The StranGe World of Human Decision Making

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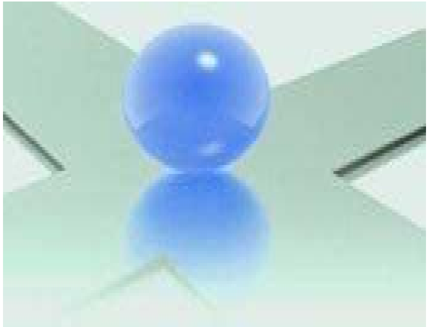

The strange world of human decision making
foibles02.tex

Contents

Part I

Foibles

§ Main Source:

Plous, Scott, 1993,

The Psychology of Judgment and Decision Making,

chapter 12.

1 *Catch-All Underestimation Bias*

¶ Sources:

• Fischhoff, B., P. Slovic, and S. Lichtenstein. 1978. Fault trees: Sensitivity of estimated failure probabilities to problem representation. *Journal of Experimental Psychology: Human Perception Performance*, 4: 330–344.

• Michael Smithson and Yakov Ben-Haim, Reasoned Decision Making Without Math? Adaptability and Robustness in Response to Surprise, *Risk Analysis*, to appear. Pre-print: http://info-gap.com/content.php?id=23

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- **Combine events in 1 super-event:** $\boxed{\boxed{E1}\quad\boxed{E2}\quad\boxed{E3}\ \textbf{Event}}$
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  - being late to rise,
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  - etc.
- The super-event skips details; ignores unanticipated surprising events.

¶ Managing the CAUB:

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- **Exploit foibles to manage a foible.**
- **Include a "novel outcome" category when eliciting probabilities:**
  Detailed descriptions of unknowns will tend to increase the intuitive probability of surprise.

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2 *Compound Events*

§ Simple and compound events:

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- **Compound event** depends on multiple outcomes. E.g. 2-stage lottery.

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3 Confusion of the Inverse

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§ **95 out of 100 physicians said: 75% chance of cancer.**

§ **Evidently, physicians assumed that**

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§ **What do you think???**

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- **Lump detected in breast.**
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  Correct classification:

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§ **This is the confusion of the inverse.**

§ How would a statistician decide?

Bayes' theorem.

$$p(\mathbf{can}|\mathbf{pos}) = \frac{p(\mathbf{can}, \mathbf{pos})}{p(\mathbf{pos})} \quad (1)$$

(2)

(3)

§ How would a statistician decide?

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$$p(\mathbf{can}|\mathbf{pos}) = \frac{p(\mathbf{can},\mathbf{pos})}{p(\mathbf{pos})} \tag{4}$$

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$$=$$

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§ Why is error so common?

§ How to decide, if those probabilities are unknown?

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4 *Optimism Bias: It'll Never Happen to Me*

§ **Optimism bias:**

Positive outcomes

are viewed to be more likely than

negative outcomes.

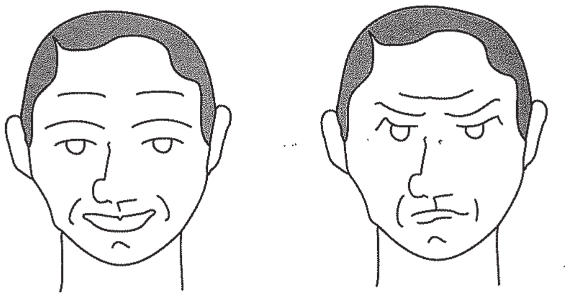

FIGURE 12.1
These are the stimuli used by David Rosenhan and Samuel Messick (1966) in their study of probability estimation.

Figure 1: **From Plous, p.135.**

§ Experiment:

- **150 cards with either "smile" or "frown".**
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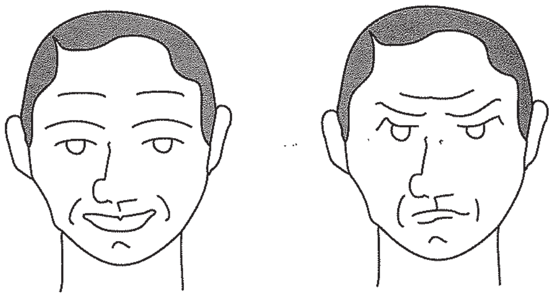

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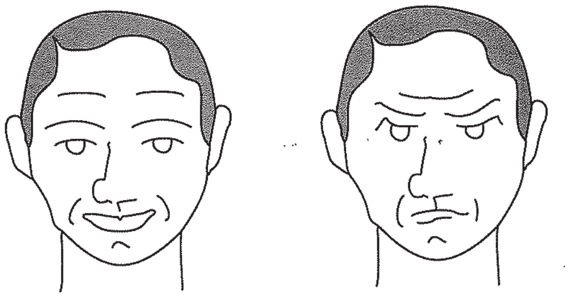

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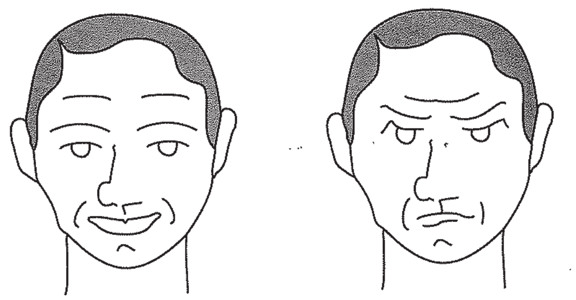

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- **Is optimism bias a reaction to uncertainty or is it wishful thinking?**

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5 *Conservatism*

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- Find: 8 red and 4 blue balls.
- What is prob that urn 2 was chosen?
- Most people answer 0.7 to 0.8.
- Bayesian posterior probability is 0.97.
- Most people revise prior probability (0.5) less than justified.

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6 *Do Accidents Make Us Safer?*

§ From Plous, p.140:

"On June 3, 1980, officers at the U.S. Strategic Air Command (SAC) were routinely watching for signs of a Russian missile attack. The shift had thus far passed uneventfully, and there were no signs of what was about to happen.

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“Suddenly, a computer display warned that the Russians had just launched a sortie of land- and submarine-based nuclear missiles. In several minutes, the missiles would reach the United States.

“SAC responded immediately. Across the country, more than 100 nuclear-armed B-52 bombers were put on alert and prepared for take-off. Nuclear submarine commanders were also alerted, and missile officers in underground silos inserted their launch keys into position. The United States was ready for nuclear war.

“. . .

“Then, just three minutes after the warning had first appeared, it became clear that the alert was a false alarm. American forces were quickly taken off alert, and a number of investigations were initiated. Following a second false alert several days later, the Defense Department located the source of error. As it turned out, a computer chip worth $0.46 had malfunctioned. Instead of registering the number of incoming missiles as a string of zeros, the chip had intermittently inserted 2s in the digital readout.”

§ **That was a serious accident.**

- **Corrective measures taken.**
- **No harm done.**
- **How did people respond?**

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§ Explanations:

- Re-inforcing prior opinions.
- Conservatism.
- Self interest.
- Lack of integrity.

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7 *Risk Compensation*

§ **Source:** John Adams, 1995, ***Risk***.

§ **"The potential safety benefit of most improvements to roads and vehicles is, it seems, consumed as a performance benefit; as a result of safety improvements it is now possible to travel farther and faster for approximately the same risk of being killed." (Adams, p.144)**

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§ Example: Icy corner.

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§ Why???

- People ignore uncertainty?
- People keep risk-level constant?
- People are foolish?

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8 *Optimizer's Curse*

§ **Sources:**

- **Smith, James E. and Robert L. Winkler, 2006, The optimizer's curse: Skepticism and postdecision surprise in decision analysis, *Management Science*, Vol. 52, No. 3, pp.311–322.**

- **Thaler, Richard H., 1992, *The Winner's Curse: Paradoxes and Anomalies of Economic Life*, Princeton University Press.**

- **Lecture notes:**
\lectures\risk\lectures\optimizers-curse03.pdf

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- V_i = **Known** **unbiased estimate of** v_i**.**

§ **Large value desired.**

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§ **Is this is a good strategy?** What would **you** do?

§ **Expect positive regret from $V_{i^\star}$:** $\mathrm{E}(V_{i^\star} - y_{i^\star}) > 0$.

On average, outcome optimum:

- Is over-estimate.
- Has positive regret.

§ **Simple example.**

§ **The true values,** v_i, **all precisely equal zero.**
They are not random variables.

§

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§ The true values, v_i, all precisely equal zero. They are not random variables.

§ The estimates, V_i, are $\mathcal{N}(0,1)$, fig. 5, left.

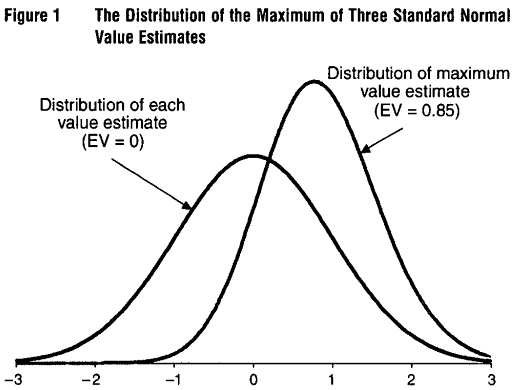

Figure 5: Smith and Winkler (2006), fig. 1.

§

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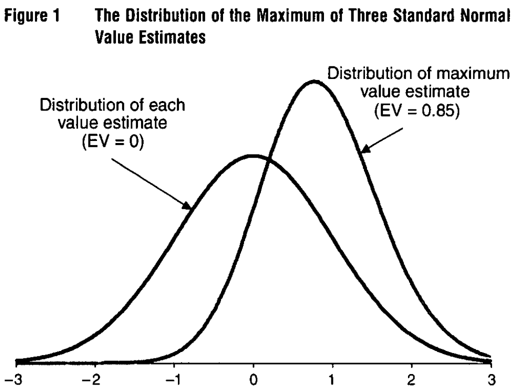

Figure 6: Smith and Winkler (2006), fig. 1.

§ **The mean of** $V_{i^\star}$ **is 0.85, fig. 6, right.**

§

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§ The true values, v_i, all precisely equal zero.
They are not random variables.

§ The estimates, V_i, are $\mathcal{N}(0, 1)$, fig. 7, left.

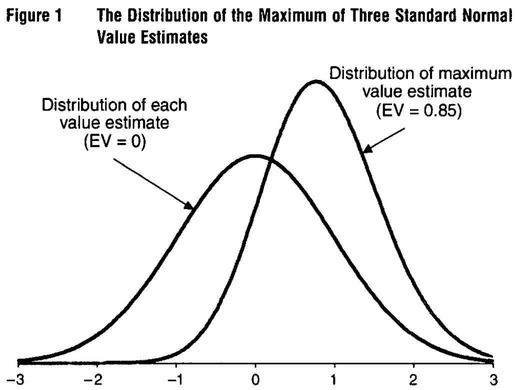

Figure 7: Smith and Winkler (2006), fig. 1.

§ The mean of $V_{i^\star}$ is 0.85, fig. 7, right.

§ Thus the average regret, $\mathrm{E}(V_{i^\star} - 0)$, is 0.85.

§

§ **Simple example.**

§ **The true values,** v_i, **all precisely equal zero. They are not random variables.**

§ **The estimates,** V_i, **are** $\mathcal{N}(0, 1)$, **fig. 9, left.**

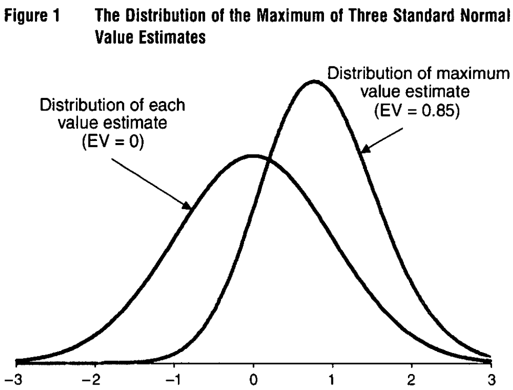

Figure 8: Smith and Winkler (2006), fig. 1.

§ **The mean of** $V_{i^\star}$ **is 0.85, fig. 9, right.**

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§ **Is outcome optimization a good strategy?**

§

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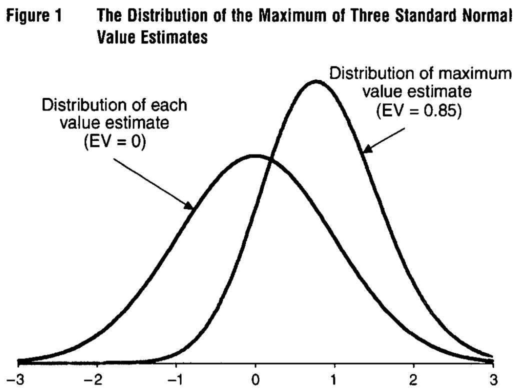

Figure 9: Smith and Winkler (2006), fig. 1.

§ The mean of $V_{i^\star}$ is 0.85, fig. 9, right.

§ Thus the average regret, $\mathrm{E}(V_{i^\star} - 0)$, is 0.85.

§ Is outcome optimization a good strategy?

§ What do engineers mean by "optimal design"?

∼∼∼

Part II
Uncertainty

§ **We have reviewed many**
human foibles of decision making:

- **Catch-All Underestimation Bias.**
-

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- **Conservatism:** **Incomplete up-dating from data.**
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§ **Part of the problem is uncertainty:**

Ignorance, surprise, change.

§

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§ Part of the problem is **uncertainty:**

Ignorance, surprise, change.

§ We now look at **uncertainty.**

9 *Theories and the Real World*

Theories and the Real World

§ **Real world:** drop a stone; it falls.

§

Theories and the Real World

§ **Real world:** drop a stone; it falls.

§ **Newtonian theory:** Distance $= \frac{1}{2}gt^2$.

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§ Is this theory:

- **True?**
- **Probably true?**
- **False?**
-

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§ Will something improve relativity? What? When?

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Theories and the Real World

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§ Will something improve relativity? What? When?

§ Science **will improve tomorrow.**
Hence **today we are ignorant.**

§

Theories and the Real World

§ **Real world:** drop a stone; it falls.

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§ Science **will improve tomorrow.**
Hence **today we are ignorant.**

§ Is **ignorance probabilistic?**

10 *Principle of Indifference*

§ Question: Is ignorance probabilistic?

§

§ **Question:** Is ignorance probabilistic?

§ **Principle of indifference** (Bayes, LaPlace, Jaynes, ...):

- Elementary events,
  about which **nothing is known**,
  are assigned **equal probabilities.**
-

§ **Question:** Is ignorance probabilistic?

§ **Principle of indifference** (Bayes, LaPlace, Jaynes, . . .):

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- Uniform distribution represents **complete ignorance.**

§

§ **Question:** Is ignorance probabilistic?

§ **Principle of indifference** (Bayes, LaPlace, Jaynes, . . .):

- Elementary events,
  about which **nothing is known**,
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§ The **info-gap contention:**

The probabilistic domain of discourse
does not encompass all epistemic uncertainty.

§

§ **Question:** Is ignorance probabilistic?

§ **Principle of indifference** (Bayes, LaPlace, Jaynes, . . .):

- Elementary events,
  about which nothing is known,
  are assigned equal probabilities.
- Uniform distribution represents complete ignorance.

§ The **info-gap contention:**

The probabilistic domain of discourse
does not encompass all epistemic uncertainty.

§ **We will consider common misuses of probability.**

10.1 *2-Envelope Riddle*

§ The riddle:

- **You are presented with two envelopes.**
  - **Each contains a positive sum of money.**
  - **One contains twice the contents of the other.**
- **You choose an envelope, open it, and find $ 50.**
- **Would you like to switch envelopes?**

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§ **You reason as follows:**

- **Other envelope contains either \$ 25 or \$ 100.**
- **Principle of indifference:**
- **Assume equal probabilities.**

  The expected value upon switching is:

  E.V. $= \frac{1}{2}$ \$ 25 $+$ $\frac{1}{2}$ \$ 100$=$ \$ 62.50.

  \$ 62.50 $>$ \$ 50.
- **Yes! Let's switch, you say.**

§ The riddle, re-visited:

- You are presented with two envelopes.
  - Each contains a positive sum of money.
  - One contains twice the contents of the other.
- You choose an envelope, but do not open it.
- Would you like to switch envelopes?

§ You reason as follows:

- **This envelope contains $ $X > $ $0.**
- **Other envelope contains either $ $2X$ or $ $\frac{1}{2}X$.**
- **Principle of indifference:**
- **Assume equal probabilities.**

  The expected value upon switching is:

  E.V. $= \frac{1}{2}\,\$\,2X + \frac{1}{2}\,\$\,\frac{1}{2}X = \$\left(1 + \frac{1}{4}\right)X > X.$
- **Yes! Let's switch, you say.**

§ **You reason as follows:**

- **This envelope contains $\$\,X > \$\,0$.**
- **Other envelope contains either $\$\,2X$ or $\$\,\frac{1}{2}X$.**
- **Principle of indifference:**
- **Assume equal probabilities.**

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  E.V. $= \frac{1}{2}\,\$\,2X + \frac{1}{2}\,\$\,\frac{1}{2}X = \$\,\left(1+\frac{1}{4}\right)X > X$.
- **Yes! Let's switch, you say.**

§ **You wanna switch again? And again? And again?**

10.2 Keynes' Example

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§ ρ = **specific gravity [g/cm^3] is unknown:**

$$1 \;\leq\; \rho \;\leq\; 3$$

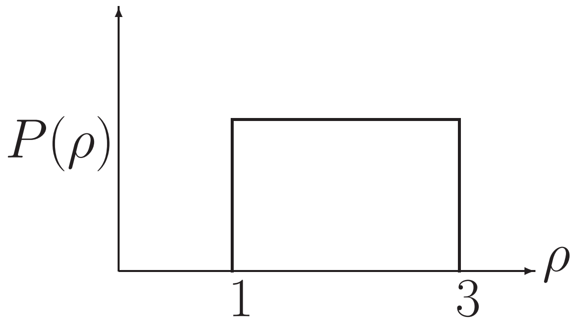
§

§ ρ = specific gravity [g/cm^3] is unknown:

$$1 \leq \rho \leq 3$$

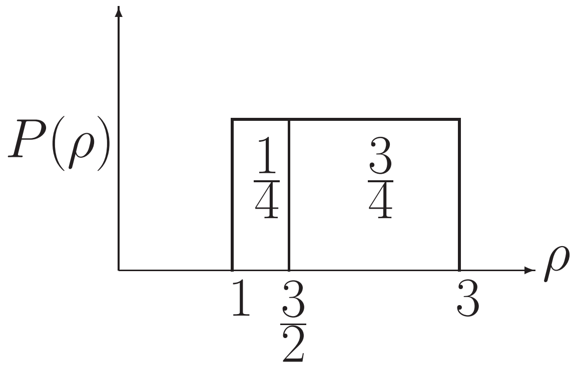
§ Principle of indifference:

Uniform distribution in $[1, \ 3]$, so:



§ Uniform distribution in $[1, \ 3]$, so:

$$\textbf{Prob}\left(\frac{3}{2} \ \leq \ \rho \ \leq \ 3\right) = \frac{3}{4}$$



§ ϕ = specific volume [cm^3/g] is unknown:

$$\frac{1}{3} \le \phi \le 1$$

§

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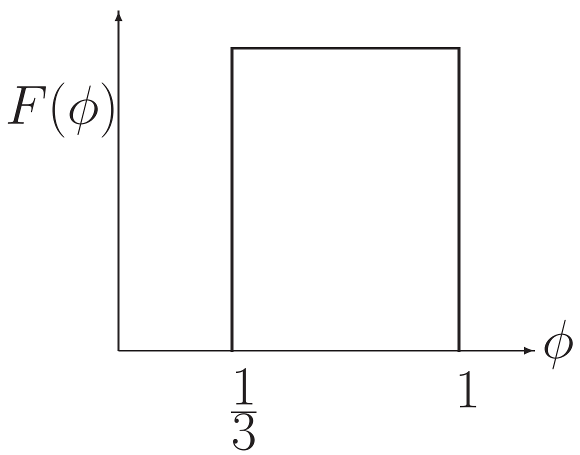
§ **Principle of indifference:**

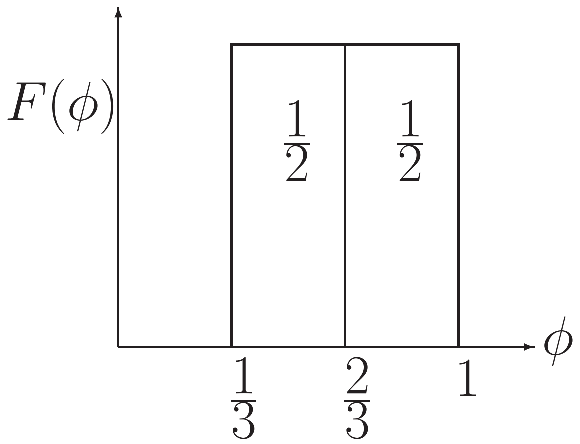
Uniform distribution in $\left[\frac{1}{3},\ 1\right]$**, so:**



§ Principle of indifference:

Uniform distribution in $\left[\frac{1}{3},\ 1\right]$**, so:**

$$\textbf{Prob}\left(\frac{1}{3} \le \phi \le \frac{2}{3}\right) = \frac{1}{2}$$



§ **These two events are identical:**

$$\underbrace{\left(\frac{1}{3} \;\leq\; \phi \;\leq\; \frac{2}{3}\right)}_{\textbf{Specific volume}} \equiv \underbrace{\left(\frac{3}{2} \;\leq\; \rho \;\leq\; 3\right)}_{\textbf{Specific gravity}}$$

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§ Hence their probabilities are equal:

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§ Hence:

$$\frac{1}{2} = \frac{3}{4}$$

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§ **The Culprit:** **Principle of indifference.**

§

§ **These two events are identical:**

$$\underbrace{\left(\frac{1}{3} \;\leq\; \phi \;\leq\; \frac{2}{3}\right)}_{\text{Specific volume}} \equiv \underbrace{\left(\frac{3}{2} \;\leq\; \rho \;\leq\; 3\right)}_{\text{Specific gravity}}$$

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§ **The Culprit: Principle of indifference.**

§ **Ignorance is not probabilistic. It's an info-gap.**

11 *Pascal's Wager*

§ **We now ask: Why is it difficult to make a binary decision under ignorance?**

§

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§ **Examples of binary decisions:**

- **God, no God?**
- **Truth, no truth?**
- **Seeing is believing?**
- **This theory is true or false?**

∼∼*Pascal's Wager*∼∼

Figure 10: **Blaise Pascal, 1623-1662.**

The wager is described in *Pensées* as:

"'God is, or He is not.' Reason can decide nothing here. ... Heads or tails will turn up. What will you wager? ...

"If you gain, you gain all; if you lose, you lose nothing. Wager, then, without hesitation that He is. ... Since there is an equal risk of gain and of loss, ..."

∼∼*Pascal's Wager*∼∼

Figure 11: **Blaise Pascal, 1623-1662.**

The wager is described in *Pensées* as:

"'God is, or He is not.' Reason can decide nothing here. ... Heads or tails will turn up. What will you wager? ...

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§ When "reason can decide nothing":

- **1st paragraph: Is probability a good tool?**
-

∼∼*Pascal's Wager*∼∼

Figure 12: **Blaise Pascal, 1623-1662.**

The wager is described in *Pensées* as:

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§ When "reason can decide nothing":

- **1st paragraph: Is probability a good tool?**
- **Do you have a better suggestion?**
-

∼∼*Pascal's Wager*∼∼

Figure 13: **Blaise Pascal, 1623-1662.**

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§ When "reason can decide nothing":

- **1st paragraph: Is probability a good tool?**
- **Do you have a better suggestion?**
- **2nd paragraph:**

  Is reasoning from the consequences legitimate?

12 *Lewis Carroll's Transcendental Probability*

Lewis Carroll's

∼∼*Transcendental Probability*∼∼

Figure 14: **Dodgson, 1832–1898.**

Figure 15: **Alice**

"A bag contains 2 counters, as to which nothing is known except that each is either black or white. Ascertain their colours without taking them out of the bag."

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Lewis Carroll's

∼∼*Transcendental Probability*∼∼

Figure 16: **Dodgson, 1832–1898.**

Figure 17: **Alice**

"A bag contains 2 counters, as to which nothing is known except that each is either black or white. Ascertain their colours without taking them out of the bag."

Answer: "One is black, and the other white."

§ Carroll assumed equal probabilities.

Was he justified?

§ Are such simple examples useful?

13 *3-Door Problem (Monty Hall Problem)*

§ Sources:

- **Plous, chapter 12.**
- **Yakov Ben-Haim, 1996, *Robust Reliability in the Mechanical Sciences*, section 7.1.**

§ **Prize in 1 of 3 boxes:** ? ? ?

§

§ **Prize in 1 of 3 boxes:** ? ? ?

§ **Choose a box:** C ? ?

§

§ **Prize in 1 of 3 boxes:** ? ? ?

§ **Choose a box:** C ? ?

§ **M.C. knows where the prize is.**

§ **M.C. opens an empty box:** C E T

§

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§ **Want to change your choice?**

$$C \Longrightarrow T$$

§

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§ **Is the situation binary indifference?** [C] [T]

§

§ **Prize in 1 of 3 boxes:** ? ? ?

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§ **Want to change your choice?**

$$C \Longrightarrow T$$

§ **Is the situation binary indifference?** **C** **T**

§ **Is the change justified?**

§ **What have you assumed? Equal probabilities?**

§ **Would you reach the same decision for any probability distribution?**

$\sim\sim\sim$

14 *Principle of Indifference: Continuation*

§ **We now generalize our discussion.**

14.1 *Shackle-Popper Indeterminism*

§ Intelligence:

What people know,

influences how they behave.

§

§ **Intelligence:**

What people know,

influences how they behave.

§ **Discovery:**

What will be discovered tomorrow

cannot be known today.

§

§ **Intelligence:**

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§ **Information-gaps, indeterminisms,**
sometimes
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Tomorrow's behavior cannot be
modelled completely today.

§ **Information-gaps, indeterminisms,**
sometimes
cannot be modelled probabilistically.

§ **Ignorance is not probabilistic.**

§ Two types of discoveries:

- **Discover what does exist (recovery).**
  - **America.**
  - **HIV virus.**
  - **House keys.**
-

§ **Two types of discoveries:**

- **Discover what does exist (recovery).**
  - **America.** ◦ **HIV virus.** ◦ **House keys.**
- **Discover what does not exist (invention).**
  - **Mathematical theorem (Hardy disagreed).**
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  - **Planck before 1905.**
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  - Einstein's argument for God, maybe:

    "Subtle is the Lord, but malicious He is not."

14.2 *Shackle-Popper and the Newtonian Paradigm*

§ Shackle-Popper indeterminism:

- **Discovery and intelligent knowledge-based behavior.**
-

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§ **Is there a conflict here?**

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§ Newtonian paradigm:

- Stable, universal, discoverable laws of nature.
- Science underlies prediction and control.

§ Is there a conflict here?

§ Yes.

- Shackle-Popper: Open universe.
- Newton: Closed universe.

Early modern:

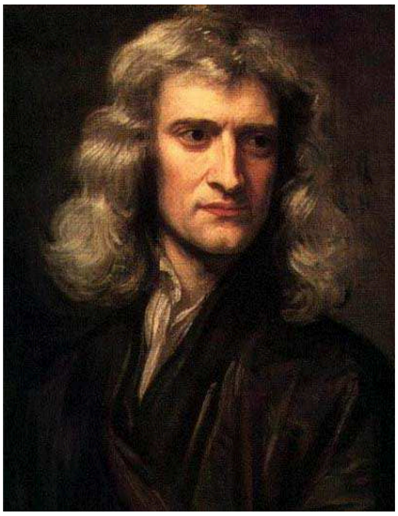

Figure 18: **Newton, 1642–1727.**

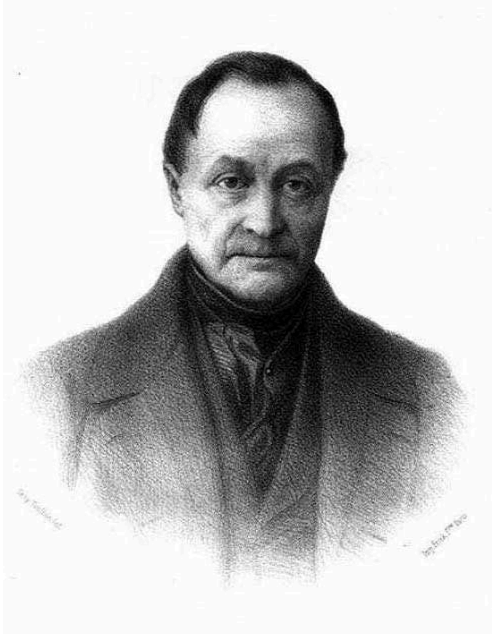

Figure 19: **Comte, 1798–1857.**

Late modern:

Figure 20: **Shackle, 1903–1992.**

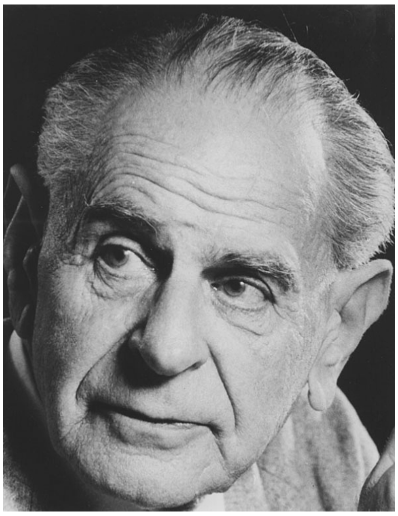

Figure 21: **Popper, 1902–1994.**

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- **Intelligent learning (open) systems.**
- **Laws of the system change.**
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Summary of the Conflict

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Summary of the Conflict

§ **Newton, Comte, Positivism:**

- **Creation ended. Universe fixed.**
- **There are true (final) laws of nature.**
- **Theories converge on the truth.**
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§ **Shackle-Popper indeterminism:**

- **Intelligent learning (open) systems.**
- **Laws of the system change.**
- **Theories (models) give insight.**
- **Prediction is always difficult . . .
  especially of the future.**

§ If not Newton, then what?

§ Crisis of models:

- Are they good for anything?

  And if so, why do buildings fall, markets crash . . .
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  - **Can simulations make up for limited understanding?**

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— **Yes: Use models to predict new phenomena.**
Eg neutrino, fatigue failure.

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  - **Can engineering handle social problems?**
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  - Can engineering handle social problems?
  - Can engineers interface with social decision makers?
- Economics: Why the frequent surprises?

Figure 22: **Henry Adams 1838–1918.**

> **"Images are not arguments, but the mind craves them. [T]wenty images better than one, especially if contradictory; since the human mind has already learned to deal in contradictions."**

§ Models, the more the merrier.

§

Figure 23: **Henry Adams 1838–1918.**

> **"Images are not arguments, but the mind craves them. [T]wenty images better than one, especially if contradictory; since the human mind has already learned to deal in contradictions."**

§ Models, the more the merrier.

§ Is this a Newton-Comte or Shackle-Popper idea?

14.3 *Intelligent Learning System: Example*

Inflation Prediction

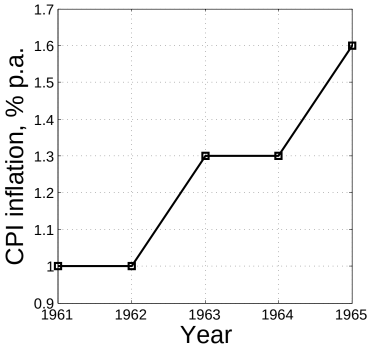

Figure 24: **US inflation vs. year, 1961–1965.**

§ Model US inflation '61–'65. Predict '66.

'61–'65: Linear?

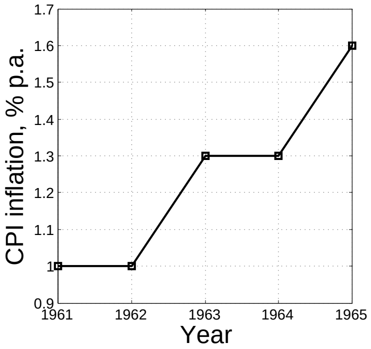

Figure 25: **US inflation vs. year, 1961–1965.**

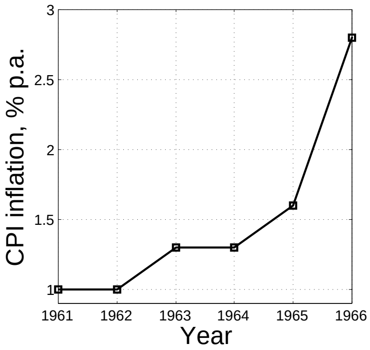

Figure 26: **US inflation vs. year, 1961–1966.**

§ ’61–’65: Linear?

§ ’61–’66: Piece-wise linear? Quadratic?

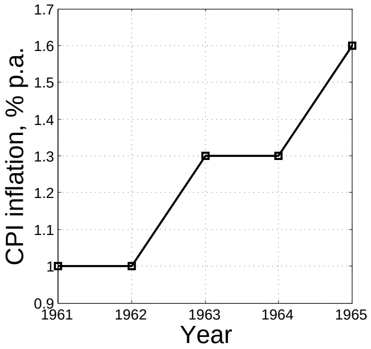

Figure 27: **US inflation vs. year, 1961–1965.**

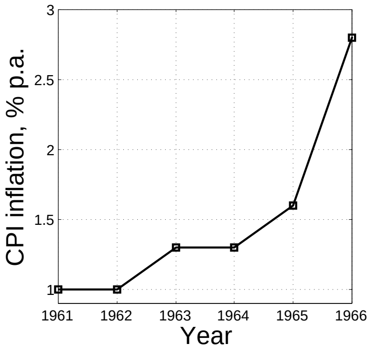

Figure 28: **US inflation vs. year, 1961–1966.**

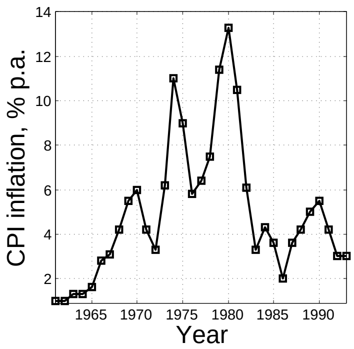

Figure 29: **US inflation vs. year, 1961–1993.**

§ '61–'65: Linear?

§ '61–'66: Piece-wise linear? Quadratic?

§ '61–'93: A mess?

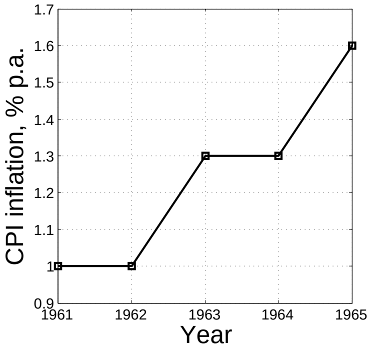

Figure 30: **US inflation vs. year, 1961–1965.**

§ US inflation '61–'65:

- **Model '61–'65 for predicting '66.**
- **Use data and contextual insight:**

  Economy heating up. No data yet.

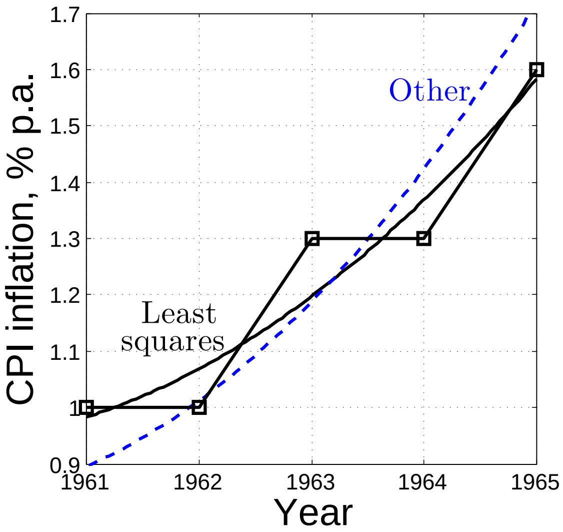

Figure 31: **US inflation vs. year, 1961–1965, and least squares fit (solid) and other fit (dash).**

§ Least squares and other fit: fig. 31.

§ Evaluate fit:

- **Fidelity to history (—).** • **Fidelity to future (– –).**
- **Which is "Newton-Comte" or "Shackle-Popper"?**

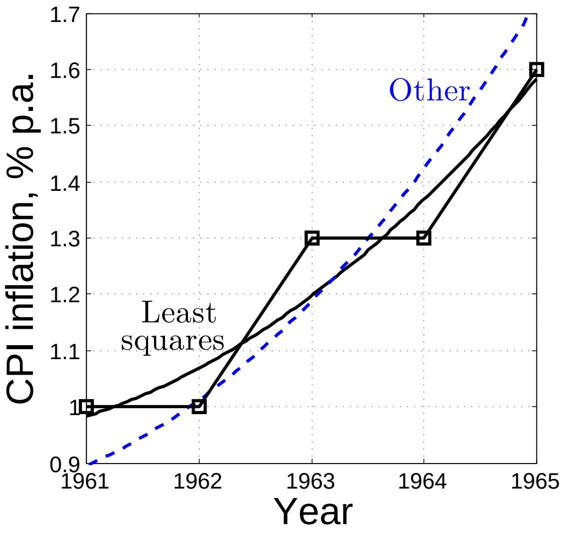

Figure 32: **US inflation vs. year, 1961–1965, and least squares fit (solid) and other fit (dash).**

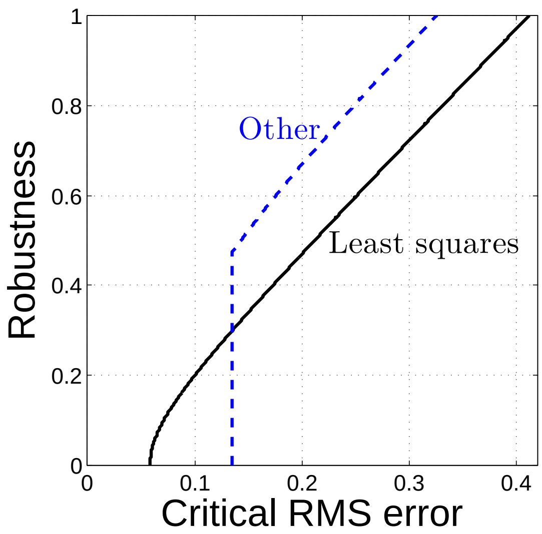

Figure 33: **Robustness vs. critical root mean squared error for inflation 1961–1965 for least squares fit (solid) and other fit (dash).**

§ **Least squares and other fit: fig. 32.**

§ **Evaluate fit:**

- **Fidelity to history (—).** • **Fidelity to future (– –).**
- **Which is "Newton-Comte" or "Shackle-Popper"?**

§ **Robust of LS and other fit: fig. 33.**

- **Curve-crossing: preference reversal.**
- **Is this pragmatic or principled?**
- **Newton-Comte or Shackle-Popper?**

§ We have discussed:

- **Newtonian paradigm:** **Law & prediction.**
-

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§ **Info-gap theory:**

- **Unstructured uncertainty.**
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- **Newtonian paradigm:** Law & prediction.
- **Shackle-Popper:** Indeterminism.
- **Adams:** 20 images better than 1.
- **Ignorance** and **probability.**

§ **Info-gap theory:**

- Unstructured uncertainty.
- Satisficing vs optimizing.
- Robustness.

15 *Questions for Further Discussion*

§ **Are people**

naturally good decision makers?

How did the species survive if not?

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§ **Some people are better DMs than others.**
Implications for democracy?

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Implications for democracy?

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§ **Does education help? What sort?**

- **Technical?**
- **Philosophical?**
- **Psychological?**

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§ Are all theories (or statements) either true or false?

- In science?
- In politics?
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§ Are all theories (or statements) either true or false?
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§ What is rationality?
- Is there only one rationality?
- Should all rational people always agree?

In Conclusion

Human decision making

under uncertainty

is

StranGe