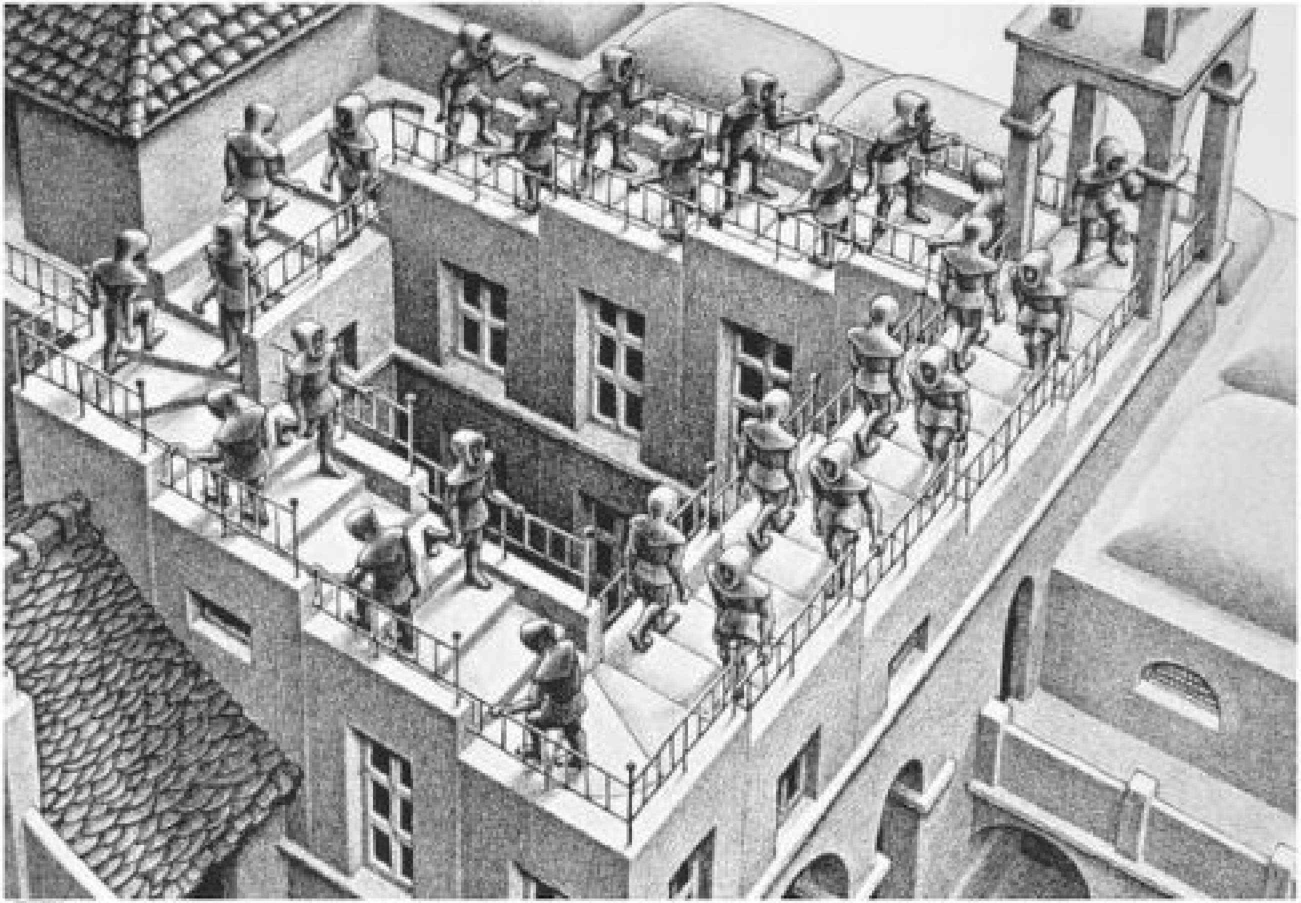
THE BIOLOGICAL BASIS OF ECONOMICS

Arthur J. Robson

New York University

February, 2013



Focussing Illusion

David A. Schkade and Daniel Kahneman. (1998) "Does living in California..."
Kahneman and Thaler (2007) Decision versus experienced utility
Gilbert "Stumbling on Happiness"
Gul and Pesendorfer "Mindless Economics"

Robson, A.J. and Samuelson, L. (2010) “The Evolutionary Optimality of Decision and Experienced Utility,” Theoretical Economics 6 (2011), 311–339.

- As in R&B, there are bounds on utilities (Simmons and Gallistel (1994)).
- Also as in R&B, there are limits on our ability to discriminate between different levels of utility.
- Given imperfect discrimination, a “steep” utility function is better. Given the bounds on utility, it can only be steep “where it counts.”
- This adaptation yields distinct decsion and experienced utilities and hence the focussing illusion.
- The agent should be naive not sophisticated (O’Donoghue and Rabin (1999)).
- With fine discrimination, actions will approximately satisfy revealed preference, based on fitness.

R&S, TE

$$\begin{aligned}\tilde{z} &= \tilde{z}_1 + \tilde{z}_2 \\ &= [\zeta_1(x_1) + \tilde{s}_1] + [\gamma \tilde{z}_1 + \zeta_2(x_1, x_2) + \tilde{s}_2].\end{aligned}$$

The individual chooses x_1 and x_2. Rv's $\tilde{s}_1$ and $\tilde{s}_2$ are unimodal, and symmetric, with pdf's g_1 and g_2. In the second period, the individual observes the realization of $\tilde{z}_1$. For simplicity,

$$\begin{aligned}\tilde{z} &= \tilde{z}_1 + \tilde{z}_2 \\ &= [\zeta_1(x_1) + \tilde{s}_1] + [\gamma \tilde{z}_1 + \zeta_2(x_2) + \tilde{s}_2].\end{aligned}$$

Nature seeks to maximize the expectation of $\tilde{z}_1 + \tilde{z}_2$. Nature constructs the utilities as functions of $\tilde{z}_1$ and $\tilde{z}_2$ and conditions second period utility on $\tilde{z}_1$. She cannot condition on x_1 or x_2.

R&S, TE

Second period utility is $V_2(z \mid z_1)$. This is "experienced utility."
Instead of choosing the x_2^* that maximizes
$E_{\tilde{s}_2} V_2(z_1 + (\gamma z_1 + \zeta_2(x_2) + \tilde{s}_2)|z_1)$, the agent chooses any x_2 such that

$$\begin{aligned} & E_{\tilde{s}_2} V_2(z_1 + (\gamma z_1 + \zeta_2(x_2^*) + \tilde{s}_2)|z_1) \\ & -E_{\tilde{s}_2} V_2(z_1 + (\gamma z_1 + \zeta_2(x_2) + \tilde{s}_2)|z_1) \\ \leq \; & \varepsilon_2. \end{aligned}$$

He randomizes uniformly over $[\underline{x}_2, \overline{x}_2]$, where $\underline{x}_2 < x_2^* < \overline{x}_2$ and

$$\begin{aligned} & E_{\tilde{s}_2} V_2((1+\gamma)z_1 + \zeta_2(\underline{x}_2) + \tilde{s}_2|z_1) \\ = \; & E_{\tilde{s}_2} V_2((1+\gamma)z_1 + \zeta_2(\overline{x}_2) + \tilde{s}_2|z_1) \\ = \; & E_{\tilde{s}_2} V_2((1+\gamma)z_1 + \zeta_2(x_2^*) + \tilde{s}_2|z_1) - \varepsilon_2. \end{aligned}$$

R&S, TE

Lemma There exists $\underline{Z}_2(z_1) < \overline{Z}_2(z_1)$ such that the optimal second-period utility function satisfies

$$\begin{aligned} V_2(z|z_1) &= 0, \text{ for all } z < \underline{Z}_2(z_1) \\ V_2(z|z_1) &= 1, \text{ for all } z > \overline{Z}_2(z_1). \end{aligned}$$

In the limit as $\varepsilon_2 \longrightarrow 0$, the agent's second-period choice $x_2 \longrightarrow x_2^*$.

R&S, TE

First period utility is $V_1(z)$, "decision utility."
Take $\varepsilon_2 \to 0$ first. The agent now has utility $V_1(z)$ with $V_1 \in [0, 1]$.
There is a satisfing set $[\underline{x}_1, \overline{x}_1]$, where

$$\begin{aligned} & E_{\tilde{s}_1,\tilde{s}_2} V_1(\zeta_1(\underline{x}_1) + \tilde{s}_1 + [\gamma(\zeta_1(\underline{x}_1) + \tilde{s}_1) + \zeta_2(x_2^*) + \tilde{s}_2]) \\ = \quad & E_{\tilde{s}_1,\tilde{s}_2} V_1(\zeta_1(\overline{x}_1) + \tilde{s}_1 + [\gamma(\zeta_1(\overline{x}_1) + \tilde{s}_1) + \zeta_2(x_2^*) + \tilde{s}_2]) \\ = \quad & E_{\tilde{s}_1,\tilde{s}_2} V_1(\zeta_1(x_1^*) + \tilde{s}_1 + [\gamma\zeta_1(x_1^*) + \tilde{s}_1) + \zeta_2(x_2^*) + \tilde{s}_2]) - \varepsilon_1. \end{aligned}$$

The individual randomizes uniformly over $[\underline{x}_1, \overline{x}_1]$. Evolution picks $V_1(z)$ to maximize expected fitness, subject to the above.

R&S, TE

Lemma. There exists $\hat{Z}_1$ such that the optimal first-period utility function is

$$\begin{aligned} V_1(z) &= 0, \text{ for all } z < \hat{Z}_1 \\ V_1(z) &= 1, \text{ for all } z > \hat{Z}_1. \end{aligned}$$

In the limit as $\varepsilon_1 \to 0$,

$$\hat{Z}_1 = (1+\gamma)\zeta_1(x_1^*) + \zeta_2(x_2^*),$$

and

$$\begin{aligned} \underline{Z}_2(z_1) &\to (1+\gamma)z_1 + \zeta_2(x_2^*) \\ \overline{Z}_2(z_1) &\to (1+\gamma)z_1 + \zeta_2(x_2^*). \end{aligned}$$

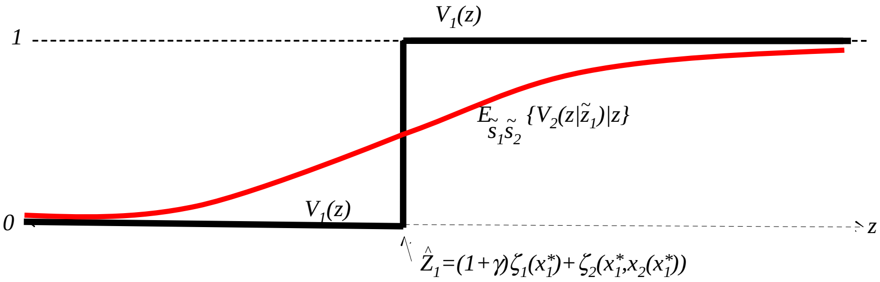
R&S, TE

Suppose agent contemplates decision utility $V_1(z)$ as arising from a specific z. It follows that $E_{\tilde{s}_1,\tilde{s}_2}\left\{V_2(z|\tilde{z}_1)|z\right\}$ is expected experienced utility, given z, and that

$$\begin{aligned} V_1(z) &\neq E_{\tilde{s}_1,\tilde{s}_2}\left\{V_2(z|\tilde{z}_1)|z\right\} \\ &= \Pr\left\{V_2(z|\tilde{z}_1) = 1|z\right\} \\ &= \Pr\left\{\tilde{s}_2 \geq 0|z\right\}. \end{aligned}$$

Indeed, $E_{\tilde{s}_1,\tilde{s}_2}\left\{V_2(z|\tilde{z}_1)|z\right\}$ increases from 0 to 1 as z increases.

R&S, TE



$V_1(z)$
1
$E_{\tilde{s}_1 \tilde{s}_2} \{V_2(z|\tilde{z}_1)|z\}$
0
$V_1(z)$
z
$\hat{Z}_1 = (1+\gamma)\zeta_1(x_1^*) + \zeta_2(x_1^*, x_2(x_1^*))$

Consider $\varepsilon_1 = \varepsilon_2 = 0$. Then

$$E_{\tilde{s}_1,\tilde{s}_2} V_2(\tilde{z}|\tilde{z}_1) = \Pr[\tilde{s}_2 \ \geq \ 0] = \frac{1}{2},$$

for *every* x_1. Correctly anticipated experienced utility provides no incentives at all... A sophisticated agent would have no strict incentive to choose x_1^* rather than any other x_1. More generally, with $\varepsilon_1 > 0$ and $\varepsilon_2 > 0$, it is strictly better for agents to be naive.

Implications

If utility has an evolutionary origin (and is hedonic), there should be a distinction between decision and experienced utility. Psychologists are prone to argue, further, that decisions would be improved if decision utility were replaced by expected experienced utility. We provide no support for this view. Decision and experienced utilities combine to produce fitness-maximizing choices. Choices based on experienced utilities can only reduce fitness. The optimal choices will nevertheless be approximately satisfy revealed-preference, with fitness as the true utility function, as long as the errors are small.

4. ATTITUDES TO RISK

The EUT is readily derived from biological evolution, but this depends on the risk being independent across individuals, and there seems no compelling reason this should be so. Perhaps some of the risk in a hunter-gatherer society concerned the weather, which clearly has a shared component.
The opposite polar extreme to idiosyncratic risk is aggregate risk. If idiosyncratic risk means a separate personal coin is flipped for each individual, aggregate risk means one big public coin is flipped.

52 cards, 26 red and 26 black. You are risk-neutral.
1) I will pay you $(0.01)(3/2)^{52} \simeq \$14,000,000$ for sure OR 2) You can bet on the outcome of each card as it comes up, with red meaning I double your total so far, black meaning no change

RISK

The payoff from the "gamble" is exactly $(0.01)2^{26} = (0.01)(\sqrt{2})^{52} \simeq \$670,000$. The "gamble" is worse because $\sqrt{2} < 3/2$.

With an infinite deck, the gamble really is a gamble, and the expected amount after T draws is $(0.01)(3/2)^T$. The two options are then equivalent.

There is a still an appealing sense in which the gamble, as in 2), is inferior to 1), when $T \to \infty$. Consider this evolutionary contest. Type 1 has 2 offspring with probability $1/2$, or 1 offspring with probability $1/2$. All the risk is idiosyncratic. Type 2 also has 2 offspring with probability $1/2$, or 1 with probability $1/2$, but the risk is aggregate.

Robson, A.J. "A Biological Basis for Expected and Non-Expected Utility," J. Econ. Theory, 1996, 68, 397-424.

Given a "large" population, the number of type 1's at date T is $x(T) = (3/2)^T$, assuming $x(0) = 1$. Note that $\frac{1}{T}\ln x(T) = \ln(3/2)$. The number of type 2's is $y(T) = 2^{n(T)}$, where $y(0) = 1$. Now $n(T)$ is the number of heads in a sequence of T flips of a fair coin. It follows that $\frac{1}{T}\ln y(T) = \frac{n(T)}{T}\ln 2 \to \frac{1}{2}\ln 2 = \ln\sqrt{2}$, w.p. 1, by the strong law of large numbers. With an infinite deck, there are exactly 1/2 red and 1/2 black cards. It follows that $E(y(t)) = (3/2)^T$, so that the mean of $y(t)$ grows at a faster exponential rate than does $y(t)$ itself!

It follows that $\frac{1}{T}\ln(x(T)/y(T)) = \frac{1}{T}\ln x(T) - \frac{1}{T}\ln y(T) \to \ln(3/2) - \ln\sqrt{2} > 0$ w.p. 1. Hence $x(T)/y(T) \to \infty$, w.p. 1.

Robson, JET

The martingale betting strategy, as used by Casanova. Consider the possible outcomes after a maximum of $T+1$ flips of the fair coin. One possibility is that you have lost every flip up to the maximum. That is, you might have lost $1+2+...+2^T = 2^{T+1}-1$. The probability of this loss is $\left(\frac{1}{2}\right)^{T+1}$. The only other possibility is that you won $1 = 2^S - (1+...+2^{S-1})$. The probability of winning is $1-\left(\frac{1}{2}\right)^{T+1}$. The expected change in wealth is $-\left(\frac{1}{2}\right)^{T+1}\left(2^{T+1}-1\right)+1-\left(\frac{1}{2}\right)^{T+1}=0$.
Martingale convergence theorem. The mean is held down by the vanishingly unlikely event of a large loss.
In the biological example, the mean of Type 2 is similarly held up by vanishingly unlikely very large populations.