The Paradox of Choice
Why MORE is LESS

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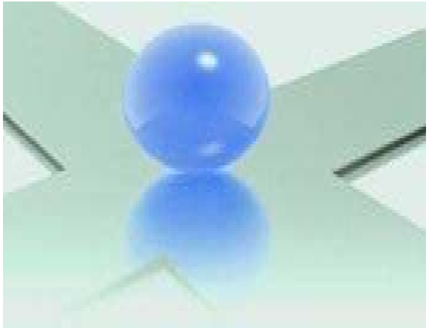

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The Paradox of Choice: Why MORE is less
pdox-choice02.tex

Contents

1 What Makes a Good Decision?

§ Schwartz, Barry, 2004
Paradox of Choice: Why More Is Less

Figure 1: **Barry Schwartz,** **1946–.**

**§ Barry Schwartz, Yakov Ben-Haim, and Cliff Dacso, 2011, What Makes a Good Decision? Robust Satisficing as a Normative Standard of Rational Behaviour, *The Journal for the Theory of Social Behaviour*, 41(2): 209-227. Pre-print to be found on:
http://info-gap.com/content.php?id=23**

1.1 *Choosing a College*

§ Decision problem:

- **You've been accepted to several good universities.**
- **You must choose one.**
- **How to go about it?**

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§ **Uncertainty: severe.**

- **What is a good strategy?**
- **What are *attributes* of a good strategy?**

1.2 *Severe Uncertainty: Good Strategy? Good Attributes?*

§ Decision strategy: Outcome optimization

- **Make best possible estimates.**
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- Identify wonderful score.
- Choose school opportune to uncertainty.

§ Which strategy to use?

§ **In order to choose a strategy we first discuss:**

Concepts of probability and uncertainty.

1.3 *Three Types of Probability*

§ Sources:

- **Schwartz, Ben-Haim, Dacso, 2011.**
- **Jonathan Baron, 2008, *Thinking and Deciding.***

§ What is probability?

What do the following statements mean?

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- **The probability that Maccabee Tel Aviv will win championship is 1/4.**

§ **Logical probability.**

- **36 equi-probable outcomes with 2 dice.**
- **6 outcomes sum to "7".**
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  "How sure are you?" ... "I'd give 'em 25% chance."
- **Personal judgment.**
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§ **Do these concepts of probability differ?**

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  - Deduction with rules of inference.
  - Pre-logical choice of rules of inference.
    E.g. reason by contradiction.

§ **All three concepts of probability,**

Logical: outcome of ideal dice,

Empirical: frequency of prostate cancer,

Personal: Maccabee's chances,

- Overlap but differ in meaning.
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- Overlap but differ in meaning.
- Are mathematically identical: Kolmogorov axioms.

1.4 *Severe Uncertainty*

§ **We discussed three types of probability.**

§ **Is all uncertainty probabilistic?**

§ **In a previous lecture[1] we claimed that ignorance is not probabilistic:**

- **Monty Hall's 3-door problem.**
- **Pascal's wager about God.**
- **Lewis Carroll's 2-bag riddle.**
- **Keynes' new material.**

§ **We now introduce a new distinction.**

[1] These examples are discussed in lecture "The Strange World of Human Decision Making", \lectures\decisions\lectures\foibles\foibles01.pdf.

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  - **Ambiguity, which we now consider.**

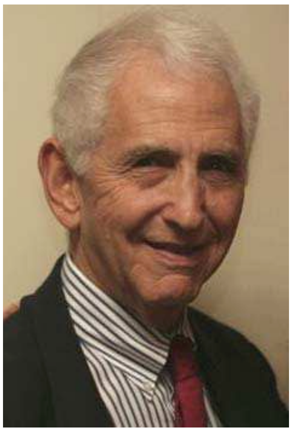


Figure 2: **Ellsberg, 1931–.**

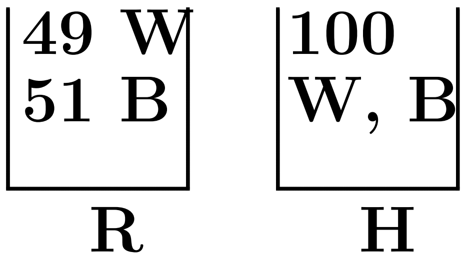
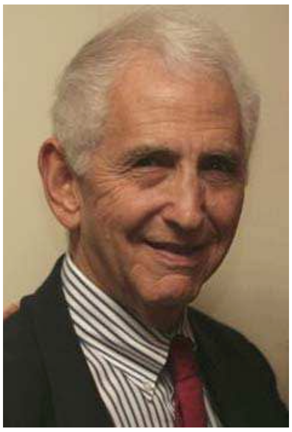


Figure 3: **Ellsberg's Urns.**

§ Ellsberg paradox:

- **1st experiment: win on black. Which urn?**
-



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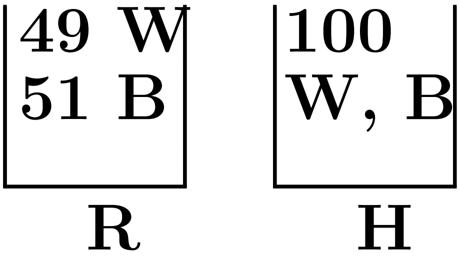

Figure 5: **Ellsberg's Urns.**

§ Ellsberg paradox:

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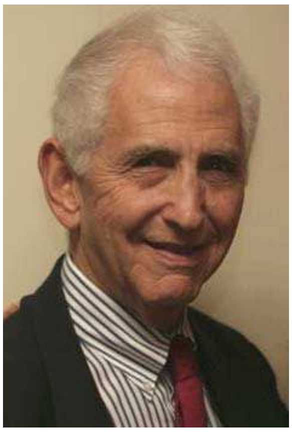

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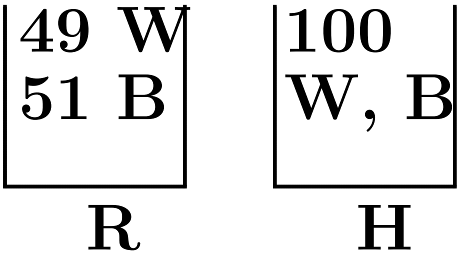

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§ Ellsberg paradox:

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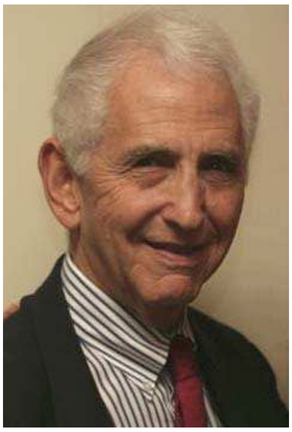

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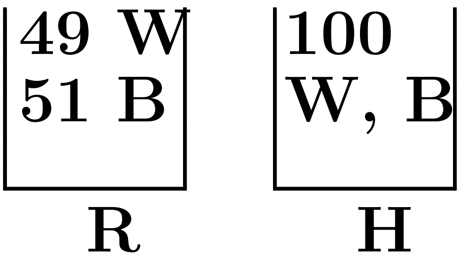

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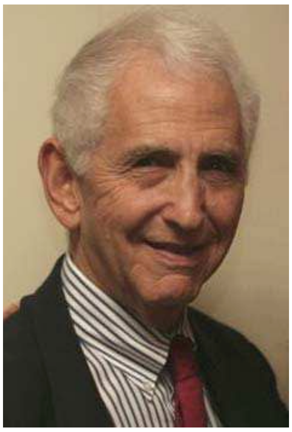

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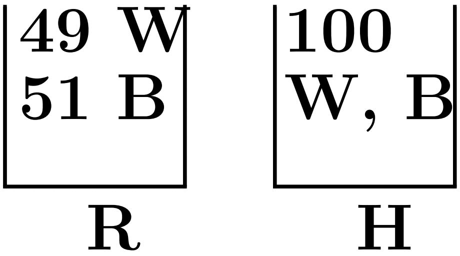

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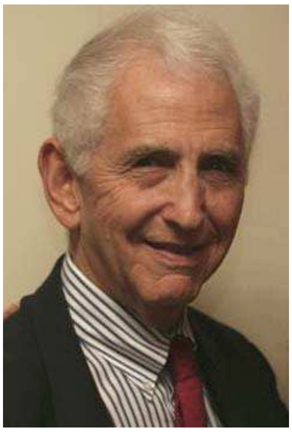

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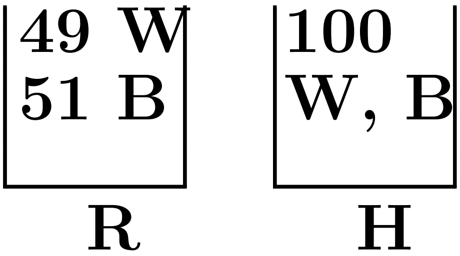

Figure 13: **Ellsberg's Urns.**

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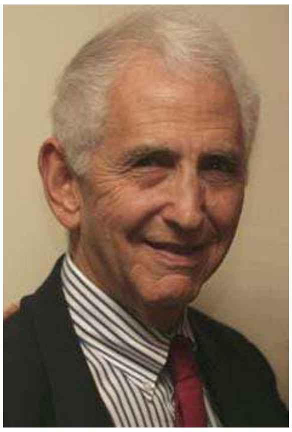
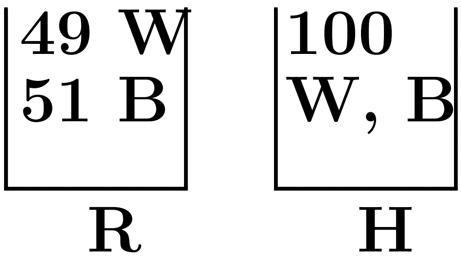


Figure 14: **Ellsberg, 1931–.**



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§ Now consider a different aspect: strategic interaction.

Figure 16: **Cuban missile crisis, Oct 1962. U-2 reconnaissance photograph of Soviet nuclear missiles in Cuba. Missile transports and tents for fueling and maintenance are visible. Courtesy of CIA. http://en.wikipedia.org/wiki/Cuban_Missile_Crisis.**

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- **Example: Cuban missile crisis.**
  - **US detects nuclear missiles on Cuba.**
  - **How many missiles? Russian intentions unclear.**
  - **What should US do?**

§ **Ignorance is not probabilistic:**[2]

- **Monty Hall's 3-door problem.**
- **Pascal's wager.**
- **Lewis Carroll's 2-bag riddle.**
- **Keynes' new material.**

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§ **Ignorance is a gap between what we do know and what we need to know in order to make a good decision.**

1.5 *Responses to Severe Uncertainty*

§ What decision strategy for severe uncertainty?

- **Best-model optimization.**
- **1-reason (lexicographic).**
- **Min-max (worst case).**
- **Robust satisficing.**
- **Opportune windfalling.**

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§ What decision strategy for severe uncertainty?

- Best-model optimization.
- 1-reason (lexicographic).
- Min-max (worst case).
- Robust satisficing.
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§ Paradox of choice (Barry Schwartz):

- Under severe uncertainty,
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§ **Paradox of choice (Barry Schwartz):**

- **Under severe uncertainty,**
  aiming for more achieves less.
- **Do you agree? Always? Sometimes?**

§ We will explore robust satisficing.

§

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§ **Response to ignorance: 2 questions.**

- **What do you want/need? What is essential outcome?**
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Choose option which:

- **Satisfies requirements.**
- **Maximally robust to surprise.**

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§ **Does rob-sat differ from outcome optimization?**

§ **Foraging strategies.**

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§ **Foraging strategies.**

- **Optimizing:** Maximize caloric intake.
- **Robust-satisficing:** survive reliably.
  - Satisfice caloric requirement.
  - Maximize robustness to uncertainty.
- Robust-satisficing **survives in evolution.**

§ **Financial market strategies.**

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- **Robust-satisficing survives in competition.**
  - **Equity premium puzzle.**
  - **Home bias paradox.**

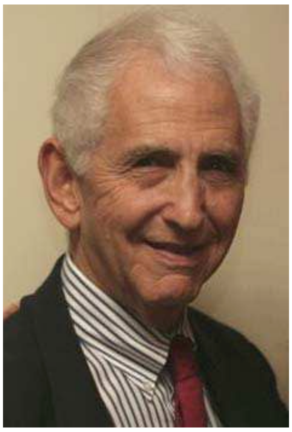


Figure 19: **Ellsberg, 1931–.**

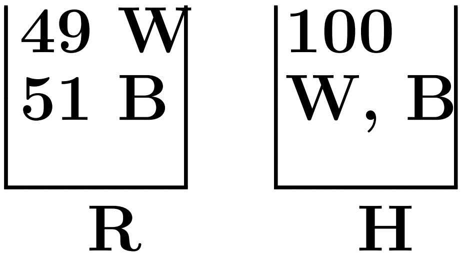
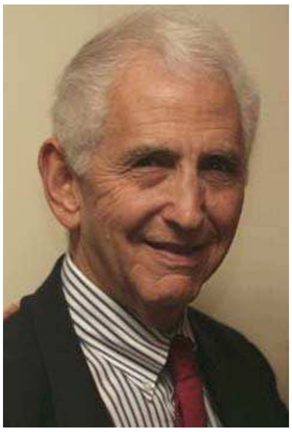


Figure 20: **Ellsberg's Urns.**

§ **Humans and ambiguity:** **Ellsberg paradox.**

- **Probabilistic risk vs uncertainty.**
- **Optimizing:** **Maximize expected utility.**
-



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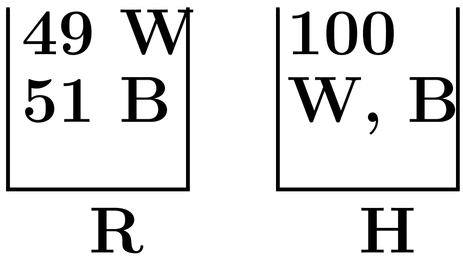

Figure 22: **Ellsberg's Urns.**

§ **Humans and ambiguity:** **Ellsberg paradox.**

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- **Robust-satisficing: do good enough.**
  - **Satisfice expected utility.**
  - **Maximize robustness to uncertainty.**
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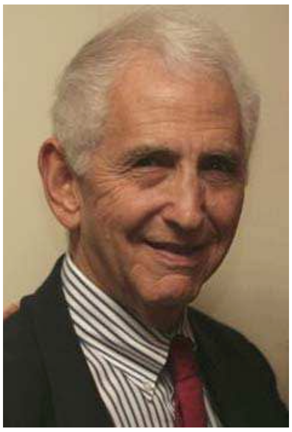

Figure 23: **Ellsberg, 1931–.**

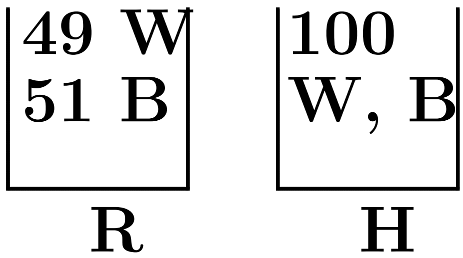

Figure 24: **Ellsberg's Urns.**

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  - **Satisfice expected utility.**
  - **Maximize robustness to uncertainty.**
- **Robust-satisficers are happier. (Schwartz)**

1.6 *Does Robust Satisficing Use Probability?*

§ **Source: Schwartz, Ben-Haim, Dacso, 2011.**

§ **It might be argued that:**

Robust-satisficing implicitly uses probability:

- **“Choose the more robust option.”**

  is the same as

- **“Choose the option more likely to succeed.”**

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  - **does not require probabilistic thinking.**

§ **Robustness question:**

- **How wrong can our estimates be and outcome of choice still acceptable?**
- **The answer does not use probability. (More on this later.)**

§ Example of robust thinking in choosing university.

- **Attribute: number of great physicists**
- **Requirement: At least 2 great physicists.**
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- **Note: this is both a bug and a feature.**

§ **Judgment of robustness is not judgment of likelihood.**

§ A common confusion: description vs prescription.

- **Describe** behavior of decision makers.

  This **can** always be done probabilistically (or robustly).

-

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- **Describe behavior of decision makers.**
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§ **Probability and Robustness are:**

- **Descriptively interchangable.**
- **Prescriptively distinct.**

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- **Prescriptively distinct.**

§ **Robust satisficing does not use probability.**

1.7 *Does Robust Satisficing Use Probability? (cont.)*

§ Sources:

- **Yakov Ben-Haim, 2010, Uncertainty, Probability and Robust Preferences, working paper.**[3]

- **Yakov Ben-Haim, 2011, Robustness and Locke's Wingless Gentleman.**[4]

---

[3] http://info-gap.com/content.php?id=23

[4] http://decisions-and-info-gaps.blogspot.com/2011/09/robustness-and-lockes-wingless.html

§ Conflicting views on uncertainty and probability.

Keynes and Carnap vs Knight and Wald.

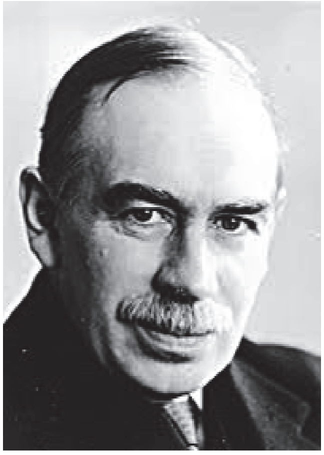

Figure 25: **John Maynard Keynes, 1883–1946.**

§ Probability is fundamental to uncertainty.

John Maynard Keynes asserts:[5] "Part of our knowledge we obtain direct; and part by argument. The Theory of Probability is concerned with that part which we obtain by argument, and it treats of the different degrees in which the results so obtained are conclusive or inconclusive. . . .

"The method of this treatise has been to regard subjective probability as fundamental and to treat all other relevant conceptions as derivative from this."

[5]Keynes, John Maynard, 1929, *A Treatise on Probability,* Macmillan and Co., London, pp.3, 281–282

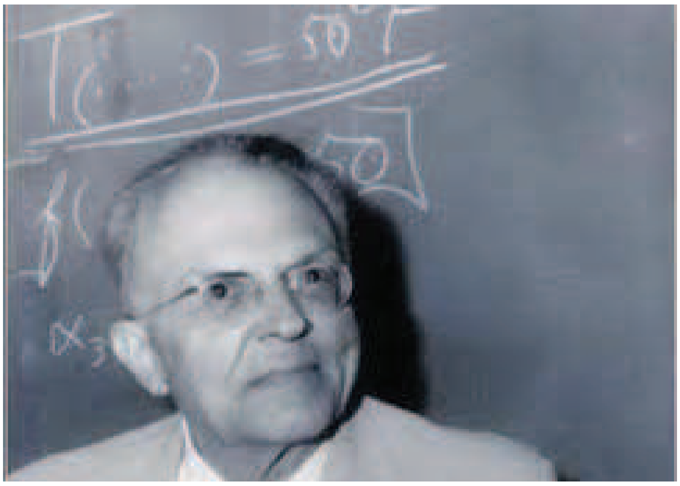

Figure 26: **Rudolph Carnap, 1891–1970.**

§ Probability is fundamental to uncertainty.

Among Rudolf Carnap's[6] "basic conceptions" is the contention that "all inductive reasoning, in the wide sense of nondeductive or nondemonstrative reasoning, is reasoning in terms of probability."

[6]Carnap, Rudolf, 1962, *Logical Foundations of Probability,* 2nd ed., University of Chicago Press, p.v

Figure 27: **Frank Knight, 1885–1972.**

§ Probability is not fundamental to uncertainty.

Frank Knight:[7] **"Business decisions ... deal with situations which are far too unique, generally speaking, for any sort of statistical tabulation to have any value for guidance. The conception of an objectively measurable probability or chance is simply inapplicable. ...**
"It is this *true uncertainty* which by preventing the theoretically perfect outworking of the tendencies of competition gives the characteristic form of 'enterprise' to economic organization as a whole and accounts for the peculiar income of the entrepreneur."

[7]Knight, Frank H., 1921, *Risk, Uncertainty and Profit.* Houghton Mifflin Co. Re-issued by University of Chicago Press, 1971, pp.231–232

Figure 28: **Abraham Wald, 1902–1950.**

§ Probability is not fundamental to uncertainty.

Abraham Wald[8] wrote that "in most of the applications not even the existence of ... an a priori probability distribution [on the class of distribution functions] ... can be postulated, and in those few cases where the existence of an a priori probability distribution ... may be assumed this distribution is usually unknown."

[8]Wald, A., 1945. Statistical decision functions which minimize the maximum risk, *Annals of Mathematics*, 46(2), 265–280, p.267

§ We consider 3 questions:

(1) Does non-probabilistic robust preference between options need to assume a uniform probability distribution on underlying uncertain events?

-

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§ **Non-probabilistic robust preferences:**

- **Based on set-theory representation of uncertainty: Sets, or families of sets, of events.**
- **E.g. min-max (worst case) or info-gap.**

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§ **Non-probabilistic robust preferences:**

- **Based on set-theory representation of uncertainty: Sets, or families of sets, of events.**
- **E.g. min-max (worst case) or info-gap.**

§ **Robust preference between options B and C:**

- B **more robust than** C.
- **Hence** B **"robust preferred" over** C: $B \succ_{\mathrm{r}} C$.

1.7.1 *First Question*

§ Does a non-probabilistic robust preference between options need to assume a uniform probability distribution on the underlying uncertain events?

§

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§ Uniform distribution nonexistent
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§ Does a non-probabilistic robust preference between options need to assume a uniform probability distribution on the underlying uncertain events?

§ Uniform distribution nonexistent
if event space unbounded.

- Thus uniform distribution cannot underlie robust preference.
- Robust preference may be unjustified.

§ Does a non-probabilistic robust preference between options need to assume a uniform probability distribution on the underlying uncertain events?

§ If uniform distribution exists:

- **It justifies robust preference if it implies B more likely than C.**
-

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  E.g. 3-door problem.
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  E.g. 3-door problem.
- **Uniform dist not necessary to justify robust pref.**
- **Robust pref may still require *some* distribution.**

1.7.2 *Second Question*

§ Does a robust preference assume *some* probability distribution on the uncertain events?

§

§ Does a robust preference assume *some* probability distribution on the uncertain events?

§ Assuming a pdf could justify robust preferences.

Such an assumption is not necessary.

§ Notation:

- u is an underlying uncertain event.
  There is a set-model of uncertain u.
-

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- S **is the set of all pdf's** $p(u)$**.**
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- $p_{\mathrm{T}}(u)$ **true pdf.**

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- $p_{\mathrm{T}}(u)$ **true pdf.**

§ Our question:

Is it necessary to assume $p_{\mathrm{T}} \in S_B$ **to justify robust pref?**

§ $p_{\mathrm{T}}(u) \in S_B$ **implies**

robust pref is justified probabilistically:

$$p_{\mathrm{T}} \in S_B \quad \Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{1}$$

The '$\Longrightarrow$' means 'justifies' or 'warrants' or 'motivates'.

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§ $p_{\mathrm{T}}(u) \in S_B$ **implies**

robust pref is justified probabilistically:

$$p_{\mathrm{T}} \in S_B \quad \Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{2}$$

The '$\Longrightarrow$' means 'justifies' or 'warrants' or 'motivates'.

§ **Converse not true:**

Reasonable DM can accept $\succ_{\mathrm{r}}$

without believing $p_{\mathrm{T}} \in S_B$**.**

§

§ $p_{\rm T}(u) \in S_B$ **implies**

robust pref is justified probabilistically:

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The '$\Longrightarrow$' means 'justifies' or 'warrants' or 'motivates'.

§ **Converse not true:**

Reasonable DM can accept $\succ_{\rm r}$

without believing $p_{\rm T} \in S_B$**.**

§ **Accept** $\succ_{\rm r}$ **if**

$p_{\rm T} \in S_B$ ***more likely*** **than** $p_{\rm T} \notin S_B$**:**

$$\textbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\rm r} C \tag{4}$$

§

§ $p_{\mathrm{T}}(u) \in S_B$ **implies**

robust pref is justified probabilistically:

$$p_{\mathrm{T}} \in S_B \quad \Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{5}$$

The '$\Longrightarrow$' means 'justifies' or 'warrants' or 'motivates'.

§ **Converse not true:**

Reasonable DM can accept $\succ_{\mathrm{r}}$

without believing $p_{\mathrm{T}} \in S_B$**.**

§ **Accept** $\succ_{\mathrm{r}}$ **if**

$p_{\mathrm{T}} \in S_B$ ***more likely*** **than** $p_{\mathrm{T}} \notin S_B$**:**

$$\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{6}$$

§ **Lower warrant of "$\Longrightarrow$" in eq.(6) than in eq.(5),**

but still relevant.

§ **Accept $\succ_{\rm r}$ if**

$$\textbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\rm r} C \tag{7}$$

§ **Converse of (7) need not hold.**

§ **Accept $\succ_{\rm r}$ if**
$\textbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2}$ ***more likely*** **than**
$\textbf{Prob}(p_{\rm T} \in S_B) \le \frac{1}{2}$**:**

$$\textbf{Prob}\left(\textbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2}\right) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\rm r} C \tag{8}$$

§

§ **Accept $\succ_{\rm r}$ if**

$$\mathbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\rm r} C \tag{9}$$

§ **Converse of (9) need not hold.**

§ **Accept $\succ_{\rm r}$ if**

$\mathbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2}$ *more likely* than
$\mathbf{Prob}(p_{\rm T} \in S_B) \le \frac{1}{2}$:

$$\mathbf{Prob}\left(\mathbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2}\right) > \frac{1}{2} \quad \Longrightarrow \quad B \succ_{\rm r} C \tag{10}$$

§ **This regression can go forever.**

One could claim:

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\rm T} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$
$$\Longrightarrow \quad B \succ_{\rm r} C \tag{11}$$

Converse not necessary at any step.

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{12}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{13}$$

§

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{14}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{15}$$

§ **Summary of Q.2 answer:**

- **Any of an infinity of probability beliefs would justify $\succ_{\mathrm{r}}$ to some extent:**

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$

$$\Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{16}$$

-

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{17}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{18}$$

§ **Summary of Q.2 answer:**

- **Any of an infinity of probability beliefs would justify $\succ_{\mathrm{r}}$ to some extent:**

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$

$$\Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{19}$$

- **Higher-order probability statements provide weaker justification.**
-

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{20}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{21}$$

§ **Summary of Q.2 answer:**

- **Any of an infinity of probability beliefs would justify $\succ_{\mathrm{r}}$ to some extent:**

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2} \\ \Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{22}$$

- **Higher-order probability statements provide weaker justification.**
- **None of any finite sequence of prob beliefs is necessary to justify $\succ_{\mathrm{r}}$.**
-

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{23}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{24}$$

§ **Summary of Q.2 answer:**

- **Any of an infinity of probability beliefs would justify $\succ_{\mathrm{r}}$ to some extent:**

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$

$$\Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{25}$$

- **Higher-order probability statements provide weaker justification.**
- **None of any finite sequence of prob beliefs is necessary to justify $\succ_{\mathrm{r}}$.**
- **At any step, prob belief can be deferred to next higher-order belief.**

§

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{26}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{27}$$

§ **Summary of Q.2 answer:**

- **Any of an infinity of probability beliefs would justify $\succ_{\mathrm{r}}$ to some extent:**

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$
$$\Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{28}$$

- **Higher-order probability statements provide weaker justification.**
- **None of any finite sequence of prob beliefs is necessary to justify $\succ_{\mathrm{r}}$.**
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§ **Answer to second: Nope.**

§

§ **Second question was, Is:**

$$p_{\mathrm{T}} \in S_B \tag{29}$$

necessary to motivate robust preferences:

$$B \succ_{\mathrm{r}} C \tag{30}$$

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$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2}$$
$$\Longrightarrow \quad B \succ_{\mathrm{r}} C \tag{31}$$

- **Higher-order probability statements provide weaker justification.**
- **None of any finite sequence of prob beliefs is necessary to justify $\succ_{\mathrm{r}}$.**
- **At any step, prob belief can be deferred to next higher-order belief.**

§ **Answer to second: Nope.**

§ **I'm arguing like Keynes on p.107:**
All reasoning (not direct knowledge) is probabilistic.

1.7.3 *Third Question*

§ **First question:**

Does $B \succ_{\rm r} C$ need to assume a uniform pdf on the underlying uncertain events?

§ **Second question:**

Does $B \succ_{\rm r} C$ assume *some* probability distribution on the uncertain events?

§

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§ **We answered NO in both cases.**

The argument was deductive, conclusive.

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§ **Third question:**

Is at least one probability belief, from among the infinite sequence of beliefs:

$$\mathbf{Prob}\left(\ldots\left[\mathbf{Prob}\left(\mathbf{Prob}(p_{\mathrm{T}} \in S_B) > \frac{1}{2}\right) > \frac{1}{2}\right]\right) > \frac{1}{2} \qquad (32)$$

necessary in order to justify $B \succ_{\mathrm{r}} C$?

§

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necessary in order to justify $B \succ_{\rm r} C$?

§ **Answer: plausibly no.**

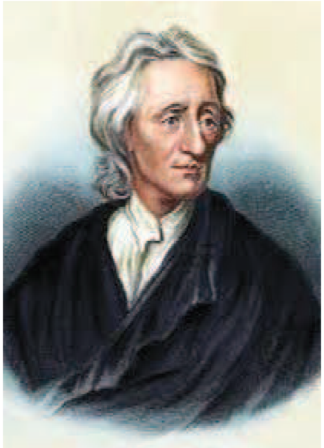


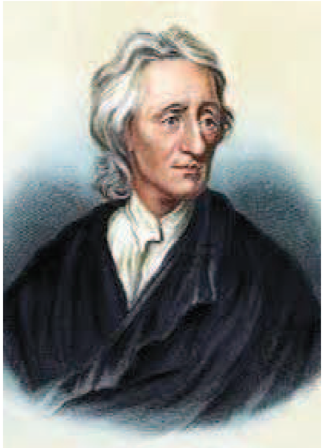
Figure 29: **John Locke, 1632–1704.**

§ John Locke's wingless gentleman.

"If we will disbelieve everything, because we cannot certainly know all things; we shall do muchwhat as wisely as he, who would not use his legs, but sit still and perish, because he had no wings to fly."[9]

§

[9]John Locke, 1706, *An Essay Concerning Human Understanding,* 5th edition. Roger Woolhouse, editor. Penquin Books, 1997, p.57, I.i.5



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§ Our situation:

- **If we disbelieve all propositions in eq.(33), rejecting $\succ_{\mathrm{r}}$ is 'muchwhat as wise' as Locke's wingless gentleman.**
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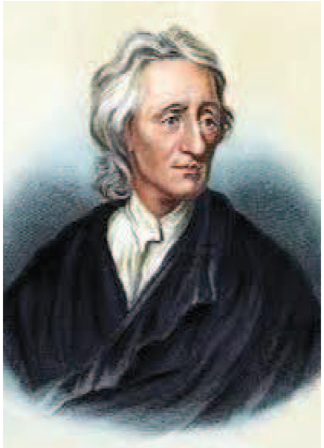

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§ Our situation:

- **If we disbelieve all propositions in eq.(33), rejecting $\succ_{\rm r}$ is 'muchwhat as wise' as Locke's wingless gentleman.**
- **Rejecting $\succ_{\rm r}$ is epistemic paralysis.**

[11]John Locke, 1706, *An Essay Concerning Human Understanding,* 5th edition. Roger Woolhouse, editor. Penquin Books, 1997, p.57, I.i.5

§ Causes of epistemic paralysis:

- **Pdf's not known: Knightian uncertainty, info-gaps.**
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§ **Implication of epistemic paralysis:**

Inaction, injury, retrogression, ...

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- **Probability is one model of the world.**
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- **Probability is one model of the world.**
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  - **Fuzzy, P-box, min-max, info-gap . . . .**
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- **Expand conceptions of uncertainty:**
  Adam's 20 images.

§

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§ **Answer to Q.3:**

- $\succ_{\rm r}$ **is epistemic last resort.**
-

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Inaction, injury, retrogression, ...

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  - **Fuzzy, P-box, min-max, info-gap . . . .**
- **Expand conceptions of uncertainty:**
  Adam's 20 images.

§ **Answer to Q.3:**

- $\succ_{\rm r}$ **is epistemic last resort.**
- $\succ_{\rm r}$ **is sometimes best bet.**
  (More on this now.)

2 *Robustness and Probability: A Short Intuitive Introduction to Proxy Theorems*

§ Is robustness a good bet for "survival"?

- **Is robustness a proxy for probability?**
- **Can we maximize "survival" probability without knowing probability distributions?**

[11] lectures talks lib proxy-very-shrt02.tex 19.11.2014

§ Robustness proxies for probability: Examples.

§ Foraging strategies.

- **Optimizing:** Maximize caloric intake.
-

§ **Foraging strategies.**

- **Optimizing:** **Maximize caloric intake.**
- **Robust-satisficing:** **survive reliably.**
  - **Satisfice caloric requirement.**
  - **Maximize robustness to uncertainty.**
-

§ **Foraging strategies.**

- **Optimizing:** Maximize caloric intake.
- **Robust-satisficing:** survive reliably.
  - Satisfice caloric requirement.
  - Maximize robustness to uncertainty.
- Robust-satisficing **survives in evolution.**

§ Financial market strategies.

- **Optimizing:** Maximize revenue.
-

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- **Optimizing:** Maximize revenue.
- **Robust-satisficing:** beat the competition.
  - Satisfice revenue requirement.
  - Maximize robustness to uncertainty.
- Robust-satisficing **survives in competition.**
  - Equity premium puzzle.
  - Home bias paradox.

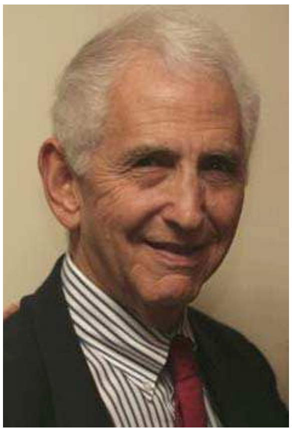

Figure 32: **Ellsberg, 1931–.**

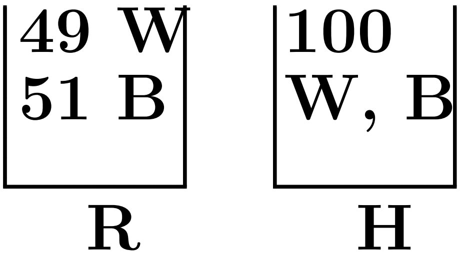

Figure 33: **Ellsberg's Urns.**

§ Humans and ambiguity: Ellsberg paradox.

- **Probabilistic risk vs uncertainty.**
- **Optimizing: Maximize expected utility.**
-

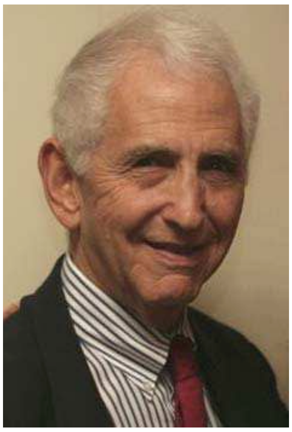

Figure 34: **Ellsberg, 1931–.**

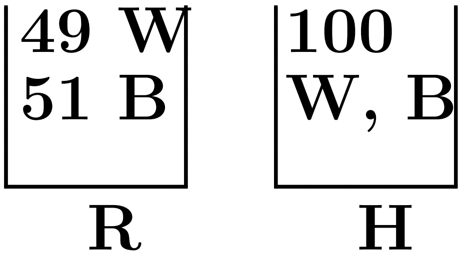

Figure 35: **Ellsberg's Urns.**

§ Humans and ambiguity: Ellsberg paradox.

- **Probabilistic risk vs uncertainty.**
- **Optimizing: Maximize expected utility.**
- **Robust-satisficing: do good enough.**
  - **Satisfice expected utility.**
  - **Maximize robustness to uncertainty.**
-

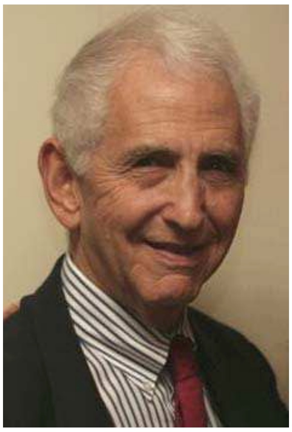

Figure 36: **Ellsberg, 1931–.**

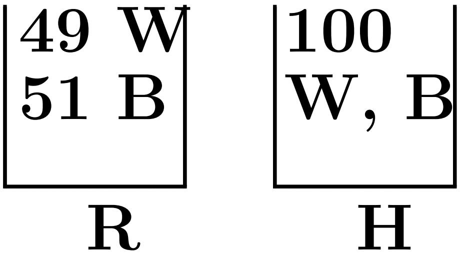

Figure 37: **Ellsberg's Urns.**

§ **Humans and ambiguity:** **Ellsberg paradox.**

- **Probabilistic risk vs uncertainty.**
- **Optimizing:** **Maximize expected utility.**
- **Robust-satisficing:** **do good enough.**
  - **Satisfice expected utility.**
  - **Maximize robustness to uncertainty.**
- **Robust-satisficers are** **happier.**

§ **Proxy theorems:** **Robustness proxies for Probability**

§ **Robust satisficing is (often) a better bet than optimizing.**

3 *Robust-Satisficing is a Proxy for Probability of Survival*

11 \lectures\talks\lib\proxy02.tex 19.11.2014

§ **Decision problem:**

- **Decision:** r.
- **Uncertainty:** u.
- **Loss function:** $L(r, u)$.
- **Satisficing:** $L(r, u) \le L_{\mathrm{c}}$.

§

§ Decision problem:

- **Decision:** r.
- **Uncertainty:** u.
- **Loss function:** $L(r, u)$.
- **Satisficing:** $L(r, u) \le L_{\mathrm{c}}$.

§ Info-gap uncertainty model: $\mathcal{U}(h, \widetilde{u})$, $h \ge 0$.

- **Unbounded family of nested sets.**
- **Axioms:**

$$\textbf{Contraction:} \quad \mathcal{U}(0, \widetilde{u}) = \{\widetilde{u}\}$$

$$\textbf{Nesting:} \quad h < h' \implies \mathcal{U}(h, \widetilde{u}) \subset \mathcal{U}(h', \widetilde{u})$$

§ Robustness: max tolerable uncertainty.

$$\widehat{h}(r, L_c) = \max\left\{h : \ \left(\max_{u\in\mathcal{U}(h,\widetilde{u})} L(r,u)\right) \leq L_c\right\} \tag{34}$$

§

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§ Robust-satisficing preferences:

$$r \succ_\mathrm{r} r' \quad \textbf{if} \quad \widehat{h}(r, L_\mathrm{c}) > \widehat{h}(r', L_\mathrm{c}) \tag{36}$$

§

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§ Robust-satisficing preferences:

$$r \succ_{\rm r} r' \quad \textbf{if} \quad \widehat{h}(r, L_{\rm c}) > \widehat{h}(r', L_{\rm c}) \tag{38}$$

§ Probability of survival:

$$P_{\rm s}(r) = \textbf{Prob}[L(r,u) \le L_{\rm c}] = \int_{L(r,u)\le L_{\rm c}} p(u)\,{\rm d}u \tag{39}$$

§

§ Robustness: max tolerable uncertainty.

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$$P_{\rm s}(r) = \textbf{Prob}[L(r, u) \le L_{\rm c}] = \int_{L(r,u) \le L_{\rm c}} p(u) \, {\rm d}u \tag{42}$$

§ Probabilistic preferences:

$$r \succ_{\rm p} r' \quad \textbf{if} \quad P_{\rm s}(r) > P_{\rm s}(r') \tag{43}$$

§ Robustness: max tolerable uncertainty.

$$\widehat{h}(r, L_\mathrm{c}) = \max \left\{ h : \ \left(\max_{u \in \mathcal{U}(h,\tilde{u})} L(r,u) \right) \le L_\mathrm{c} \right\} \tag{44}$$

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§ Probabilistic preferences:

$$r \succ_\mathrm{p} r' \quad \textbf{if} \quad P_\mathrm{s}(r) > P_\mathrm{s}(r') \tag{47}$$

§ Do $\succ_\mathrm{r}$ and $\succ_\mathrm{p}$ agree?

- $\widehat{h}(r, L_\mathrm{c})$ **proxies for** $P_\mathrm{s}(r)$**???**
- $\widehat{h}(r, L_\mathrm{c}) > \widehat{h}(r', L_\mathrm{c})$ **implies** $P_\mathrm{s}(r) \ge P_\mathrm{s}(r')$**???**

Why $\succ_{\mathrm{r}}$ and $\succ_{\mathrm{p}}$ Are Not Necessarily Equivalent

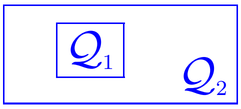
§ **Two actions,** r_1 **and** r_2**, with robustnesses:**

$$\widehat{h}(r_1, L_{\mathrm{c}}) < \widehat{h}(r_2, L_{\mathrm{c}}) \tag{48}$$

Denote $\widehat{h}_i = \widehat{h}(r_i, L_{\mathrm{c}})$, $\mathcal{U}_i = \mathcal{U}(\widehat{h}_i,\, \tilde{q})$.

§ $\mathcal{U}_i$ **are nested:**

$$\mathcal{U}_1 \subseteq \mathcal{U}_2 \quad \textbf{because} \quad \widehat{h}_1 < \widehat{h}_2 \tag{49}$$



$\mathcal{U}_i$ **reflect agent's beliefs.**

§ Survival set:

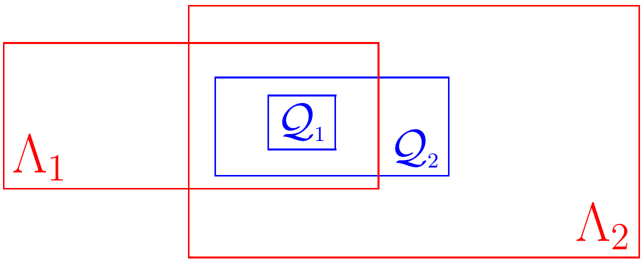
$$\Lambda(r, L_{\mathrm{c}}) = \{u : \; L(r, u) \leq L_{\mathrm{c}}\} \tag{50}$$

§ Prob of survival:

$$P_{\mathrm{s}}(r) = \mathbf{Prob}[\Lambda(r, L_{\mathrm{c}})] \tag{51}$$

§ Survival sets:

- **Need not be nested.**
- **Do not reflect agent's beliefs.**



§ Proxy theorem need not hold.

Systems with Proxy Theorems

(Each theorem with its own "fine print")

§ Uncertain Bayesian mixing of 2 models.

- **Decision r.**
- **Outcome depends on which of 2 models, A or B, is true.**
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- **$P_{\rm s}(r)$ is probability for satisficing at $L_{\rm c}$.**
- **$\widehat{h}(r, L_{\rm c})$ is a proxy for $P_{\rm s}(r)$:**

  Any change in r that increases $\widehat{h}$ cannot decrease $P_{\rm s}$.

§ Risky and risk-free assets.

- r is fraction of budget invested in risky assets.
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- $\widehat{h}(r, L_c)$ is **robustness** for satisficing at L_c.
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Is the grass really greener?

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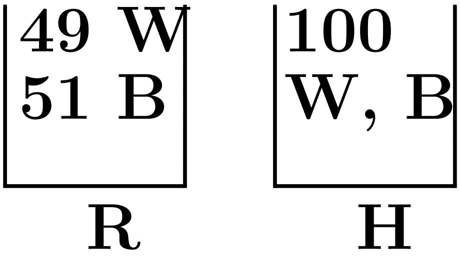

Figure 38: **Ellsberg's Urns.**

§ Ellsberg's paradox.

- **2 lotteries: 1 risky, 1 ambiguous.**
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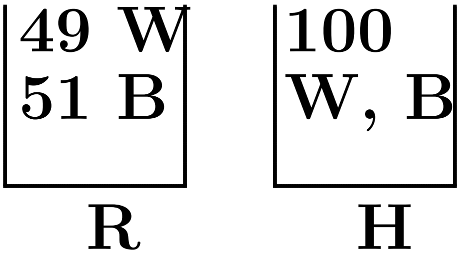

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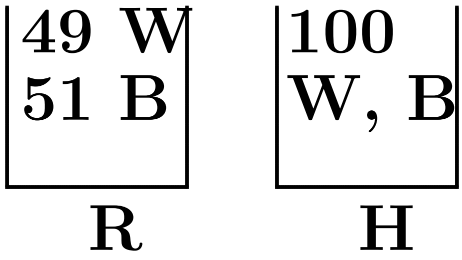

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- **Choice between risk and ambiguity.**
- **Ellsberg's agents prefer risky lottery both times.**
- **Ellsberg's agents are robust-satisficers because:**
- **Robustness is a proxy for probability, so:**
  Agents maximize probability of adequate return.

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- **Many systems don't have proxy prop.**
- **How prevalent is the proxy property?**
  - **Human:** economic competition.
  - **Biological:** foraging.
  - **Physical:** quantum uncertainty.

4 *Robust Satisficing: Normative or Prescriptive?*

§ Main Source:

Barry Schwartz, Yakov Ben-Haim, and Cliff Dacso, 2011, What Makes a Good Decision? Robust Satisficing as a Normative Standard of Rational Behaviour, *The Journal for the Theory of Social Behaviour*, 41(2): 209-227. Pre-print to be found on:
http://info-gap.com/content.php?id=23

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  Describe how DM's decide.
- **Normative:**
  Establish norm, gold standard for decision making.
- **Prescriptive:**
  Specify implementable strategies
  given human and epistemic limitations.

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- **People, animals, organizations don’t have info and ability to optimize.**
- **If they did have, they would optimize:**
  - **Moral imperative.**
  - **Competitive advantage.**

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In Conclusion

Human decision making

under uncertainty

is

Interesting