Choice under uncertainty:
Basic theory and behavioral evidence

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Outline: Theory

• Dual systems models
  – experiential/affective vs. analytic processing
  – Uncertainty elicits affective and analytic responses
  – Learning occurs by trial and error (from experience) and by vicarious transmission (from description)

• Models of choice under risk or uncertainty
  – EU theory and descriptive successors
    • Prospect theory (1979)
    • Cumulative prospect theory (1992)
  – Risk—return model and descriptive successors
Outline: Date

• Behavioral evidence
  – Related to outcomes
    • Risk aversion
    • Reference-dependent perception and encoding
    • Loss aversion
  – Related to probabilities/likelihood
    • Certainty effect
    • Rank-dependent probability evaluation
    • Ambiguity aversion
  – Related to variability/risk
    • Reference-dependent perception and encoding
Outline: Predictors

• Individual difference
  – Risk attitude
    • How to assess/measure
    • Confound with individual and group differences in perception of risk
  – Degree of loss aversion
  – Others

• Situational differences
  – Amount and type of uncertainty
  – Degree of risk
  – Domain of decision
    • Familiarity of decision maker with domain
    • Expertise of decision maker in domain
Dual Systems Models
Epstein, 1994; Kahneman, 2002; Sloman, 1996; and others

• **Analytic system**
  – new evolutionary accomplishment; only available to homo sapiens in full form
  – effortful, slow, requires conscious awareness, and knowledge of rules
    • e.g., probability calculus, Bayesian updating, formal logic
  – Conscious calculation-based decisions
    • May become habits/rules by virtue of repeated execution

• **Experiential system**
  – evolutionarily older, hard-wired, fast, automatic
    • Trial and error learning: Association between behavior and consequences
    • Emphasis on outcomes of decisions (probabilities not explicitly represented)
    • Emotions as a powerful class of associations
      – risk represented as a “feeling” that serves as an “early warning system”
  – Affect-based decisions (fear or worry as motivator for action)
  – Rule-based decisions that get triggered (automatically) by cues in the environment
    • Emergency room procedures, trading floor decisions
Analytic and Experiential System

• Interact to some extent
  – Emotional reactions can be input into analytic processing

• Operate in parallel
  – “Is a whale a fish?”
  – Affective/experiential system is fast, delivers output earlier
  – when output of two systems in conflict, behavior typically determined by experiential processing system (Loewenstein, Weber, Hsee, & Welch, 2001)

• Discrepancy in output of two systems often accounts for controversies and debates about magnitude and acceptability of risks
  – e.g., nuclear power, genetic engineering
    • Technical experts and academics rely more heavily on analytic processing
    • Politicians, policy makers, media, and general public rely more heavily on experiential/affective processing
Predictability

• Powerful human need and human skill
  – result of evolutionary selection (or “intelligent design”)

• Provides control
  – avoid threats to physical and material well-being

• Allows to plan and budget for the future
  – Homo sapiens arguably the most successful species on earth
Need for Control

• So strong, it can lead to wishful thinking
  – “illusion of control” in situations that are obviously determined by chance
    • superstitious behaviors
    • control, even when illusory, has important health benefits
  – Overconfidence in our ability to predict correctly

• Perceived lack of control raises anxiety, individually and socially
  – Inverse u-shaped function for beneficial effect of anxiety
  – Moderate levels motivate behaviors to regain control
    • information search, theory building
    • science and technology development
      – Forecast developments for weather, climate, earthquakes, economy, etc.
Risk as Feelings

• **Affect is the wellspring of action**
  – Emotions are evolution’s way to get us to do things that are good for our survival and reproductive success
    • Positive emotions want to be maintained
    • Negative emotions (fear, anxiety) act as an early warning system that triggers protective action
      – “…woe speaks: ‘cease, go,’ but all lust wants eternity, wants deep, deep, deep eternity…” Nietzsche

  – Without *feeling* of being at risk, we fail to allocate attentional and material resources to risk management
    • Attention as our ultimate scarce resource
      – Source of bounded rationality (Simon, 1957)
Psychological Risk Dimensions

• Psychological risk dimensions shape the feeling of being “at risk” in specific situations
  – Reducible to two dimensions: predictability and dread (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987)
  – “Dread”/affective component predicts risk perceptions of financial investments by U Chicago MBA students above and beyond probability distribution of possible outcomes
    • Holtgrave & Weber, 1993

• Risks that score low on both psychological risk dimensions fail to elicit adequate protective responses
  – inadequate saving for retirement
  – Inadequate mitigation of or adaptation to climate change
How do we learn/know about the possible outcomes of different actions?

• Via analytic system, in “Decisions from Description”
  – Outcome distribution fully described
    • possible outcomes and their probabilities provided numerically or graphically
      – seasonal climate forecast for next growing season
      – hurricane warning issued by local TV station
  – Extensive use of analytic processing system
    • rare events are overweighted (Prospect Theory)

• Via experiential system, in “Decisions from Experience”
  – Outcome distribution initially unknown
    • knowledge of possible outcomes and their likelihood acquired by personal exposure in repeated choices
      – intuitive forecast of climate in next growing season based on years of experience
      – intuitive assessment of likelihood of being affected by hurricane based on past experience with warnings and events
  – Extensive use of experiential processing system
    • Recency bias
      – recent events get disproportionate weight
      – rare events are underweighted, unless they recently occurred
Adaptive Value of Recency Bias in Experiential Processing

• Good idea in nonstationary environments
  – When contingencies between behavior and outcomes change over time (e.g., trends, cyclical changes), putting more weight on recent observations makes sense

• Underweighting of low-probability events until they occur and overreaction to them once they occur as the price we pay for a generally adaptive behavior
Expected Utility (EU) Theory as Model of Decisions under Uncertainty

• Conceptually present since Bernoulli (1838)
  – St. Petersburg paradox

• Axiomatized by von Neumann & Morgenstern (1947)
  – Transitivity, connectedness, independence axioms
  – Bedrock of rationally-consistent responses by economic man

• Problems
  – Failures of description invariance
    • Outcome framing
    • Response task
  – Failures of coefficient of risk aversion as a stable individual difference measure
    • Different risk attitudes in different domains
    • Degree of risk aversion inferred from choices for small stake gambles does not predict degree of risk aversion for choices between large stake gambles (Rabin 2003)
Prospect Theory

• Psychological extension/”fix” of expected utility theory
  – by Kahneman and Tversky (1979)

• Prospects are evaluated by
  – Value function
  – Decision Weight Function

• Value Function:
  – Defined over gains and losses on deviations from some reference point
  – Concave for gains (risk-averse), convex for losses (risk-seeking)
  – Steeper for losses than for gains ("losses loom larger")
If you were faced with the following choice, which alternative would you choose?

Option A: A sure gain of $240.

Option B: A 25% chance to gain $1,000 and a 75% chance of getting $0.
If you were faced with the following choice, which alternative would you choose?

Option A: A 100% chance of losing $50.

Option B: A 25% chance of losing $200 and a 75% chance of losing nothing.
Prospect Theory Value Function

• **Relative Evaluation:**
  Value is judged relative to a reference point

• **Diminishing sensitivity**
  – Risk averse for gains
  – Risk seeking for losses

• **Loss Aversion:**
  Losses loom larger than gains
Endowment Effect and Status Quo Bias
as a result of Loss Aversion
(Camerer, 2000)

• Endowment effect
  – more painful to *give up* an asset than it is pleasurable to *acquire* it
    • *selling* prices are higher than *buying* prices, contrary to economic theory
    • violates Coase’s theorem that initial ownership of assets does not matter
  – results in status quo biases
    • disadvantages of leaving the current state seem larger than advantages
    • provides powerful advantages for decision defaults (Johnson & Goldstein, 2003)
Prospect Theory (1979) Decision Weight Function

- Certainty Effect
  - Overweight low p
  - Underweight high p
(Q3)

If you were given a choice which of the following gambles would you prefer?

Option A: $1,000,000 for sure.

Option B: A 10% chance of getting $2,500,000 and a 89% chance of getting $1,000,000 and a 1% chance of getting $0.
(Q4)

If you were given a choice, which of the following gambles would you prefer?

Option A: An 11% chance of getting $1,000,000 and an 89% chance of getting $0.

Option B: A 10% chance of getting $2,500,000 and a 90% chance of getting $0.
Effect of affective vs. analytic processing on decision weights

• Probability of event has less impact for emotionally engaging outcomes than for less engaging outcomes
  – Decision weight function flattens out between 0 and 1 (Hsee & Rottenstreich, 2001)
Cumulative Prospect Theory (CPT, 1992)

- Replaced 1979 decision weight function with rank-dependent formalization of decision weights
  - Decision weights still subjectively different from objective probabilities (“distorted”), but now add up to one
    - avoids predictions of violations of stochastic dominance of previous formalization
  - Weighting of probability no longer independent of outcomes
    - Specifically, dependent on the rank of outcome
Decision weights as attentional weights
(Weber & Kirsner, 1997)

• Different redistributions of weight are possible
  – S-shaped CPT version puts extra weight on highest and lowest outcome, “robbing” weight from middle outcomes
  – Optimistic weighting function puts extra weight on higher outcomes
  – Pessimistic weighting function puts extra weight on lower outcomes

• Attention can be drawn by both perceptual (external, situational) and motivational (internal) variables
  – Perceptual effects
    • Looking at highest and lowest outcomes to process “range” is very natural
  – Motivational effects
    • Buyers vs. sellers have different asymmetric loss functions for over- vs. undervaluing risky or uncertain choice options
    • Stable individual differences in optimism vs. pessimism
Ambiguity Avoidance
Camerer & Weber, 1992

• People prefer to bet on known odds rather than on ambiguous odds of equal size
  – Ellsberg’s paradox

• However, in domains of perceived competence, they prefer ambiguous odds
  – Basketball game vs. game of chance (Fox & Tversky, 1998)
  • Related to emotional comfort with familiar situations
  • Ambiguous odds in such contexts do not send an affective “risk” signal
  • Familiarity and perceived expertise leads to lower perceptions of riskiness (Weber, Siebenmorgen, Weber, 2005)
Ellsberg’s Paradox
Imagine an urn known to contain 90 balls. Thirty of the balls are red, the remaining 60 are black and yellow in unknown proportions. One ball is to be drawn at random from the urn. Consider the following actions and payoffs:

**Situation X**

<table>
<thead>
<tr>
<th>Act</th>
<th>Red</th>
<th>Black</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act 1. Bet on red</td>
<td>$100</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Act 2. Bet on black</td>
<td>$0</td>
<td>$100</td>
<td>$0</td>
</tr>
</tbody>
</table>

**Situation Y**

<table>
<thead>
<tr>
<th>Act</th>
<th>Red</th>
<th>Black</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act 3. Bet on red or yellow</td>
<td>$100</td>
<td>$0</td>
<td>$100</td>
</tr>
<tr>
<td>Act 4. Bet on black or yellow</td>
<td>$0</td>
<td>$100</td>
<td>$100</td>
</tr>
</tbody>
</table>
Risk—Return Models of Risky Choice

• Finance literature
  • Risk—Return models: e.g., Capital Asset Pricing Model (Markowitz, 1952)
    – $\text{WTP}(X) = V(X) - bR(X)$
    – Willingness to Pay for Option X involves a tradeoff between Return (EV) and Risk, or between “greed and fear”

• Animal literature (behavioral ecology)
  • risk-sensitivity theory
    – energy-budget model describes a very similar tradeoff for the risky foraging decisions made by birds and insects

• Common feature of models
  – Decomposition of risky options into two moments
  – Risk is a function of variability/variance of outcomes
Problems with Risk as Variance

• Variance of outcomes does not describe how people perceive the risk of risky options
  – Upside and downside variability do not enter symmetrically
    • Downside gets greater weight
  – Variability and risk often perceived in a relative fashion
    • found in very basic psychophysical judgments like perceived loudness or brightness (Weber’s law, 1834)
    • coefficient of variation (CV) a measure of relative risk: risk per unit of return
      – defined as standard deviation / expected value
      – used in many applied areas
        » engineering, medicine, agricultural economics, etc.

• Perceptions of risk vary between individuals and groups
  – Is not a situational constant
Psychological Risk—Return Models
(Bell, 1995; Jia & Dyer, 1996)

• Keep EV as measure of return
• Substitute different measures of risk for variance
  – Correcting for general shortcomings of variance
  – Allowing for group of cultural differences in the perception of risk
• Introduce perception of risk (with analytic and affective determinants) as another predictor of choice
  – Removal of confound of situational differences in perception of risk (due to familiarity or expertise) often restores cross-situational generality to pure attitude towards risk
Summary: Choice under Uncertainty

• Basic theory
  – Relative perception and representation of outcomes and variability has necessitated modifications of prescriptive theory
    • Relative perception is fundamental
      – Three-buckets-of-water thought experiment
    • Relative judgments and ordinal representation are far easier than absolute judgments
      – Thurber joke

• Behavioral evidence
  – Deviations of choice from prescriptive models can be either
    • Biases that result from adaptations of human decision making system to bounded rationality constraints
    • Functional adaptations to specific decision making environment
      – Nonstationarities
      – Specific distributions of objects or events
Overconfidence

“Sensible and responsible women do not want to vote.”
Grover-Cleveland, President of U.S., 1905

“There is no likelihood man can ever tap the power of the atom.”
Robert Milikan, Nobel Prize in Physics, 1923

“Heavier than air flying machines are impossible.”
Lord Kelvin, President of Royal Science Society, 1895
Overconfidence in judgments or decisions

• Confidence ratings
  – Poor calibration found in most cases
    • Proportion of time a prediction of answer is correct ought to equal the confidence assigned to that estimate
    • Only weather forecasters, bookies, and expert bridge players are well calibrated
      – Due to availability of quick and frequent corrective feedback

• Confidence intervals (CIs) tend to be too narrow
  – 95% CIs are closer to 50% CIs
    • E.g., in series of general knowledge questions
      – Length of Nile river?
    – engineering discount/safety factors are social acknowledgment of systemic overconfidence
A sample of 20 golf pros were asked to predict their success in making the six-foot put:

• “Most of the players on the PGA tour guessed that at least 70% of their six-footers would drop. Tour rookie Billy Mayfair, a former U.S. Amateur champion and a very good putter, thought the success average was about 80% and his own average ‘around 91%-92%.’”

• “Veteran Dave Barr, who was more typical, said: ‘If you aren’t making at least 85% of your six-footers, you aren’t making any money.’ Told the actual average was 54.8%, Barr said, “I don’t believe that.”

(Sports Illustrated, March 1989)
PGA Tour: Probability of making putts from different lengths.

<table>
<thead>
<tr>
<th>Length</th>
<th>% made</th>
<th>Length</th>
<th>% made</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’</td>
<td>93.3</td>
<td>11’</td>
<td>31.6</td>
</tr>
<tr>
<td>3’</td>
<td>83.1</td>
<td>12’</td>
<td>25.7</td>
</tr>
<tr>
<td>4’</td>
<td>74.1</td>
<td>13’</td>
<td>24.0</td>
</tr>
<tr>
<td>5’</td>
<td>58.9</td>
<td>14’</td>
<td>31.0</td>
</tr>
<tr>
<td>6’</td>
<td>54.8</td>
<td>15’</td>
<td>16.8</td>
</tr>
<tr>
<td>7’</td>
<td>53.1</td>
<td>16’</td>
<td>13.4</td>
</tr>
<tr>
<td>8’</td>
<td>46.3</td>
<td>17’</td>
<td>15.9</td>
</tr>
<tr>
<td>9’</td>
<td>31.8</td>
<td>18’</td>
<td>17.3</td>
</tr>
<tr>
<td>10’</td>
<td>33.5</td>
<td>&gt;19’</td>
<td>14.6</td>
</tr>
</tbody>
</table>

(Sports Illustrated, March 1989)
Reasons for Overconfidence

• **Attentional**
  – Selective information and memory search
    • Difficult to know what we don’t know
    • Confirmation bias
    • Implications for veridicality of personal recollections of climate information

• **Motivational**
  – Need to appear competent and confident to others and oneself
  – Confidence and optimism help to get the job done
"Perpetual optimism is a force multiplier."

The ripple effect of a leader's enthusiasm and optimism is awesome. So is the impact of cynicism and pessimism. Leaders who whine and blame engender those same behaviors among their colleagues. I am not talking about stoically accepting organizational stupidity and performance incompetence with a "what, me worry?" smile. I am talking about a gung-ho attitude that says "we can change things here, we can achieve awesome goals, we can be the best." Spare me the grim litany of the "realist," give me the unrealistic aspirations of the optimist any day.