THE TAMING OF CHANCE

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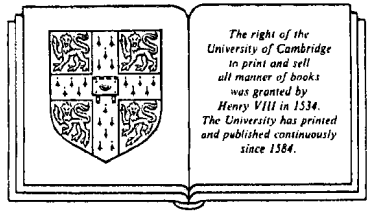

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The argument

The most decisive conceptual event of twentieth century physics has been the discovery that the world is not deterministic. Causality, long the bastion of metaphysics, was toppled, or at least tilted: the past does not determine exactly what happens next. This event was preceded by a more gradual transformation. During the nineteenth century it became possible to see that the world might be regular and yet not subject to universal laws of nature. A space was cleared for chance.

This erosion of determinism made little immediate difference to anyone. Few were aware of it. Something else was pervasive and everybody came to know about it: the enumeration of people and their habits. Society became statistical. A new type of law came into being, analogous to the laws of nature, but pertaining to people. These new laws were expressed in terms of probability. They carried with them the connotations of normalcy and of deviations from the norm. The cardinal concept of the psychology of the Enlightenment had been, simply, human nature. By the end of the nineteenth century, it was being replaced by something different: normal people.

I argue that these two transformations are connected. Most of the events to be described took place in the social arena, not that of the natural sciences, but the consequences were momentous for both.

Throughout the Age of Reason, chance had been called the superstition of the vulgar. Chance, superstition, vulgarity, unreason were of one piece. The rational man, averting his eyes from such things, could cover chaos with a veil of inexorable laws. The world, it was said, might often look haphazard, but only because we do not know the inevitable workings of its inner springs. As for probabilities – whose mathematics was called the doctrine of chances – they were merely the defective but necessary tools of people who know too little.

There were plenty of sceptics about determinism in those days: those who needed room for freedom of the will, or those who insisted on the individual character of organic and living processes. None of these thought for a moment that laws of chance would provide an alternative to strictly causal laws. Yet by 1900 that was a real possibility, urged as fact by an

adventurous few. The stage was set for ultimate indeterminism. How did that happen?

This is not a question about some sort of decay in knowledge or management. The erosion of determinism is not the creation of disorder and ignorance – quite the contrary. In 1889 Francis Galton, founder of the biometric school of statistical research, not to mention eugenics, wrote that the chief law of probability 'reigns with serenity and in complete effacement amidst the wildest confusion'.[1] By the end of the century chance had attained the respectability of a Victorian valet, ready to be the loyal servant of the natural, biological and social sciences.

There is a seeming paradox: the more the indeterminism, the more the control. This is obvious in the physical sciences. Quantum physics takes for granted that nature is at bottom irreducibly stochastic. Precisely that discovery has immeasurably enhanced our ability to interfere with and alter the course of nature. A moment's reflection shows that a similar statement may be attempted in connection with people. The parallel was noticed quite early. Wilhelm Wundt, one of the founding fathers of quantitative psychology, wrote as early as 1862: 'It is statistics that first demonstrated that love follows psychological laws.'[2]

Such social and personal laws were to be a matter of probabilities, of chances. Statistical in nature, these laws were nonetheless inexorable; they could even be self-regulating. People are normal if they conform to the central tendency of such laws, while those at the extremes are pathological. Few of us fancy being pathological, so 'most of us' try to make ourselves normal, which in turn affects what is normal. Atoms have no such inclinations. The human sciences display a feedback effect not to be found in physics.

The transformations that I shall describe are closely connected with an event so all-embracing that we seldom pause to notice it: an avalanche of printed numbers. The nation-states classified, counted and tabulated their subjects anew. Enumerations in some form have been with us always, if only for the two chief purposes of government, namely taxation and military recruitment. Before the Napoleonic era most official counting had been kept privy to administrators. After it, a vast amount was printed and published.

The enthusiasm for numerical data is reflected by the United States census. The first American census asked four questions of each household. The tenth decennial census posed 13,010 questions on various schedules addressed to people, firms, farms, hospitals, churches and so forth. This 3,000-fold increase is striking, but vastly understates the rate of growth of printed numbers: 300,000 would be a better estimate.

The printing of numbers was a surface effect. Behind it lay new

technologies for classifying and enumerating, and new bureaucracies with the authority and continuity to deploy the technology. There is a sense in which many of the facts presented by the bureaucracies did not even exist ahead of time. Categories had to be invented into which people could conveniently fall in order to be counted. The systematic collection of data about people has affected not only the ways in which we conceive of a society, but also the ways in which we describe our neighbour. It has profoundly transformed what we choose to do, who we try to be, and what we think of ourselves. Marx read the minutiae of official statistics, the reports from the factory inspectorate and the like. One can ask: who had more effect on class consciousness, Marx or the authors of the official reports which created the classifications into which people came to recognize themselves? These are examples of questions about what I call 'making up people'. This book touches on them only indirectly.[3]

What has the avalanche of printed numbers to do with my chief topic, the erosion of determinism? One answer is immediate. Determinism was subverted by laws of chance. To believe there were such laws one needed law-like statistical regularities in large populations. How else could a civilization hooked on universal causality get the idea of some alternative kind of law of nature or social behaviour? Games of chance furnished initial illustrations of chance processes, as did birth and mortality data. Those became an object of mathematical scrutiny in the seventeenth century. Without them we would not have anything much like our modern idea of probability. But it is easy for the determinist to assume that the fall of a die or the spin of a roulette work out according to the simple and immutable laws of mechanics. Newtonian science had no need of probabilities, except as a tool for locating underlying causes. Statistical laws that look like brute, irreducible facts were first found in human affairs, but they could be noticed only after social phenomena had been enumerated, tabulated and made public. That role was well served by the avalanche of printed numbers at the start of the nineteenth century.

On closer inspection we find that not any numbers served the purpose. Most of the law-like regularities were first perceived in connection with deviancy: suicide, crime, vagrancy, madness, prostitution, disease. This fact is instructive. It is now common to speak of information and control as a neutral term embracing decision theory, operations research, risk analysis and the broader but less well specified domains of statistical inference. We shall find that the roots of the idea lie in the notion that one can improve – control – a deviant subpopulation by enumeration and classification.

We also find that routinely gathering numerical data was not enough to make statistical laws rise to the surface. The laws had in the beginning to be

read into the data. They were not simply read off them. Throughout this book I make a contrast of a rough and ready sort between Prussian (and other east European) attitudes to numerical data, and those that flourished in Britain, France, and other nations of western Europe. Statistical laws were found in social data in the West, where libertarian, individualistic and atomistic conceptions of the person and the state were rampant. This did not happen in the East, where collectivist and holistic attitudes were more prevalent. Thus the transformations that I describe are to be understood only within a larger context of what an individual is, and of what a society is.

I shall say very little about mathematical conceptions of probability. The events to be described are, nevertheless, ingredients for understanding probability and for grasping why it has been such an incredible success story. Success story? A quadruple success: metaphysical, epistemological, logical and ethical.

Metaphysics is the science of the ultimate states of the universe. There, the probabilities of quantum mechanics have displaced universal Cartesian causation.

Epistemology is the theory of knowledge and belief. Nowadays we use evidence, analyse data, design experiments and assess credibility in terms of probabilities.

Logic is the theory of inference and argument. For this purpose we use the deductive and often tautological unravelling of axioms provided by pure mathematics, but also, and for most practical affairs, we now employ – sometimes precisely, sometimes informally – the logic of statistical inference.

Ethics is in part the study of what to do. Probability cannot dictate values, but it now lies at the basis of all reasonable choice made by officials. No public decision, no risk analysis, no environmental impact, no military strategy can be conducted without decision theory couched in terms of probabilities. By covering opinion with a veneer of objectivity, we replace judgement by computation.

Probability is, then, *the* philosophical success story of the first half of the twentieth century. To speak of philosophical success will seem the exaggeration of a scholar. Turn then to the most worldly affairs. Probability and statistics crowd in upon us. The statistics of our pleasures and our vices are relentlessly tabulated. Sports, sex, drink, drugs, travel, sleep, friends – nothing escapes. There are more explicit statements of probabilities presented on American prime time television than explicit acts of violence (I'm counting the ads). Our public fears are endlessly debated in terms of probabilities: chances of meltdowns, cancers, muggings, earthquakes, nuclear winters, AIDS, global greenhouses, what next? There is

nothing to fear (it may seem) but the probabilities themselves. This obsession with the chances of danger, and with treatments for changing the odds, descends directly from the forgotten annals of nineteenth century information and control.

This imperialism of probabilities could occur only as the world itself became numerical. We have gained a fundamentally quantitative feel for nature, how it is and how it ought to be. This has happened in part for banal reasons. We have trained people to use numerals. The ability to process even quite small numbers was, until recently, the prerogative of a few. Today we hold numeracy to be at least as important as literacy.

But even compared with the numerate of old there have been remarkable changes. Galileo taught that God wrote the world in the language of mathematics. To learn to read this language we would have to measure as well as calculate. Yet measurement was long mostly confined to the classical sciences of astronomy, geometry, optics, music, plus the new mechanics. T.S. Kuhn has iconoclastically claimed that measurement did not play much of a role in the 'Baconian' sciences that came to be called chemistry and physics.[4] He urged that measurement found its place in physics – the study of light, sound, heat, electricity, energy, matter – during the nineteenth century. Only around 1840 did the practice of measurement become fully established. In due course measuring became the only experimental thing to do.

Measurement and positivism are close kin. Auguste Comte coined the word 'positivism' as the name of his philosophy, holding that in all the European languages the word 'positive' had good connotations. His own philosophy did not fare especially well, but the word caught on. Positive science meant numerical science. Nothing better typified a positive science than a statistical one – an irony, for Comte himself despised merely statistical inquiries.

The avalanche of numbers, the erosion of determinism, and the invention of normalcy are embedded in the grander topics of the Industrial Revolution. The acquisition of numbers by the populace, and the professional lust for precision in measurement, were driven by familiar themes of manufacture, mining, trade, health, railways, war, empire. Similarly the idea of a norm became codified in these domains. Just as the railways demanded timekeeping and the mass-produced pocket watch, they also mandated standards, not only of obvious things such as the gauge of the lines but also of the height of the buffers of successive cars in a train. It is a mere decision, in this book, to focus on the more narrow aspects that I have mentioned, a decision that is wilful but not arbitrary. My project is philosophical: to grasp the conditions that made possible our present organization of concepts in two domains. One is that of physical indeter-

minism; the other is that of statistical information developed for purposes of social control.

This study can be used to illustrate a number of more general philosophical themes. I have mentioned one above: the idea of making up people. I claim that enumeration requires categorization, and that defining new classes of people for the purposes of statistics has consequences for the ways in which we conceive of others and think of our own possibilities and potentialities.

Another philosophical theme is reasoning. In thinking about science we have become familiar with a number of analytic concepts such as T.S. Kuhn's paradigms, Imre Lakatos's research programmes and Gerald Holton's themata. Following A.C. Crombie I have thought it useful to employ the idea of a style of reasoning.[5] Crombie had in mind enduring ways of thinking such as (a) the simple postulation and deduction in the mathematical sciences, (b) experimental exploration, (c) hypothetical construction of models by analogy, (d) ordering of variety by comparison and taxonomy, (e) statistical analysis of regularities of populations, and (f) historical derivation of genetic development.[6]

Each of these styles has its own sources and its own pace. Those who envisage continuity in the growth of knowledge see each style evolving at its own rate. Catastrophists see sharp beginnings and radical mutations. One need not dogmatically adhere to either extreme in order to see styles of reasoning coming together. Each contributed to what Crombie calls 'the growth of a research mentality in European society'.

My topic is Crombie's style (e) which, of the six that he distinguishes, is quite the most recent. Despite various discernible precursors and anticipations, our idea of probability came into being only around 1660, and the great spurt of statistical thinking did not occur until the nineteenth century. The statistical example makes plain that the growth of a style of reasoning is a matter not only of thought but of action. Take so seemingly unproblematic a topic as population. We have become used to a picture: the number of people in a city or in a nation is determinate, like the number of people in a room at noon, and not like the number of people in a riot, or the number of suicides in the world last year. But even the very notion of an exact population is one which has little sense until there are institutions for establishing and defining what 'population' means. Equally there must be ways of reasoning in order to pass from cumbersome data to sentences with a clear sense about how many were such and such. Most professionals now believe that representative sampling gives more accurate information about a population than an exhaustive census. This was unthinkable during most of the nineteenth century.[7] The very thought of being representative has had to come into being. This has required techniques of thinking together with technologies of data collection. An entire style of scientific reasoning has had to evolve.

Its development was intimately connected with larger questions about what a society is, and thus leads to speculation and historical study of the formation of the western concept of a community.[8] But it also invites more abstract analytical philosophy, because styles of reasoning are curiously self-authenticating. A proposition can be assessed as true-or-false only when there is some style of reasoning and investigation that helps determine its truth value. What the proposition means depends upon the ways in which we might settle its truth. That innocent observation verges nervously on circularity. We cannot justify the style as the way best to discover the truth of the proposition, because the sense of the proposition itself depends upon the style of reasoning by which its truth is settled. A style of thinking, it seems, cannot be straightforwardly wrong, once it has achieved a status by which it fixes the sense of what it investigates. Such thoughts call in question the idea of an independent world-given criterion of truth. So the seemingly innocent notion of a style of reasoning can lead to deep waters, and it is wiser to enter them by wading into examples than by a high dive into abstraction. The development of statistical thinking may be our best example available – because most recent and enduring and now pervasive.

Historians will see at once that what follows is not history. One may pursue past knowledge for purposes other than history of science or history of ideas. A noncommittal account of what I am attempting might be: an epistemological study of the social and behavioural sciences, with consequences for the concept of causality in the natural sciences. I prefer a less expected description. This book is a piece of philosophical analysis. Philosophical analysis is the investigation of concepts. Concepts are words in their sites. Their sites are sentences and institutions. I regret that I have said too little about institutions, and too much about sentences and how they are arranged.

But what sentences? I use only the printed word, a minuscule fraction of what was said. The distinguished statistician I. J. Good noted in a review that 'the true history of probability or of science in general will never be written because so much depends on unrecorded oral communication, and also because writers often do not cite their sources'.[9] The true historian of science is well able to solve the second problem, but not the first. One may nevertheless make a good stab at it by consulting the ample Victorian troves of notebooks, letters and other ephemera. I do not do so, for I am concerned with the public life of concepts and the ways in which they gain authority. My data are published sentences.

But which ones? I omit many pertinent words because one cannot do

everything. I leave out Malthus and Mendel, for example, A.A. Cournot, Gustav Fechner, Florence Nightingale and ever so many more modest participants in the taming of chance. Very well: but I say nothing of Maxwell, Bolzmann or Gibbs, although statistical mechanics is critical to the spread of chance and probability not only into physics but also into metaphysics. I say nothing of Charles Darwin, although evolutionary theorizing was to import chance into biology. I say nothing of Karl Marx fabricating an iron necessity out of the very same numerals, the identical official statistics, that I have incorporated into an account of the taming of chance.

There is an uncontroversial good reason for silence about these figures. Scholars and teams of scholars dedicate their lives to the study of one or another. It would be folly to venture a short story here, a mere chapter. But it is not only prudence and respect, but also method, that makes me hold my tongue. Transformations in concepts and in styles of reasoning are the product of countless trickles rather than the intervention of single individuals. Marx, Darwin and Maxwell worked in a space in which there was something to find out. That means: in which various possibilities for truth-or-falsehood could already be formulated. This book is about that space. So although a lot of sentences are reproduced in this book, they are the words not of heroes, but of the mildly distinguished in their day, the stuff of the more impersonal parts of our lives.

Sentences have two powers. They are eternal, and they are uttered at a moment. They are anonymous, and yet they are spoken by flesh and blood. I have tried to answer to these two facts. On the one hand, I do regard the sentences as mere material objects, inscriptions. But to do that, and only that, is to become lost in vain abstraction. As counterbalance, my epigraphs to each chapter are dated, to recall that on a real day important to the speaker, those very words were uttered, or are said to have been uttered. My footnotes (marked with asterisks) are anecdotes that would be improper in the more solemn text.* They give some tiny glimpse of who the speakers were. But there is seldom anything personal about the footnotes. They address the individual as official, as public writer, even if his behaviour may strike us, so much later, as strange.

Thus although many chapters have a central character or text, it is not because Salomon Neumann, A.-M. Guerry or John Finlaison is 'important'. They are convenient and exemplary anchors for a particular organization of sentences. I use the antistatistical method, that of Frédéric Le Play, topic of chapter 16. After having interminably trekked across the

* Notes at the end of the book provide references, and, rarely, numerical formulae. They are marked with numerals. A numeral after an asterisk (as *[3]) indicates that note 3 at the end of the book bears on the material in the footnote marked *.

written equivalent of his Hartz mountains, I take what I think is the best example of one speaker. Much like Le Play, I include a few stories, but the personages whom I use are in some ways like his household budgets, if, alas, less thorough.

There is one exception among these chapters. The final one is twice as long as the others, and is a rather full account of one side of one writer, namely C.S. Peirce. He really did believe in a universe of absolute irreducible chance. His words fittingly end this book, for as he wrote, that thought had become possible. But I argue that it became possible because Peirce now lived a life that was permeated with probability and statistics, so that his conception of chance was oddly inevitable. He had reached the twentieth century. I use Peirce as a philosophical witness in something like the way that I used Leibniz in *The Emergence of Probability*.[10] But Leibniz was a witness to the transformation that I was there describing, namely the emergence of probability around 1660 and just afterwards. Here Peirce is the witness to something that had already happened by the time that he was mature. That is why he is the topic of the last chapter, whereas in *Emergence* the name of Leibniz recurred throughout.

Although other philosophers are mentioned in the two books, only Leibniz and Peirce play a significant part. The two works do, however, differ in structure in other ways. *Emergence* is about a radical mutation that took place very quickly. Doubtless, as Sandy Zabell and Daniel Garber have shown in an exemplary way, the book underestimated various kinds of precursors.[11] My central claim was, however, that many of our philosophical conceptions of probability were formed by the nature of the transition from immediately preceding Renaissance conceptions. Accounts of the methodology have been given elsewhere.[12] *Taming*, in contrast is about a gradual change. Hence the geological metaphors: avalanches, yes, but also erosion.

Most of my selections and omissions – such as my long treatment of Peirce and my neglect of any other philosopher – have been deliberate. But sloth and good fortune have also played their part. When I began work there was hardly any recent secondary material; now there is a great deal. I am particularly glad of new books by my friends Lorraine Daston, Ted Porter and Stephen Stigler, and of earlier ones by William Coleman and Donald MacKenzie. We all participated in a collective inspired and guided by Lorenz Krüger. The joint work of that group has also appeared. Hence there is now a number of brilliant and often definitive accounts of many matters that overlap with mine.[13] They have made it unnecessary for me to examine a good many matters. And aside from specific histories, there are also points of great generality that I have allowed myself to gloss over in the light of that collective work. For example, another virtue of my

geological metaphor is that the erosion of determinism took place at markedly different rates on different terrains. Not uncommonly the least deterministic of disciplines most fiercely resisted indeterminism – economics is typical. This phenomenon emerges from the individual studies of the research group, and is further emphasized in a recent summing up of some of its results.[14]

I have mentioned a number of more specific topics on which I have only touched, or have entirely avoided: making up people; styles of reasoning; great scientists; philosophers; mathematical probability. There is a more glaring omission. I write of the taming of chance, that is, of the way in which apparently chance or irregular events have been brought under the control of natural or social law. The world became not more chancy, but far less so. Chance, which was once the superstition of the vulgar, became the centrepiece of natural and social science, or so genteel and rational people are led to believe. But how can chance ever be tamed? Parallel to the taming of chance of which I speak, there arose a self-conscious conception of pure irregularity, of something wilder than the kinds of chance that had been excluded by the Age of Reason. It harked back, in part, to something ancient or vestigial. It also looked into the future, to new, and often darker, visions of the person than any that I discuss below. Its most passionate spokesman was Nietzsche. Its most subtle and many-layered expression was Mallarmé's poem, 'Un Coup de dés'.[15] That graphic work, whose words are more displayed than printed, began by stating that we 'NEVER ... will annul chance'. The images are of shipwreck, of a pilot whose exact mathematical navigation comes to naught. But the final page is a picture of the heavens, with the word 'constellation' at its centre. The last words are, 'Une pensée émet un coup de dés', words that speak of the poem itself and which, although they do not imagine taming chance, try to transcend it.

2

The doctrine of necessity

In 1892 the iconoclastic American philosopher C.S. Peirce proposed 'to examine the common belief that every single fact in the universe is determined by law'.[1] 'The proposition in question' – he called it the doctrine of necessity – 'is that the state of things existing at any time, together with certain immutable laws, completely determines the state of things at every other time.' His examination was venomous. At the end: 'I believe I have thus subjected to fair examination all the important reasons for adhering to the theory of universal necessity, and shown their nullity.'[2] That was only the negative beginning. Peirce positively asserted that the world is irreducibly chancy. The apparently universal laws that are the glory of the natural sciences are a by-product of the workings of chance.

Peirce was riding the crest of an antideterminist wave. As is so often the case with someone who is speaking for his time, he thought himself alone. 'The doctrine of necessity has never been in so great a vogue as now.' He did warn against supposing 'that this is a doctrine accepted everywhere and at all times by all rational men.' Nevertheless he had to peer back into the distant past to find people with whom he agreed. The philosophy of Epicurus and the swerving atoms of Lucretius were, in his opinion, precursors of the statistical mechanics of Maxwell, Boltzmann and Gibbs. He had more allies than he imagined, but he was right in thinking that his examination of the doctrine of necessity would have been unthinkable in the eighteenth century.

For a before-and-after portrait, we inevitably contrast Peirce with the greatest of probability mathematicians, Laplace, author of the classic statement of necessity. 'All events, even those which on account of their insignificance do not seem to follow the great laws of nature, are a result of it just as necessarily as the revolutions of the sun'.[3] With those words Laplace opened his *Philosophical Essay on Probabilities*, a text that goes back to his introductory lectures at the Ecole Polytechnique in 1795.[4] It was full of memorable passages like this:

> Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it – an intelligence sufficiently vast to submit these data to analysis – it would