Cognitive decision making

Recall decision theory is a *precriptive* rather than *descriptive* theory. Human beings frequently make incoherent decisions.

Many pitfalls in the ways people assess probabilities and utilities have been identified through psychological experiments.

Classic paper:

Many follow-up studies and extensions, including many discussions in the popular literature.

Tom W.

Tom W. is of high intelligence, although lacking in true creativity. He has a need for order and clarity, and for neat and tidy systems in which every detail finds its appropriate place. His writing is rather dull and mechanical, occasionally enlivened by somewhat corny puns and by flashes of imagination of the sci-fi type. He has a strong drive for competence. He seems to have little feel and little sympathy for other people and does not enjoy interacting with others. Self-centered, he nonetheless has a deep moral sense.

†Kahneman & Tversky (1973)
Tom W.

This personality sketch of Tom W. was written during his senior year in high school by a psychologist on the basis of projective tests. Tom W. is now a graduate student. Rank the following 9 fields of graduate specialization in order of the likelihood that Tom W. is now a graduate student in each field:

- Business administration
- Computer science
- Engineering
- Humanities and education
- Law
- Library science
- Medicine
- Physical and life sciences
- Social science and social work

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Linda

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.

Which is more probable?

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

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Representativeness: Tom W.

(summarize rankings on board)

On what did you base your rankings?
Most people rank based on how similar Tom W. sounds to their preconceived notions of types of people in each field.

i.e. “Nerd” ⇒ CS or engineering

Ignores important information: Many more graduate students in humanities/education/social science than CS/engineering!

\[
p(\text{field} \mid \text{personality}) = \frac{p(\text{personality} \mid \text{field})p(\text{field})}{p(\text{personality})}
\]

Basing judgements on similarity ignores the incidence (or baseline)
(Common mistake for doctors; must consider symptoms and prevalence)

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Representativeness

The use of prototypical examples to categorize objects is known as the representativeness heuristic†.

The failure to properly account for prior prevalence is called the base rate fallacy or base rate neglect.

Widespread use of the representativeness heuristic has also been linked to other common cognitive biases and reasoning errors:

- Conjunction fallacy
- Disjunction fallacy
- Gambler’s fallacy
- Regression fallacy

†A heuristic is a “rule of thumb” that we use everyday to make decisions more quickly, but without guarantee of correctness.
**Base rate fallacy and screening**

**HIV example**

**Conjunction fallacy: Linda**

(summarize rankings on board)

Did majority choose (1) or (2)?
What’s wrong with (2)?

The probability of two events \(A\) and \(B\) occurring together (in "conjunction") is always less than or equal to the probability of either one occurring alone.

\[
Pr(A \land B) \leq Pr(A)Pr(B \mid A) \leq Pr(A)
\]

**Israeli Flight Instructors**

Pilots get praised for good landings, reprimanded for bad ones.

Flight instructors noticed that
- After receiving praise for good landing, pilot’s subsequent landing tended to be worse
- After reprimand for bad landing, subsequent landing tended to be better

Conclusion: Negative feedback (scolding) works; positive feedback (praise) doesn’t.

Reality: easily explained by regression to the mean: in presence of randomness, extreme events tend to be followed by less extreme ones.

**Regression fallacy**

The regression fallacy occurs when people ascribe the effects of statistical fluctuation to non-existent causal relationships.

"Proper treatment will cure a cold in seven days, but left to itself, a cold will hang on for a week."

Tversky & Kahneman classify the regression fallacy as a consequence of the representativeness heuristic. People identify exceptional outcomes as representative of average ones§.

We are more likely to take action when outcomes are extreme, and then attribute regression to the mean as resulting from action.

§(See also availability bias below)
Cats and sharks

Do cats have an unusual ability to survive long falls?

Which is more likely, dying from a shark attack or from being hit by falling airplane parts?

Fewer heartwarming anecdotes told about cats falling out of trees and dying.

Shark attacks widely reported in media; airplane part deaths not.

Availability bias: People judge the probability that an event will occur according to the ease with which we can retrieve similar events from memory.

Retrievability is a function of
- Recency
- Unusualness

Availability

Example: after driving past a traffic accident, you probably drive more carefully (for awhile) - increases your perceived likelihood of having accident.

News: Reports sensational stories. People left with impression murder much more likely than it is, relative to e.g. heart attack. ⇒ Leads to inefficient resource allocation (security vs exercise).

Illusory correlation: If you think good things happen every time you wear your “lucky shirt”, you’ll be more likely to recall cases where
- Something good happened while wearing shirt than
- Wearing shirt, nothing good or
- Something good, not wearing shirt
thus reinforcing your superstitious belief.

(e.g. homeopathic medicine - remember “successes”, not failures)

Illusory correlation

Note: human mind has tendency to find patterns where none exist.

This itself has a decision-theoretic basis in evolution:

Negative utility of running away when see a bush moving in the wind is relatively small.

Negative utility of not running when caused by tiger is fairly large.

Our brain is good at finding spurious correlations, since cost is often minimal - hence prevalence of superstitious behavior.

Anchoring

In estimating, we often choose an initial value or the first piece of information offered (the anchor) and then adjust that value based on the specifics of the event in question.

What will your monthly expenses be for the upcoming year?
Take last year’s, and adjust up/down.

Usually the adjustment is insufficient.

Study (Dan Ariely, Duke): Subjects were asked to write the last 2 digits of their SSNs at top of auction form. Then bid on items of unknown value: wine, gourmet chocolate, computer equipment.

Those with higher SSNs bid 60-120% higher!
Anchoring

Advertising and marketing industries make extensive use of this:

Menu design in restaurants: including some expensive wines (always at the top of the list . . . ) makes others seem a bargain.

Luxury goods stores carry one very expensive item (handbag, dress, watch, car) they don’t expect anyone to buy.

Maybe you can’t have the $10,000 handbag, but you can afford the $20 (whatever) with the same logo. (on which profit margin is obscenely high)

For an entertaining discussion aimed at lay audiences see:
- *Priceless: The myth of fair value (and how to take advantage of it)* by William Poundstone.

Anchoring

Has implications for probability assessment.

When assessing continuous probability distributions, if start with mean/median, tend to get distributions that are *too narrow*.

⇒ overconfidence; underestimating variance/risk.

To help avoid this, assess .05 and .95 quantiles *first*, before median.

In general (due to both anchoring and availability biases) we tend to *under*estimate the probability of extreme events.

As in previous discussion of scoring rules, people can improve ability to accurately assess probs with practice.

Easier when feedback immediate and opportunities frequent.

Motivational Bias

In addition to weaknesses in human information processing, *incentives* often lead people to (consciously or unconsciously) report probabilities/predictions that don’t accurately reflect beliefs.

*Stockbrokers*: who receive commission on sales, tend to predict
- New stocks will go up (buy)
- Old stocks owned will go down (sell)

*Realtors*: “Best offer is first offer” but . . .

Tend to wait longer, and sell houses several % higher, when selling own houses. Why?

Only 3% of sales price; holding out for few $1000’s more on a $300k house not worth risk of delay, more work

But may be worth it to you!

*Salespeople*: May forecast lower sales in order to look better, get bonus when sales exceed forecast.

Similar effect with political campaigns forecasting debates.

Framing

*(summarize influenza example results)*

Risk attitudes can depend on way decision problem is posed.

People tend to be:
- *risk-averse* when considering gains
- *risk-seeking* when considering losses

Call *loss aversion*.

Implies a “utility function”\(^*\) for changes in wealth of form: *(Figure)*

Implications for personal financial decision making:

Is your tax return money you didn’t lose? Or money you won?

Affects whether you spend or save it

\(^*\) Not a true utility function - why?
Framing

Prospect theory is an area of behavioral psychology, that describes human decision making under uncertainty. It attempts to be descriptive rather than prescriptive or normative, and deals with the certainty effect, differential risk aversion for losses and gains, etc.

Side note: beware of push-polls: “surveys” actually designed to sway your opinion
Common in marketing, politics.

Sunk Cost Fallacy

What is “status quo” when making decisions?
Gambler on losing streak: current vs initial balance
Manager with project gone bad: doesn’t want to “waste” resources already spent
⇒ tendency to “throw good money after bad”.

Abandoning project seems like certain loss of money invested, vs risky gain by continuing. (using old status quo)
But real status quo is money gone; if prospects of success poor, better to spend new funds on better ventures.

In decision analysis, money already spent has no relevance; all decisions forward-looking. (sunk costs subtracted from all branches, so can’t affect decision)

Which gamble do you prefer?

Make the following decision quickly, without any calculation:

A Win $1 million with prob 1
B Win  
\[
\begin{align*}
$5 \text{ million} & \quad \text{w prob} \ .1 \\
$1 \text{ million} & \quad \text{w prob} \ .89 \\
$0 \text{ million} & \quad \text{w prob} \ .01 
\end{align*}
\]

Which would you choose?

Now consider:

C Win  
\[
\begin{align*}
$1 \text{ million} & \quad \text{w prob} \ .11 \\
$0 \text{ million} & \quad \text{w prob} \ .89 
\end{align*}
\]

D Win  
\[
\begin{align*}
$5 \text{ million} & \quad \text{w prob} \ .1 \\
$0 \text{ million} & \quad \text{w prob} \ .9 
\end{align*}
\]

Which would you choose?
Allais Paradox

Most people prefer:

A over B
D over C

Let $U(0) = 0$ and $U(5M) = 1$ (best and worst outcomes).

But note that for decision 1:

$$EU(A) = U(1M)$$
$$EU(B) = 0.1 + 0.89U(1M)$$

$$\Rightarrow EU(A) > EU(B) \text{ iff } U(1M) > 0.1 + 0.89U(1M)$$

or $U(1M) > 0.91$

For decision 2,

$$EU(C) = 0.11U(1M)$$
$$EU(D) = 0.1$$

$$\Rightarrow EU(D) > EU(C) \text{ iff } U(1M) < 0.91$$

Inconsistent!

Tversky & Kahneman attribute this to the certainty effect: people place too much weight on avoiding uncertainty.

Policy implications: We tend to spend too much time/money trying to completely eliminate risks (e.g. environmental exposure to carcinogens). Zero risk is not achievable.

Another illustration of loss aversion.

Other biases and further reading

Psychologists love to measure and name these; google "cognitive bias" for a long list of others.

These topics have received extensive treatment in the popular literature, especially w.r.t. financial decision making and marketing. Some examples:

- *Thinking Fast and Slow*, by Daniel Kahneman.
- *Priceless: The myth of fair value (and how to take advantage of it)* by William Poundstone.