onto the stage where they dance uncontrollably, as well as entrancing a man to cross a river on a tightrope.

Although little more is known about her life, such acts were common fare among the hundreds of travelling performers who practised mesmerism in the UK and abroad from the 1840s. Although many were charlatans who used stooges to perform impossible deeds, others—like Spencer Hall, the son of a Nottinghamshire cobbler—gained a reputation for treating people for conditions ranging from stammering to deafness even though the medical establishment remained sceptical.

The growing band of doctors who did champion mesmerism, like John Elliotson, were dismissive of lay performers. Stage acts that induced people to bark like dogs or dance demonically gave hypnotism a bad name—and ultimately cast it to the fringes of medicine where it languishes still today.

Wendy Moore

Wendy Moore will be talking about John Elliotson and mesmerism at the British Library, London, UK, on March 6, 2017, but has no direct involvement in this exhibition. Her book, *The Mesmerist: The Society Doctor Who Held Victorian London Spellbound* (Weidenfeld & Nicolson), will be published in April, 2017.
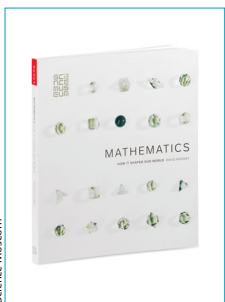
The mathematics of life, death, and beauty

Mathematics rules the world, as first revealed by Isaac Newton in his *Philosophiae Naturalis Principia Mathematica* published in 1687. It underpins all of the sciences, including the social sciences. It is central to medical services, communication networks, financial systems, and entertainment and leisure activities. Digital computers are inconceivable without mathematics.

But it is a challenge for most of us. "Some of you who have small children may perhaps have been put in the embarrassing position of being unable to do your child's arithmetic homework, because of the current revolution in mathematics teaching known as the New Math", Harvard University mathematician and songwriter Tom Lehrer told a receptive American audience during the mid-1960s, while introducing his song, *New Math*. Lehrer then satirised the revolution: "In the new approach, as you know, the important thing is to understand what you're doing—rather than to get the right answer."

I was reminded of this ever-present debate while studying the stylish-looking Mathematics gallery designed by Zaha Hadid Architects at London's Science Museum, along with its accompanying publication, *Mathematics: How It Shaped Our World*, written by the lead curator of the gallery, David Rooney. Both the gallery and the book deliberately eschew any

display of alien mathematical symbols or theorems and instead choose to focus on mathematics' real-world implications and applications. In fact, there is not a single equation to alarm the non-mathematical reader in the book's enjoyable text and only a passing mention of Albert Einstein, despite coverage of the design of the atomic bomb. For as the Science Museum is fully aware from audience research conducted half a century after the passing of the New Math, in a world of electronic devices made possible by mathematics, most visitors can have virtually no understanding of what is going on mathematically when they use their technology; they simply trust it to give them the right answer.

> **"Both the gallery and the book deliberately eschew any display of alien mathematical symbols or theorems and instead choose to focus on mathematics' real-world implications and applications."**

Thus the exhibition, like the lavishly illustrated book, is divided into six sections based on readily understood human concerns: "Trade and Travel", "War and Peace", "Money", "Life and Death", "Form and Beauty", and "Maps and Models". "These concerns are at the root of human existence", argues Rooney. This approach allows a rich array of objects to be

displayed, such as 16th-century Elizabethan weights and measures, a World War 2 aircraft navigational aid known as a "computor", a mid-20th-century cash register, 19th-century actuarial calculators of life insurance and human skulls with phrenological markings, 18th-century classical architectural designs, and a 17th-century astrolabe.

Rooney's book also has four essays by noted academic curators, historians, and mathematicians reflecting on the appeal of mathematics, and on the role of women mathematicians such as Emilie du Châtelet and Mary Somerville, plus a concise conclusion by Zaha Hadid, who died in 2016, to whom the book is dedicated. She writes: "When I was growing up in Iraq, math was an everyday part of my life. My parents instilled in me a passion for discovery, and they never made a distinction between science and creativity. We would play with math problems just as we would play with pens and paper to draw—math was like sketching."

"Life and Death" is the section of most direct medical relevance, although the other five sections raise issues relating to the mapping of complex proteins, tricks of visual perception caused by the artistic manipulation of perspective, the possibilities for artificial intelligence based on neural networks, and the seemingly endless development of digital computers. In

this part of the exhibition the visitor can see contrasting mortality statistics—discussed by location in astronomer Edmond Halley's pioneering Royal Society paper, *An Estimate of the Degrees of the Mortality of Mankind* (1693) or according to cause in Florence Nightingale's famously graphic *Diagram of the Causes of Mortality in the Army of the East* (1858), which revealed that the largest proportion of deaths in the Crimean war was due to disease rather than battlefield wounds. There are also displays relating to the measurement of almost all aspects of living human beings introduced in the 1880s by psychologist and eugenicist Francis Galton in his Anthropometric Laboratory, along with a multidrawer cabinet containing tissue samples collected by pathologist Chris Wagner and two colleagues, who in 1960 first showed a link between exposure to blue asbestos and mesothelioma.

The problematic concept of risk underlies most "Life and Death" objects. Consider the Pedoscope, an X-ray machine that resembles a peculiar-looking piece of wooden furniture. Designed in the UK around 1950, it displayed the fit of the foot in a shoe on a screen, and was especially alluring to children (including my elder sister, later a physician). But the cold-war 1950s was a time of high public concern about the dangers of radiation in the fallout from the atomic bombs dropped in 1945 on Japan. In the USA, where an equivalent device to the Pedoscope delivered a larger dose of radiation, a 1950 report by two physicians advised the medical community that "because of the latent period between cause and effect in low dosage radiation, it is impossible at present to determine merely by clinical examination whether or not deleterious influences have been produced by this device". In the UK, the Atomic Energy Research Establishment was asked by the government to investigate the Pedoscope in 1956. 2 years later, the Home Office required all machines to be fitted with a health warning advising customers not to

Mathematics: The Winton Gallery at the Science Museum, photo Jody Kingzett

use the machine more than 12 times a year, but did not ban the device. The Pedoscope company riposted by circulating a booklet to shoe shop managers claiming that "the possibility of harm resulting from the use of Pedoscopes exists only in the realm of fantasy". In Rooney's words, the dispute brought the shoe shop "firmly into the realms of mathematics"—the mathematics of probability and risk. No scientist in the 1950s could state with certainty that Pedoscopes caused a potential radiation hazard without access to (non-existent) statistics of cancer among Pedoscope users and non-users collected over a long period. In practice, Pedoscopes remained in use for some years, but disappeared in the 1970s. The gallery's example was donated to the museum in 1985 by a shoe shop.

Now consider the London Hospital Survival Predictor, a calculator built around 1972 for the London Hospital in Whitechapel and donated to the museum in 1997. The brainchild of medical physicist Douglas Maynard working closely with clinical neurophysiologist Pamela Prior, it was designed to predict the likelihood of a comatose patient recovering, so that a clinician could decide whether or not to attempt resuscitation. Once programmed with the patient's electroencephalogram (EEG) readings, the needle on the indicator dial would point either towards "S" on the right, indicating "survive", or towards "IBD" on the left, indicating irreversible brain death. This device was based on the use of historical statistics. Its software was an early form of artificial neural network that had been "trained" with EEG data from a large series taken from patients who had either recovered completely after resuscitation or died after a myocardial infarction. That said, the clinician was still required to interpret the EEG traces, and to dial up personal scores for 13 features of a particular patient, such as "awareness", before the survival predictor could compute a result. Even then, the final decision about resuscitation was always left to the clinician, not the machine. "The survival predictor was never, in fact, used to determine whether life support should be withdrawn", noted a 2002 *Lancet* paper—although this important fact is not clarified in the gallery, which describes and contextualises some objects much more comprehensively than others.

That said, *Mathematics*—both the gallery and the book—bring a difficult subject alive. They successfully dramatise, as stated in the book's final essay by Celia Hoyles and Helen Wilson, that: "Mathematics is beautiful and useful."

Andrew Robinson

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