Non-standard Decision-making

Cognitive foundations

Advanced course in Behavioural and Psychological Economics

Tampere University

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Link to updated version

Bibliography:

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Topics

Introduction

Noisy Approximations

Comparative Thinking

Reduced Cardinality

Analogies and Categorization

Complexity Aversion

Introduction

Standard theory poses:

$$\max_{x_t^i \in X_t} \sum_{t=0}^{\infty} \delta^t \sum_{s_t \in S_t} p(s_t) U(x_t^i \mid s_t) \tag{1}$$

- $U(x \mid s)$: utility
- x^t: period t payoffs
- $p(s)$: probability of state s
- δ: (time-consistent) discount factor

Introduction

Standard theory poses:

$$\max_{x_t^i \in X_t} \sum_{t=0}^{\infty} \delta^t \sum_{s_t \in S_t} p(s_t) U(x_t^i \mid s_t) \tag{1}$$

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. . . but **individuals not always optimize**

Information Processing is Imperfect!

1. **Procedures and Algorithms complexity**
   - Simple problems
     → Behavior can be well-approximated by the standard maximizing model
   - Complex problems
     → People rely on specific procedures or algorithms
     → Arrieta & Nielsen (2023): As problems become more complex, people perform better in describing their decision-making process to others
   - '*Complexity*': refers to the cost of information processing in computer science
     → Oprea (2020): People are willing to pay to avoid implementing certain rules!
     Which ones? Those with higher 'dimensionality'

Information Processing is Imperfect!

2 Decision Maker

- Cognitive resources
  - → Abundant evidence of differential choices and beliefs
    - Hard to reconcile with preferences
    - Natural from a perspective of imperfect information processing
- Experience
  - → Behavioral attenuation weakens as decision makers gather more experience with a specific problem configuration
    - Suggestive of efficient coding
      - Optimal reduction of noise for problems encountered frequently

The Cognitive Turn on Behavioral Economics

Focus on explaining and unifying anomalies

- Shift away from accumulating new deviations from neoclassical predictions
- Explore interrelationships between biases
- Many behaviors reflect imperfections in basic information processing

Replace reduced-form notions of biases

- Focus on cognitive mechanisms underlying choice behavior:
  - → 'Which cognitive limitation generates this choice behavior?'
  - → 'How does it resemble anomalies in other domains?'
- Rather than:
  - → 'Which utility function rationalizes this choice?'

The Cognitive Turn on Behavioral Economics

- **Literature:**
  - Mostly recent: 2020s
  - Classical antecedents:
    - → Bounded rationality (Simon, 1956)
    - → System 1 vs. System 2 (Kahneman, 2011)

- **Why so recent?**
  - More complex than previous explanations
    - → Reduced-form approach avoids complexity
    - → Reduced-form approach is more workable in (theory and) practice

The Cognitive Turn on Behavioral Economics

- **(Most) economic decisions are difficult**
  - Intensive information processing requirements
- **People rely on simplification strategies**
  - Strategies play out similarly across contexts:
    1. Noisy Aproximations
    2. Comparative Thinking
    3. Reduced Cardinality
    4. Analogies or Categorization
    5. Complexity Aversion (avoiding options that are difficult-to-assess)
- **Decision problem features affect information-processing imperfections**
- **Still no unified model**

Theoretical Framework

Consider a decision maker taking a decision to maximize overall utility, which is comprised of different problem dimensions i:

$$\max_{a} U(a, \theta) = \sum_{i} u_i(y_i) = \sum_{i} u_i(g_i(a, \theta)) \tag{14}$$

- $u_i(y_i)$: dimension-by-dimension utility
- y_i: outcomes
- $g_i(\cdot)$: outcome production functions
- a: decision
- θ: economic fundamentals

Theoretical Framework

Decision maker would choose the decision that maximizes utility:

$$a^*(\theta) \in \arg\max_a U(a, \theta), \qquad \frac{\partial a^*(\theta)}{\partial \theta_j}|_\theta \equiv \beta_j$$

This maps economic fundamentals in a way the maximizes utility ...

but this is a rather strong assumption!

Some examples:

- How many hours should you work per week to maximize your discounted expected lifetime utility?
- How much of your money should you invest in the stock market?
- Interest rate increases from 0% to 4%. What additional fraction of your income should you save now?
- Do you prefer a 30% chance of getting 120 EUR or a 85% chance of getting 40 EUR ?

Do people know the optimal decision?

Indirect evidence of choice uncertainty

- Standard measures of preferences strongly depend on the elicitation format
  - → e.g., *self-reported altruism* vs. *incentivized donation to A* vs. *incentivized donation to B*
- Experimental manipulations have systematic effects on observed choices
  - → Problem complexity (e.g., 1 vs. $\int_0^\infty e^{-x}\,dx$)
  - → Cognitive resources (e.g., *high or low time constraints*)
- Anomalous preferences correlated with behavior in cognitive problems

Measurements of choice uncertainty

- Direct questions to decision makers
- Deliberate randomization strategies
- Willingness to delegate decisions

What makes problems hard?

Cardinality

- The more dimensions a problem has, the harder
  - → Outcomes of interest
  - → Variables to consider
  - → Signals received
- e.g., *'vanilla or chocolate?'* vs. *'small vanilla with sprinkles vs large chocolate with nuts?'*

Aggregation

1. Requires introspection
   - → 'What is my discount/risk factor?'
2. Even with all information available, decision makers still need to process it
   - → Tradeoffs present vs future / risk vs certainty

What do people do?

- They avoid information processing by simplifying!
- Main responses:

Simplify the aggregating process

1. (Noisily) approximate
2. Bracket and compare

Subset to simplify the problem

3. Reduce cardinality

Solve a simpler problem

4. Thinking in analogies and categories
5. Avoiding objects one cannot properly evaluate

Are these responses deliberate?

Sometimes yes, . . . but sometimes no.

Proposed solutions will depend on the source of the response:

- **Deliberate simplifications**
  - In line with procedural choice and bounded rationality
    - → e.g., *noisily approximation*
    - → Possible policy response: simplify procedure
- **Intuitive simplifications**
  - In line with distinction between 'system 1' and 'system 2' thinking
    - → e.g., *salience bias*
    - → Possible policy response: promote time to think

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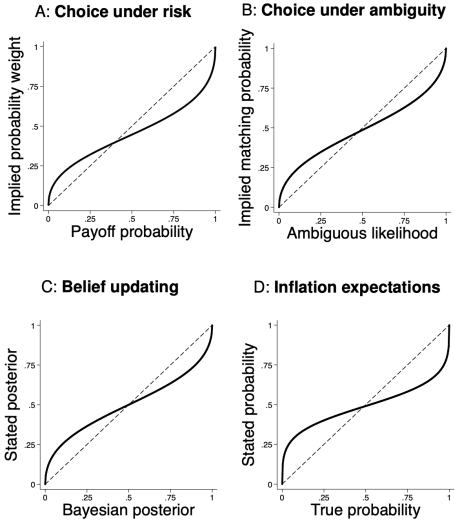
Noisy Approximations

Noisy Approximations

People approximate, rather than solving a problem precisely

- Time: *"about 30 minutes"*
- Risk: *"seems like a low chance"*
- Labor: *"roughly two days to study for the exam"*
- Budget: *"costs around 200 EUR a month"*

‘Weighting functions’ in choices and beliefs



- **A** Risk: people overweight small probabilities and underweight large probabilities
- **B** Ambiguity: people avoid ambiguity for probable gains but seek it for unlikely gains
- **C** Beliefs: people overreact after weak signals but underreact after strong signals
- **D** Expectations: people expect too much when low but too little when high

Theoretical Framework

Suppose that people's average decisions can be described as a convex combination:

$$E[a(\theta)] = (1 - \lambda)a^*(\theta) + \lambda d \tag{15}$$

- a: decision
- θ: economic fundamentals
- λ: degree of attenuation
- d: default decision

Theoretical Framework

This yields an attenuated effect:

$$\frac{\partial E[a(\theta)]}{\partial \theta} = \underbrace{(1-\lambda)}_{\text{Attenuation}} \frac{\partial a^*(\theta)}{\partial \theta}$$

- $\frac{\partial a^*(\theta)}{\partial \theta}$: *normative sensitivity*, that is the optimal sensitivity

Why does attenuation (λ) emerge?

Policy uncertainty

- People know the fundamentals (θ) but do not know how to map them into optimal decision ($a^*(\theta)$)
- In response, people make noisy decisions ($s(\theta) = a^*(\theta) + \epsilon$) to update on true utility-maximizing decision
  - $\rightarrow$ e.g., *dine Ethiopian cuisine on Friday* vs. *dine Bolivian cuisine on Saturday*

Noisy perceptions

- People do not know the fundamentals (θ), but only observe noisy signals ($s = \theta + \epsilon$)
- Implied decisions also show attenuation bias
  - $\rightarrow$ as individuals decide based on prior fundamentals (θ)

What determines default decisions (d)?

When people have prior experience

- Default is shaped by memory: what one usually experiences
  - → e.g., *maintaining status quo*

When people have no prior experience

- Less clear
- Probably, related to simple heuristics that 'usually work'
  - → e.g., *choosing the middle-ground*

When is noisy approximation stronger?

When aggregating trade-offs is difficult

- More noise when far from dominance
  - → e.g., *providing additional labour hour when payoff is 2 EUR than when it is 200 EUR*
- More noise when more dimensions to consider and dimension-by-dimension dissimilarity
  - → e.g., *A arrives later, is superior, is costlier, is more econ-friendly than B*

When the problem is less important

- More noise when people incur in less thinking about a problem (e.g., rational inattention)
  - → e.g., *snack vs mobile phone purchase*
  - → Determinants: relevance of decision, frequence of decision

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People avoid aggregating across dimensions and compare within-dimensions

- e.g., '*I prefer mobile A because it has better camera and battery-life, while B only is cheaper*'
- e.g., '*I will buy car C because it looks nicer and is cheaper, while D only is more efficient*'
- e.g., '*I study E because it is easier and more interesting, while F only pays more*'

Why do people do this?

- Assessments are typically **relative** rather than absolute
  - Compare relevant quantities with (relevant or irrelevant) reference points
- Interpretations:
  - Reference-dependent utility functions (*leading interpretation*)
  - Simplification strategy (*alternative interpretation*)
    - → Helps dealing with the difficulty of information processing across dimensions
    - → Difficult to translate different dimensions into a 'common currency'
    - → Relative assessments are easier than absolute assessments

      e.g., *'How much is this wine worth to me?' vs.*

      'Is this wine better than the one I had yesterday?'

Pairwise Comparison

- Consider two goods with two dimensions
  - e.g., *expensive high-quality wine and a cheap low-quality wine*
- Under neoclassical theory, equivalence between:
  1. Compare Aggregations
     → 1. Aggregate components within each option → 2. Compare aggregated values across options
  2. Aggregate Comparisons
     → 1. Compare component-by-component → 2. Aggregate these comparisons
- But people tend to follow (ii)
  - Ariely (2011): Eye-tracking in decision making
    → Frequency of within-dimension comparisons is higher and increases when the number of dimensions increases

Reference points

- People compare utility-relevant outcomes with normatively irrelevant reference points
  - e.g., *status quo, what they usually get, what they expect to get*

Why decisions are particularly sensitive around reference points?

1. Difficulty of aggregating tradeoffs across dimensions
   - People understand whether an outcome is better or worse than a comparison point, but not necessarily by how much
     → e.g., *Person's references for product A is mid-quality and very high-price. Prefers high-quality and high-price (gains in both) over low-quality and low-price (gains in one)*

Why decisions are particularly sensitive around reference points?

2. Efficient coding
   - People have much experience around these points, and values are more precisely
     → However, this is not *per se* a reference-point comparison nor comparative thinking

Why decisions are particularly sensitive around reference points?

3. Normalization
   - Within-dimension differences matter more when relatively larger

     Average-based

     → e.g., *difference between 30 and 20 is larger than between 130 and 120*

     Range-based

     → e.g., *difference between 30 and 20 is larger when third item is 19 than when it is 0*

   - People extrapolate relative difference to utility gains, overweighting dimensions

Sequential contrast effects

- People hold quantities (or qualities) as larger if preceding one is smaller
  - e.g., *30 looks larger in (2,30) than in (29,30)*
  - Proven to have an impact in candidate assessment (Radbruch & Schiprowski, 2022), stock evaluations (Hartzmark & Shue, 2018)
  - Sequential contrast effects increase as tradeoffs become difficult (Enke & Graber, 2024)
- Prove-of-concept that reference point effects can be ultimately cognitive

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Reduced Cardinality

- **People don’t use all of the available information**
  - In many problems, the dimension size is too large
  - Simplification strategy: use a subset of information and decide with what is top of mind
    → e.g., *selective attention or memory*

Why they do this?

1. **Goal-driven process**
   - People attend/remember the **most important** elements
   - Literature on rational inattention, sparsity, optimal bounded memory
   - Focus on specific problem at hand
2. **Stimuli-driven process**
   - People attend/remember elements **cued by the environment**
   - Can be optimal *on average*
     - → Maybe a response to constraints in attention/memory
     - → Focus on variance/similarity broadly makes sense

Incomplete Representations

System Neglect

- People excessively **focus on the visible 'output' rather than on the underlying data-generating process** (DGP)
  - Example: Belief updating with bimodal response
    - → Rational agents: Focus on the DGP
    - → Simplifiers: Equate observed signals with the underlying process
  - Drawing people's attention to the neglected aspect of the DGP impacts behavior
    - → i.e., *selective attention*
- Extends to indirect effects:
  - People do not pay sufficient attention to how others' behavior is driven by fundamentals
  - People do not pay sufficient attention to how behavioral responses impact aggregates

Incomplete Representations

Data Neglect

- People simplify by **entirely ignoring certain problem aspects**
  - Example: Belief updating with multi-modal response
    - → Rational agents: Focus on the DGP
    - → Signal-neglect agents: Only focus on the base rate
    - → Base-neglect agents: Only focus on the signal
  - Non-rational agents only pay attention to one statistic
  - Drawing people's attention to the neglected aspect of the DGP impacts behavior
    - → e.g., *selective attention*

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Analogies and Categorization

Analogies and Categorization

People repeat previous solutions rather than solving the actual problem

- e.g., '*I will take route A because I took it last time and worked well*'
- e.g., '*I will buy car B because I have always bought cars from that company*'
- e.g., '*I will buy a Japanese mobile because I like Japanese films*'

Why people do this?

Model-free learning

- People don't form a mental model of the problem, they just learn purely by experience
  - → e.g., 'I don't know why, but this works'
- People choose previously successful decisions for the same task
  - → Main mechanism: reinforcement
  - → **Problem 1:** most problems differ from each other
  - → **Problem 2:** people do rely on model-based reasoning
- Extensions
  - → Case-based reasoning, weighting past decisions by similarity to current environment
  - → Dual-decision process, combining model-free with model-based learning

Why people do this?

Categorization

- People lump together current situations that are similar but differ
  - → e.g., 'all Nordics speak North Germanic languages'
- People lump together observations into categories and then analyze categories as one
  - → e.g., investors categorize as similar companies just because they report earnings same day or appear next to each other on reports, which makes stock move jointly (Charles, 2022).

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People undervalue what requires much information processing to evaluate

- Similar to risk aversion to uncertainty resulting from imperfect information processing
  - → e.g., 'picking which stock to investment in is too hard, so I avoid it'
  - → e.g., 'economic news are difficult to understand, so I don't incorporate them to update my beliefs'
  - → e.g., 'option A has too many caveats, so I prefer option B because is simpler'

Source of complexity

Cardinality

- Different states increase the complexity of assessing a decision
  - → e.g., 'people shy away from products with many add-ons due to obfuscation' (Fehr & Wu, 2023)
  - → e.g., 'financial assets with many distinct payouts tend to be avoided'

Tradeoffs

- People act cautiously
  - → Uncertainty about derived utility makes for conservative assessments
    concave transformation of utils due to risk aversion
  - → Can explain endownment effect, certainty effect, and present bias