

Personal Reflections on Beauty and Terror

Jonathan David Farley

Abstract The history of the Conference on Mathematical Methods in Counterterrorism is briefly described.

1 Shadows Strike

It was a Tuesday morning, and I awoke into a nightmare. The phone rang; a friend spoke. “Turn on the television,” she said.

You couldn’t see it at first. This was before anyone knew it had been caught on camera. All you could see was a plane disappearing behind a building, and a burst of hellfire.

Terrorism is the watchword of the day, and the fear – regardless of whether the threat is real or imagined – requires an antidote.

2 The “Thinking Man’s Game”

The opening line of the Oscar-winning movie *A Beautiful Mind* is: “Mathematicians won the war.” Winston Churchill recognized Alan Turing, the mathematician who had mastered the German codes, as the man who had perhaps made the single greatest individual contribution to Hitler’s defeat. Bletchley Park is now a place out of legend. During the Cold War, research in game theory heated up, even as the first frosts descended on the Soviet East.

Now there is a new war. What is the new mathematics?

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At Los Alamos National Laboratory, the lab that built The Bomb, Cliff Joslyn's team used formal concept analysis, a branch of applied lattice theory, to mine data drawn from hundreds of reports of terrorist-related activity, and to discover patterns and relationships that were previously in shadow.

Formal concept analysis is a way of determining non-obvious implications between data. It could potentially help discover links between people connected to terrorist cells: individuals who share many of the same characteristics are grouped together as one node, and links between nodes in this picture, called a *concept lattice*, indicate that all the members of a certain subgroup with certain attributes also have other attributes in common. For instance, you might group together people based on what cafés, bookstores and churches they attend, and then find out that all the people who go to a certain café also attend the same church (but maybe not vice versa).

Lattice theoretical ideas developed at the Massachusetts Institute of Technology (MIT) tell us the probability that we have disabled a terrorist cell based on how many members we have captured and what rank they hold in the organization: Assume that terrorist plans are formulated by the leaders of a cell, and are transmitted down through the chain of command to the foot soldiers, who carry out those plans. Further assume that the message only needs to reach one foot soldier for damage to result. We endeavor to block all routes from the leaders to the foot soldiers by capturing some subset of the agents. (The agents we remove need not be leaders or foot soldiers.) Such a subset is called a *cutset* in a *partially ordered set* or *poset*.

Boston-area student Lauren McGough experimentally tested the accuracy of this model. She simulated the way that commands pass from the leaders of cells to foot soldiers by organizing fifteen of her classmates as a "binary tree": each person, except the eight foot soldiers at the bottom, had two immediate subordinates. The "leader" was assigned a message or "command" to pass on to her subordinates (for instance, "Look for a red flower with blue thorns," or, my favorite, "Twinkle-toes says hello"). These individuals then passed the message on to their direct subordinates, and so on, until the message reached the foot soldiers, like a game of "telephone". To simulate the capture of terrorists in a cell, three people were randomly removed from the binary tree for each of fifty trials. Each of the three was told not to pass on the message that was sent out for that specific trial (unless it had already reached him or her). McGough's findings showed that, if anything, the predictions of the model concerning the likelihood that a cell would be disrupted were too conservative. The point of all this is that you could calculate how much it would take to turn a comprehensive plan into a botched operation. Of course, the model assumes we know the structure of the cell to begin with, but elucidating that structure is the job of law enforcement, not mathematicians (although the theory, with its perhaps flawed assumptions, can account for gaps in our knowledge of the structure of a terrorist cell by making assumptions about how the "perfect" terrorist cell must be organized).

There is the ever-present threat of a dirty bomb being carried across the borders of the US or Europe. Which border do you guard? Which border do you want the terrorist to think is weak? Phoenix Mathematics, Inc., co-founded by lattice theo-

rist Stefan Schmidt and later joined by Tony Harkin, is using reflexive theory – a branch of mathematical psychology developed by Vladimir Lefebvre and the Soviet military – to devise a quantitative way to help border patrols allocate personnel, and spread disinformation to the adversary. The US Army Research Lab, the US State Department, and a major defense contractor have been interested in applications of reflexive theory to military matters as well.

3 The Elephant: Politics

I am perhaps one of only two mathematicians in the world working on counterterrorism who have actually been targeted by terrorists (the other being fellow algebraist and former Iraqi Oil Minister Ahmed Chalabi). I became interested in developing mathematical methods in counterterrorism around the time I was forced to flee the US state of Tennessee, leaving many of my possessions behind, after receiving a few dozen death threats. (Gordon Gee, now president of Ohio State University, has written about the single death threat he received in the same episode; Vanderbilt University student Nia Toomer received another.) I arrived at MIT and saw a flier for a talk entitled, “Modeling the Al Qaeda Threat.” The speaker was a Gordon Woo of Risk Management Solutions.

It was – like all his talks, I would learn – stimulating, and it led me to draft my first paper on this topic. If you will remember the climate in 2003, my mother and brother were afraid that even writing about counterterrorism would lead to reprisals. Regardless, I published the article in the journal *Studies in Conflict and Terrorism* and, a year later, Mel Janowitz, associate director of the Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), Tony Harkin, Stefan Schmidt and I organized the first in a series of Conferences on Mathematical Methods in Counterterrorism.¹ Later Bernard Brooks joined us as an organizer. I am particularly glad we chose Nasrullah Memon, the driving force behind this volume, as one of our speakers. (I also appreciate the efforts of editors David Hicks and Torben Rosenørn, as well as Claus Atzenbeck of Aalborg University for his help with layout and typesetting, and Stephen Soehnlén for the support of Springer Verlag.) As with this volume, my intention for the conferences (not always realized) was to have speakers talk about mathematical methods that could actually be applied, and not merely discuss theory, although interesting theoretical questions could conceivably arise.

For this reason, I have been pleased to have as speakers or participants at our conferences US Air Force majors, US Army colonels, a division head of the US Army Research Lab, and representatives of the Royal Dutch Defense Academy,

¹ Success breeds competition. In 2006, after initially promising to fund our third conference, the so-called “Center for Advanced Defense Studies” instead organized a competing conference at almost exactly the same time as ours in the same city: It was called “the Conference on Mathematical Models in Counterterrorism,” to distinguish it from our “Conference on Mathematical Methods in Counterterrorism.”

the Canada Border Services Agency, and the Jamaican Constabulary Force. The representatives from the last two organizations were actually using mathematics in their jobs: Kevin Blake, an Assistant Superintendent of Police who heads of a unit of Operation Kingfish (which has been credited with reducing the amount of drug trafficking going through Jamaica), not only carries a gun but draws posets of criminal networks ferrying drugs and weapons between Jamaica and Haiti.

Although it may seem odd for a mathematician to be concerned with this, the media reaction to our work has been quite good, with television coverage by Fox News and CNBC Europe, radio coverage by Air America Radio, US National Public Radio, and Public Radio International, newspaper coverage by the *New York Times*, the *San Francisco Chronicle*, the *Associated Press*, and *The Times Higher Education Supplement*, magazine coverage by *The Economist* and *Seed Magazine*, and on-line coverage by *Science News* and MIT's *Technology Review*. The hit television crime drama *Numb3rs* even began drafting a script dealing with reflexive theory, and the American television series *Medium* aired an episode about a mathematician who was fighting terrorists.

The reaction from funding agencies, on the other hand, has been less than expected: other than the welcome support of the Proteus Group and the US Army War College, we have seen little financial support and no sustained interest by US (or other) government agencies in our enterprise, despite face-to-face meetings with the Jamaican Minister of National Security, a former senior official of the US National Security Agency and a former senior official of the CIA, the director of Homeland Security for one of America's largest ports, a former US ambassador to the European Union, a former governor of the US state of New Mexico, a US Air Force general, two US Navy admirals, at least three tycoons, and the presidents of the Massachusetts Institute of Technology, the California Institute of Technology (Caltech), and the Rochester Institute of Technology.

One reason, I believe, is the inability of some people to imagine that mathematics other than cryptography could really be useful in counterterrorism. One MIT professor openly lampooned the idea of using mathematics for counterterrorism, asking me if I was going to use a fixed point theorem to catch Osama bin Laden. (He thus revealed also a lack of originality, as there is an old joke about using math to catch a lion.) Another MIT professor actually laughed at the mere mention of the word "poset."

But I suspect that a bigger reason is politics. When I tried to garner support for a European Institute for Mathematical Methods in Counterterrorism in Vienna, an Austrian algebraist told me that this could not (or should not) be created there, as Austria was a neutral country.

At a dinner held at the home of the Austrian ambassador to the United States, a senior officer of the US National Academies asked me about using mathematical psychology for counterterrorism. But when he uncovered a 2001 article I had written for the British newspaper *The Guardian*, despite the fact that I myself always

assiduously separated my interactions with mathematical colleagues from personal politics, communication ceased.²

But this is not about politics. Mathematicians as world citizens can and should reject anyone's demand to be "with them or against them," and soberly get on with the business of pursuing cheaper but more rational methods to save civilian lives, whether it be in London, Bali, Nairobi, or New York.

4 Toward a Mathematical Theory of Counterterrorism

Contributors Bert Hartnell and Todd Sandler were writing about mathematics, counterinsurgency and counterterrorism decades before it became "fashionable." But as Fred Roberts, director of DIMACS, has indicated, since 2001, tremendous amounts of information have been gathered regarding terrorist cells and individuals potentially planning future attacks. There is now a pressing need to develop new mathematical and computational techniques to assist in the analysis of this information, both to quantify future threats and to quantify the effectiveness of counterterrorism operations and strategies.

Progress on these problems requires the efforts of researchers from various disciplines such as mathematics, computer science, political science, and psychology. By having researchers from diverse disciplines come to one place to conduct their research, greater progress will be made in developing scientific and analytical tools to deal with the problem of terrorism. Hence, to facilitate the invention of new tools, the exchange of new ideas, and the dissemination of new results to users in the intelligence and law enforcement communities, we have endeavored to publish this volume.

Can mathematics contribute the way it did in World War II? The "war on terror" is a much more haphazard, unpredictable operation. In some ways the problems are more complicated: we generally knew, then, where the German panzer divisions were. But there are clear benefits to trying: mathematics can help take some of the guesswork out of the decision-making process (if only by replacing laypeople's guesses with mathematicians').

I do not know if the conference co-organizers, the other editors, or the volume contributors will agree with all, or even any, of the thoughts I have expressed above. But I believe they will all agree with me when I say that it's high time we chose brains over brawn: Against terror, beauty may succeed where brute force has failed.

² On November 18, 2001, as a result of the *Guardian* article, I was invited to be the second speaker at what was then the largest peace rally in the United Kingdom, with a crowd estimated at 100,000; amongst the other speakers were various Members of Parliament. On September 11, 2002, I was invited by BBC World News Television to discuss the issues in the article in special anniversary coverage live from Ground Zero in New York City.