Chapter 10. Probabilistic Reasoning

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Probabilistic Reasoning

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- Men are taller than women, right?
- All men are taller than all women, right?
- By probabilistic trend, we simply mean that it is more likely than not but does not hold true in all cases.
- These are all statistically demonstrable trends, yet there are exceptions to every one of them.

Probabilistic Reasoning

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- Every failure to predict is not a mistake.

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- Probabilistic prediction is, indeed, real prediction.
- Because probabilistic prediction is numerical, and therefore abstract, people sometimes have a hard time viewing it as real.
- We must get over this feeling that, because of its numerical abstraction, probabilistic prediction is not real.

Probabilistic Reasoning

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- Scientists are indeed talking about real people when they make these probabilistic predictions.
- However, the prediction is no less real just because it is probabilistic.

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Probabilistic Reasoning

- People have a hard time accepting the reality of probabilistic prediction —that they do not live in a world of certainties.
- Virtually all the facts and relationships that have been uncovered by the science of psychology are stated in terms of probabilities. There is nothing unique about this.
- Many of the laws and relationships in other sciences are stated in probabilities rather than certainties.

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- The entire subdiscipline of population genetics, for example, is based on probabilistic relationships.
- Physicists tell us that the distribution of the electron's charge in an atom is described by a probabilistic function.
- Thus, the fact that behavioral relationships are stated in probabilistic form does not distinguish them from those in other sciences.

Probabilistic Reasoning

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- “People seem to be in a land of sometimes and perhaps, and they had hoped to go on living with always and with certainty” (Bronowski, 1978a, p. 94).

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- “People seem to be in a land of sometimes and perhaps, and they had hoped to go on living with always and with certainty” (Bronowski, 1978a, p. 94).
- In this chapter, we will try to make you more comfortable in the ”land of sometimes and perhaps”.

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“Person-Who” Statistics

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- Oh, get outta here! Look at old Joe Ferguson down at the store. Three packs of Camels a day since he was sixteen! Eighty-one years old and he looks great!

Person-Who Statistics

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“Person-Who” Statistics

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- This agreement reflects a failure to understand the nature of statistical laws. If people think a single example can invalidate a law, they must feel the law should hold in every case.
- In short, they have failed to understand the law’s probabilistic nature.

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- Situations in which well-established statistical trends are questioned because someone knows a “person who” went against the trend.

Brad Pitt and Angelina Jolie

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- Thus, it could be argued that people actually know better and simply use the “person who” as a technique to invalidate facts that go against their opinions.

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“Person-Who” Statistics

- However, the work of psychologists who have studied human decision making and reasoning suggests that the tendency to use the “person who” comes not simply from its usefulness as a debating strategy.
- Instead, it appears that this fallacious argument is used so frequently because people experience great difficulty in dealing with probabilistic information.
- Much research into the nature of human thinking has indicated that probabilistic reasoning may well be the Achilles’ heel of human cognition.

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- Very similar probabilistic statements about behavioral trends cause widespread disbelief and are often dismissed by many people with the first appearance of a single “person who.”
- No one would doubt the worth of medical knowledge just because it is probabilistic and does not apply in every case.
- Yet this is exactly what happens in the case of many psychological findings and treatments.

“Person-Who” Statistics

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- The prediction of outcomes based on group characteristics is often called aggregate or actuarial prediction.

“Person-Who” Statistics

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- “The science of global warming has nothing to say about any particular hurricane (or drought or heat wave or flood), only about the larger statistical pattern”.

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“Person-Who” Statistics

- Psychology probably suffers the most from the general public’s inability to think statistically.
- Yet, of all the disciplines, the most research into the nature of probabilistic reasoning abilities has been done in psychology.

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Introduction

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- Unless he or she exercises and changes diet, he or she has a high risk of heart attack.
- There is an 80 percent probability of a magnitude 8.0 or greater earthquake in a certain area in the next 30 years.

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- The key initial developments did not occur until the sixteenth and seventeenth centuries and many essential developments date not much past the last century.
- The dates of the initial developments in probability theory highlight a significant fact: Games of chance existed centuries before the fundamental laws of probability were discovered.

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- If ordinary citizens are to have a basic understanding of the society in which they live, they must possess at least a rudimentary ability to think statistically.

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- We will, however, briefly discuss some of the more common pitfalls of probabilistic reasoning.

Daniel Kahneman

Daniel Kahneman
Prize share: 1/2

Half of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2002 was awarded to Daniel Kahneman *for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty.*

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- In short, people actually know better but are initially drawn to an incorrect conclusion. Psychologists have termed problems like these “cognitive illusions”.
- In cognitive illusions, even when people know the correct answer, they may be drawn to an incorrect conclusion by the structure of the problem.

Failure to Use Sample-Size Information

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- 一个小镇有大小两所医院。
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- 另一个人从里面拿出 20 个球, 发现有 12 个是红色的, 8 个是白色的.
- 哪一个人更有自信的认为这个缸里有 2/3 的球是红色的, 有 1/3 的球是白色的, 而不是有 1/3 的球是红色的, 有 2/3 的球是白色的? 这两个人会给出什么样的概率来说明这两种说法的正确程度呢?

Bayesian equation

$$\frac{P(A|B)}{P(\neg A|B)} = \frac{\frac{P(B|A) \times P(A)}{P(B)}}{\frac{P(B|\neg A) \times P(\neg A)}{P(B)}} = \frac{P(B|A)}{P(B|\neg A)} \times \frac{P(A)}{P(\neg A)}$$

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- Smaller samples will always generate more extreme values.

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- The counties in which the incidence of kidney cancer was lowest tended to be rural counties that were sparsely populated.
- The counties in which the incidence of kidney cancer was highest tended to be rural counties that were sparsely populated!
- Rural counties with sparse populations are small samples, and they are bound to produce more extreme values of all types - extremely high values and extremely low values.

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- Many people have problems recognizing that they are in situations involving sampling.
- That is, they have difficulty realizing that they are dealing with a sample rather than the entire entity.
- Failure to realize this leads them to miss the fact that a sample measurement will be subject to sampling error.

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Failure to Use Sample-Size Information

- Your physician is making assumptions about your entire composition from a tiny sample.
- It is likewise when a tumor is biopsied.
- We often are taking a small sample to represent a much larger population of behavior.

The Gambler's Fallacy

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- Problem A: Imagine that we are tossing a fair coin (a coin that has a 50/50 chance of coming up heads or tails) and it has just come up heads five times in a row. For the sixth toss, do you think that

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  - c. Heads and tails are equally probable on the sixth toss?

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  - a. It is more likely that tails will come up than heads?
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- Problem B: When playing slot machines, people win something one out of every 10 times. Julie, however, has just won on her first four plays. What are her chances of winning the next time she plays?

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  - b. It is more likely that heads will come up than tails?
  - c. Heads and tails are equally probable on the sixth toss?
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- The gambler's fallacy: the tendency for people to see links between events in the past and events in the future when the two are really independent.
- Two outcomes are independent when the occurrence of one does not affect the probability of the other. Most games of chance that use proper equipment have this property.

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- It is important to realize that the gambler's fallacy is not restricted to games of chance. It operates in any domain in which chance plays a substantial role, that is, in almost everything.

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- It is important to realize that the gambler's fallacy is not restricted to games of chance. It operates in any domain in which chance plays a substantial role, that is, in almost everything.
- The genetic makeup of babies is an example.

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- The gambler's fallacy stems from many mistaken beliefs about probability.
- One is the belief that if a process is truly random, no sequence —not even a small one (six coin flips, for instance)—should display runs or patterns.
- People routinely underestimate the likelihood of runs (HHHH) and patterns (HHTTHHTTHHTT) in a random sequence.

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- For this reason, people cannot generate truly random sequences when they try to do so.
- The sequences that they generate tend to have too few runs and patterns.
- When generating such sequences, people alternate their choices too much in a mistaken effort to destroy any structure that might appear.

The Gambler's Fallacy

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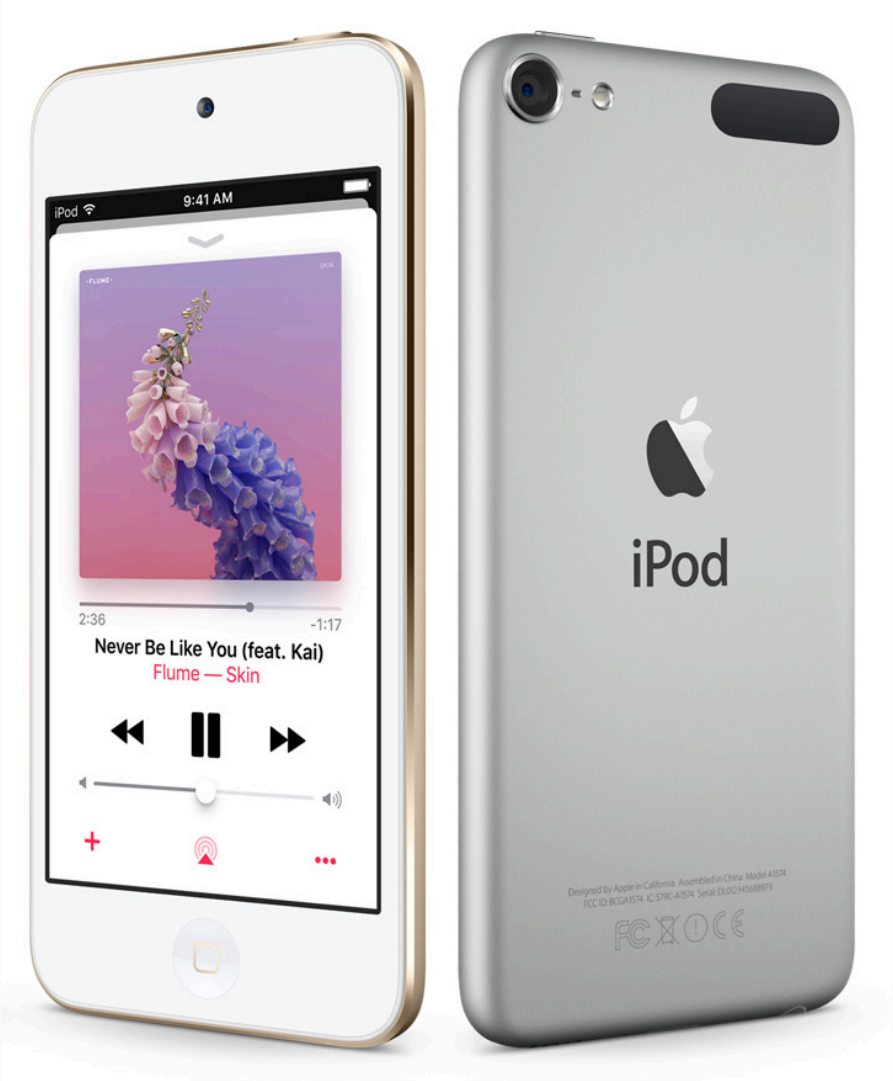
- Those who claim to have psychic powers can easily exploit this tendency.

Randomrization



A Further Word About Statistics and Probability

Statistics and Probability

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- Unfortunately, there is no simple rule to follow when confronted with statistical information.
- Unlike some of the other components of scientific thinking that are more easily acquired, functional reasoning skills in statistics probably require some type of formal study.

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- Although many scientists sincerely wish to make scientific knowledge accessible to the general public, it is intellectually irresponsible to suggest that a deep understanding of a particular subject can be obtained by the layperson when that understanding is crucially dependent on certain technical information that is available only through formal study.

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- No one can be a competent contemporary psychologist without being fully conversant with statistics and probability.

"in the long run, teaching students to evaluate data may be just as important. They are not going to remember the difference between negative reinforcement and punishment six weeks after the exam, but if they can remember the lessons about critical-thinking about data. ... that is what I'd really like to see as the legacy of the course" (Dingfelder, 2007, p. 26)

Questions?