The Science of Murphy's Law

Life's little annoyances are not as random as they seem: the awful truth is that the universe is against you

by Robert A. J. Matthews

JASON GOLTZ (*photograph*); TOMO NARASHIMA (*drawing*); SLIM FILMS (*computer montage*)

BAD DAY might feature some improbable misfortunes as well as some that are not so improbable—such as taking along an umbrella that turns out to be unneeded or being unable to find a matching pair of socks.

Late for work, you paw frantically through your sock drawer, unable to find a matching pair in its jumbled disarray. In the kitchen, your toast slides off the plate and lands on the floor—butter-side down, of course. Finally out of the house, you reach the train station and join a line for a ticket—and then find yourself watching the lines on either side shoot ahead, while you remain stuck behind someone arranging a world tour.

Is it all just chance misfortune—and no more likely, probabilistically speaking, than happier outcomes? Or is there something about the way the universe works that favors this kind of aggravation? Alas, a strong case can be made for the latter explanation. Indeed, there is evidence that the universe is against you.

Of course, this idea has for many years been a part of popular wisdom; there is even a name for it: Murphy's Law. "If something can go wrong, it will" is how the law is usually expressed. But though most nonscientists have never doubted the validity of Murphy's Law, scientists typically dismiss it as nothing more than a product of our selective memory for those times when things don't go well.

In this case, however, the scientists appear to have dismissed popular wisdom too hastily. Using a wide range of mathematics and science, from probability theory to rigid-body dynamics, I have been investigating Murphy's Law.

And the awful truth is that many of the most famous manifestations of Murphy's Law actually do have a basis in fact.

The familiar version of Murphy's Law is not quite 50 years old, but the essential idea behind it has been around for centuries. In 1786 the Scottish poet Robert Burns observed that

> The best laid schemes o' mice an' men
> Gang aft agley ("Are prone to go awry").

In 1884 the Victorian satirist James Payn described perhaps the most famous example of Murphy's Law:

> I had never had a piece of toast
> Particularly long and wide
> But fell upon the sanded floor
> And always on the buttered side.

The modern version of Murphy's Law has its roots in U.S. Air Force studies performed in 1949 on the effects of rapid deceleration on pilots. Volunteers were strapped on a rocket-propelled sled, and their condition was monitored as the sled was brought to an abrupt halt. The monitoring was done by electrodes fitted to a harness designed by Captain Edward A. Murphy.

After what had seemed to be a flawless test run one day, the harness's failure to record any data puzzled technicians. Murphy discovered that every one of its electrodes had been wired incorrectly, prompting him to declare: "If there are two or more ways of doing something, and one of them can lead to catastrophe, then someone will do it."

At a subsequent press conference, Murphy's rueful observation was presented by the project engineers as an excellent working assumption in safety-critical engineering. But before long—and to Murphy's chagrin—his principle had been transformed into an apparently flippant statement about the cussedness of everyday events. Ironically, by losing control over his original meaning, Murphy thus became the first victim of his eponymous law.

I became intrigued by Murphy's Law in 1994, after reading a letter in a magazine describing what happens when a paperback book slides off a desk. The writer claimed that a book initially with its front cover uppermost almost always lands face down. Did this, he asked, have any bearing on the notorious buttered-toast phenomenon?

My first reaction was perhaps typical of most scientists: I thought that the book was as likely to land face up as face down and that the reader hadn't repeated the experiment often enough. Yet when I tried it, it became clear that the behavior of a tumbling book was far from random. Its final state was clearly dictated by its rate of spin, which was typically too low to allow the book to make a complete revolution and come face up again by the time it hit the floor. The torque induced by gravity as the book—or piece of toast, for that matter—goes over the edge simply does not lead to a sufficiently fast spin rate.

Straightforward measurements and dynamical calculations approximating the book (or toast) as a rigid, rough, thin plate confirmed that the motion has nothing to do with aerodynamic effects, which are negligible. The presence of the thin layer of butter is also irrelevant: the butter-down landings are primarily the result of gravity and surface friction.

I later learned that others had published similar analyses of the tumbling toast phenomenon years earlier. It was when I began to dig deeper into its causes that I uncovered something truly surprising: a connection between the dynamics of tumbling toast and the fundamental constants of nature.

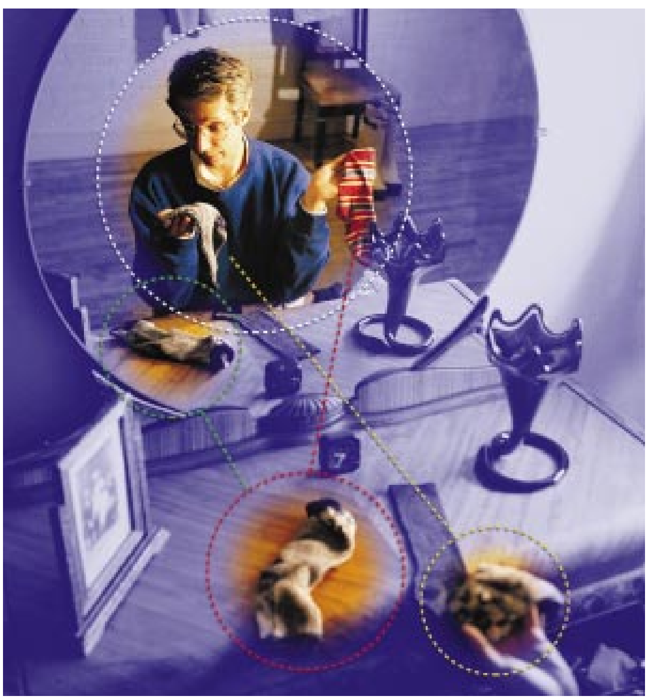
Clearly, toast would land butter-side up if it fell from sufficiently tall tables. So why are tables the height they are? Because they must be convenient for human beings. So why are humans the height they are? Some years ago William H. Press, a professor of astrophysics at Harvard University, pointed out that as bipedal, essentially columnar animals we humans are relatively unstable against toppling. If we were a lot taller, he further reasoned, we would be in danger of severely injuring our head every time we fell over. At a more fundamental level, this likelihood of injury means there is a limit on human height set by the relative strengths of the chemical bonds making up our skull and by the strength of gravity pulling us over.

Cosmic Constants

The strengths of these two forces are in turn dictated by various fundamental constants—such as the charge on the electron—whose values were fixed in the cosmic big bang some 15 billion years ago. Using an argument similar to that of Press, I found that the values of these constants lead to a maximum height for human beings of around three meters, which is still below that needed to avoid butter-down landings of toast [see "The Anthropomurphic Principle," by Ian Stewart; Scientific American, December 1995]. It seems that toast tends to land butter-side down because the universe is designed that way.

The publication of this result in the *European Journal of Physics* in 1995 generated an astonishing amount of popular interest. I soon found myself being asked to explain other examples of Murphy's Law: Why is the weather always worse during weekends, say, or why do cars break down on the way to important meetings?

The trouble with many such examples is that either they are not true or they are entirely anecdotal and thus beyond the reach of analysis. For some, like car break-



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ODD SOCKS are likely to accumulate as a result of random and repeated sock loss, combinatoric analysis shows.

downs, the standard scientific explanation of "selective memory" seems reasonable. Nevertheless, I have found some well-known manifestations of Murphy's Law that are amenable to analysis. And again, the results tend to support popular belief in the law's validity.

Lost on the Fringes

One manifestation of the Murphy principle that is rather easy to explain is Murphy's Law of Maps, which might be expressed as, "If a place you're looking for can lie on the inconvenient parts of the map, it will." The reason turns out to involve an interesting combination of probability and optical illusion. Suppose that the map is square; the "Murphy Zone" consists then of those parts of the map close to its edges and down the central crease, where following roads to their destination is most awkward.

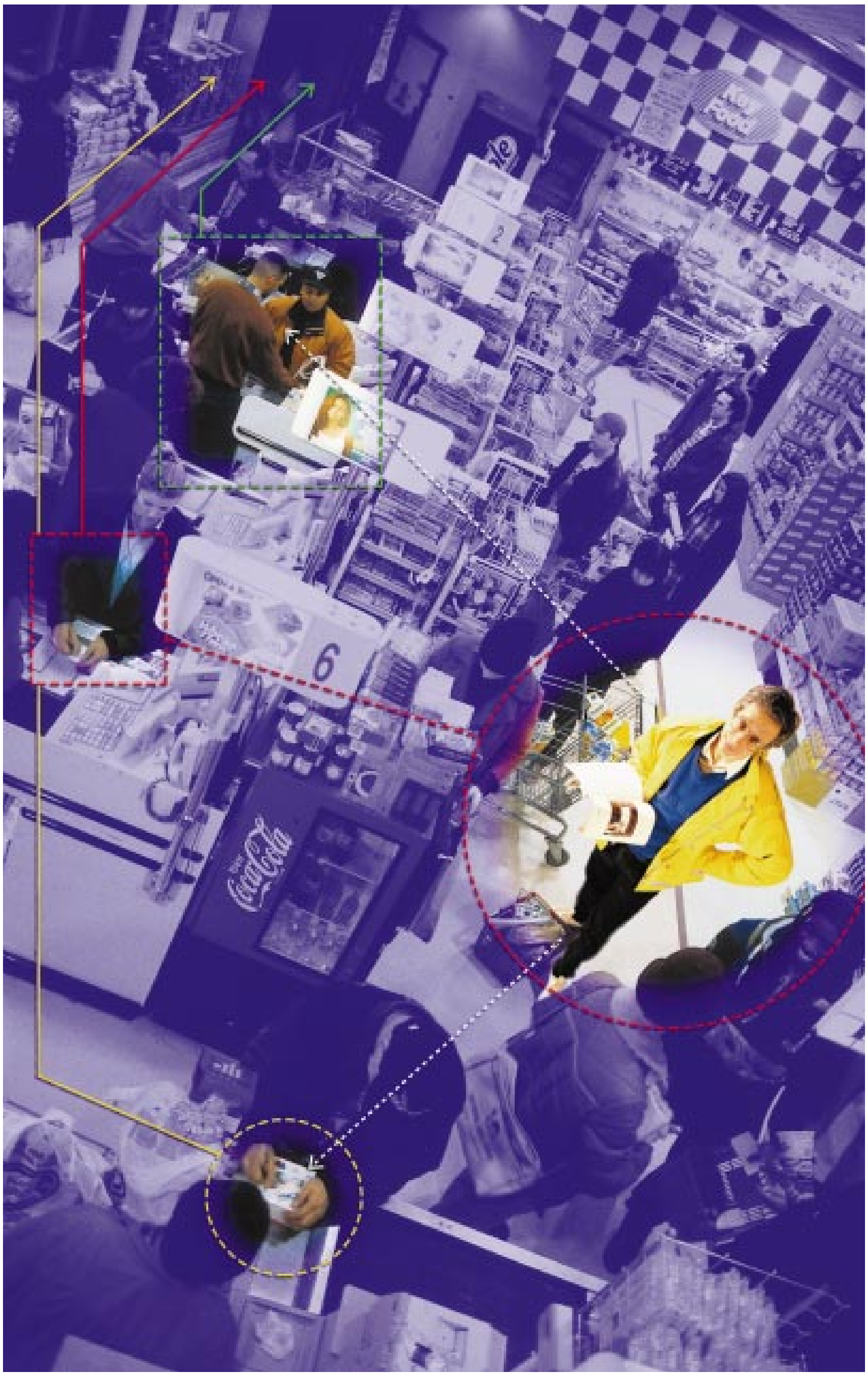
Simple geometry shows that if the width of the Murphy Zone makes up just one tenth of the width of the entire map, it nonetheless accounts for more than *half* the area of the map. Hence, a point picked at random on a map has a better than 50–50 chance of falling into the Murphy Zone. This surprising result stems from the fact that although the Murphy Zone looks rather narrow, its perimeter tracks the largest dimension of the map, so the total area of this zone is deceptively large.

Another example of Murphy's Law that is relatively easily explained is Murphy's Law of Queues: "The line next to you will usually finish first." Of course, if you stand in line behind a family of 12 shopping for the winter, it is hardly surprising if all the other queues finish before yours does. But what if your line is identical in length and makeup to all the others? Surely then you'll be safe from Murphy's Law?

Sorry, but the answer is no. It is true that, on average, all the queues will move at more or less the same rate—each being equally likely to suffer from the kind of random delays that occur when, for example, the cashier has to change the cash-register tape or a customer wants to use a personal check drawn on an obscure bank to pay for a pack of chewing gum. But during any one trip to the supermarket, we don't care about averages: we just want our line to finish first on that particular visit. And in that case, the chances that we've picked the queue that will turn out to be the one least plagued by random delays is just $1/N$, where N is the total number of queues in the supermarket.

Even if we are concerned only about beating the queues on either side of ours, the chances we'll do so are only one in three. In other words, two thirds of the time, either the line to the left or the one on the right will beat ours.

Probability theory and combinatorics, the mathematical study of arrangements, hold the key to another notorious example of Murphy's Law: "If odd socks can be created, they will be." Anyone who has hunted through a drawer looking for a matching pair will have been struck by the ubiquity of odd socks. Popular folklore has blamed everything from gremlins to quantum black holes. Yet it is possible to probe the mystery



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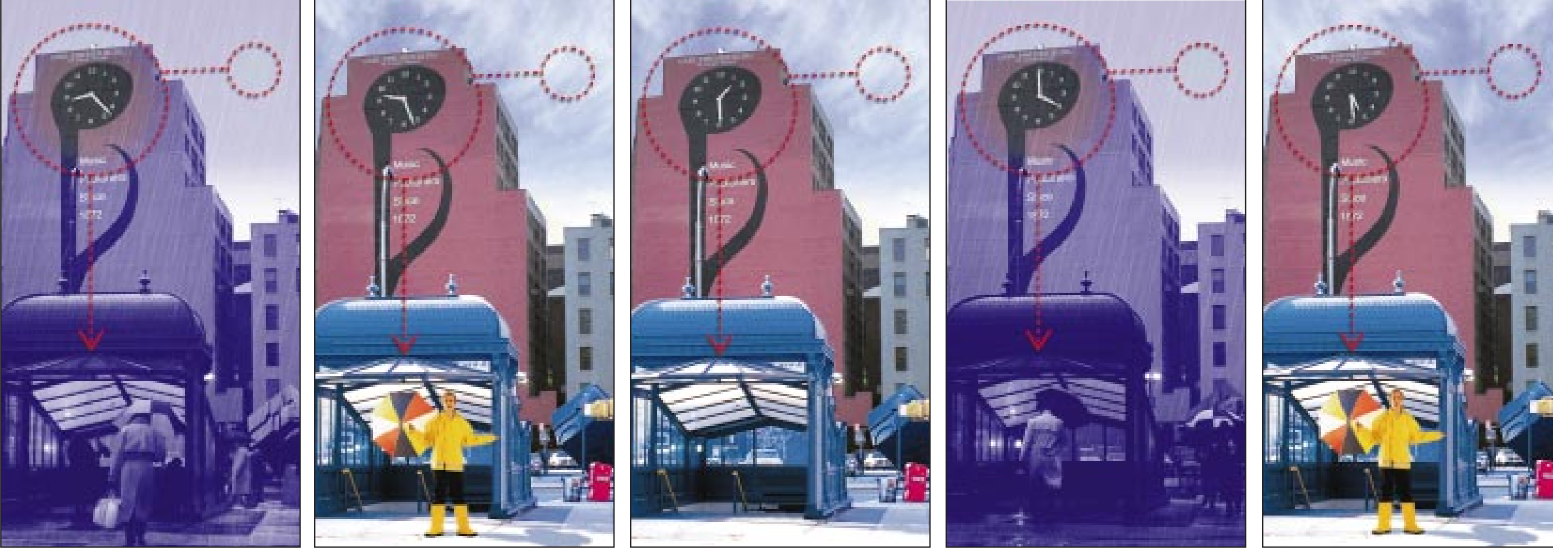
WHICH LINE will move fastest? Each is likely to be held up by the kind of random delays that occur when, for example, customers pay by check, but simple probability confirms that it is quite likely that the fastest line will be one you are not in.



RAIN GEAR often goes unneeded because the base rate of rain—the probability that rain will fall during the typically brief time when a person is outside—is low throughout much of the world. Rare weather events cannot be predicted reliably.

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of odd socks without knowing anything about where they go.

To see how, imagine you have a drawer containing only complete pairs of socks. Now suppose one goes missing; don't worry about where or how. Instantly you have an odd sock left behind in the drawer. Now a second sock goes missing. This can be either that odd sock just created or—far more likely—it will be a sock from an as yet unbroken complete pair, creating yet another odd sock in the drawer.

Already one can see signs of a natural propensity that can be confirmed by combinatoric analysis. Random sock loss is always more likely to create the maximum possible number of odd socks than to leave us free of the things. For example, if we started with 10 complete pairs, by the time half our socks have gone missing, it is four times more likely that we will be left with a drawerful of odd socks, rather than one containing only complete pairs. And the most likely outcome will be just two complete pairs lost among six odd socks. No wonder matching pairs can be so difficult to find in the morning.

Probability theory also casts light on Murphy's Law of Umbrellas: "Carrying an umbrella when rain is forecast makes rain less likely to fall." With meteorologists now claiming rain-forecast accuracy rates of more than 80 percent, it seems obvious that taking an umbrella on their advice will prove correct four times out of five. This reasoning, however, fails to take into account the so-called base rate of rain. If rain is pretty infrequent, then most of the correct forecasts that resulted in that impressive 80 percent accuracy figure were predictions of no rain. This is hardly impressive (especially in, say, Phoenix or San Diego).

Don't Take the Umbrella

Thus, when deciding whether to take an umbrella, you need to take into account the probability of rain falling during the hour or so you are on your walk, which is usually pretty low throughout much of the world. For example, suppose that the hourly base rate of rain is 0.1, meaning that it is 10 times more likely not to rain during your hour-long stroll. Probability theory then shows that even an 80 percent accurate forecast of rain is twice as likely to prove wrong as right during your walk—and you'll end up taking an umbrella unnecessarily. The fact is that even today's apparently highly accurate forecasts are still not good enough to predict rare events reliably.

Captain Murphy was perhaps justifiably irritated by what in his view was the trivialization of his worthy principle for safety-critical engineering. Nevertheless, I believe the popular version of his law is not without merits.

That many of the manifestations of Murphy's Law do have some basis in fact suggests that perhaps scientists should not be so hasty to explain away the experience of millions as mere delusion. And with many of the explanations based on disciplines ranging from rigid-body dynamics to probability theory, analysis of various manifestations of Murphy's Law may also help motivate students to study otherwise dry topics.

But perhaps the most important lesson behind Murphy's Law is its lighthearted demonstration that apparently trivial phenomena do not always have trivial explanations. On the whole, that is not such a bad legacy. SA

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The Author

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Further Reading

TUMBLING TOAST, MURPHY'S LAW AND THE FUNDAMENTAL CONSTANTS. R.A.J. Matthews in *European Journal of Physics,* Vol. 16, pages 172–176; June 1995.

ODD SOCKS: A COMBINATORIC EXAMPLE OF MURPHY'S LAW. R.A.J. Matthews in *Mathematics Today,* Vol. 32, Nos. 3/4, pages 39–41; March–April 1996.

BASE-RATE ERRORS AND RAIN FORECASTS. R.A.J. Matthews in *Nature,* Vol. 382, No. 6594, page 766; August 29, 1996.

