STATISTICS OF DEADLY QUARRELS

Brian Hayes

Look upon the phenomenon of war with dispassion and detachment, as if observing the follies of another species on a distant planet: From such an elevated view, war seems a puny enough pastime. Demographically, it hardly matters. War deaths amount to something like 1 percent of all deaths; in many places, more die by suicide, and still more in accidents. If saving human lives is the great desideratum, then there is more to be gained by prevention of drowning and auto wrecks than by the abolition of war.

But no one on this planet sees war from such a height of austere equanimity. Even the gods on Olympus could not keep from meddling in earthly conflicts. Something about the clash of arms has a special power to rouse the stronger emotions—pity and love as well as fear and hatred—and so our response to battlefield killing and dying is out of all proportion to its rank in tables of vital statistics. When war comes, it muscles aside the calmer aspects of life; no one is unmoved. Most of us choose one side or the other, but even among those who merely want to stop the fighting, feelings run high. ("Antiwar militant" is no oxymoron.)

The same inflamed passions that give war its urgent human interest also stand in the way of scholarly or scientific understanding. Reaching impartial judgment about rights and wrongs seems all but impossible. Stepping outside the bounds of one's own culture and ideology is also a challenge—not to mention the bounds of one's time and place. We tend to see all wars through the lens of the current conflict, and we mine history for lessons convenient to the present purpose.

One defense against such distortions is the statistical method of gathering data about many wars from many sources, in the hope that at least some of the biases will balance out and true patterns will emerge. It's a dumb, brute-force approach and not foolproof, but nothing else looks more promising. A pioneer of this quantitative study of war was Lewis Fry Richardson, the British meteorologist whose ambitious but premature foray into numerical weather forecasting I described in this space a year ago. Now seems a good time to consider the other half of Richardson's life work, on the mathematics of armed conflict.

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Wars and Peaces

Richardson was born in 1881 to a prosperous Quaker family in the north of England. He studied physics with J. J. Thomson at Cambridge, where he developed expertise in the numerical solution of differential equations. Such approximate methods are a major mathematical industry today, but at that time they were not a popular subject or a shrewd career choice. After a series of short-term appointments—well off the tenure track—Richardson found a professional home in weather research, making notable contributions to the theory of atmospheric turbulence. Then, in 1916, he resigned his post to serve in France as a driver with the Friends' Ambulance Unit. Between tours of duty at the front he did most of the calculations for his trial weather forecast. (The forecast was not a success, but the basic idea was sound, and all modern weather prediction relies on similar methods.)

After the war, Richardson gradually shifted his attention from meteorology to questions of war and international relations. He found some of the same mathematical tools still useful. In particular, he modeled arms races with differential equations. The death spiral of escalation—where one country's arsenal provokes another to increase its own armament, whereupon the first nation responds by adding still more weapons—has a ready representation in a pair of linked differential equations. Richardson showed that an arms race can be stabilized only if the "fatigue and expense" of preparing for war are greater than the perceived threats from enemies. This result is hardly profound or surprising, and yet Richardson's analysis nonetheless attracted much comment (mainly skeptical), because the equations offered the prospect of a *quantitative* measure of war risks. If Richardson's equations could be trusted, then observers would merely need to track expenditures on armaments to produce a war forecast analogous to a weather forecast.

Mathematical models of arms races have been

Figure 1. The Great War in La Plata (1865–1870), also known as the War of the Triple Alliance, is ranked among the worst calamities of modern history, yet it is little known outside the countries where it was fought: Paraguay, Uruguay, Argentina and Brazil. The war reached magnitude 6, meaning that about 10^6 combatants died. Shown here is a detail of "After the Battle of Curupaytí," by the Argentinian artist Cándido López, who lost his right hand at Curupaytí and therefore learned to paint with his left. The painting is held by the Museo Nacional de Bellas Artes in Buenos Aires.

further refined since Richardson's era, and they had a place in policy deliberations during the "mutually assured destruction" phase of the Cold War. But Richardson's own investigations turned in a somewhat different direction. A focus on armaments presupposes that the accumulation of weaponry is a major cause of war, or at least has a strong correlation with it. Other theories of the origin of war would emphasize different factors—the economic status of nations, say, or differences of culture and language, or the effectiveness of diplomacy and mediation. There is no shortage of such theories; the problem is choosing among them. Richardson argued that theories of war could and should be evaluated on a scientific basis, by testing them against data on actual wars. So he set out to collect such data.

Others had the same idea at roughly the same time. The Russian-born sociologist Pitirim A. Sorokin published a long list of wars in 1937, and Quincy Wright of the University of Chicago issued another compilation in 1942. Richardson began his own collection in about 1940 and continued work on it until his death in 1953. Of the three contemporaneous lists, Richardson's covers the narrowest interval of time but seems to be best adapted to the needs of statistical analysis.

Richardson published some of his writings on war in journal articles and pamphlets, but his ideas became widely known only after two posthumous volumes appeared in 1960. The work on arms races is collected in *Arms and Insecurity*; the statistical studies are in *Statistics of Deadly Quarrels*. In addition, a two-volume *Collected Papers* was published in 1993. Most of what follows in this article comes from *Statistics of Deadly Quarrels*. I have also leaned heavily on a 1980 study by David Wilkinson of the University of California, Los Angeles, which presents Richardson's data in a rationalized and more readable format.

"Thinginess Fails"

The catalogue of conflicts in *Statistics of Deadly Quarrels* covers the period from about 1820 until 1950. Richardson's aim was to count all deaths during this interval caused by a deliberate act of another person. Thus he includes individual murders and other lesser episodes of violence in addition to warfare, but he excludes accidents and negligence and natural disasters. He also decided not to count deaths from famine and disease associated with war, on the grounds that multiple causes are too hard to disentangle. (Did World War I "cause" the influenza epidemic of 1918–1919?)

The decision to lump together murder and war was meant to be provocative. To those who hold that "murder is an abominable selfish crime, but war is a heroic and patriotic adventure," Richardson replies: "One can find cases of homicide which one large group of people condemned as murder, while another large group condoned or praised them as legitimate war. Such things went on in Ireland in 1921 and are going on now in Palestine." (It's depressing that his examples, 50 years later, remain so apt.) But if Richardson dismissed moral distinctions between various kinds of killing, he acknowledged methodological difficulties. Wars are the province of historians, whereas murders belong to criminologists; statistics from the two groups are hard to reconcile. And the range of deadly quarrels lying between murder and war is even more problematic. Riots, raids and insurrections have been too small and too frequent to attract the notice of historians, but they are too political for criminologists.

For larger wars, Richardson compiled his list by reading histories, starting with the *Encyclopaedia Britannica* and going on to more diverse and specialized sources. Murder data came from national crime reports. To fill in the gap between wars and murders he tried interpolating and extrapolating and other means of estimating, but he acknowledged that his results in this area were weak and incomplete. He mixed together civil and international wars in a single list, arguing that the distinction is often unclear.

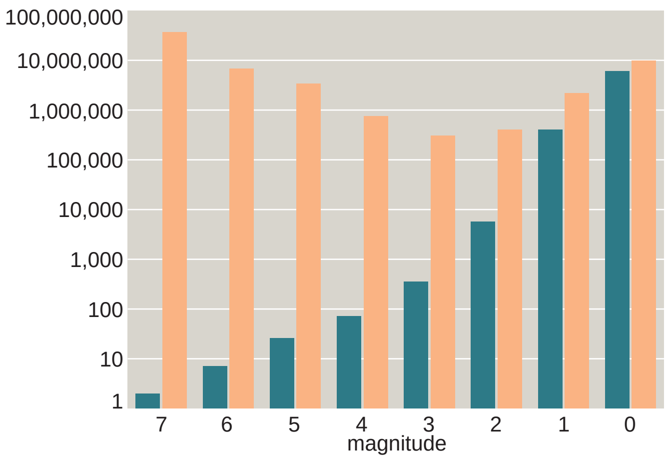

Figure 2. Magnitude of a war, as defined by Lewis Fry Richardson, is the base-10 logarithm of the number of deaths. Blue bars indicate the number of wars in each magnitude range; orange bars are the total deaths from wars of that magnitude. Two magnitude-7 wars account for 60 percent of all deaths.

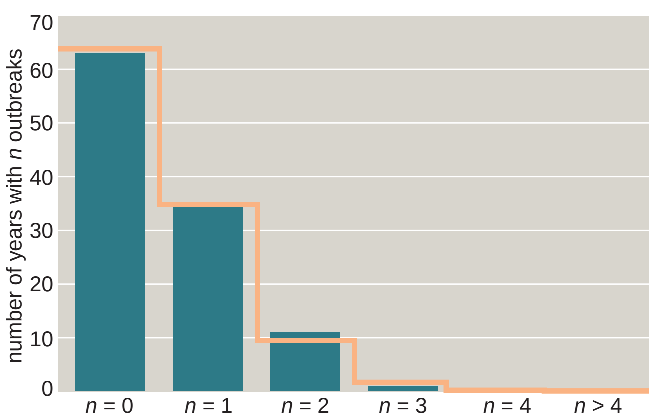

Figure 3. Frequency of outbreaks of war (*blue bars*) is very closely modeled by the Poisson distribution (*orange line*), suggesting that the onset of war is an essentially random process.

An interesting lesson of Richardson's exercise is just how difficult it can be to extract consistent and reliable quantitative information from the historical record. It seems easier to count inaccessible galaxies or invisible neutrinos than to count wars that swept through whole nations just a century ago. Of course some aspects of military history are always contentious; you can't expect all historians to agree on who started a war, or who won it. But it turns out that even more basic facts—Who were the combatants? When did the fighting begin and end? How many died?—can be remarkably hard to pin down. Lots of wars merge and split, or have no clear beginning or end. As Richardson remarks, "Thinginess fails."

In organizing his data, Richardson borrowed a crucial idea from astronomy: He classified wars and other quarrels according to their *magnitude*, the base-10 logarithm of the total number of deaths. Thus a terror campaign that kills 100 has a magnitude of 2, and a war with a million casualties is a magnitude-6 conflict. A murder with a single victim is magnitude 0 (since $10^0 = 1$). The logarithmic scale was chosen in large part to cope with shortcomings of available data; although casualty totals are seldom known precisely, it is usually possible to estimate the logarithm within ± 0.5. (A war of magnitude 6 ± 0.5 could have anywhere from 316,228 to 3,162,278 deaths.) But the use of logarithmic magnitudes has a psychological benefit as well: One to survey the entire spectrum of human violence on a single scale.

Random Violence

Richardson's war list (as refined by Wilkinson) includes 315 conflicts of magnitude 2.5 or greater (or in other words with at least about 300 deaths). It's no surprise that the two World Wars of the 20th century are at the top of this list; they are the only magnitude-7 conflicts in human history. What *is* surprising is the extent to which the World Wars dominate the overall death toll. Together they account for some 36 million deaths, which is about 60 percent of all the quarrel deaths in the 130-year period. The next largest category is at the other end of the spectrum: The magnitude-0 events (quarrels in which one to three people died) were responsible for 9.7 million deaths. Thus the remainder of the 315 recorded wars, along with all the thousands of quarrels of intermediate size, produced less than a fourth of all the deaths.

The list of magnitude-6 wars also yields surprises, although of a different kind. Richardson identified seven of these conflicts, the smallest causing half a million deaths and the largest about 2 million. Clearly these are major upheavals in world history; you might think that every educated person could name most of them. Try it before you read on. The seven megadeath conflicts listed by Richardson are, in chronological order, and using the names he adopted: the Taiping Rebellion (1851–1864), the North American Civil War (1861–1865), the Great War in La Plata (1865–1870), the sequel to the Bolshevik Revolution (1918–1920), the first Chinese-Communist War (1927–1936), the Spanish Civil War (1936–1939) and the communal riots in the Indian Peninsula (1946–1948).

Looking at the list of 315 wars as a time series, Richardson asked what patterns or regularities could be discerned. Is war becoming more frequent, or less? Is the typical magnitude increasing? Are there any periodicities in the record, or other tendencies for the events to form clusters?

A null hypothesis useful in addressing these questions suggests that wars are independent, random events, and on any given day there is always the same probability that war will break out. This hypothesis implies that the average number of new wars per year ought to obey a Poisson distribution, which describes how events tend to arrange themselves when each occurrence of an event is unlikely but there are many opportunities for an event to occur. The Poisson distribution is the law suitable for tabulating radioactive decays, cancer clusters, tornado touchdowns, Web-server hits and, in a famous early example, deaths of cavalrymen by horse kicks. As applied to the statistics of deadly quarrels, the Poisson law says that if p is the probability of a war starting in the course of a year, then the probability of seeing n wars begin in any one year is $e^{-p} p^n/n!$. Plugging some numbers into the formula shows that when p is small, years with no onsets of war are the most likely, followed by years in which a single war begins; as n grows, the likelihood of seeing a year with n wars declines steeply.

Figure 3 compares the Poisson distribution with Richardson's data for a group of magnitude 4 wars. The match is very close. Richardson performed a similar analysis of the dates on which wars ended—the "outbreaks of peace"—with the same result. He checked the wars on Quincy Wright's list in the same way and again found good agreement. Thus the data offer no reason to believe that wars are anything other than randomly distributed accidents.

Richardson also examined his data set for evidence of long-term trends in the incidence of war. Although certain patterns catch the eye when the data are plotted chronologically, Richardson concluded that the trends are not clear enough to rule out random fluctuations. "The collection as a whole does not indicate any trend towards more, nor towards fewer, fatal quarrels." He did find some slight hint of "contagion": The presence of an ongoing war may to some extent increase the probability of a new war starting.

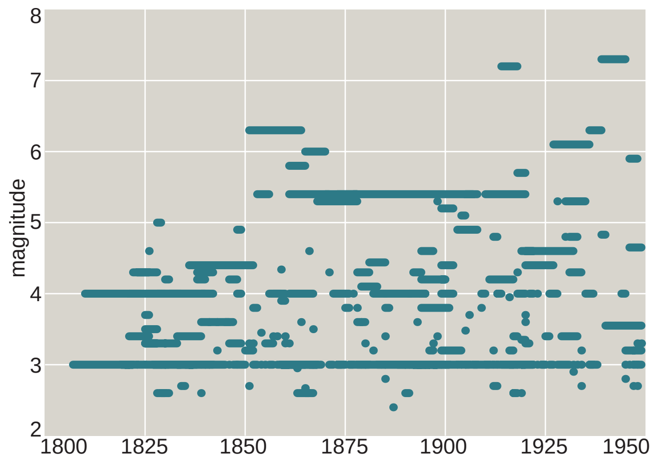

Figure 4. Distribution of wars in time reveals no clear pattern in Richardson's catalogue of 315 conflicts. Although the eye may detect an apparent increase in high-magnitude wars, Richardson's statistical tests failed to confirm this trend.

Love Thy Neighbor

If the temporal dimension fails to explain much about war, what about spatial relations? Are nearby countries less likely than average to wind up fighting one another, or more likely? Either hypothesis seems defensible. Close neighbors often have interests in common and so might be expected to become allies rather than enemies. On the other hand, neighbors could also be rivals contending for a share of the same resources—or maybe the people next door are just plain annoying. The existence of civil wars argues that living together is no guarantee of amity. (And at the low end of the magnitude scale, murder is known to run in families.)

Richardson's approach to these questions had a topological flavor. Instead of measuring the distance between countries, he merely asked whether or not they share a boundary. Then, in later studies, he refined this notion by trying to measure the length of the common boundary—which led to a fascinating digression. Working with maps at various scales, Richardson paced off the lengths of boundaries and coastlines with dividers, and realized that the result depends on the setting of the dividers, or in other words on the unit of measurement. A coastline that measures 100 steps of 10 millimeters each will not necessarily measure 1,000 steps of 1 millimeter each; it is likely to be more, because the smaller units more closely follow the zig-zig path of the coast. This result appeared in a somewhat out-of-the-way publication; when Benoit Mandelbrot came across it by chance, Richardson's observation became one of the ideas that inspired Mandelbrot's theory of fractals.

During the period covered by Richardson's study there were about 60 stable nations and empires (the empires being counted for this purpose as single entities). The mean number of neighbors for these states was about six (and Richardson offered an elegant geometric argument, based on Euler's relation among the vertices, edges and

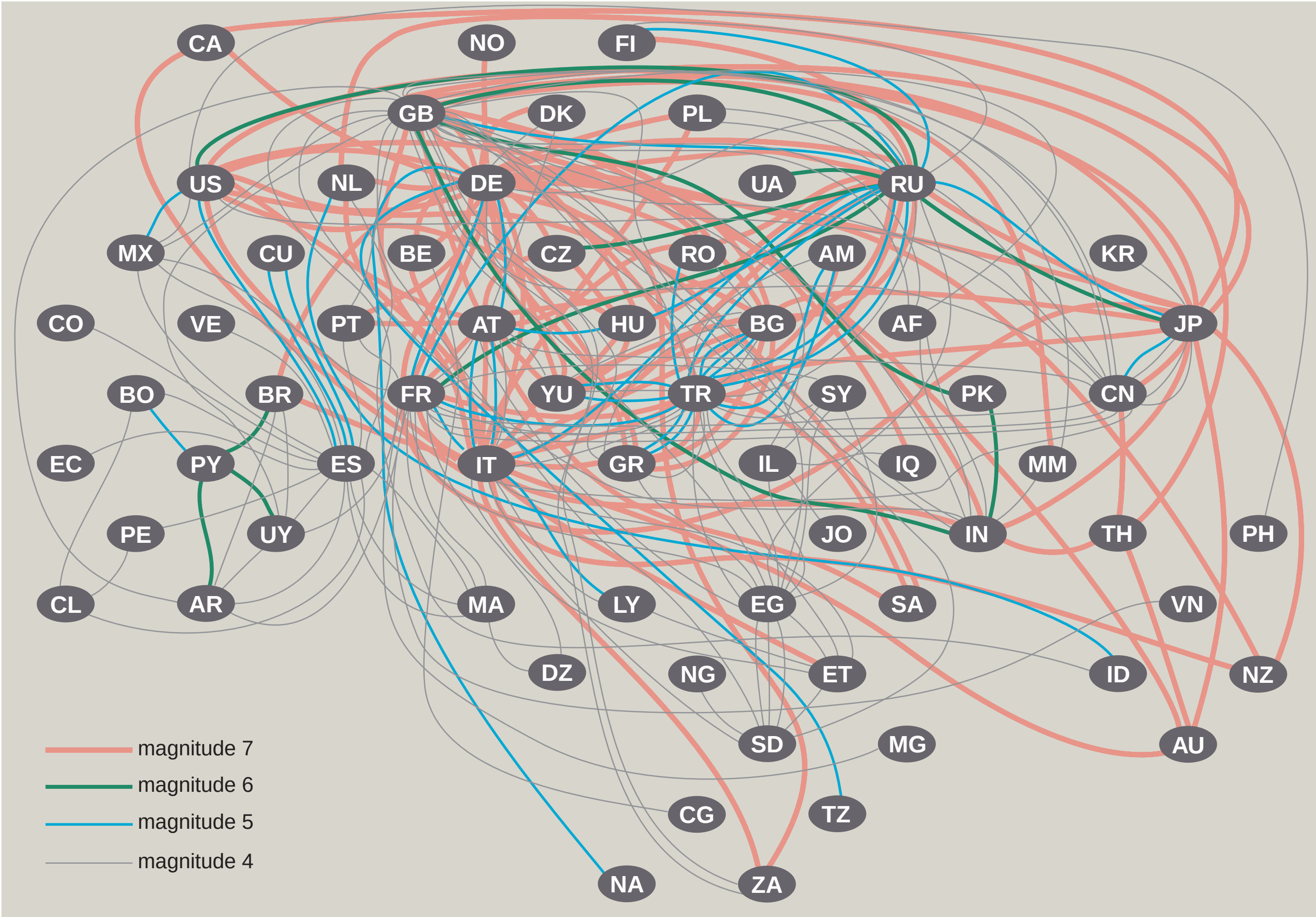

Figure 5. Web of wars is constructed from Richardson's data for international conflicts of magnitude greater than 3.5. Two nations are connected by a line if they had actual hostilities (not just a formal declaration). The color and thickness of the line indicate the magnitude of the overall war, not the specific conflict between the two nations. Civil wars are omitted, and the diagram ignores many changes in national status (such as the assembly and disassembly of Yugoslavia). The two-letter codes for country names are those used for Internet domains.

faces of a polyhedron, that the number *must* be approximately six, for any plausible arrangement of nations). Hence if warring nations were to choose their foes entirely at random, there would be about a 10 percent chance that any pair of belligerents would turn out to be neighbors. The actual proportion of warring neighbors is far higher. Of 94 international wars with just two participants, Richardson found only 12 cases in which the two combatants had no shared boundary, suggesting that war is mostly a neighborhood affair.

But extending this conclusion to larger and wider wars proved difficult, mainly because the "great powers" are effectively everyone's neighbor. Richardson was best able to fit the data with a rather complex model assigning different probabilities to conflicts between two great powers, between a great power a smaller state and between two lesser nations. But rigging up a model with three parameters for such a small data set is not very satisfying. Furthermore, Richardson concluded that "chaos" was still the predominant factor in explaining the world's larger wars: The same element of randomness seen in the time-series analysis is at work here, though "restricted by geography and modified by infectiousness."

What about other causative factors—social, economic, cultural? While compiling his war list, Richardson noted the various items that historians mentioned as possible irritants or pacifying influences, then he looked for correlations between these factors and belligerence. The results were almost uniformly disappointing. Richardson's own suppositions about the importance of arms races were not confirmed; he found evidence of a preparatory arms race in only 13 out of 315 cases. Richardson was also a proponent of Esperanto, but his hope that a common language would reduce the chance of conflict failed to find support in the data. Economic indicators were equally unhelpful: The statistics ratify neither the idea that war is mainly a struggle between the rich and the poor nor the view that commerce between nations creates bonds that prevent war.

The one social factor that does have some detectable correlation with war is religion. In the Richardson data set, nations that differ in religion are more likely to fight than those that share the same religion. Moreover, some sects seem generally to be more bellicose (Christian nations participated in a disproportionate number of conflicts). But these effects are not large.

Mere Anarchy Loosed upon the World

The residuum of all these noncauses of war is mere randomness—the notion that warring nations bang against each other with no more plan or principle than molecules in an overheated gas. In this respect, Richardson's data suggest that wars are like hurricanes or earthquakes: We can't know in advance when or where a specific event will strike, but we do know how many to expect in the long run. We can compute the number of victims; we just can't say who they'll be.

This view of wars as random catastrophes is not a comforting thought. It seems to leave us no control over our own destiny, nor any room for individual virtue or villainy. If wars just happen, who's to blame? But this is a misreading of Richardson's findings. Statistical "laws" are not rules that govern the behavior either of nations or of individuals; they merely describe that behavior in the aggregate. A murderer might offer the defense that the crime rate is a known quantity, and so *someone* has to keep it up, but that plea is not likely to earn the sympathy of a jury. Conscience and personal responsibility are in no way diminished by taking a statistical view of war.

What *is* depressing is that the data suggest no clear plan of action for those who want to reduce the prevalence of violence. Richardson himself was disappointed that his studies pointed to no obvious remedy. Perhaps he was expecting too much. A retired physicist reading the *Encyclopaedia Britannica* can do just so much toward securing world peace. But with larger and more detailed data sets, and more powerful statistical machinery, some useful lessons might emerge.

There is now a whole community of people working to gather war data, many of whom trace their intellectual heritage back to Richardson and Quincy Wright. The largest such undertaking is the Correlates of War project, begun in the 1960s by J. David Singer of the University of Michigan. The COW catalogues, like Richardson's, begin in the post-Napoleonic period, but they have been brought up close to the present day and now list about a thousand wars. Offshoots and continuations of the project are being maintained by Russell J. Leng of Middlebury College and by Stuart A. Bremer of Pennsylvania State University.

Peter Brecke of the Georgia Institute of Technology has begun another data collection. His catalogue extends down to magnitude 1.5 (about 30 deaths) and covers a much longer span of time, back as far as A.D. 1400. The catalogue is approaching completion for five of 12 global regions and includes more than 3,000 conflicts. The most intriguing finding so far is a dramatic, century-long lull in the 1700s.

Even if Richardson's limited data were all we had to go on, one clear policy imperative emerges: At all costs avoid the clash of the titans. However painful a series of brushfire wars may seem to the participants, it is the great global conflagrations that threaten us most. As noted above, the two magnitude-7 wars of the 20th century were responsible for three-fifths of all the deaths that Richardson recorded. We now have it in our power to have a magnitude-8 or 9 war. In the aftermath of such an event, no one would say that war is demographically irrelevant. After a war of magnitude 9.8, no one would say anything at all.

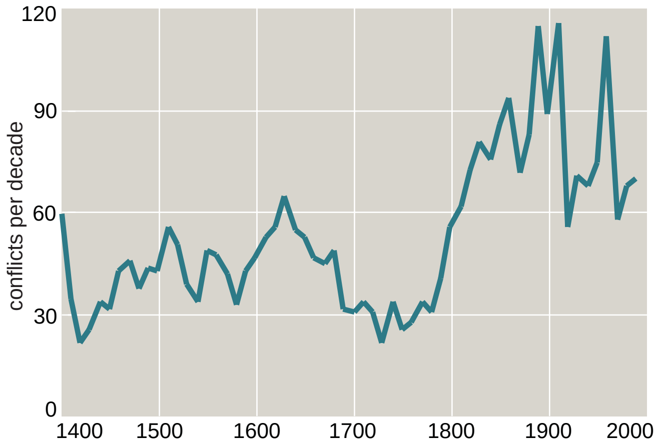

Figure 6. Long-term catalogue of global conflicts is being compiled by Peter Brecke of the Georgia Institute of Technology. When the catalogue is complete, the average level of hostilities in early centuries is expected to match that of recent times, but the conspicuous dip in the 1700s will probably remain. Data courtesy of Peter Brecke.

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