# Information and Human Society

Andrew Odlyzko

James Gleick is one of the great science writers of our age, and his latest book, *The Information*, has been well received. This is understandable, for it is an entertaining and instructive romp through the history of information technologies from cuneiform tablets to search engines. The book can be read piecemeal, and no technical background is required. The well-done sections explaining the science behind some developments can be skipped over by anyone wanting just a light overview.

As we are often reminded, we live in the Information Age, and Gleick tells the story of how we got here. Along the way, the reader learns about the talking drums of Africa (which enabled messages to be transmitted a hundred miles in less than an hour), the calculation of $\pi$ to five trillion decimal places, and evaporating black holes, among other things. The book also offers serious discussions of the origins and essence of information theory and of attempts to ground physics in information. The ever-popular topic of information overload is touched upon. And the reader is introduced to many of the great minds who have grappled with issues of information and computation, including Charles Babbage, Andrei Kolmogorov, Alan Turing, Norbert Wiener and Claude Shannon. Shannon, who founded information theory with a landmark paper published in 1948, plays a central role in the book.

Gleick's extremely ambitious (but in my view misguided) goal is to present information as an independent force that gets harnessed through the efforts of brilliant pioneers. The definite article in the title of the book hints at the reification and almost deification of information Gleick aims for. And in the text, we find the statement that "history is the story of information becoming aware of itself," a claim that may sound profound but is merely silly. The book contains many interesting vignettes and tidbits, as well as some substantive analyses; however, these do not coalesce into a coherent picture that supports Gleick's goal. Plenty of material that could serve as the basis for a more solid and illuminating treatment of information is present in the book. A better approach to achieving such a treatment would have been to present information as something that human society produces and uses for its own purposes, which are often not the same as those of the great figures making technological advances.

Some of the stories included in the book offer examples of inventors coming up with brilliant solutions for what they perceive to be society's pressing problems, only for society to then use those inventions for something entirely different. Alexander Graham Bell, for instance, imagined that the telephone would be used as a broadcasting device, sending music and sermons across long distances. But as "as soon as people laid their hands on

telephones," Gleick notes, "they worked out what to do. They talked." The failure of inventors and promoters of new technologies to appreciate what role their inventions would serve shows that history is less a matter of "information becoming aware of itself," and more one of people using information in unpredictable and often mundane ways. (The trend toward mundanity manifested itself very early; as Gleick observes, most of the surviving early cuneiform tablets are "humdrum: civic memoranda, contracts and laws, and receipts and bills for barley, livestock, oil, reed mats, and pottery.")

In Gleick's account of technological progress, leading thinkers and inventors play a prominent role. But one could make the case that many past breakthroughs were "hanging in the air," waiting to be plucked, once a certain knowledge base had been built up in a society, and that these breakthroughs were made because they solved pressing practical or intellectual problems. Sometimes pioneers are riding a wave rather than directing or creating one. The many examples of independent and almost simultaneous discoveries of key theories and technologies (by Gottfried Wilhelm Leibniz and Isaac Newton in calculus, and by Charles Darwin and Alfred Russel Wallace in evolution, for instance) certainly support the claim that society at large plays a role more crucial than that of the individual discoverer. This is not to say that the pioneers are unimportant. There were not dozens of Leibnizes and Newtons working on calculus, nor were there dozens of Darwins and Wallaces working on evolution. Had epidemics carried off those four men before they announced their discoveries, the innovations for which they are famous would have been delayed for decades. Some other breakthroughs, however, would likely have been delayed only a short time if the person now celebrated for making the advance had not been around. For instance, many people other than Samuel Morse were working on developing a telegraph. William Cooke and Charles Wheatstone placed one in service in England before Morse and his associate Alfred Vail did in the United States.

One can also argue that information theory would have been developed in the mid-20th century even without Claude Shannon. Extensive work in communication theory and practice (some of which is discussed by Gleick) preceded Shannon, including that done by Shannon's colleagues Ralph Hartley and Harry Nyquist at Bell Labs and by Vladimir Kotelnikov in the Soviet Union. One of them, or somebody else, soon would likely have had insights similar to Shannon's. Furthermore, although Shannon's elegant formulations did offer a much cleaner way of looking at the fundamental issues of communication than had been available before, their practical impact was likely small for quite a while. His predecessors had a difficult time stating precisely what they meant by transmission capacity. But they were brilliant thinkers and tinkerers, and they understood intuitively what they were doing. Just how important was Shannon's contribution to their work? That question receives no attention in *The Information.*

The birth of information theory with the publication of Shannon's paper in 1948 was followed by a vast literature promising revolutions in psychopharmacology, geophysical data interpretation, crystal structure and melody, says Gleick. This prompted (as the book nicely shows) warnings from Shannon himself against going far beyond what the theory itself was designed for or could reasonably be expected to provide. There is no denying that information theory had a wide influence, changing the way in which many

researchers approached their disciplines. But this influence was often minor and diffuse. Shannon's concept of information theoretic entropy had to be adapted by researchers in other fields to be useful. (Such adaptations were similar to the process by which Shannon took the concept of physical entropy and transformed it into one of the foundation stones of information theory.) There was some cross-fertilization of ideas, but the hard work still had to be done within each discipline. In general, information theory has not been a magic elixir, nor have some other highly touted approaches that caught the public's attention in the past few decades, such as cybernetics and catastrophe theory. Therefore one should be cautious about embracing the idea, advocated by some physicists, that physics should be reestablished on the basis of information as the fundamental quantity in the universe, a speculative proposal to which Gleick devotes considerable space.

While Gleick treats in detail some of the far-fetched ideas that have been inspired by information theory, he does not say much about the many concrete achievements that have grown out of Shannon's breakthrough. There have been huge advances since Shannon's seminal paper, advances that have made possible the communication systems we use, from smart phones to systems that let us control spacecraft near Saturn. One of Shannon's major accomplishments was to provide a rigorous bound indicating how much information could be sent over a noisy channel. Over the past couple of decades, three methods have been invented that manage to communicate at rates close to the Shannon bound. This remarkable intellectual achievement has significant practical value, but it isn't discussed at all in *The Information.*

Another pioneer featured in the book is Charles Babbage. Gleick presents an engaging account of the life and career of this 19th-century polymath, who was far ahead of his time; more than a century of further technological development had to take place before his ideas could be realized. Gleick describes Babbage's calculating engines, his complaints about lack of support from the British government, and his influence on and collaboration with Ada Lovelace, who was both his acolyte and his muse. Yet Gleick omits what I consider to be the far more important but much less known story of the Scheutzes. Per Georg Scheutz, a Swedish lawyer turned mechanical engineer, modified the Babbage design of the Difference Engine and had his teenage son, Edvard, build a prototype that actually worked. The cost was a tiny fraction of what the British government spent on Babbage's version without getting a functioning machine. There are unresolved questions as to whether it was Babbage himself or Joseph Clement (the person in charge of construction) who was to blame for the lack of results, but government support for the Babbage Difference Engine project was a waste. One can even argue that it harmed British science by discrediting the idea of government funding for research.

We should honor Babbage for his brilliant insights. He did far more than just design his computing engines; he had a deep appreciation for the system aspects of the project. Therefore he planned for the output of the computations to be coupled directly to printing engines, to eliminate human transcription errors. However, the story of information processing in the 19th century is not that of Babbage's Difference and Analytical Engines but the far more mundane story of the Jacquard loom. As Gleick points out, Jacquard's technology, involving punch cards, helped inspire some of Babbage's work, and led to tabulating

machinery that was used by census bureaus and insurance companies at steadily growing rates. And that was the genesis of the computer industry. (IBM was founded in 1911 as the Computing Tabulating Recording Corporation through the merger of four companies in that industry.)

Similarly, the exciting technological story of information transmission in the 19th century is that of the pioneering Chappe optical semaphore, followed by the electric telegraph. *The Information* covers these technologies and their inventors well. But in the minds of much of the population of Britain in the middle of the 19th century, the striking development of the day was something not mentioned by Gleick: Rowland Hill's Penny Post reform of 1840, which was a change in a business model, not a technology. Hill introduced inexpensive mail prepaid at low, uniform rates based on weight, not distance; this reform led to a huge rise in the usually humdrum communication that matters to society, and it was soon imitated in other countries. Just as today countries are compared on the basis of penetration of broadband or the average speeds of their Internet connections, in the 19th century what countries were compared on was the volume and efficiency of what is now derisively called "snail mail."

As I read this book, I found myself wishing that Gleick had grounded his presentation in historical statistics on volumes of data, information and knowledge. Over the past 500 years, there has been relatively steady growth in the number of books published each year, the sizes of large libraries and the volume of communication—initially via postal services, later by telegraph and telephone, and finally over the Internet. Many developments were stimulated by this growth, and others obviously were required to enable it. There are many hints of this in *The Information.* For example, there is a brief discussion of growth in size of dictionaries. Also, Gleick notes that library catalogs were initially printed with books listed by subject, and then, as collections grew, alphabetically; later yet, as growth continued, card catalogs were introduced. This was a reflection of the growing complexity and sophistication of human society over time. By concentrating more than he does on quantitative measures of information, Gleick might better have illuminated a number of issues, including the thorny question of apportioning credit for scientific, economic and technological progress.

So there are ways in which *The Information* could have been more instructive, and there are approaches Gleick could have taken that might have yielded deeper insights. Nevertheless, for anyone interested in learning more about the important and ever more prominent role that information plays in our society, the book is not only a pleasure to read, it is well worth reading.

---

Andrew Odlyzko is a professor in the School of Mathematics at the University of Minnesota. His interests include cryptography, computing, communications, economics of information, networks and the dynamics of technology manias. His recent work is available at http://www.dtc.umn.edu/~odlyzko.