Introduction

Klaas Landsman, Ellen van Wolde and Noortje ter Berg

Das Gewebe dieser Welt ist aus Notwendigkeit und Zufall gebildet
(The fabric of reality is built from necessity and chance)
Goethe

Abstract This chapter introduces the theme of the book (i.e., the challenge of chance) and includes brief surveys of the individual chapters.

The collapse of cohesion is one of the features that characterize chance. By sheer accident, or so it seems, something breaks the typical regularity of the natural world, like a comet disrupting the solar system. At a human scale, we find examples like unexpectedly bumping into an old friend, or losing a loved one in an accident. Such (seemingly) random phenomena appear arbitrary; they disrupt our lives and frustrate our human need for logic and meaning. The ensuing feelings of uncertainty and apprehensiveness, in turn, trigger us to search for explanations that will help restore order and normal patterns of cause and effect. In a word, we are challenged by chance, and we have been so at least since antiquity.

How do we respond to such challenges? For thousands of years people have tried to decide whether chance is a fundamental and irreducible phenomenon, i.e. certain events are not caused—they just happen, or whether chance is merely a reflection of our ignorance. Either way, we find the experience of chance hard to deal with. Humans constantly try to understand random phenomena and prefer explanations that (re)install meaning. The question, then, is whether this search for explanation and meaning has succeeded, or, at least, has a fighting chance (sic) to succeed.

This question is more subtle than it appears, since with his revolutionary claim that the universe is necessarily the way it is and yet has no goal, Spinoza cut the thread connecting explanation and purpose. Even necessity was subsequently

K. Landsman (✉)
Faculty of Science, Radboud University, Nijmegen, The Netherlands
e-mail: landsman@math.ru.nl

E. van Wolde
Faculty of Philosophy, Theology and Religious Studies, Radboud University, Nijmegen, The Netherlands
e-mail: e.vanwolde@ftr.ru.nl

N. ter Berg
Radboud Honours Academy, Radboud University, Nijmegen, The Netherlands

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challenged by Darwin's theory of evolution in the 19th century, followed by quantum theory in the 20th, in both of which chance plays a fundamental role. Insult following injury, from Hume and Kant onwards even the causal patterns that permeate traditional science began to be questioned. From Aristotle to the 18th century, natural philosophy had seen these patterns as real, our role being limited to discovering them. Now, however, causality was claimed to be a mere by-product of our subjective need for rules, patterns, and meaning, which eventually led Bertrand Russell to his witticism that causality is "a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm."

The overall picture was summarized by the chilling words of Physics Nobel Laureate and popular science writer Steven Weinberg: "The more the universe appears comprehensible, the more it also appears pointless." However, he immediately qualified this pessimistic view (quoted from his popular account of the Big Bang entitled *The First Three Minutes*) in the following way: "But if there is no solace in the fruits of our research, there is at least some consolation in the research itself. Men and women are not content to comfort themselves with tales of gods and giants, or to confine their thoughts to the daily affairs of life; they also build telescopes and satellites and accelerators, and sit at their desks for endless hours working out the meaning of the data they gather. The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy."

This effort to understand includes the present book, which complements the excellent interdisciplinary books on chance that have already appeared over the last decades, both at a scholarly[1] and a popular[2] level. By incorporating a wide range of historical and contemporary sciences, the studies presented here allow us to develop a transdisciplinary perspective on chance. Thus our multidisciplinary approach, in which a team of authors explores the issue of chance in the disciplines of philosophy, mathematics, economics, game theory, statistics, physics, theology, neuropsychology, genetics, ecology, history, law, and linguistics, makes us aware of shared insights in these distinct disciplines. Let us first give a short survey of the articles originating in these various disciplines, to conclude with a few thoughts towards a transdisciplinary perspective on chance.

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[1]See, for example, G. Gigerenzer et al. (eds.), *The Empire of Chance* (Cambridge University Press, 1989), L. Krüger et al., *The Probabilistic Revolution*, Vols. 1, 2 (MIT Press, 1990), I. Hacking, *The Taming of Chance* (Cambridge University Press, 1990), I. Hacking, *The Emergence of Probability* (Cambridge University Press, 2nd ed. 2006), S. Kern, *A Cultural History of Causality* (Princeton University Press, 2004), P. Vogt, *Kontingenz und Zufall: eine Ideen- und Begriffgeschichte* (Akademie-Verlag, 2011).

[2]E.g., N.N. Taleb, *Fooled by Randomness* (Penguin, 2004), W. Poundstone, *Fortune's Formula* (HIll and Wang, 2005), K. Mainzer, *Der kreative Zufall* (C.H. Beck, 2007), N. Silver, *The Signal and the Noise: The Art and Science of Prediction* (Penguin, 2012), D. Hand, *The Improbability Principle* (Bantam Press, 2014).

1 Contents of This Book: Addressing the Challenge

The opening chapter by Lüthy and Palmerino presents a survey of 2500 years of linguistic, philosophical, and scientific reflections on chance, coincidence, fortune, randomness, luck and other related concepts. In particular, they show that any concept of chance could only be understood through the alternative that the particular notion of chance attempted to exclude. And precisely because the alternative that was to be excluded did not have a stable identity, also its anti-pole (i.e. the idea of what chance is) had a variable meaning. For example, 'chance' has been opposed to 'fate', 'providence', 'natural laws', 'determinism,' and 'the knowledge of causes'. This heterogeneous list illustrates what a slippery concept 'chance' really is. The endeavour to pin down and define concepts by contrasting with opposites is a thread that runs throughout this book.

Perhaps the most rigorous way to analyse chance is through pure mathematics. In Terwijn's chapter we are told that even the best efforts in the 20th century to capture randomness mathematically have yielded no single 'true' notion of randomness." Instead, a number of (equivalent) definitions have been proposed that contextualize randomness relative to prior notions such as computability. Accordingly, an object is defined as random if its description cannot be shortened in a computable way, that is, randomness is opposed to computable compressibility. For example, according to this definition, despite the completely irregular distribution of its infinitely many digits the number $\pi = 3.14\ldots$ is not random at all, since instead of giving all these digits we could write a short program to compute them. On the other hand, most real numbers are random in this sense, although, curiously, this fact cannot be proven for any given random number.

Historically, the first application of mathematics to chance was to betting and gambling. Unexpectedly, two centuries later similar methods turned out to lie at the heart of game theory in economics (Weitzel and Rosenkranz). In finance, one typically assumes complete rationality on the part of all actors. In combination with the 'efficient market hypothesis', this would naively seem to imply a deterministic course of events. However, one of the remarkable predictions of game theory is that even on these assumptions the most rational strategy is often a random mixture of a number of alternative possibilities. Of course, this again blurs the alleged demarcation between determinism and chance.

Moving from probability to statistics, Goeman describes how researchers in medical statistics and psychology look for statistical correlations between data in the hope of revealing (publishable) evidence of a chain of cause and effect (for example, to conclude or predict that drinking milk is healthy whereas smoking is not). In a word, statistics is used to 'negotiate' chance. However, as Goeman argues, even ignoring notorious (especially Dutch) cases of scientific fraud, estimates of the unreliability of serious and published clinical studies range from 14 to 89 %, and he makes several proposals to improve this situation.

In the next chapter, Landsman's analysis of the 'fine-tuning argument' bridges the gap between chance in mathematics and physics on the one hand and chance in

philosophy and theology on the other. The laws of nature contain parameters that are set at highly specific values for the universe to exist, and for us, humans, to exist in it. The list of possible explanations for this fine-tuning of the universe includes: design by a deity, a 'multi-verse' (so as to increase the probability of the existence of our own universe), 'blind chance', and finally, 'blind necessity'. For Landsman the latter two are the best options but he adds: "The present state of science does not allow us to make such a choice now, and the question even arises whether science will ever be able to make it, except perhaps philosophically."

Contrary to common belief, theological stances from the past were not all deterministic. In the Hebrew Bible, for instance, the book of Job describes the dramatic alternation between fortune and misfortune in a non-deterministic way, as Van Wolde's analysis shows. Job is unaware that God is carrying out an experiment because of a wager with the satan. Job tries to find his own explanations and reasons, but is chastised by God for obscuring "the design by words without knowledge". God's dismissive words reverberate throughout the years of thinking about chance, coincidence, luck, randomness and such concepts. Are these just words without knowledge? Or is it our historical, spatial, and cultural perspective that limits our type of rationality? Van Wolde also discusses this question with respect to the first chapter of the book of Genesis, which for many people, secular or non-secular, is the clearest example of God initiating a cause-driven chain of events. The question, then, is whether this is really the case.

It is a relatively small step from the ancient Near-East to the ancient Greek and Asian worlds. Bringing both philosophical and Buddhist attitudes towards chance into the picture, Thijssen and Loy point out that at first, 'luck' (or 'chance') and 'karma' seem to be opposing concepts. If something happens because of good or bad luck, it is beyond the agent's control whereas, in contrast, karma, implies that agents have a great deal of control (albeit indirect) over what happens. However, both philosophical traditions believe that being invulnerable to bad luck depends upon mental transformation. Western traditions focus more on coping with the emotional effects of bad luck, whereas Eastern traditions concentrate on the agent's motivations. But both aim to change our experience of the world and are still helpful today in our attempts to secure happiness in the face of adversity.

In contrast, the contemporary western approach to chance as an aspect of human life is set in the framework of cognitive neuroscience. van Elk, Friston, and Bekkering discuss the deeply engrained human tendency to give meaning to coincidences. However, it turns out that not only are humans remarkably bad at estimating chances and probabilities, they also tend to perceive a causal nexus between situations even where there is none. In doing so, the original meaning of coincidence is subverted, as it gestures at a perceived connection between events even though we cannot explain the causal mechanism behind it. Following Helmholtz, they argue that the human brain a priori constructs a predictive model of the world, which however may be interrupted or distracted by seemingly random events (neuroscientists typically have a deterministic world picture, so that randomness is never absolute but is only experienced as such). However, it is their

very randomness that endows such events with at least subjective explanatory power, in that the brain may conclude that the inexplicable becomes explicable, precisely because it was random.

Medical research has to bridge another chasm, namely from biology and genetics to the feelings of loss when a handicapped child is born 'by chance' to healthy parents. Brunner shows in his study that random genetic mutations that originate at the molecular level can subsequently have either causal or probabilistic consequences for genes, individuals, species, ecosystems, and eventually even for the planet. The example of genetics also raises the question whether random events are beneficial or harmful: on the one hand, random errors of replication during the formation of germ cells can cause birth defects that result in a miscarriage or severe problems for the child and parents. On the other hand, such mutations drive evolution at the level of the species, typically enabling it to improve.

Coincidence also plays a central role in De Kroon and Jongejans' chapter. They counter the statement that "if it's a coincidence, it is not scientific"—a judgment implied in the premises of the previous two chapters. They argue that if 'chance processes' such as a heavy storm occur at the right place and time they could well determine the development of ecosystems and they claim "chance is pervasive in ecological systems." But what is the status of chance here? Qualifying their thesis, the authors argue that chance events typically have a deterministic origin, and that the stochastic nature of their occurrences can often be defined within a range of predictable variation. What remains problematic is the uneasy relationship between the scale-dependence of cause and effect with that of stochasticity.

In his chapter, Hekster tells us that because coincidences are, by definition, not causally related, traditional historians have tended to ignore them. So when is a coincidence just a coincidence, and when does a pattern occur? And why would a historian be interested in 'accidents', 'singular events', or 'contingent circumstances'? Surely, it has been historically decisive that Hitler survived all attempts to kill him (except his own). Yet it is tempting to walk the path of 'what-if history'. But does counterfactual thinking liberate us from a false sense of historical determinism or does it, instead, lead to a view of history as a series of random events? The answer to this question depends entirely on one's sense of the causal forces active in history. A providentialist or determinist will see inevitabilities and necessities. As Hekster argues, much will also depend on how one defines "the intersection between private actions and the public world," where "history develops." At those intersections, coincidences might play an explanatory role, but only if understood in terms of micro-causes related to individual human agency.

In Jansen's article, which deals with 'accidental harm' under Roman law (which has exerted a paramount influence on modern European Law), we once more encounter the Latin word 'casus' with its many meanings, which signifies not just 'accident', but also 'misfortune', 'fate', 'adversity' or 'setback,' which, in the legal context, all amount "to an event resulting in damage which cannot be traced back to another party's fault." For the Roman lawyer, however, 'casus' is not opposed to necessity, but to some state of intentionality. In any case, accidents are seen as purely negative, and the question is simply who is liable for the damage they cause.

Yet at least in Western Europe, after WW II this principle was increasingly countered by the tendency of governments to protect citizens from misfortune, notably by means of a social security system—"from womb to tomb" (Churchill). In recent years such systems seem to be weakening, partly for financial reasons (they are arguably becoming unaffordable), but also under the influence of liberal tendencies to restore the individual's responsibility for whatever happens to him or her.

The chapter by Van Hout and Muysken starts with a rejection of complete generative models of linguistics à la Chomsky, in which chance hardly plays any role and at best represents a lack of knowledge. Instead, they use numerous examples to show that chance, in the sense of language variation, plays a major role at each of the four levels of linguistics: inter-species variability, inter-language variability, variability in the linguistic signal within a given language, and finally inter-individual variability. In each of these four levels, the notion of chance figures as an inherent property; it is a probability mechanism to explain variability. They conclude the final chapter of this book with the comment that random variations in language ultimately originate from the fact that human ways of expressing meaning are far from unique.

2 A Transdisciplinary Perspective on Chance

One of the insights of this collection of articles that struck us as meaningful when looking at chance from such diverse disciplinary perspectives is that two aspects return in many of the contributions, namely the contextuality of chance and its role in explanations.

Contextuality of chance is most clearly seen in scale-dependence, which is found in many biological ecosystems (cf. De Kroon and Jongejans). What seem to be random events at a lower level can produce stability at a higher level. For example, seeds are dispersed at random by the wind, then may germinate into a plant or disappear. Another example is the origins of language variation. Ideas about random origins will be different if studied at the level of species, language in general, different languages, or individual speakers of a given language (Van Hout and Muysken). Random genetic mutations (Brunner) provide yet another case in point. They originate at a molecular level but, subsequently, have causal or probabilistic consequences for genes, individuals, species, ecosystems and thus, ultimately, for the planet as a whole. In history, what seem to be a small-scale state of affairs (such as the legendary beauty of Cleopatra's nose) can have huge consequences for nations and even epochs (Hekster). As a final example, in economics, the (random) individual psychology of a single investor interacts with the rather more deterministic psychology of the 'masses', for example, during the tulip mania in 1637 or the dotcom bubble in the 1990s (Weitzel and Rosenkranz).

Another instance of the contextuality of chance is its perspectival nature. In mathematics (Terwijn), no *absolute* notion of randomness can exist, and in order to

properly define the notion, one has to specify *with respect to what* the supposed random objects should be random. Thus a random object is random with respect to a given type of definition, or class of sets. Strikingly, this view is comparable to the theological view presented in literary form in the biblical book of Job (Van Wolde). In the narrated divine speech out of the whirlwind, chance is related to a multifocal view of a universe and interpreted in terms of perspective: God, reflecting on the universe and its inhabitants, states that he does not share the perspective of the stars, weather phenomena, or animals, and that he does not even share the moral convictions of human beings who only want him to share *their* perspective, such as their ideas of justice. Thus what seems to be coincidental at the level of humans (or animals and plants) may be the effect of order at a higher level.

Secondly, throughout history including contemporary science, chance has been used both as an explanation and as the hallmark of an absence of explanation. Thus one may wonder if these apparent antipodes are really as antithetical as they seem. Historiography itself is a prime example. One could argue that Western philosophy would have emerged without Plato, or that there would have been a Scientific Revolution without Newton. But would there have been a communist Russian Revolution without Lenin, or a Holocaust without Hitler? If not, the actual occurrence of these momentous events in history was eventually *caused* by the *random* events of the births of these particular individuals. Similarly, parents with a severely handicapped or stillborn child may feel that their misfortune has no explanation, while their doctor may say it was *caused* by a *random* genetic defect. Appeals to God as the instigator of certain random events play a similar role. In quantum physics it could be claimed that radio-active atoms decay *because* of random events, or it could be said that this decay cannot be explained. The Fine-Tuning Argument brings this dual role of chance to a head, as many contemporary secular scientists seem perfectly happy to attribute the occurrence of life to chance, whereas others regard this as the lack of an 'explanation', and look elsewhere.

The reader is invited to also look at other chapters from these two angles, or indeed from any angle he or she prefers, as chance is an infinitely rich phenomenon that will continue to fascinate humans as long they live. We hope this book will challenge our readers as much as it did the authors.

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