Informatics 1 Cognitive Science

Lecture 15: Biases in Human Decision Making

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Overview

Recap

Previous lecture:

- Rational analysis
- Expected utility and utility functions
- Prospect Theory

This lecture:

- More on cognitive biases
- A cognitive bias is a deviation from optimal, normatively correct behavior
- Example: choosing a bet even though it doesn't have the highest expected gain

Recap

Framing effects – people choose dominated pairs of bets, i.e., bets that are non-optimal according to probability theory.

Prospect theory:

- We evaluate bets one at a time.
- $U()$ focuses not on overall wealth, but gains and losses.
- $U()$ flattens out as gains/losses become more extreme, more so for gains. We over-weight extreme probabilities.

Today's Lecture

- More examples of behavior that departs from probability theory (at least under the researchers' original conception of their experiments)
- Are people solving different problems than experimenters thought?
- Are people striking a balance between good decisions and resource constraints?

Representativeness Bias

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"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."

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Rank the following statements in terms of how likely they are to be true:

- Bill is a physician who plays poker for a hobby.
- Bill is an architect.
- Bill is an accountant.
- Bill plays jazz for a hobby.
- Bill surfs for a hobby.
- Bill is a reporter.
- Bill is an accountant who plays jazz for a hobby.
- Bill climbs mountains for a hobby.

(Tversky & Kahneman, 1983)

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(Tversky & Kahneman, 1983)

Conjunction Fallacy

- Bill is an accountant. (A)
- Bill plays jazz for a hobby. (J)
- Bill is an accountant who plays jazz for a hobby. (A&J)

Most people said A&J is more likely than J. Since J includes both J&A and J&!A, this appears to be a fallacy.

(Tversky & Kahneman, 1983)

Conjunction Fallacy

Tversky & Kahneman's explanation:
Bill being an accountant is representative of his description.

In terms of probabilities, $P(\text{description}|\text{category})$ is high. This is not the same as $P(\text{category}|\text{description})$.

(Tversky & Kahneman, 1983)

Let's Estimate some Probabilities

Time for a short quiz on Wooclap!

https://app.wooclap.com/GJCPSB

Availability Bias

Availability Bias

What's more dangerous?

- Spending an hour on a large aircraft?
- Spending an hour in a typical passenger car?

Availability Bias

Tversky & Kahneman's explanation:

We estimate probabilities by generating or recalling examples

"Consider the letter R.

Is R more likely to appear in

- the first position [in a word]?
- the third position [in a word]?"

152 participants; 105 incorrectly said the first position is more likely.

Tversky & Kahneman (1973). Availability: A heuristic for judging frequency and probability.

Availability Bias

Availability can be a useful heuristic; we can't consider all possible events.

- "inference by sampling" is an active research area.
- Availability should increase with actual probability.
- If extreme events tend to be those with extreme utilities $\rightarrow$ overweighting gives better expected utility estimates.

Lieder et al. (2018). Overrepresentation of extreme events in decision making reflects rational use of cognitive resources.

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You can find the probabilities for causes of death here:
https://www.floridamuseum.ufl.edu/shark-attacks/odds/compare-risk/death/

Base Rate Neglect

Base Rate Neglect

Blue and the green cabs operate in a city:

- **85%** of cabs are blue.
- **15%** of cabs are green.

A cab was involved in a hit-and-run accident at night.
A witness later identified the cab as a green cab.

The witness was tested for their ability to judge the color of cabs under similar conditions. They were correct **80%** of the time but confused it with the other color **20%** of the time.

Was the hit-and-run cab green or blue?

Kahneman & Tversky (1972) via Maya Bar-Hillel (1980).

Base Rate Neglect

Typical human judgment: green.

Bayes' theorem:

$$P(\text{green}|\text{witness} = g) = \frac{P(\text{green})P(\text{witness} = g|\text{green})}{P(\text{green})P(\text{witness} = g|\text{green}) + P(\text{blue})P(\text{witness} = g|\text{blue})}$$

That is: $0.15 \times 0.80/(0.15 \times 0.80 + 0.85 \times 0.20) = 0.12/(0.12 + 0.17) = 0.41$
less than $0.5 \rightarrow$ Should say blue.

Kahneman & Tversky (1972) via Maya Bar-Hillel (1980).

Base Rate Neglect

What's going on?

Maya Bar-Hillel: We have heuristics for determining the relevance of info

Kahneman: The green cab is more representative of the witness's report

This phenomenon is important:

- Physicians are subject to base rate neglect in evaluating diagnostic tests!
- Relevant in legal settings too – See Bar-Hillel (1980) for more.

Kahneman & Tversky (1972) via Maya Bar-Hillel (1980).

Examples of Heuristics and Biases

Time for a short quiz on Wooclap!

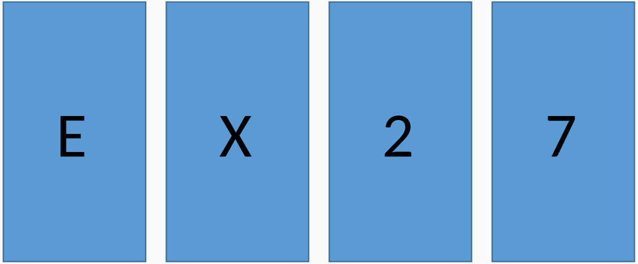
https://app.wooclap.com/GJCPSB

Wason's Card-selection Task

Wason's Card-selection Task

The rule:

> *If there is a vowel on one side of a card, then there is an even number on the other side.*



Which cards should we reverse to determine whether the rule is true, assuming cards have letters on one side and numbers on the other?

(Oberauer et al. 1999; Wason, 1968; participants were Edinburgh first-year psychology undergraduates)

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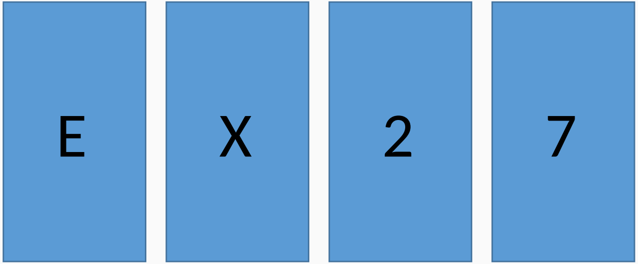

According to logic: E and 7.

(Oberauer et al. 1999; Wason, 1968; participants were Edinburgh first-year psychology undergraduates)

Wason's Card-selection Task

Why **E & 7** (P and not-Q), and not X or 2 (not-P or Q)?

The rule: P (vowel) implies Q (even number).

If we flip over **E** and see an odd number (P and not-Q),
we have falsified the rule.

If we flip over **7** and see a vowel (not-Q and P),
we have falsified the rule.

Wason's Card-selection Task

Why E & 7 (P and not-Q), and not **X or 2** (not-P or Q)?

The rule: P (vowel) implies Q (even number).

If we flip over **X,** it doesn't matter if the number is even or odd – neither falsifies the rule.

If we flip over **2,** it doesn't matter if the letter is a vowel or not – neither falsifies the rule.

Wason's Card-selection Task

The logical answer is P and not-Q (or "!Q" for short).

In one representative experiment, participants chose:

- P & Q (18 of 34 participants)
- P (7 of 34)
- P & !Q (1 of 34)
- P & !P (1 of 34)
- P, Q, & !Q (4 of 34)
- P, !P, & Q (1 of 34)
- Everything (2 of 34)

(Wason (1968). Reasoning about a rule. Quarterly Journal of Experimental Psychology.)

Wason's Card-selection Task

What's going on?

Wason:

- The task requires reasoning in accordance with logical rules.
- People do not reason in accordance with logical rules.

So, people are bad at logic and "formal operations" in general.

Card Selection and Biases

Time for a short quiz on Wooclap!

https://app.wooclap.com/GJCPSB

Wason's Card-selection Task

What if we consider other goals?

Is falsifying logical rules something we're adapted to do?

Perhaps Wason's participants weren't solving a logic problem.
What about more concrete and familiar problems?

Information-seeking

An alternate view of the card-selection task:

There are two competing hypotheses:

1. The $P \to Q$ rule is true.
2. The $P \to Q$ rule is false.

We choose examples to get the most information about the truth of the rule – including evidence **for** its truth.

(“A Rational Analysis of the Selection Task as Optimal Data Selection”, Oaksford & Chater, 1994)

Information-seeking

A rule:

"If you eat tripe (P), you feel sick (Q)"

Selecting:

- [P/!P]: "Hello tripe-[eater/non-eater], how do you feel?"
- [Q/!Q]: "Hello [sick/well] person, have you had tripe recently?"

("A Rational Analysis of the Selection Task as Optimal Data Selection", Oaksford & Chater, 1994)

Information-seeking

Alice's policy:

- Ask tripe-eaters how they feel.
- Ask sick people if they have eaten tripe lately.

(P & Q)

Bob's policy:

- Ask tripe-eaters how they feel.
- Ask well people if they have eaten tripe recently.

(P & !Q)

Which policy seems more reasonable?

("A Rational Analysis of the Selection Task as Optimal Data Selection", Oaksford & Chater, 1994)

Information-seeking

The idea:
People choose options that give them information or minimize uncertainty.

Formally:

- Uncertainty can be quantified as Shannon entropy.
- How many bits of information we need to be certain. For two outcomes, maximal when outcomes are equally likely, zero when we're certain.

("A Rational Analysis of the Selection Task as Optimal Data Selection", Oaksford & Chater, 1994)

Information-seeking

Some predictions:

- The rarity of P and Q should affect Q vs !Q choices
- The probability or plausibility of the rule matters
- Choices of P, Q, and !Q should depend on one another – some combinations are more useful than others

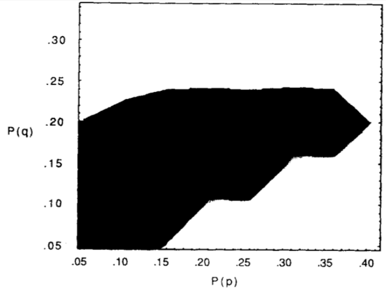

Figure 3. Plot of $P(p)$ against $P(q)$ with $P(M_I) = .5$, showing the region R (in black) where $E[I_g(q)] > E[I_g(not\text{-}q)]$.

(“A Rational Analysis of the Selection Task as Optimal Data Selection”, Oaksford & Chater, 1994)

Summary

- Classic experiments about judgment and decision-making:
  - Paired lotteries (framing effects)
  - Representative bias
  - Availability bias
  - Base rate neglect
  - Wason's card selection task
- Understanding behavior as rational, given limitations and expectations