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Playing the Odds

By [GEORGE JOHNSON](#)

State lotteries, it's sometimes said, are a tax on people who don't understand mathematics. But there is no cause for anyone to feel smug. The brain, no matter how well schooled, is just plain bad at dealing with randomness and probability. Confronted with situations that require an intuitive grasp of the odds, even the best mathematicians and scientists can find themselves floundering.

Suppose you want to calculate the likelihood of tossing two coins and coming up with one head. The great 18th-century mathematician Jean Le Rond d'Alembert thought the answer was obvious: there are three possibilities, zero, one or two heads. So the odds for any one of those happening must be one in three.

But as Leonard Mlodinow explains in "The Drunkard's Walk: How Randomness Rules Our Lives," there are, in fact, four possible outcomes: heads-heads, heads-tails, tails-heads and tails-tails. So there is a 25 percent chance of throwing zero or two heads and a 50 percent chance of throwing just one. In the long run, anyone offering d'Alembert's odds in a coin-flipping contest would lose his shirt.

The key to puzzles like this, Mlodinow writes, is Cardano's method, named for Gerolamo Cardano, author of the 16th-century "Book on Games of Chance." To lay the odds for even the simplest-seeming event, one constructs a table, or "sample space," of all the ways Fortuna's dice might fall. Trust your instincts instead and you're bound to go wrong.

If a woman has two children and one is a girl, the chance that the other child is also female has to be 50-50, right? But it's not. Cardano again: The possibilities are girl-girl, girl-boy and boy-girl. So the chance that both children are girls is 33 percent. Once we are told that one child is female, this extra information constrains the odds. (Even weirder, and I'm still not sure I believe this, the author demonstrates that the odds change again if we're told that one of the girls is named Florida.)

Mlodinow — the author of "Feynman's Rainbow," "Euclid's Window" and, with [Stephen Hawking](#), "A Briefer History of Time" — writes in a breezy style, interspersing probabilistic mind-benders with portraits of theorists like Jakob Bernoulli, Blaise Pascal, Carl Friedrich Gauss, Pierre-Simon de Laplace and Thomas Bayes. The result is a readable crash course in randomness and statistics that includes the clearest explanation I've encountered of the Monty Hall problem (named for the M.C. of the old TV game show "Let's Make a Deal").

You are presented with three doors, behind one of which is a new car. You take your pick, but before your fate is revealed, the M.C. swings open one of the other doors, revealing a booby prize.

So far, so good, but now comes the big decision. Do you stay with your original choice or switch to the other unopened door? Even the great mathematician Paul Erdos was dumbfounded to realize that this is not a 50-50 proposition. If you lay out the possibilities on Cardano's grid, you will see that your odds actually improve if you change doors.

The key to this puzzle is that the door the M.C. opens is not chosen at random. (He's not going to ruin the game by prematurely

THE DRUNKARD'S WALK

How Randomness Rules Our Lives.

By Leonard Mlodinow.

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revealing the car.) As in the two-daughter problem, the additional information skews the odds, and with Cardano's method you can make a rational, though counterintuitive, decision.

In all these cases, people err by assuming a situation is more random and unconstrained than it really is. More often we make the opposite mistake: overestimating the amount of control we have over life. Mlodinow tells the story of a Paramount executive, [Sherry Lansing](#), who presided over the company's motion picture group during a string of blockbusters: "Forrest Gump," "Braveheart" and "Titanic." She was hailed in the Hollywood press as a genius, until she suddenly lost her touch. After a series of box-office disasters, she was replaced. The studio appeared to be justified in its decision when it went on to have its best summer in a decade.

But not so fast, Mlodinow cautions. More recent winners, "War of the Worlds" and "The Longest Yard," were in production when Lansing was still in charge. Like so many things in life, the success or failure of a movie is heavily influenced by factors beyond anyone's control. Fortunate events like a string of hit movies are most likely to be followed by more ordinary events. Lansing, Mlodinow writes, was a victim of what statisticians call regression toward the mean.

Anyone who has ever bought a mutual fund because it has been on a roll or bet that a racehorse will extend its winning streak has fallen into the same confusion. Chances are the champion will regress toward the mean and another will have its glory day. In all life's games, some players are better than others, but randomness maintains the upper hand.

Hardest of all for our blinkered brains are cases involving Bayesian statistics, where one must gauge how the probability of one event hinges on that of another. Mlodinow learned the difficulty firsthand nearly 20 years ago when his doctor told him, out of the blue, that it was 99.9 percent certain that he was infected with H.I.V. Mlodinow had none of the risk factors (except for being human), but he had scored H.I.V.-positive on a test that had a false positive rate of one in 1,000.

If his doctor had studied probability in medical school, he would have seen the situation in a different light. Statistics from the [Centers for Disease Control and Prevention](#) showed that in Mlodinow's demographic group, one in 10,000 people tested positive and was ultimately confirmed as carrying the virus. In addition, there were the statistical flukes — the 10 (one in 1,000) who were false positives. Compare those numbers, and the chance that Mlodinow was infected (he wasn't) was one in 11.

When statistics are used in a court of law the effect can be just as misleading. Mlodinow recalls the [O. J. Simpson](#) trial, in which the prosecution depicted the defendant as an inveterate wife abuser. One of Simpson's lawyers, [Alan Dershowitz](#), countered with statistics: in the United States, four million women are battered every year by their male partners, yet only one in 2,500 is ultimately murdered by her partner.

The jury may have found that persuasive, but it's a spurious argument. [Nicole Brown Simpson](#) was already dead. The relevant question was what percentage of all battered women who are murdered are killed by their abusers. The answer, Mlodinow notes, didn't come up in the trial. It was 90 percent.

Lawyers, it seems, are no better than doctors at this kind of math. But juries are even worse.

George Johnson's most recent book is "The Ten Most Beautiful Experiments."

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