Reasoning & Decision Making

Intro Psychology
Georgia Tech
Instructor: Dr. Bruce Walker

Today

- Heuristics, rules
- Decisions
- Reasoning

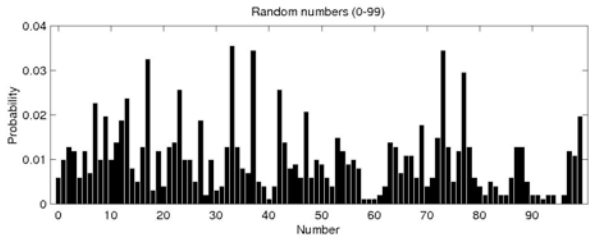
Heuristics and Biases

Simple rules we use for reasoning about chance

and

The errors we make as a consequence

Random Numbers



Foundations of Probability

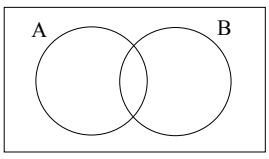
Frequentists
- Probabilities refer to repeatable events
- P(A) is the proportion of times A occurs

Subjectivists
- Probabilities refer to statements
- P(A) is the degree of belief in the truth of A

Foundations of Probability

Conflict because both interpretations of probability result in the same rules

eg. P(A&B) < P(A)



Bayes' Rule

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

- To frequentists, a tautology
- To subjectivists, how to update beliefs

Back to Flipping Coins...

- How likely am I to have a two-headed coin?
- After five heads in a row, how likely is it that the coin I was using had two heads?

$$P(\text{two heads}|\text{HHHHH}) = \frac{P(\text{HHHHH}|\text{two heads})P(\text{two heads})}{P(\text{HHHHH})}$$

Other Uses of Bayes' Rule

- P(cube in world |  on retina)
- P(disease|symptoms)
- P(hypothesis|data)

Reasoning under uncertainty

- Easy - just use subjective probabilities!
- Are people Bayesian?

Yes! (although a little slow)

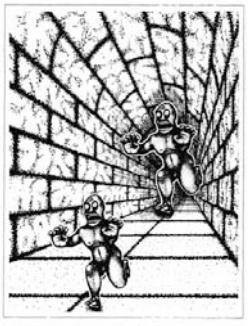
(Edwards, 1968; Peterson & Beach, 1967)

No! (they're horribly "non-optimal")

(Slovic & Lichtenstein, 1971; Pitz et al., 1967)

Enter Kahneman and Tversky

- Calculating subjective probabilities is hard
- People systematically use approximations to simplify the problem (heuristics)
- These approximations help a great deal, but result in errors (biases)
- Analogy to vision - "cognitive illusions"



(illusion by Roger Shepard)

The Findings About Heuristics

- Representativeness
- Availability
- Anchoring and adjustment

The Linda Effect

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

The Linda Effect

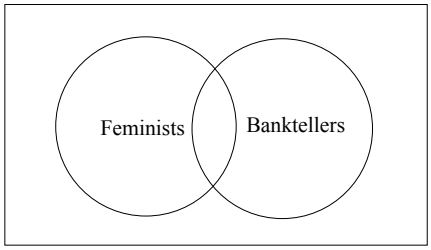
Rate the following, in order of likelihood:

Linda is a bank teller

Linda is a bank teller and is active in the feminist movement

Linda is active in the feminist movement

The Linda Effect (The Conjunction Fallacy)



The Conjunction Fallacy

- 75 out of 88 UBC undergraduates rated P(F&B) > P(B)
- Further tests: naïve, informed, and sophisticated participants, indirect, subtle, and transparent manipulations
- In every case, P(F&B) > P(B)

(Tversky & Kahneman, 1983)

The Conjunction Fallacy

"…in a series of increasingly desperate manipulations …"

Check the more probable statement

Linda is a bank teller

Linda is a bank teller and is active in the feminist movement

121 of 142 UBC undergraduates pick P(T&F)>P(T)

The Conjunction Fallacy

Argument 1: Linda is more likely to be a bank teller than she is to be a feminist bank teller, but some women bank tellers are not feminists, and Linda could be one of them

Argument 2: Linda is more likely to be a feminist bank teller than she is likely to be a bank teller, because she resembles an active feminist more than she resembles a bank teller

38 of 58 undergraduates chose Argument 2

The Jack Effect

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 issues and spends most of his free time on his many hobbies which include home carpentry, sailing, and mathematical puzzles.

The Jack Effect (Neglect of Prior Probability)

- Remember Bayes' Rule?

$$P(\text{engineer}|\text{jack}) = \frac{P(\text{jack}|\text{engineer})P(\text{engineer})}{P(\text{jack})}$$

So if we change P(engineer), people's judgments should change accordingly…

…but they don't (Kahneman & Tversky, 1973)

Randomness and Representativeness

- When asked to produce random sequences, or judge their probability, the results differ from uniformity
- Representativeness: people prefer sequences similar to the generating process
  - e.g. Sequences with the same statistics

H H H
T T H
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The Gambler's Fallacy

- People consider alternation to be an important aspect of random sequences
- Binary sequence production: alternation with probability 0.6, instead of 0.5
- As a result, sequences with "runs" are deemed non-random

The Hot Hand Phenomenon

"If I'm on, I find that confidence just builds … you feel nobody can stop you. It's important to hit that first one, especially if it's a swish. Then you hit another, and … you feel like you can do anything"

-- World B. Free

The Hot Hand Phenomenon

For the Philadelphia 76ers, 1980-1981:

P(x|ooo)	P(x|oo)	P(x|o)	P(x)	P(x|x)	P(x|xx)	P(x|xxx)
.56	.53	.54	.52	.51	.50	.46

x = hit, o = miss

(Gilovich, Vallone & Tversky, 1985)

Representativeness

- Probability judgments are made based on similarity
- As a result, we violate the rules of probability theory…
- …and are poor at recognizing randomness

Availability

- What is the probability of a tornado?
- How frequently does a tornado occur?
- If we can easily *generate* examples of a tornado from memory, we think it is more likely

Availability

- In judging how often things happen, we rely on our memory
- Because memory is influenced by things other than frequency, we make mistakes
- In particular, we act in ways inconsistent with the normative standard of probability

Availability

- Tversky & Kahneman (1983) – even "experts" can be led astray
  - 2 Scenarios, 115 participants at Second International Congress on Forecasting
  - a. A complete suspension of diplomatic relations between the United States and the Soviet Union sometime in 1983.
  - b. A Soviet invasion of Poland, and a complete suspension of relations between US and USSR sometime in 1983.

Availability

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  b. A Soviet invasion of Poland, and a complete suspension of relations between US and USSR sometime in 1983.

Judged probabilities for b. were 3 times that judged for a.

Reasoning

Utility Theory

- Foundation of economic thought (at least, it used to be)
- People seek to maximize Utility (e.g., expected value of an outcome)

Reasoning about losses and gains

- Which do you prefer?
  – 50% chance at $200
  – 100% chance for $100

Reasoning about losses and gains

- In terms of expected values, both are equal.
  – $200 * .50 = $100
  – $100 * 1 = $100
  – Utility theory predicts that people will be indifferent.
  – But, people consistently rate the sure thing as highly preferred. In this way, people are *risk averse*

Reasoning about losses and gains

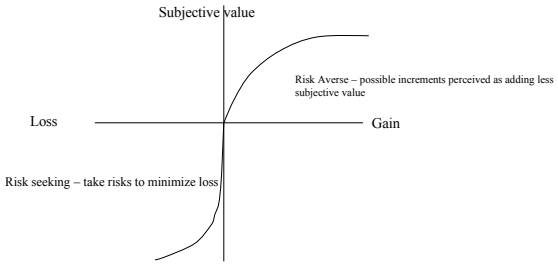
- Which do you prefer?
  – 50% chance at losing $200, 50% for losing 0
  – Sure loss of $100

Reasoning about losses and gains

- Again, both expected values are equal.
  - 50% chance at losing $200, 50% for losing 0
  - Sure loss of $100
  - Consistent strong preference is for risky 50/50 option than the sure loss. In terms of losses, people are *risk seeking*

Prospect Theory

- Kahneman & Tversky's descriptive theory of how people actually reason about risk



Framing Effects

- Reasoning is powerfully influenced by whether problem is framed in terms of losses or gains.
- If frame emphasizes loss, risky decisions, if emphasis is on gains, risk averse.

Framing Effects

US is preparing for an outbreak of a disease. Expected deaths is 600. Two programs can be used to combat the disease.

72% Program A – 200 people will be saved

28% Program B – 1/3 probability that all 600 will be saved, 2/3 probability that no one will be saved.

Framing Effects

US is preparing for an outbreak of a disease. Expected deaths is 600. Two programs can be used to combat the disease.

22% Program A – 400 people will die.

78% Program B – 1/3 probability that no one will die, 2/3 probability that 600 will die.

Framing Effects

- Affect all types of decisions by all types of people
  - Stanford MBA students reasoning about business plans
  - Experienced doctors reasoning about different treatments for breast cancer
  - Safety engineers at NASA reasoning about equipment modifications

Conflicted decision making…

- Suppose you are considering buying a DVD player but have not decided what model to buy. You pass a store that is having a one day sale. They offer a popular Sony player for just $99, well below the list price. What do you do?
  - Buy the Sony player
  - Wait until you learn more about the various models.

Conflicted decision making…

- Suppose you are considering buying a DVD player but have not decided what model to buy. You pass a store that is having a one day sale. They offer a popular Sony player for just $99, and a top of the line Aiwa player for $169, both well below the list price. What do you do?
  - Buy the Sony player
  - Buy the Aiwa player
  - Wait until you learn more about the various models.

Respondents are more likely to buy under previous scenario than this.

Conflicted decision making…

- Suppose you are considering buying a DVD player but have not decided what model to buy. You pass a store that is having a one day sale. They offer a popular Sony player for just $99, well below the list price and an inferior Aiwa player for the regular price of $105. What do you do?
  - Buy the Sony player
  - Buy the Aiwa player
  - Wait until you learn more about the various models.

Now, addition of an alternative increases probability that people will decide to purchase Sony. Why?

Conflicted decision making…

- Dominated by uncertainty of alternative options.
- Addition of options are informative about the possible solution space.
- High conflict emphasizes decision makers paucity of knowledge, relative merits of solutions.
- Addition of inferior option suggests that preferred solution may be better than alternative(s)

Rationality

- People do not always follow normative laws of probability (e.g., their probability functions are incoherent)
- But… Many problems framed in terms of frequencies of outcomes rather than probabilities of single events show much better (e.g., more coherent decisions)

Rationality

- Representativeness – side effect of an strong bias toward structure discovery.
  - Attempts to understand underlying process is then run in reverse to make judgments about probabilistic events.
  - Gambler's fallacy
  - Illusory correlations

Rationality

- Utility theory – “expected value” is useless
  - Risk seeking when behind is good if you don’t get to run the process over and over again
  - Survival is often a single shot, so if behind, better be risky. If ahead, don’t mess things up.