Cognitive Evolutionary Psychology

How do we make decisions under uncertainty?

- Rational choice theory
- The Tversky-Kahneman challenge
- The Evolutionary psychology response
- Probabilities vs relative frequencies
Ben Franklin’s advice

“If you doubt, set down all the Reasons, pro and con, in opposite Columns on a Sheet of Paper, and when you have consiered them two or three Days, perform an Operation similar to that in some questions of Algebra; observe what Reasons or Motives in each Column are equal in weight, one to one, one to two, two to three, or the like, and when you have struck out from both Sides all the Equalities, you will see in which column remains the Balance [...] This kind of Moral Algebra I have often practiced in important and dubious Concerns, and tho’ it cannot be mathematically exact, I have found it extremely useful. By the way, if you do not learn it, I apprehend you will never be married.”

I am ever your affectionate uncle,
B. FRANKLIN
Rational choice theory and its detractors

Do people actually do this?

No.
Darwin’s dilemma

Marry

Children—(if it Please God)—Constant companion, (& friend in old age) who will feel interested in one,—object to be beloved & played with.—better than a dog anyhow.—Home, & someone to take care of house—Charms of music & female chit-chat.—These things good for one’s health.—but terrible loss of time.—

My God, it is intolerable to think of spending ones whole life, like a neuter bee, working, working, & nothing after all.—No, no won’t do.—Imagine living all one’s day solitarily in smoky dirty London House.—Only picture to yourself a nice soft wife on a sofa with good fire, & books & music perhaps—Compare this vision with the dingy reality of Grt. Marlbro’ St.

Not Marry

Freedom to go where one liked—choice of Society & little of it.—Conversation of clever men at clubs—Not forced to visit relatives, & to bend in every trifle.—to have the expense & anxiety of children—perhaps quarrelling—Loss of time.—cannot read in the Evenings—fatness & idleness—Anxiety & responsibility—less money for books &c—if many children forced to gain one’s bread.—(But then it is very bad for ones health to work too much)

Perhaps my wife wont like London; then the sentence is banishment & degradation into indolent, idle fool—

Marry—Mary—Marry Q.E.D.
The Tversky-Kahneman revolution

People use rules of thumb, do not calculate probabilities in their head

These heuristics can lead to systematic biases and distortions.
The representativeness heuristic

"Steve is very shy and withdrawn, invariably helpful, but with little interest in people or in the world of reality. A meek and tidy soul, he has a need for order and structure and a passion for detail".

Is Steve:

- a farmer?
- a salesman?
- an airline pilot?
- a librarian?
- a physician?
"Dick is a 30 year old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well liked by his colleagues”

Is he an engineer or a lawyer?
Availability heuristic

What is more frequent, dying from shark attacks or from falling airplane parts?

Are there more words that begin with the letter k or have k in the third position?
Is the brain just badly designed?

The Evolutionary Psychology response: Heuristics produce good results in real life circumstances especially when:

- information is given as it would have appeared in the EEA
- when it is not possible to estimate the probability of different outcomes (uncertainty vs risk)
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The Linda problem, first version

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which of the following is more probable?

1. Linda is a bank teller
2. Linda is a bank teller and active in the feminist movement
The conjunction fallacy: What does “and” mean?

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Why are we fooled by the story?

1. We assume that the speaker follows the principle “be relevant”
2. The words “and” and “probable” have several meanings:

- Verona is in Italy and Valencia is in Spain
- Valencia is in Spain and Verona is in Italy
- Peggy and Paul married and Peggy became pregnant
- Peggy became pregnant and Peggy and Paul married
- Mark got angry and Mary left
- Mary left and Mark got angry
The Linda problem, second version

There are a hundred people who fit the description above. How many of them are:

1. bank tellers
2. bank tellers and active in the feminist movement

(from Hertwig and Gigerenzer, reported in Gigerenzer 2007)
The mammogram problem: probability version

- The probability of breast cancer is 1% for a woman at age forty who participates in routine screening.
- If a woman has breast cancer, the probability is 80% that she will have a positive mammogram.
- If a woman does not have breast cancer, the probability is 9.6% that she will also have a positive mammogram.
- Imagine a woman in this age group who had a positive mammogram in routine screening. What is the probability that she has breast cancer?
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How to solve it using Bayes’s rule:

\[
p(C|M) = \frac{p(C)p(M|C)}{p(C)p(M|C) + p(\neg C)p(M|\neg C)} = \frac{(0.01)(0.80)}{(0.01)(0.80) + (0.99)(0.096)} = 0.078
\]
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The correct answer is 7.8%, but 95% of 100 physicians judged it to be between 70% and 80%
Imagine an old, experienced physician in an illiterate society. She has no books or statistical surveys and therefore must rely solely on her experience. Her people have been afflicted by a previously unknown and severe disease. Fortunately, the physician has discovered a symptom that signals the disease, although not with certainty.

In her lifetime, she has seen 1,000 people, 10 of whom had the disease. Of those 10, 8 showed the symptom; of the 990 not afflicted, 95 did.

Now a new patient appears. He has the symptom. What is the probability that he actually has the disease?

(Gigerenzer and Hoffrage 1995)
“In her lifetime, she has seen 1,000 people, 10 of whom had the disease. Of those 10, 8 showed the symptom; of the 990 not afflicted, 95 did.”

- 103 (95+8) people have shown the symptom
- 8 people have had the disease
- The likelihood that a person with the symptom also has the disease is $8/103$ (7.8%)

(Gigerenzer and Hoffrage 1995)
Probabilities vs. frequencies

\[
p(\text{diseaselsymptom}) = \frac{8}{8 + 95}
\]

\[
p(\text{diseaselsymptom}) = \frac{.01 \times .80}{.01 \times .80 + .99 \times .096}
\]

(Gigerenzer and Hoffrage 1995)
Defense attorney Dershowitz argued that O.J.’s prior beatings of his murdered ex-wife were not relevant. Statistician I. J. Good disputed that:

Good bases his calculations of \( p(G|\text{Bat and } M) \) on the odds version of Bayes’s rule:

\[
\text{posterior odds} = \text{prior odds} \times \text{likelihood ratio},
\]

which, in the present case is:

\[
\frac{p(G|\text{Bat and } M)}{p(\bar{G}|\text{Bat and } M)} = \frac{p(G|\text{Bat})}{p(\bar{G}|\text{Bat})} \times \frac{p(M|G \text{ and Bat})}{p(M|\bar{G} \text{ and Bat})}
\]

(3)

where \( \bar{G} \) stands for “the husband is not guilty.”

Good’s analysis follows in 6 equations starting with Dershowitz’s estimate that the probability of a battered woman being killed by her husband is at least 1/10,000:
Probabilities vs. frequencies: A real-life story

\[ p(G|\text{Bat}) > (1/10) (1/1,000) = 1/10,000 \quad \text{(Good-1)} \]

Therefore, the prior odds (O) are:

\[ O(G|\text{Bat}) > 1/9,999 \approx 1/10,000 \quad \text{(Good-2)} \]

Furthermore, the probability of a woman being murdered given that her husband has murdered her (whether he is a batterer or not) is unity:

\[ p(M|G \text{ and Bat}) = p(M|G) = 1 \quad \text{(Good-3)} \]

Because there are about 25,000 murders per year in the US population of about 250,000,000, Good estimates the probability of a woman being murdered, but not by her husband, as:

\[ p(M|\bar{G} \text{ and Bat}) = p(M|\bar{G}) \approx 1/10,000 \quad \text{(Good 4)} \]

From Equations Good-3 and Good-4, it follows that the likelihood ratio is about 10,000/1; therefore, the posterior odds can be calculated:

\[ O(G|M \text{ and Bat}) > 10,000/10,000 = 1 \quad \text{(Good-5)} \]

That is, the probability that a murdered, battered wife was killed by her husband is:

\[ p(G|\text{Bat and M}) > 1/2 \quad \text{(Good-6)} \]
Good’s argument in natural frequencies

Think of 10,000 battered married women. Within one year, at least one will be murdered by her husband. Of the remaining 9,999 who are not killed by their husbands, one will be murdered by someone else.

Thus we expect at least two battered women to be murdered, at least one by her husband, and one by someone else.

Therefore, the probability $p(G|\text{Bat and M})$ that a murdered, battered woman was killed by her husband is at least $1/2$. 
The brain’s heuristics work splendidly, but only if you give it inputs (data) of the sort it experienced in its evolutionary past.

Your calculator expects data in base 10. If you enter data in base 2, don’t complain that its algorithm is wrong.

We evolved experiencing data in frequencies (counts), not probabilities. Given a problem in that form, people are able to solve it.