Some People Have All the Luck . . . Or Do They?

By Richard Arratia, Skip Garibaldi, Lawrence Mower, and Philip B. Stark

The three mathematicians among us have answered questions about the lottery for reporters before, but the query from Lawrence Mower of the *Palm Beach Post* was different.

He didn't ask whether winning the lottery twice was less likely than being struck by lightning while being eaten by a shark. Instead, he had a list of big prizes ($600 or more) and the people who had claimed them. Some had received hundreds of big prizes, and this seemed to require too much luck to be legitimate. To convince officials that things were fishy, Mower wanted help figuring out just how lucky the claimants must have been—assuming they were honest gamblers—to win.

The list was of all the prizes given out by the Florida Lottery worth $600 or more, numbering just over 1 million prizes awarded between January 4, 1993, and August 7, 2013, encompassing hundreds of thousands of winning players. It is hard to give an exact number of how many people won more than one prize, because there are not unique identifiers in the data; we just have names (which may be recorded with some variations like with or without a middle initial) and hometowns (people can move from city to city during a 20-year period). The people we investigated all claimed more than 80 prizes.

Even though lottery odds are known, to answer this question required some nontrivial math, in part because there's no way to know how many bets any given gambler made, or even what games he or she bet on. And some combinations of bets are probabilistically dependent. This was a delicious mathematical excursion, using recent pure mathematics. One ingredient, the BKR inequality, was proved in the 1990s; we also relied on convex optimization.

We confirmed Mower's suspicion that most of the claimants were implausibly lucky. The chance of winning as often as they did was essentially zero, even under very generous assumptions. (Our calculations showed that two of the claimants could have been plausibly lucky, innocent—but heavy—gamblers.)

This might be the first time that a theorem launched criminal investigations: Mower's story about our probability calculations prompted Florida police to raid some of the stores involved. The story is online at mypalmbeachpost.com/gaming-the-lottery.

If they didn't win legitimately, what had the claimants been up to? You might imagine they had hacked the game somehow, for instance, figuring out which scratcher tickets are winners without scratching them. But they had claimed prizes in all sorts of different games, not just scratchers.

Ways to Cheat

Mower's investigation revealed many possible scams and confirmed that the suspicious claimants had been up to some of them. Store clerks can dupe legitimate gamblers to get their winning tickets, for instance, by telling a gambler that a high-value ticket is a loser (or a lower-dollar winner) and then collecting the high-value prize.

Some gamblers don't want to collect high-value prizes because they owe back taxes or child support that would be subtracted from the winnings, so they pay someone else, called an aggregator, to turn in their ticket for them. That's a crime in some states, but profitable for the aggregator.

Some aggregators with other criminal enterprises use the lottery to launder money: they pay the gambler with

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A look into lottery mathematics found illegal doings.

"dirty" cash and get paid by the lottery with a "clean" check, making a profit in the process. This is a brilliant double chisel, since laundering money is usually expensive.

The aftermath of our work included arrests and seizures of Lotto terminals from the stores involved. In Florida, to date, 52 stores across the state have lost their ability to sell lottery tickets, and six clerks have been arrested. Investigations and policy changes were made in 10 other states as well. Mathematics has the power to excite, delight, and indict!

The mathematical details involved in these lottery scams can be read in the June *Mathematics Magazine.* To access the journal, go to your MAA member page, click on "My Subscriptions," and select *Mathematics Magazine.*

Skip Garibaldi is associate director of the UCLA Institute for Pure & Applied Mathematics (skip@garibaldibros.com). Richard Arratia is a professor in the USC Department of Mathematics. Lawrence Mower is an investigative reporter, Palm Beach Post. *Philip B. Stark is a professor and chair of the UC Berkeley Department of Statistics.*

MAA Awards

A list of the awards given by the MAA is at *maa.org/awards*. Look online to learn more about awards' history, nomination process, and prizes. The awards include these: Alder Award • Allendoerfer Award • Beckenbach Book Prize • Certificate of Merit • Chauvenet Prize • Dolciani Award • Euler Book Prize • Evans Award • Halmos-Ford Award • Gung and Hu Award for Distinguished Service • Hasse Prize • Haimo Award for Distinguished Teaching • Hedrick Lectures • High School Sliffe Awards • James R. C. Leitzel Lecture • JPBM Communications Award • MAA-NAM David Blackwell Lectures • Meritorious Service • Morgan Prize • Pólya Award • Pólya Lectures • Putnam • Robbins Prize • Selden Award

Interdisciplinary, *from p. 36*

topic. First, they discussed the scientific context and related policy questions. Second, they needed to explain what assumptions they used to formulate a model, what difficulties they encountered, and what they believed the strong and weak elements of their analysis were.

I asked students to emphasize how their initial questions evolved during the project. Each presentation ended with a list of directions they would pursue if the project continued. One student told me that this was the first technical assignment she had ever had where she didn't feel pushed toward a particular "right answer."

The computational lab, literature review, and project were designed to emphasize the iterative nature of scientific progress. After proposing a first approach, we explored the results: Do they have the qualitative properties appropriate to the application? Are there unexpected things happening? Do these strange features stem from the application or from our modeling and implementation choices? How can we refine our original model?

Pointing out that similar refinements occur in the scientific literature seemed to resonate with my students. This provides an important message about how science works (in contrast with the apparent authority of scientific facts) and carves out a legitimate space for the novice.

Before students graduate with the idea that they are not math people, I want them to know that novice-hood is a regular step on the path to understanding. Two of my most mathematically self-conscious students finished the course with top grades.

In talking with colleagues and students, it seems that many smart people never reach the mathematical topics that would interest them because of demanding prerequisites. Drawing on primary sources (from other fields) may seem intimidating, but if expectations are framed appropriately, it can be an invigorating component of an interdisciplinary course.

Finally, in addition to cultivating some practical mathematical and programming skills, students leave a course of this type with substantial practice interrogating model assumptions, the ability to ask productive questions about generalizations, and the confidence to continue building a rich toolbox to grapple with the issues they care about.

Gwen Spencer works in combinatorial optimization, operations research, and theoretical computer science. She has just joined the Math and Statistics Department at Smith College.