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Plus or minus

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T HE STORY OF MEASUREMENT. By Andrew Robinson. 224pp. Thames and Hudson. Pounds 19.95.978 0 500 51367 5.

SMOOT'S EAR. The measure of humanity. By Robert Tavernor. 249pp. Yale University Press. Pounds 18.99 (US $25). 978 0 300 12492 7

IQ. The brilliant idea that failed. By Stephen Murdoch. 269pp. Duckworth. Pounds 20. 978 0 7156 3598 8

The Egyptians and Babylonians were among the first to produce standards for weights for exchanging goods in the market. The Romans, with the expansion of their empire, brought their own system of measurement, which became the most widely adopted in the Western world. It used different parts of the human body to provide various standards of length, such as the digit (the breadth of the middle part of the first joint of the forefinger), the palm (which measures four digits across the palm) and the foot (sixteen digits or four palms). The Roman mile equalled a thousand paces, and their yard was the length of a stride; but for King Henry I (1068-1135), the royal yard was the length of the arm, which equalled three feet.

One of the earliest English systems of measurement was decreed in 1324 by Edward II, who adopted the Latin uncia as both "ounce" and "inch", the latter representing one-twelfth part of the foot; this system eventually led to the creation of imperial units of measurement. Once kings began to embody a nation's measuring standards, rival kingships in Europe established their own systems. Although monarchs enforced national standards of measurement, in practice regional and local governing bodies imposed their own, thereby creating intractable problems with European commerce and trade.

Instruments of measurement have enabled man to define and understand nature by determining the shape of the Earth, exploring planetary motions, probing celestial activities, calculating location on land or at sea and predicting the weather. Andrew Robinson's The Story of Measurement provides a fine introduction to the topic. Robinson aims to discuss just about everything that is measurable in nature and in man. Our division of time, which measures the recurring cycles of celestial motions, was bestowed to us by the Babylonians, who gave us the sixty-second minute, the ancient Egyptians, from whom stem the twenty-four hours in a day, and Hellenistic astrology, which contributed the seven-day week. Mechanical clocks date from the end of the thirteenth century and were driven by falling weights: the oldest surviving working clock in England was set up at Salisbury Cathedral in 1386. By 1967, atomic clocks, which are accurate to less than one second in a million years, formed the basis of International Atomic Time (TAI). Following an International Conference of Weights and Measures in 1975, it was recommended that Coordinated Universal Time (UTC) be derived from the more accurate TAI, which became the accepted civil and legal timescale for all nations. UTC is transmitted from more than 200 atomic clocks around the world with an accuracy of plus or minus two milliseconds. Following these developments for global timekeeping in the 1970s, the National Physical Laboratory in Teddington maintains Britain's national time standard, which is based on a collection of accurate atomic clocks, active hydrogen masers and time-transfer equipment that allows comparisons with other time standards around the world.

Although Robinson's aim to cover immensely diverse and wide-ranging topics is impressive, it would have been helpful if he had defined the term "measurement". While virtually all of the entries in the section on "Nature" (latitude, longitude, spectroscopy, electricity and magnetism, the solar and planetary systems and temperature) use standardized systems of measurement, most of the entries on "Man" (such as writing systems, photography, blood types, sun protection factor, disease incubation) do not fall under the rubric of measurement. Measurement involves, first, the estimation of the magnitude of some attributes of an object from a set of statistically continuous variables (length, mass, volume, time and temperature) and, secondly, uses instruments to measure these attributes (rulers, scales, clocks and thermometers) that are calibrated to a standard. Conversely, virtually all the items in the section on man may be classified, instead, as forms of enumeration or counting, which involves finding the number of elements of a finite set of statistically discrete variables (colour of eyes, political affiliations, and gender).

While man's physical attributes of height, weight and body temperature involve measurement, entries such as blood types, stress factors, pollen count, calorie counting, postal codes, option polls and the classification of library books involve simple enumeration. In this respect, an entry on the quantitative discipline of epidemiology would have been more suitable for a discussion of measurement than the entry on disease incubation, which simply counts the number of days for the incubation of each disease. Nevertheless, Robinson has the knack to explain any number of complex concepts lucidly and with simplicity, without being condescending. Although he doesn't embark on any historiographical analysis, he does write with historical sensitivity and incorporates the work of various historians. He has produced a highly readable book.

To illustrate how central the human body has been to the history of measurement, Robert Tavernor, in Smoot's Ear: The measure of humanity, relates the story of Oliver R. Smoot (b1940), whose 5'7" body was used as a standard unit of measurement, termed a "smoot", in 1958 as a pledge to MIT's Lambda Chi Alpha fraternity. The fraternity initiates measured the span of Harvard Bridge, which was found to be 364.4 smoots plus or minus one ear (the ear signified a built-in error).

Much of what follows concentrates on the development of the metre as a global unit of measurement. The debates on the idea of an international and standardized system of weights and measures happened at a time when early modern scientists were grappling with problems of measurement in astronomy, cartography, geography, optics and physics - something Tavernor never acknowledges, but which would have helped the reader to understand the broader social, scientific and institutional context in which these events occurred. As one of the founding members of the Royal Society in London, Sir Christopher Wren suggested a national standard of weights and measures in 1665, while members of the Academie des Sciences in Paris wrangled with recalcitrant differences in national standards of measurement across France. Subsequently, an international body of scientists in Paris proposed a common European measure that could be both natural and scientific. National prestige and convenience meant that the metre was measured as the arc of the meridian aligning Dunkirk, Paris and Barcelona - while the English protested that the meridian latitude should be Greenwich, and the Americans countered that it should be measured in the United States.

However, not even the French could reform their own system: in the late eighteenth century there were more than 250,000 different units of measurements in every province, district and town in France. As Robinson points out, all attempts to bring one national system of measurement had failed because uniformity was not in the interests of the feudal aristocracy, who could manipulate the various units in their favour against peasantry. By 1789, even the aristocracy realized that this chaos and their increasing dissatisfaction with the bewildering units of measurement could not continue, thus enabling the French to willingly embrace a completely new system of measurement. This is why the French Revolution was able to gain acceptance for such a far- reaching social change as metrication. The conventions adopted to create this new system signified that the metre was to equal one ten-millionth of the circumference of the Earth, as measured by scientific surveyors; however, the economic difficulties inherent in switching systems of measurement led Napoleon to reject this system in France.

By the time an international conference on the metric system was held in Paris, in 1798-9, England was at war

with France and the United States was in a state of undeclared war; consequently, neither the English nor the Americans attended the conference and nor did the French invite them; thus, the metric and the imperial system learned to co-exist with each other. Although the metric system became compulsory in France in 1799, it was not until the end of the nineteenth century that the wavelength of red cadmium light was used to determine the length of the metre. The adoption of this newly defined metre spread gradually across Europe and to most countries around the globe. The British, however, continued to use their imperial standard of measurement and weights, formally established in the British Weights and Measures Act of 1824, while the Americans resolutely adhered to a nearly identical system. Although President Gerald Ford signed the Metric Conversion Act in 1975, twelve years later President Ronald Reagan disestablished it to reduce Federal spending.

Despite the many attempts that have been made for the British to adopt the metre, it has never been compulsory, apart from the 1995 ruling that all commercial packaging had to display metric units alongside imperial measurements. On September 11, 2007, the EU decided that Britain no longer had to adopt the metric system, since, as Europe's Commissioner for Enterprise and Industry, Gunter Verheugen, admitted, it was a "pointless battle that would only affect British tradition, culture and lifestyle".

In spite of Tavernor's announced intention to explore the role of architecture in the changing ideas of measurement, it is only in the last chapter that he addresses how Marcel Duchamp and Le Corbusier reacted to the ways in which French scientists determined the length of the metre. While that chapter doesn't really fit with the long discussion on the metre, it could form the basis of a more interesting and original book.

Stephen Murdoch's provocatively titled book, IQ: The brilliant idea that failed, will, no doubt, attract a number of readers who, like Murdoch himself, have had some disagreeable experiences with various types of psychometric tests. The overriding difficulty of the book, however, is the way Murdoch consistently presents nineteenth- century ideas of intelligence through the prism of a twenty-first-century journalist. This present-minded approach, his denouncements of Victorian innovations and science (which he deems "profoundly useless and idiosyncratic"), combined with his highly emotive prose, profoundly misrepresents the work and ideas of various people who lived in earlier centuries. Murdoch's tendency to interpret material from an American perspective is particularly problematic when he discusses Victorian terminology. Imposing American derisive and judgemental colloquialisms such as "crazy" and "dumb" onto the Victorian vernacular of such psychiatric terms as "insane" and "feeble-minded" is open to serious misinterpretation when, for example, the British usage of "dumb", as unable to speak, is confused with the American "dumb" as foolish or dim-witted.

The first IQ test was devised in 1905 by the French psychologists Alfred Binet and Theophile Simon. Influenced by Francis Galton's ideas of individual differences and hereditary genius, Binet was interested in creating a diagnostic instrument to identify children who did not benefit from instruction in regular schools in Paris. If the test indicated that a student was not performing well in some area, he would then receive additional instruction. Binet's work was, in turn, of interest to the English psychologist Charles Spearman who created the first psychometric test of intelligence. These findings attracted the attention of the educational psychologist Cyril Burt, who popularized IQ tests in Britain and became the architect of the 11-plus examination, introduced in the 1920s for schoolchildren in England and Wales. Although Binet never argued that his test was a measure of some innate or fixed characteristic of the child, Burt not only believed that IQ tests measured intelligence and that intelligence was hereditary, but that this could be determined by the age of eleven, thereafter remaining constant throughout an individual's life. For Burt, education was an elitist pursuit - intended for those who inherited money and their parents' intelligence.

Given Murdoch's propensity for sensationalism, it is surprising that he failed to acknowledge that, a year after Burt's death, evidence began to emerge that he had simply invented results to fit his theories about the hereditability of intelligence. This charge was corroborated in 1976 by Oliver Gillie, then medical correspondent of the Sunday Times. The exposure of Burt's fraudulent data was of enormous significance in the movement to remove the 11-plus examination and replace it with a comprehensive system by amalgamating or building new schools, enacted by the 1967 Education Act, which introduced the national curriculum and national tests at seven, eleven, fourteen and sixteen.

Both Murdoch and Robinson misrepresent Spearman's idea of intelligence by focusing exclusively on Spearman's "g" factor (which is never explained to the reader), and further claim that Spearman believed intelligence could be measured by this one factor. He developed his ideas of intelligence by borrowing some of the statistical methods of the Victorian mathematician Karl Pearson, who was one of the principal architects of modern mathematical statistics. Using Pearson's product-moment correlation and his principal components, Spearman created a new statistical procedure known as factor analysis, which reduces a set of complex data into a more manageable form that makes it possible to detect structures in the relationship between variables. With this new tool, Spearman went on to create the first psychometric theory of intelligence with his two-factor theory. His first factor "g" measured general intelligence and was a statistical measure of performance across a variety of tests, which described the ability to do common tasks and abstract reasoning, necessary for performance of all kinds of intelligence. The second component was his "s" factor, which measured specific types of intelligence and refers to the ability to perform specific tasks, for example those requiring verbal, mathematical or spatial abilities. Spearman interpreted his findings to connote that the same people who scored highly on a variety of general mental tests used a particular part of their brain that he labelled "g", which provided the foundation to the idea of a single intelligence, viewed by psychometricians today as the basic element of intelligence tests. His theory thus challenged the idea that there is one kind of intelligence only. The idea of measuring more than one kind of intelligence was further developed in 1983 by Howard Gardner, Professor of Education at Harvard. He proposed that there were seven different types of intelligence: verbal/linguistic, logical/mathematical, visual/spatial, musical, interpersonal, intrapersonal and bodily/kinaesthetic, which considers a broader range of human potential in both children and adults. Since the 1920s, intelligence tests have been devised by two groups: psychometricians who use Pearsonian-based statistical methods of correlation to look at traditional IQ tests, and cultural psychologists who tend to regard these conventional IQ tests as biased and unfair, while arguing that intelligence is changeable and has more to do with cultural backgrounds.

Murdoch's chapter on international sterilization eugenic policies in the early twentieth century centres on an unpropitious incident of an American girl, Carrie Buck, whose poor and uneducated mother was institutionalized for being feeble-minded and whose father had died by the time she was three years old. Carrie was adopted by a family whose nephew raped her when she was seventeen. Her adoptive family concealed this crime by conspiring to institutionalize her on the ground that she was, like her mother, feeble-minded. Her heinous treatment by the American legal and medical professions in the 1920s led to her being sterilized without consent by a Dr Bell. This event was enshrined in the 1927 Buck vs Bell ruling by the United States Supreme Court that upheld a statute instituting compulsory sterilization of the mentally retarded "for the protection and health of the state", which subsequently led to an estimated 65,000 Americans being sterilized without their consent or that of a family member. Based on this one particular outcome, Murdoch claims that this case "served as a fount of rationalisation for sterilisation in Europe", including the concentration camps of Nazi Germany. Murdoch's monocausal explanations of major historical events here lead to a tunnel vision of history, which does not employ a historical narrative, makes no attempt to contextualize any historical material whatsoever, and never addresses the historiography of intelligence testing.

Although Murdoch concedes that IQ tests offered a fairer way to assess a student's potential talent than one that depended on being born into the right family, he nevertheless lambasts IQ tests throughout the book. His unidimensional and monolithic approach precludes any discussion of their validity. These much maligned tests are useful diagnostic tools for neurologists who use them to determine the potential memory loss of patients after neurosurgery. Moreover, recent research has endorsed Spearman's theory of intelligence. Neuroscientists at Cambridge University and Dusseldorf University, who used MRI scanning, identified how mental tests that are closely allied to general intelligence use specific parts of the brain's frontal lateral cortex. A more critically incisive, historically sensitive and popular account of intelligence testing can be found in Stephen Jay Gould's The Mismeasure of Man (1981).