Statistical Reasoning & Decision Making

Decision Making

- Is human decision making optimal?
  – Guided by normative theories devised by economists and philosophers
- Traditional Assumption: Yes.
  – Just need to figure out what's being optimized
  – Study what people value
  – If we know what people value, can predict their choices

Decision Making

- Modern Take: Probably Not!
  – Limited information
  – Limited processing capacity
- However, people good at quick decisions under non-optimal conditions
- But first, how does human decision making deviate from economists' norms?

Heuristics & Biases

- Visual Illusions
- Cognitive Illusions
  – Situations where heuristics and strategies fail or are misleading
  – Sub-optimal/Irrational decisions point to mechanisms
- Sub-optimal, but largely effective
  – Analogous to vision
  – Bounded Rationality (Simon)

Normative Rational Models

- Irrational Reasoning
  – Reasoning processes that reach contradictory conclusions based on the same evidence
    - A > B AND B > A ← Irrational
- Consistency important
  – If John prefers a paper clip to a stereo, and a stereo to a free trip around the world, then John should prefer a paper clip to a free trip around the world

Normative Rational Models

- Prescriptive Models
  – How we should perform
  – Given assumptions about a person's goals, these models tell us what choices are optimal
  – Provides norms for evaluating human decision making
- Descriptive Models
  – How we do perform
  – Sometimes differs from that prescribed by normative models

Expected Value Theory

- Winning $40 with probability of .2
- Winning $30 with probability of .25

- $40 x .2 = $8
- $30 x .25 = $7.50
- Expected Value = (Value of Outcome) x (Probability of Outcome)

Come on! Who takes EVT seriously?

The Government

- Since Executive Order 12291 all federal agencies must weigh costs against benefits before writing new regulations
- 51 construction workers died when a scaffold collapsed at a power plant. OSHA proposed new safety rules estimated to save 23 lives/year and cost $27.3 million

"Since OSHA valued a life at $3.5 million, the regulation easily passed the cost-benefit test. But the Office of Management and Budget, the administration's regulatory gatekeeper, stepped in with a new price on a construction worker's life – $1 million, based on its own research – that stalled the rules for years." *San Diego Union* July 14, 1990

Paradoxes Generated by EVT

- Limitations of EVT revealed in paradoxes it produces
- Paradox – 2 inconsistent statements, both of which are intuitively true
- Resolution of a paradox can lead to changes in theory that gives rise to it

Allais Paradox

- Propose 2 choice situations where people agree on the rational decision in each case
- Then show that these 2 decisions are inconsistent

Allais Paradox: Choice One

- $1,000 w/probability of 1.0

- $1,000 w/probability of .89
- $5,000 w/probability of .10
- $0 w/probability of .01

Allais Paradox: Choice Two

- $1,000 w/probability .11
- $0 w/probability .89

- $5,000 w/probability .10
- $0 w/probability .90

Inconsistency

- Expected Value has not been maximized
- Expected Value has been maximized

Same Choice

Choice 1
- $1,000 w/probability of 1.0

Choice 2
- $1,000 w/probability .11
- $0 w/probability .89

- $1,000 w/probability of .89
- $5,000 w/probability of .10
- $0 w/probability of .01

- $5,000 w/probability .10
- $0 w/probability .90

Same Choice

Choice 1
- **$1,000 w/probability of 1.0**

Choice 2
- $1,000 w/probability .11
- $0 w/probability .89

- $1,000 w/probability of .89
- $5,000 w/probability of .10
- $0 w/probability of .01

- **$5,000 w/probability .10**
- **$0 w/probability .90**

Responses to Allais Paradox

- Expected Value Theory should be revised to account for special status of “sure thing” options
- People don’t calculate EV when confronted w/complicated choices

Certainty Effect (Kahneman & Tversky)

- 80% probability of losing 100 lives
- 100% probability of losing 75 lives
- People prefer 80% probability of losing 100 lives

- 10% chance to lose 75 lives
- 8% chance to lose 100 lives
- People prefer 10% chance to lose 75 lives
- But this choice is the same as the first, with probabilities reduced by a factor of 10

Certainty Effect (Kahneman & Tversky)

- **80% probability of losing 100 lives**
- 100% probability of losing 75 lives
- EVT says
  - first choice loses 80 lives
  - second loses only 75 lives
  - second choice better
- Outcomes perceived with certainty are overweighted relative to uncertain outcomes

- **10% chance to lose 75 lives**
- 8% chance to lose 100 lives
- EVT says
  - first choice loses 7.5 lives
  - second loses 8 lives
  - first choice (the one people choose) better
- When certainty doesn't cloud the picture, people choose in accordance with the normative theory

Preference Reversals

- People make a distinction between how attractive a particular choice is and how much they're willing to pay for the chance to make the gamble
- Decision making theories typically consider these two factors equivalent measures of preference

Preference Reversals

- Bet A
  - 11/12 chance to win 12 chips
  - 1/12 chance to lose 24 chips
- Bet A chosen 50% of time
- Bet A received a higher selling price 12% of time

- Bet B
  - 2/12 chance to win 79 chips
  - 10/12 chance to lose 5 chips
- Bet B chosen 50% of time
- Bet B received a higher selling price 88% of time

Slovic and Lichtenstein, 1968

Framing Effects

- Irrational (inconsistent) decision making can be shown by presenting the same information in two different forms
- Changes in decision associated with different presentation forms are known as framing effects

Framing Effects

- Imagine the US is preparing for an outbreak of disease which is expected to kill 600 people. 2 programs are proposed:
- Which would you choose?
- Program A: 200 people will be saved
- Program B:
  - 1/3 prob 600 people saved
  - 2/3 prob no people will be saved

Alternative Framing

- Program C: 400 people will die
- Program D: 1/3 probability no people will die, 2/3 probability 600 people will die
- Which would you choose?

Framing Effect

- Program A and Program C identical
- Program B and Program D identical
- But people prefer
  - A (save 200 people) over B (1/3 save 600) and
  - D (2/3 600 die) over C (400 people die)
- Certainty affected decisions about lives *lost* differently from lives *saved*

Sunk Cost Fallacy

- When past actions affect future choices in an irrational manner
- Walk out of a play when you've paid $10/ticket, but not when you've paid $50/ticket
- If you walk out, you will not get your money back, regardless of how much you paid!

Framing Effects

- Change in decision associated w/different presentation forms
  - Lives Saved versus Lives Lost
  - Sunk Cost of $10 vs. Sunk Cost of $50
- Irrational because inconsistent
- But can lead to adaptive decisions in some circumstances
  - E.g. sunk cost 'fallacy' adaptive in cases that require modest negatives followed by strongly positive outcomes
    - learning tennis
    - long-term investment in the stock market

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Problems with EVT

- Generates Paradoxes
  - EVT's best option doesn't always seem best
- Preference Reversals
  - Attractiveness of gamble doesn't predict how much people willing to buy or sell for
- Subjective vs. Objective Worth
  - Diminishing returns
  - Thresholds (e.g. tuition)

Expected Utility Theory

- Utility – subjective value, not objective value
- People maximize expected utility rather than expected value

Expected Utility

$$\sum_{i=1}^{n} P_iW_i = P_1W_1 + P_2W_2 + \ldots P_nW_n$$

W = subjective worth of consequences (utility)
P = probability of outcome

- To calculate worth
  - Compute worth of each of the possible consequences and the probability of each
  - Multiply each W by its P
  - Sum the products

Why people gamble…

- Expected Value

= P(W)*V(W) + P(L)*V(L)
= 1/6($4) + 5/6(-$1)
= – $1/6

- Expected Utility

= P(W)*U(W) + P(L)*U(L)
= 1/6($4+$2) + 5/6(-$1)
= +$1/6

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Prospect Theory

- Kahneman & Tversky
- Modification of EUT
  - Utilities not evaluated in absolute sense
    - Evaluated wrt reference point
  - Utilities not multiplied by objective probabilities
    - Multiplied by the π function instead

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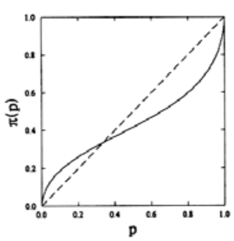
π Function in Prospect Theory



- Low and High Probabilities Over-weighted
- pi(1) > 2*pi(.5)
- Probabilities are not additive

Regret Theory

- People overweight anticipated feelings of regret when the difference between outcomes is large

	Ticket Numbers			
Option	1-9	10-21	22-24	
A	$24	$0	$0	←
B	$0	$16	$0	

	Ticket Numbers			
Option	1-9	10-12	13-24	
C	$24	$0	$0	
D	$16	$16	$0	←