Imagine that you have decided to see a play where admission is \$10 per ticket. As you enter the theater you discover that you have lost a \$10 bill. Would you pay \$10 for a ticket for the play? _____
- People are more likely to pay in (B), but decision is the same: is the play worth \$10?
- Mental accounting: People think of money as belonging to certain categories, but it is really all the same money

Sunk costs

- Fallacy: the more investment a person has made into something, the more likely they will continue to invest in it
- Normatively, past investments should not affect decision making unless it affects outcomes
- Why stay with boy/girl friend? Often because of invested time
- Congressional budget decisions
- Movie watching

- (A) You go to a fancy French restaurant. You have a good meal, and decide to get a very expensive chocolate mousse. When it comes, you find that it is a bit too sweet for your tastes. Do you finish it (answer honestly)?
- (B) You go to a fancy French restaurant. You have a good meal, and decide to get an inexpensive chocolate mousse (it was the daily special). When it comes, you find that it is a bit too sweet for your tastes. Do you finish it (answer honestly)?
- People are more likely to eat the mousse if it was expensive.

Overconfidence

- People are often more confident in their judgments than they should be
- A little knowledge goes a long way – too far!
 - Answer trivial pursuit questions and estimate likelihood correct
 - People get 70% of questions correct that they estimate they are 70% likely to answer correctly
 - People get 73% of questions correct that they estimate they are 95% likely to answer correctly
 - People get 81% of questions correct that they estimate they are 99.9% likely to answer correctly
- People's 95% confidence intervals are too narrow

- Provide a lower and upper bound that you feel has a 95% chance of containing the correct number
- How many pounds of wheat flour were consumed by an average American in 1986?
- What was the total U.S. Defense Department budget in 1986?
- How many students were enrolled in elementary and secondary schools in the state of Hawaii in fall, 1985?
- What is the height in feet of Mount McKinley, in Alaska?

- Provide a lower and upper bound that you feel has a 95% chance of containing the correct number
- How many pounds of wheat flour were consumed by an average American in 1986? 130
- What was the total U.S. Defense Department budget in 1986? \$286,116,000,000
- How many students were enrolled in elementary and secondary schools in the state of Hawaii in fall, 1985? 164,169
- What is the height in feet of Mount McKinley, in Alaska? 20,320

Hindsight bias

- People exaggerate their confidence in an outcome occurring when they know what did occur
- After an accident, people say “John was always unsafe”
- Stock market analysis – a story for every outcome
- What will be the outcome of Nixon’s trip to China?
 - Estimate probabilities of a trade agreement, missile treaty, etc. before the trip
 - After the trip, subject is asked to recall probabilities that they gave earlier
 - Subjects incorrectly remember the probabilities of events that did occur as being higher than they originally estimated

Causal Reasoning

- People tend to reason from cause to effect, inferring effects from causes
- Normatively, to find the predictive relationship between two events, causality is not relevant

Which would be more accurate, predicting a daughter’s eye color from her mother’s eye color, or a mother’s eye color from her daughter’s eye color?

- The rows that let you correctly predict a daughter’s eye color from a mother’s eye color are exactly the same as the rows that allow the converse prediction

Mother	Daughter
Blue	Blue
Blue	Green
Green	Blue
Green	Green

- Judgment as story telling

How deep is our knowledge?

- Shallowness of explanation (Keil and colleagues)
- People believe they understand more than they do
 - Asked college students about devices
 - Toilet, Car ignition, Bicycle derailleur
 - Said they understood devices
 - Could not actually explain them
 - Why does this happen?
- Knowledge is packed
 - When we know how to use an object and it is familiar, we believe we know how it works.

Scientific reasoning

- Scientific reasoning
 - Combination of abilities
- Hypothesis testing
 - Generate an explanation for some phenomenon
 - Develop an experiment to test the hypothesis
 - Seek disconfirming evidence
- How good are people at this type of reasoning?
 - People tend to have a confirmation bias – we seek confirming evidence
 - Wason 246 task, Wason selection task
 - How good are scientists at living up to this ideal?
 - Scientists tend to be more critical of evidence that is inconsistent with their beliefs.