Chapter 1

Lewis Fry Richardson – A Pioneer Not Forgotten

Nils Petter Gleditsch

Abstract Lewis F Richardson, a physicist by training, remains a towering presence in two academic subjects, meteorology and peace research. Prizes are named for him in both fields. This chapter introduces a collection of articles assessing Richardson's legacy and his enduring influence in the social sciences. It reviews his citations as an indication of the range of his influence and discusses his impact in five areas of social science: the study of arms races, data collection on deadly quarrels, the stability of the long peace, the role of geography in conflict, and the role of mathematics in peace studies. It also includes a brief discussion of the conscience of a scholar with regard to preparations for war.

1.1 His Life and Work

Lewis F Richardson was trained as a physicist, but gained his fame first in meteorology and then in the study of conflict. Although he never gained employment at a leading university, his work in meteorology was widely respected by his contemporaries and has remained among the foundations of the field. His work on conflict was seen as more unorthodox. Certainly, his formal models and quantitative empirics were well ahead of the curve in the discipline of international relations in his lifetime. It was not until seven years after his death that his two major volumes on conflict found a publisher (Richardson, 1960a, b).

Since then, Richardson has been honored in various ways. In 1972, British Prime Minister Edward Heath opened a new wing of the Headquarters Building of the

My work on this volume was supported by the Gløbius fund and by the Conflict trends project (#402561). Most of the chapters were first presented to two sessions on Richardson at the 59th Annual Convention of the International Studies Association, San Francisco, 4–7 April 2018. I am grateful to Håvard Hegre, Gerald Schneider, and the contributors to this volume for comments on my introduction.

Meteorological Office named the Richardson Wing.¹ The Department of Mathematics at the University of York has sponsored a Lewis F Richardson lecture series since 2015.² Unusually, scientific prizes are named for him in both his main fields. In 1960, the Royal Meteorological Society established the annual LF Richardson Prize for meritorious papers by young authors in one of the journals of the society.³ Since 1997, The European Geosciences Union has awarded the Lewis Fry Richardson Medal for ‘exceptional contributions to nonlinear geophysics in general’.⁴ And from 2001, scholars who have spent most of their academic life in Europe and who have made exemplary scholarly contributions to the scientific study of militarized conflict, have been honored with the Lewis F Richardson Lifetime Award, with Michael Nicholson as the first recipient.⁵ As I have experienced on a couple of occasions, if a conflict researcher gets an opportunity to speak to a group of meteorologists (say on the topic of climate change and conflict), a favorable mood can be generated by an early reference to Richardson.

Richardson was in many ways a loner. Although he carried out an extensive correspondence and was receptive to criticism of his own work – in fact, his two major volumes contain a number of fictional dialogues with his critics – he generally worked without assistants, and most of his work is single-authored. He often worked under difficult conditions. The extreme case is his work on meteorology while serving as an ambulance driver in France in World War I. In 1917, during the battle of Champagne, he sent his working copy of the manuscript on weather prediction ‘to the rear, where it became lost, only to be re-discovered some months later, under a heap of coal’ (Richardson, 1922: ix). Of course, as befitting a scholar of his generation, he relied very heavily on his wife Dorothy not just for moral support but in the practical work of carrying out experiments and in copy-editing.⁶

As is evident from the timeline in the Appendix, Richardson spent most of his professional life in positions where he either worked on practical problems or taught science at the basic level, notably at Paisley Technical College (1929–40). Apparently, Richardson was not the world’s best teacher, but he is described as ‘conscientious and caring’ (Ashford, 1985: 150f). Much of his research was carried out in his spare time. It was only after retirement, for the last 13 years of his life, that he was able to devote himself full-time to research.

Richardson’s publications in meteorology, notably *Weather Prediction by Numerical Process* (Richardson, 1922) and a later article on atmospheric diffusion (Richardson, 1926), remain his most frequently cited items. The 1926 article is recorded with well over 1000 citations on Web of Science, including 42 citations in

¹Ashford (1985: 246ff).

²www.york.ac.uk/maths/events/lfr/.

³Ashford (1985: 245), www.rmets.org/our-activities/awards/l-f-richardson-prize.

⁴www.egu.eu/awards-medals/lewis-fry-richardson/.

⁵http://ksgleditsch.com/richardson_award.html.

⁶Ashford (1985: 239f).

the first seven months of 2018!⁷ Among his social science writings, his two posthumously published books top the list, with *Arms and Insecurity* (Richardson, 1960a) a little ahead of *Statistics of Deadly Quarrels* (1960b). Both of these books continue to be cited to this day, although not at the level of his 1926 article. Richardson (1961), another posthumous publication, is also widely cited.

For several years, Richardson maintained a strong interest in psychology, and delved into topics like intelligence, the quantitative assessment of pain, perception, and national hatred. He published in scholarly journals, including several articles in *British Journal of Psychology*, attended professional meetings, and even went to the trouble of acquiring an academic degree in psychology at the age of 48.⁸ He also taught a psychology course in college. Several of Richardson's articles in psychology are respectably cited, particularly his work on the measurement of sensations (Poulton, 1993). But on the whole he appears to have had more limited impact in this field, although some of his methods have been widely adopted. Richardson's first major publication on conflict was, characteristically, titled *The Mathematical Psychology of War* (Richardson, 1919). That he focused on psychology rather than war when he more or less left meteorology in the 1920s, has been explained as a result of a hope that World War I had been so devastating that another major war seemed unlikely. When political and military developments turned to the worse in the 1930s, Richardson devoted almost all his research time to the question of war and peace (Nicholson, 1999: 543).

1.2 The Study of Arms Races

The notion of an arms race is an old one and extends well beyond the field of international relations, e.g. in biological studies of adaptation and counter-adaptation between predators and prey (Smith, 2020, in this volume: 8–9). Boulding (1962: 25) suggested the label 'Richardson processes', since he had provided the most extensive theoretical treatment. Richardson was concerned with how the acquisition of arms by two or more hostile powers could lead to a competitive race (Richardson, 1960a). He analyzed under what conditions such a race would become unstable and was likely to end in war. He studied a number of arms races from this perspective, notably the arms races preceding the two World Wars. He developed a formal model which was driven by competition with the other side, a 'fatigue' factor determined by the level of one's own military spending, and the 'grievance' against the other side. A very large number of scholars have tried to improve on this model and the empirical measures used to test it. Two major debates have emerged out of this literature: First, whether arms acquisitions are driven mainly by competition, or by internal processes as

⁷All searches on ISI Web of Science, 8 August 2018.

⁸Ashford (1985: 112f).

argued, for instance, by Senghaas (1990). Secondly, to what extent arms races are associated with the outbreak of war, as maintained by Wallace (1979) and others.

Both of these debates became quite heated and acquired ideological overtones. Smith (2020) concludes that the lack of specificity in the Richardson model was a strength as well as a weakness. It could be applied in a wide variety of contexts, but at the same time it was difficult to evaluate empirically. Its simplicity also makes it a great teaching tool. Diehl (2020, in this volume) shows how the empirical testing of the arms-race-to-war linkage has become more sophisticated since Richardson's original analyses, notably in examining the no-arms race cases. No clear consensus has emerged, but Richardson continues to provide an inspiration to study the role of arms races in raising the risk of war.

The bulk of the work on arms races has focused on competition between two hostile powers. However, Richardson also developed extensions of his arms race model to three or more nations (Richardson, 1960a, Chs 15, 17). The greater complexity of these models makes it harder to derive the conditions for stability, and the empirical testing also becomes much more complicated. However, as argued by Michael Ward (2020, in this volume), Richardson's work points the way towards a network perspective on international affairs. And recent progress in data collection and processing makes it much more feasible to simulate complicated systems of interdependent processes.

1.3 Identifying Deadly Quarrels

Unlike present-day scholars, Richardson could not pick a suitable dataset off the shelf in order to test his theories of the causes of war. He had to develop his own, and Richardson (1960b) is the final result of this effort, listing all 'fatal quarrels' after 1820 which had ended. He consulted a large number of historical sources as well as police statistics and the notes on each conflict list the sources used. In parallel endeavors, Sorokin (1937) and Wright (1942) also developed datasets on wars. Richardson only became aware of these lists when his own was largely complete, and in his book he comments on some similarities and differences. In his own list, inclusion was determined strictly by the number of deaths, which he believed to 'the most reliable method for statistical purposes' (Richardson, 1960b: 5). A 'deadly quarrel' is defined as 'any quarrel which caused death to humans (p. 6). This includes not just wars, but also 'murders, banditries, mutinies, insurrections', but not 'accidents, and calamities such as earthquakes and tornadoes' or indirect deaths from famine and disease.

The two most frequently used datasets in current empirical research on armed conflict, the Correlates of War (COW) Project⁹ and the Uppsala Conflict Data

⁹<http://www.correlatesofwar.org/>.

Program (UCDP),¹⁰ draw directly or indirectly on the earlier lists, but have settled for narrower definitions than Richardson. For instance, UCDP defines an armed conflict as ‘a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths in one calendar year’.¹¹

The trend in recent empirical work on armed conflict has been in the direction of greater inclusion, although not necessarily by including everything in a master category such as ‘deadly quarrels’. The COW project’s first dataset (Singer & Small, 1972) included interstate wars only, while the current lists also include data on civil wars, extra-state wars, and non-state wars. While UCDP started out with data on three types of conflicts – interstate, intrastate, and extra-state – it has later added data on non-state conflicts and on one-sided violence. These data are reported in separate spreadsheets, but it is possible to merge the information, and UCDP now reports an annual world total for deaths in all these forms of violence (Pettersson & Eck, 2018).

There is some controversy over the issue whether or not to include deaths from crime in the study of armed conflict. The study of violent crime is usually conducted quite separately from the study of war. But the basic framework, where actions are seen as a function of motive and opportunity, is the same, and the recent decline in homicide rates is frequently interpreted as part of the same turn away from violence as the decline in war casualties (Pinker, 2018). In a controversial study, the International Institute of Strategic Studies reported in 2017 that Mexico had the world’s second-most-lethal conflict in 2016 (after Syria) (IISS, 2017: 5).¹² But this assumed that all or most of the murders in Mexico (23,000) were connected to organized crime, whereas UCDP limits non-state conflict to the use of armed force between two organized groups and attributed a much smaller number (1300) of deaths in Mexico to this type of armed conflict. Since deaths from homicides vastly exceed casualties in war or civil war in most countries and most years, it matters a great deal how large a share is classified as armed conflict. It is essential that the classification criteria are the same across time and space.

Richardson reported all casualties in his deadly quarrels in logarithms to the base ten. He was wary of fictitious accuracy. He commented on three seemingly very different estimates of the number of deaths in the Union army in the American Civil War (359,528, 279,376 and 166,623). Reporting the logarithms (5.6, 5.4, and 5.2) ‘brings out their substantial agreement’ (Richardson, 1960b: 7). The rationale was the same as for measuring the severity of earthquakes with the Richter scale (Nicholson, 1999: 550) or its successor the Moment Magnitude Scale.

¹⁰<http://ucdp.uu.se/>.

¹¹www.pcr.uu.se/research/ucdp/definitions/.

¹²For critiques of the IISS report, see e.g. Phillips (2017) and Estévez-Soto (2017).

1.4 The Stability of the Long Peace

A number of scholars have argued that the world is becoming less violent if the violence is measured by casualties in armed conflict (Lacina, Gleditsch & Russett, 2006; Pinker, 2018). Others question the stability of this trend and outline plausible scenarios that could produce a large war (e.g. Ellsberg, 2017). Richardson (1948, 1960b: Chs 3–4) found that war sizes followed a power-law distribution where the frequency of wars of size x is proportional to $x^{-\alpha}$, where α is a constant. Bigger wars are less common than smaller ones and the value of α determines the rate at which war frequencies decrease as war sizes increase. Aaron Clauset (2020, in this volume) confirms this, using more sophisticated statistical tools and better data than were available to Richardson. His analysis is consistent with a constant hazard of interstate war. This does not contradict the empirical fact of a decline in the lethality of war over the last 70 years, but Clauset concludes that the pattern of relative peace would have to last another 100 years before one can conclude that it is a statistically significant trend rather than the result of chance. Michael Spagat & Stijn van Weezel (2020, in this volume) do not dispute this. However, they point out that when the fatalities are measured relative to the size of the population, measuring the risk that a random person will suffer a battle-related death, the evidence for a real change becomes stronger. The same is true if one moves the hypothesized break-point forward to 1950 rather than the end of World War II. Finally, when including civil wars, the no-change hypothesis can be rejected with confidence. This debate will no doubt continue to inspire a host of new studies. Richardson is frequently quoted for his statement that his ‘equations are merely a description of what people would do if they did not stop to think’ (Richardson, 1960a: 12). Indeed, Clauset (2020: 124–125) finds it puzzling that the hazard of war should remain constant, given the non-stationarity of human population, the number of recognized states, commerce, communication etc. If the straitjacket of the power-law distribution for the size of wars can be broken, Richardson would probably have been delighted to find that people had actually stopped to think.

1.5 The Role of Geography in Conflict

Meteorology is very much a geographical science. Weather prediction depends crucially on estimates of how and when air pressures and sources of precipitation move geographically. It is not surprising when Richardson took his tools from physics and set them to work on conflict, that geographical considerations should permeate his writings in the new field.

Richardson was one of the first to write about the importance of contiguity to fighting. ‘The obvious reason why the murderer and his victim were usually

subjects of a common government is their localization.’ (Richardson, 1960b: 297). He therefore needed to develop appropriate measures for geographical opportunities for fighting. One of these was the length of a common border between two countries. Here, Richardson was the first to point out that this length depended on the scale of measurement. The shorter the yardstick, the longer the boundary (Richardson, 1961/1993: 607ff). Although ignored at the time, this would later inspire Mandelbrot’s work on fractals (Mandelbrot, 1967).

As noted by Gleditsch & Weidmann (2020) and Scheffran (2020), both in this volume, Richardson pioneered the use of cell-based approaches to conflict analysis, long before the introduction of Geographic Information Systems (GIS). He noted that the number of ‘conceivable belligerents’ in a civil war could not simply be determined by what groups had actually fought. Such potential parties to fighting could not be identified from works of history ‘because insurgents were often not recognized as a group until they had declared themselves to be such by revolting.’ (Richardson, 1960b: 307). Richardson therefore estimated the number of cells of equal numbers of people (potential conflict actors) and discussed how ‘local pacifying influences’, such as common government, language, or religion, might reduce the risk of civil war between them. The rapid growth of GIS and of spatial datasets on political, demographic, socioeconomic, and environmental characteristics of subsets of nations, has led to a major reorientation of empirical analyses of war and peace, as noted by Gleditsch & Weidmann (2020).

Richardson also pointed out a curious fact about national boundaries: There are no examples of four countries meeting in a single point, as in the Four Corners area of the US. He attributed this to the role of warfare in shaping boundaries (Gleditsch & Weidmann, 2020: 73f).

Scheffran (2020) suggests that Richardson’s conflict model offers a basis for insights in the potential impacts of climate change on conflict and cooperation. This is a credible extension of his model. Given Richardson’s enduring interest in the weather and in conflict, it is a fascinating thought that he might have been a pioneer in the now blooming research area on climate, weather, and conflict (Buhaug, 2016). However, while his *Statistics of Deadly Quarrels* has chapters on several potential causes of war (such as poverty, language, religion, and contiguity), there is no chapter on climate or the weather. Indeed, the only place I have been able to find a link of sorts is on p. 129 where he cites an observation by Quincy Wright that wars in the north temperate zone have ordinarily begun in spring or summer.

1.6 The Role of Mathematics in Peace Studies

The discipline of international relations in Richardson’s time, including the study of war and peace, was case-oriented and strongly influenced by legal and normative considerations. Attempts at generalizations were rarely based on systematic data. Along with Pitirim Sorokin and Quincy Wright, Richardson was one of the few pioneers in what today is a vibrant field of quantitative conflict studies.

Richardson's achievements in this regard is all the more remarkable in that he seemed largely unaware of the introduction of mathematical models in other social sciences, particularly in economics, which was taking place at the same time (Nicholson, 1999: 556).

Much current work in international relations is cross-sectional because temporal data are lacking. Kelly Kadera, Mark Crescenzi & Dina Zinnes (2020, in this volume) point out that in his work on the dynamics of conflict, Richardson was a pioneer in investigating the role of time in international relations. They argue that studies in the Richardson tradition using differential equations model time more explicitly than most game theory models, which focus on equilibria. As Nicholson (1999: 547) points out, most economists of his era would probably have approached the arms race as a problem in comparative statics, 'where determining the equilibrium was the main problem and the paths along which the system moved to achieve it was a subsidiary issue if considered at all.'

While early empirical analyses of the conditions of war and peace tended to look at the influence of one variable at a time, Richardson was clearly sensitive to multivariate analysis with interactions between factors: As Smith (2020: 26) notes, he recognized that a common border would increase the probability of war, but also amount of trade, which may in turn have a pacifying effect.' This basic point was frequently overlooked in many early studies of the trade-conflict relationship (Schneider, Barbieri & Gleditsch, 2003).

Niall MacKay (2020, in this volume) offers a comparison between Lanchester's model of war attrition and the Richardson arms race model. Their starting-points were quite different. Richardson was concerned with the hazard of war and how arms races could be prevented or limited. Lanchester was interested in how to win a war. Both are models of two-way interaction. Both can be generalized from duels to 'truels'. In both models, a scholar can work out the conditions for a stalemate. MacKay discusses the possibilities of combining insights from the two models.

1.7 The Conscience of a Scholar

Richardson came from a Quaker background and his religious affiliation had a pervasive influence on his life and career. His interest in psychology was apparently inspired by the social service of the Society of Friends (Ashford, 1985: 51). When World War I broke out, he was working for the Meteorological Office in Eskdalemuir. Given the national importance of his work there, he could probably have continued until the end of the war. Instead, he applied for leave from the Met Office to join the Friends Ambulance Unit in France as a conscientious objector. His application for leave was turned down, and he eventually resigned from his position in order to join the ambulance unit in 1916. He served there for nearly three years. While in France, he wrote some of his early papers on war and peace. He rejoined the Met Office in 1919 at Benson Observatory. However, in 1920 the Met Office was transferred to the Air Ministry, and Richardson resigned. As he wrote to

the Norwegian meteorologist Vilhelm Bjerknes, ‘I do not like preparations for war’ (Ashford, 1985: 105). Richardson nevertheless continued to publish papers in meteorology in the 1920s. In the 1930s, researchers in chemical warfare became interested in Richardson’s work on atmospheric turbulence and made ‘delicate approaches’, causing ‘a time of heart-break’ according to his wife. He then destroyed research results that had not been published (Körner, 1996: 189).

Not all Quakers or other British pacifists reacted to World War I in the same way that Richardson did. For some, national patriotism trumped their peaceful principles. This was, of course, even more so in World War II, because the enemy seemed particularly evil. Körner (1996: 207), in a sympathetic review of Richardson’s work, is left uneasy by Richardson’s refusal to assign blame for any conflict, although he acknowledges that participants in a deadly conflict routinely accuse the other side of starting it.

Scholars today are faced with similar dilemmas. Is it immoral to do research on weapons of mass destruction? Or is it immoral to leave the field to the other side? Traditionally, such dilemmas have been faced mainly by natural scientists. However, the military and intelligence services are also increasingly interested in the social sciences. In the US, for instance, they are heavily involved in funding the social sciences through the Minerva Research Initiative (<https://minerva.defense.gov/>) and the Political Instability Task Force.¹³ The research is unclassified and published openly and has spawned a number of seminal books and articles. The policy orientation of these funding initiatives is not in doubt and they serve as vehicles for bringing social scientists and policymakers in closer touch. Critics might argue, as they did in the mid-1960s when the US Department of Defense started recruiting social scientists for a counterinsurgency program called Project Camelot (Horowitz, 1967), that such efforts aid US policymakers in cementing a hierarchical and unjust international order. Others would respond that it would be counterproductive to leave major sources of social science funding to ideologues or less competent social scientists. There are no easy answers to these dilemmas, but those who shy away from research sponsorship under the rubric of national security today, probably sacrifice less in career terms than did Richardson.¹⁴

Despite Richardson’s devotion to theory, he was not an impractical scientist unconcerned with practical implementation. He developed ingenious procedures for carrying out experiments and held several patents. He wrote two papers on voting procedures in international organization and seemed to have been convinced that if he could persuade decision makers of the hazard of arms races and war preparations, he could help to prevent them. It was precisely because he was concerned

¹³PITF does not appear to have an official website, but a Wikipedia article explains the history and nature of the research sponsorship: https://en.wikipedia.org/wiki/Political_Instability_Task_Force.

¹⁴There is little public discussion of these issues, but one member of the PITF resigned after the election of Donald Trump, with a harsh indictment of his colleagues (‘academic courtiers’) who preferred to remain silent in the face of a situation where ‘the greatest source of political instability in the world will be the administration of the US Federal Government.’ Cf <https://scatter.wordpress.com/2017/01/20/why-i-resigned-from-the-political-instability-task-force/>.

with putting science into practice, that he was wary of contributing to the preparation for war. One of the things he had learned from a teacher at Bootham School in York, was that ‘science ought to be subordinate to morals.’ (Gold, 1954: 218)

1.8 The Impossible Dream

Richardson helped to create a new field of research virtually from nothing. In this brief introduction, I have focused on some of the key areas of his research on war and peace, but those who consult *Statistics of Deadly Quarrels* will find chapters on languages and war, religions and war, economic causes of war, and many others. One of his conclusions on interreligious wars speaks directly to an important current debate: ‘There were more wars between Christians and Moslems than would be expected from their populations, if religious differences had not tended to instigate quarrels between them.’ (Richardson, 1960b: 245)

Richardson was ahead of his times in approaching the question of war and peace with tools he had acquired in his work in physics. He was unafraid to tackle problems that were hard to solve, or even insoluble with the resources available to him at the time. His work on weather forecasts required an enormous number of calculations just to predict tomorrow’s weather from today’s. In fact, his own attempts at weather prediction took longer than the passage of the actual weather. Unfazed, Richardson calculated that a ‘staggering’ staff of 64,000 (human) computers would be needed to complete a weather forecast before the deadline. (Actually, there was an error in his calculations, the correct figure was 256,000.) ‘Perhaps in some years’ time it may be possible to report a simplification of the process.’¹⁵ Indeed! With the advent of digital computers, predicting the weather using the methods introduced by Richardson has become standard practice.

With the benefit of hindsight, we can see that his work was given less attention at the time of publication than it deserved. Cambridge University Press agreed to publish his now celebrated book *Weather Prediction by Numerical Process* in 1922 only after receiving subsidies from the Royal Society and the Met Office. It was printed in just 750 copies and sold even fewer. This and similar experiences have led to Richardson being portrayed as neglected genius. Nevertheless, his work did in fact inspire early pioneers in peace research like Kenneth Boulding, Karl Deutsch, Anatol Rapoport, J David Singer, and Quincy Wright (Nicholson, 1999: 555, 559). The very first issue of *Journal of Peace Research* contained an article on Richardson’s arms race model (Smoker, 1964) and the first volume of *Journal of Conflict Resolution* a whole special issue (1957, 3) on Richardson. Dina Zinnes (2020, in this volume) explains how her encounter with Richardson came to determine the direction of her own distinguished career in the field. No doubt, the work of Lewis Fry Richardson will continue to inspire new generations of scholars.

¹⁵Richardson (1922: 219). Cf Ashford (1985: 91f).

References

Chapters in this volume have been omitted in the reference list.

- Ashford, Oliver M (1985) *Prophet – or Professor? The Life and Work of Lewis F Richardson*. Bristol: Hilger.
- Ashford, Oliver M et al. (eds) (1993) *Collected Papers of Lewis F Richardson*, 2: Quantitative Psychology and Studies of Conflict. Cambridge: Cambridge University Press.
- Boulding, Kenneth E (1962) *Conflict and Defense. A General Theory*. New York: Harper and Brothers.
- Buhaug, Halvard (2016) Climate change and conflict: Taking stock. *Peace Economics, Peace Science and Public Policy* 22(4): 331–338.
- Clauset, Aaron (2020) On the frequency and severity of interstate wars. Ch. 10 in this volume.
- Diehl, Paul F (2020) What Richardson got right (and wrong) about arms races and war. Ch. 4 in this volume.
- Ellsberg, Daniel (2017) *The Doomsday Machine: Confessions of a Nuclear War Planner*. London: Bloomsbury.
- Estévez-Soto, Patricio R (2017) A report says that Mexico is the second-deadliest conflict zone in the world –it's just not true. *The Conversation*, 18 May, <http://theconversation.com/a-report-says-that-mexico-is-the-second-deadliest-conflict-zone-in-the-world-its-just-not-true-77898>.
- Gleditsch, Kristian Skrede & Nils B Weidmann (2020) From hand-counting to GIS: Richardson in the information age, Ch. 7 in this volume.
- Gold, Ernest (1954) Lewis Fry Richardson. *Obituary Notices of Fellows of the Royal Society* 9: 217–235, <https://royalsocietypublishing.org/doi/10.1098/rsbm.1954.0015>.
- Horowitz, Irving Louis (ed.) (1967) *Rise and Fall of Project Camelot*. Cambridge, MA: MIT Press.
- IISS (2017) *Armed Conflict Survey 2017*. London: International Institute of Strategic Studies.
- Körner, Thomas William (1996) Ch. 8 A Quaker mathematician and Ch. 9 Richardson on War. In: *The Pleasures of Counting*. Cambridge: Cambridge University Press, 159–193, 194–227.
- Lacina, Bethany; Nils Petter Gleditsch & Bruce Russett (2006) The declining risk of death in battle. *International Studies Quarterly* 50(3): 673–680.
- MacKay, Niall (2020) When Lanchester met Richardson: The interaction of warfare with psychology. Ch. 9 in this volume.
- Mandelbrot, Benoît (1967) How long is the coast of Britain? Statistical self-similarity and fractional dimension. *Science* 156(3775): 636–638.
- Nicholson, Michael (1999) Lewis Fry Richardson and the study of the causes of war. *British Journal of Political Science* 29(3): 541–563.
- Pettersson, Therése & Kristine Eck (2018) Organized violence, 1989–2017. *Journal of Peace Research* 55(4): 535–547.
- Phillips, Brian J (2017). Is Mexico the second-deadliest 'conflict zone' in the world? Probably not. MonkeyCage, *Washington Post*, 18 May, www.washingtonpost.com/news/monkey-cage/wp/2017/05/18/is-mexico-the-second-deadliest-conflict-zone-in-the-world-probably-not/.
- Pinker, Steven (2018) *Enlightenment Now: The Case for Reason, Science, Humanism and Progress*. New York: Penguin.
- Poulton, EC (1993) The quantifying of mental events and sensations. In: Ashford et al., 491–514.
- Richardson, Lewis F (1919) *The Mathematical Psychology of War*. London: Hunt.
- Richardson, Lewis F (1922) *Weather Prediction by Numerical Process*. Cambridge: Cambridge University Press.
- Richardson, Lewis F (1926) Atmospheric diffusion shown on a distance-neighbour graph. *Proceedings of the Royal Society A* 110(756): 709–737.
- Richardson, Lewis F (1948) Variation of the frequency of fatal quarrels with magnitude. *Journal of the American Statistical Association* 43(244): 523–546. Reprinted in Ashford et al., 577–627.
- Richardson, Lewis F (1960a) *Arms and Insecurity: A Mathematical Study of the Causes and Origins of War*. Pittsburgh, PA: Boxwood.

- Richardson, Lewis F (1960b) *Statistics of Deadly Quarrels*. Pittsburgh, PA: Boxwood.
- Richardson, Lewis F (1961) The problem of contiguity: An appendix of Statistics of Deadly Quarrels. *General Systems Yearbook* 6: 139–186. Reprinted in Ashford et al., 579–627.
- Schneider, Gerald; Katherine Barbieri & Nils Petter Gleditsch (eds) (2003) *Globalization and Armed Conflict*. Lanham, MD: Rowman & Littlefield.
- Senghaas, Dieter (1990) Arms race dynamics and arms control. Ch. 2 in: Nils Petter Gleditsch & Olav Njølstad (eds) *Arms Races: Technological and Political Dynamics*. London: Sage, 15–30.
- Singer, J David & Melvin Small (1972) *The Wages of War, 1816–1965: A Statistical Handbook*. New York: Wiley.
- Smith, Ron P (2020) The influence of the Richardson arms race model. Ch. 3 in this volume.
- Smoker, Paul (1964) Fear in the arms race. *Journal of Peace Research* 1(1): 55–64.
- Sorokin, Pitirim (1937) *Social and Cultural Dynamics: Fluctuations of Social Relationships, War, and Revolution*. New York: American Book Company.
- Spagat, Michael & Stijn van Weezel (2020) The decline of war since 1950: New evidence.
- Wallace, Michael D (1979) Arms races and escalation: Some new evidence. *Journal of Conflict Resolution* 23(1): 3–16.
- Wright, Quincy (1942) *A Study of War*. Two volumes. Chicago, IL: University of Chicago Press. Updated version in one volume, 1965.

Nils Petter Gleditsch, b. 1942, is Research Professor at the Peace Research Institute Oslo and Professor Emeritus of Political Science at NTNU. He served as Director of PRIO (1972, 1978–79) and as Editor of *Journal of Peace Research* (1977, 1983–2010) and was President of the International Studies Association in 2008–09, nilspg@prio.org.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.