Informatics 1 Cognitive Science

Lecture 13: Judgement and Decision Making

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Overview

Judgment and Decision Making

Judgment and Decision Making

How do people decide between different options?

- What courses should I take next year?
- What opening move should I make in a game of Go?
- Is it worth paying 50% more for nicer headphones?

Judgment and Decision Making

How do people trade off between risk and reward?

- Is the risky rescue mission worthwhile?
- Should I eat that brown thing?
- What odds/prize make it worth buying a lottery ticket?

Judgment and Decision Making

How do people decide what is true in an uncertain environment?

- Did that food make me ill?
- Is this drug effective?
- What did they really think of my presentation?
- What is that animal?

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How can we understand, explain, and predict human behavior in these settings?

Judgment and Decision Making

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We will introduce rational analysis as a framework for cognitive modeling.

Rational Analysis

Rational Analysis

Anderson (1991) spelled out a program of rational analysis for understanding and modeling behavior, broken into steps:

1. Specify the goals of the cognitive system, e.g.,
    - Minimize our expected errors when making judgments
    - Make the choice that maximizes expected reward or utility

(Anderson, J.R. 1991. Is human cognition adaptive? Behav. Brain Sci. 14, 471–517)

Rational Analysis

2. Specify the environment the system is adapted to, and the tacit assumptions or expectations that entails, e.g.,
    - Sickness is more frequently caused by food than social interaction.
    - Light comes from above.
    - People rarely say things that aren't intended to be informative.

(Anderson, J.R. 1991. Is human cognition adaptive? Behav. Brain Sci. 14, 471–517)

Rational Analysis

3. Specify any necessary computational limitations, e.g., memory and time.

"Rational behavior that is compatible with the access to information and the computational capacities that are actually possessed by organisms . . ." (Herb Simon on 'bounded rationality', 1955)

(Anderson, J.R. 1991. Is human cognition adaptive? Behav. Brain Sci. 14, 471–517)

Rational Analysis

4. Derive optimal behaviors/judgments/inferences from 1–3.
   Sometimes what's "optimal" is debatable – common to choose:
   - Inferences consistent with probability theory
   - Choices consistent with Bayesian decision theory

Sometimes "optimal" behavior is counter-intuitive; may be important to consider the bigger picture, e.g., prisoners' dilemma.

(Anderson, J.R. 1991. Is human cognition adaptive? Behav. Brain Sci. 14, 471–517)

Rational Analysis

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- A framework for developing testable theories and models
- A way to complement and constrain mechanistic and "implementation-level" theories

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- A way to complement and constrain mechanistic and “implementation-level” theories

Rational analysis – and the idea that people tend toward optimal behaviors or judgments – is not itself a testable theory:

- Under-constrained; many degrees of freedom
- Especially wrt computational limitations (usually afforded a minimal role)

The Fine Print

We must accept that:

- People sometimes have the wrong tacit expectations.
- People are sometimes solving a different problem than the experimenter thinks they are.
- Optimal solutions may not be computable (or worth computing) in the face of resource limitations.
- People are poorly adapted to solving some tasks.

With this is mind, we'll now look at some classic departures from "rational" behavior.

Heuristics and Biases

Heuristics and Biases

"[are] departures from the normative rational theory... Some of these biases were defined as deviations from some 'true' or objective value, but most by violations of basic laws of probability." (Gilovich and Griffin, 2002)

Biases:

Departures from rational behavior, e.g., from what probability theory says we should do.

Heuristics:

Simple but imperfect strategies for making decisions or inferences.

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Heuristics:

Simple but imperfect strategies for making decisions or inferences.

Note: we're now discussing cognitive biases, deviations from optimal/rational behavior. This is different from inductive biases, preferences for hypotheses in the absence of data (e.g., in word learning).

Examples of Heuristics and Biases

In this lecture and the next, we will discuss a range of biases in human decision making:

1. Framing effect
2. Representativeness bias
3. Availability bias
4. Base rate neglect

We will focus on how these have informed cognitive models of decision making.

Examples of Heuristics and Biases

Time for a short quiz on Wooclap!

https://app.wooclap.com/ZRJALA

Framing Effects

Framing Effects

Which of the following options do you prefer?

Bet 1.

A. Win £240.
B. 25% chance to win £1000, 75% chance to win nothing.

Framing Effects

Which of the following options do you prefer?

Bet 1.

A. Win £240.

B. 25% chance to win £1000, 75% chance to win nothing.

Bet 2.

C. Lose £750.

D. 25% chance to lose nothing, 75% chance to lose £1000.

Framing Effects

Which of the following options do you prefer?

Bet 1.

A. Win £240.
B. 25% chance to win £1000, 75% chance to win nothing.

Bet 2.

C. Lose £750.
D. 25% chance to lose nothing, 75% chance to lose £1000.

Possible combined bets: A and C, A and D, B and C, B and D.

(Tversky & Kahneman (1981): The framing of decisions and the psychology of choice)

Framing Effects

What might we expect people to do?

- Choose bets with the best best-case
- Choose bets with the least-bad worst-case
- Choose bets with the best expected value

Expected Utility

The expected utility of a bet with N outcomes $o_1, o_2, \ldots, o_N$:

$$\sum_{i}^{N} P(o_i) U(o_i)$$

Where $P(O_i)$ is the probability of the outcome, and $U(o_i)$ is its utility.

How might we define $U()$?

Expected Utility

We might say utility is exactly equal to monetary value:

$$U(-£750) = -750 \qquad U(£240) = 240$$

Here the expected utility with a

- 25% chance to win £1000,
- 75% chance to win £0 is:

$$U = 0.25 \times £1000 + 0.75 \times £0 = £250$$

Expected Utility

Is this a valid assumption about how we assign value to money?

Is it exactly 10 times as nice to win £100 as £10?

Expected Utility

People make choices consistent with utility (or anticipated utility) changing less than linearly with monetary gains/losses.

- Insurance: spend some money to reduce the risk of losing everything.
- Most prefer guaranteed gain of £10 to 50% chance of £20.
- Self-reported happiness increases with income but flattens off.

(But what about buying lottery tickets?)

Back to Framing Effects

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Framing Effects

Most popular choice: A and D (73% of participants)

25% chance: $240 - 0 =$ £240

75% chance: $240 - 1000 =$ −£760

Compare to B and C (3% of participants):

25% chance: $1000 - 750 =$ £250

75% chance: $0 - 750 =$ −£750

(Tversky & Kahneman (1981): The framing of decisions and the psychology of choice)

Framing Effects

Most popular choice: A and D (73% of participants)

25% chance: $240 - 0 =$ £240

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Compare to B and C (3% of participants):

25% chance: $1000 - 750 =$ £250

75% chance: $0 - 750 =$ $-$£750

If the problem is framed like this, then 100% of participants choose B and C!

(Tversky & Kahneman (1981): The framing of decisions and the psychology of choice)

Framing Effects

Many chose dominated options – strictly worse than an alternative!

Doesn't matter what utility function you use!
(Also applies with real money, and questions about human lives.)

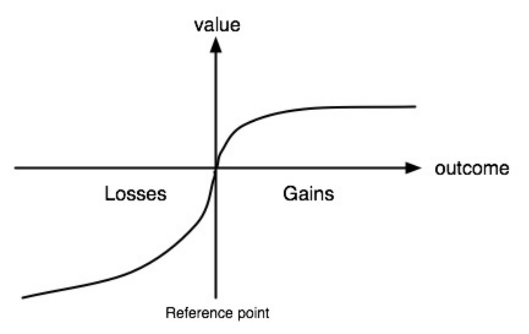
What's going on?

Prospect Theory

Prospect Theory

Three key ideas:

1. We assign diminishing value to gains and losses
2. loss aversion: gains diminish more quickly; large losses are more important to us
3. We over-weight improbable events

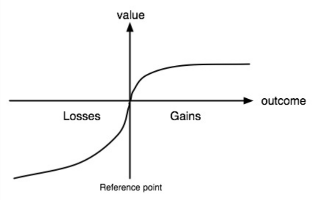


Prospect Theory

1. We assign diminishing value to gains and losses.

If $U()$ is a utility function, that is:
$U(x)$ = subjective value (or "utility") of x

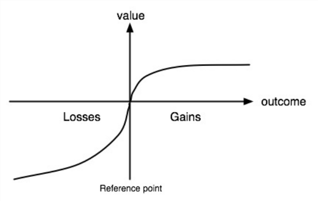
Then according to prospect theory:
$U(+£120) - U(+£110) < U(+£20) - U(+£10)$



2. Gains diminish more quickly; large losses are more important to us.

For example, losing all our money is a bigger deal than doubling it.

$U(£100) < -U(-£100)$



3. We over-weight improbable events.

More prone to long-shot gambles than we would otherwise be:

- lotteries with long odds and big payoffs
  (but tempered by the diminishing subjective gains)
- risky opportunities to avoid losses

In order to model this, we need to also introduce a probability weighting function π.

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Summary

- Rational analysis is a framework for analyzing and modeling cognition
- Rational analysis can be applied to human decision making
- Classic experiments about decision making show:
  - decisions are subject to framing effects
  - the value of gains and losses doesn't grow linearly
  - losses have a bigger effect than gains
  - the probability of rare events is overestimated
- Prospect Theory models this behavior using a value function and a probability weighting function