The science in social science

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A recent poll showed that most people think of science as technology and engineering—life-saving drugs, computers, space exploration, and so on. This was, in fact, the promise of the founders of modern science in the 17th century. It is less commonly understood that social and behavioral sciences have also produced technologies and engineering that dominate our everyday lives. These include polling, marketing, management, insurance, and public health programs.

success of social science | public understanding of social science | social science technologies

In January 2012, I ran a telephone survey and asked a random, representative sample of 516 people in Florida the following: "Since the beginning of the 1900s, please tell me what you think are the major contributions that science has made to humanity."

Science got high marks. Eighty-one percent (420) of the respondents answered the question and did so easily. Two people of those 420—one half of 1%—said something negative about science ("All the medicine they are making is killing us" and "Science is putting us in the hole"). All of the rest had good things to say. Depending on how you code the answers, 30–35 people (approximately 8% of the 420 respondents) mentioned something about basic science—"understanding the physical world," "discovery of DNA," "understanding human evolution." Of the hundreds of comments, the following headed the list of contributions: advances in medicine and health care—including vaccines, antibiotics, and transplants—along with computer technology, telecommunications, the Internet, space exploration, and transportation.

In other words, the contributions of science are, in the public imagination, technologies—the things that are derived from basic knowledge of how things work and that really affect our daily lives.

This is not a complaint. Modern science was founded on the promise that it would produce exactly these kinds of results. In 1662, when Isaac Newton, Robert Hooke, and others were looking for support from the king of England for what would become the Royal Society, they sold it as a way to "improve the knowledge of naturall things, and all useful Arts, Manufactures, Mechanick practises, Engines ..." (1). When the plague killed 70,000 people in London in 1666, Thomas Sprat (2) wrote that this should only make us strive for more advances in science; and in 1699, Bernard de Fontanelle, secretary of the French Academy, predicted that "the day will come when man will be able to fly by fitting on wings to keep him in the air [and] . . . one day we shall be able to fly to the moon" (3).

How do the social sciences measure up against the expectation that we produce useful technologies? I asked the same 516 people in my survey this question: "Since the beginning of the 1900s, please tell me what you think are the major contributions that social science has made to humanity." Only 270 of the 516 respondents (52%) answered the question. The rest either refused or said they didn't know. For those who had a ready answer, leading the list with 30 responses (11%) was psychology's success in helping people. One person mentioned social security. With regard to basic research, 27 people (10% of those who answered) mentioned understanding how things work (how cultures work, how the brain works, how international trade works). One person mentioned operant conditioning. No one mentioned cognitive dissonance theory or relative deprivation theory or social learning theory or dependency theory. Additionally, 25 respondents (approximately 9% of people who answered at all) volunteered either that social science had made no contribution or had made things worse for humankind—"created loopholes so that people can avoid responsibility for their own actions," "caused the decline of humanity," "bringing the world down."

Despite its relatively poor reputation, however, social and behavioral science has been very effective—in exactly the same way that the 17th century founders of modern science imagined would be the case for the physical sciences—in turning knowledge into technologies. Our respondents' intuition about the success of psychology was correct. One hundred years ago, physicians were unable to do much about people's crippling fears of things like spiders and snakes, of leaving the house, or of going up a flight of stairs. This changed with the development of behavioral psychology, beginning with the work of Ivan Pavlov. Pavlov won the Nobel Prize in Physiology or Medicine in1904 and is justly acclaimed for his work on the physiology of gastric secretions, but he is equally remembered for his discovery of the conditioned reflex (4).

In the United States, John B. Watson (5), influenced by Pavlov, developed experimental methods for psychology and advanced his program of behaviorism. B. F. Skinner (6) contributed basic knowledge about operant conditioning and schedules of reinforcement. Building on this knowledge about stimulus and response, Joseph Wolpe (7) developed the systematic desensitization technique in which people gradually become desensitized to the source of their phobia and eventually conquer it. Think of systematic desensitization as a technology that emerges from fundamental scientific knowledge about human behavior—a technology that has made the treatment and management of many phobias routine, bringing comfort to millions of people.

Other social science-based technologies include polling, marketing, management, insurance, public health.... These technologies dominate so much of our everyday life that they have become invisible.

Polling

I begin with polling. Scientific polling is a multibillion-dollar industry, penetrating almost every country in the world. It has transformed the way democracies function, particularly in the industrialized world. Candidates for public office at all levels of government mold their campaign rhetoric and speaking schedules according to polls. This dramatic effect is the result of social science research on things like how to ask good questions about sensitive or threatening topics; how to maximize response to surveys; and, above all, how to ensure that the answers of a sample of people to a survey represent the population from which the sample was drawn.

Random sampling was introduced into polling in the 1930s by Chandra Mahalanobis, an Indian physicist and statistician. In the days before a modern road system was installed, it took a year to count everyone in that vast country, and by the time everyone

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was counted, the population had changed—by an unknown amount (8). A random, representative sample, taken quickly, can be more accurate than an actual count taken over the course of a year. In the United States, the decennial census is still conducted by counting everyone because Article 1, Section 2 of the US Constitution calls the Census an "actual Enumeration" (9, 10). Pollsters, however, are not burdened by that restriction, and after most of them predicted Thomas Dewey to defeat Harry Truman in 1948, they turned to random sampling. Today, scientific polling is so much a part of our lives it is easy to forget its roots in fundamental social science research.

Marketing and Consumer Behavior

In 1990, marketers in the United States, using the (then) latest supercomputers, found that if someone at a supermarket bought disposable diapers at 5 PM, the next thing he or she was likely to buy was a six-pack of beer. So they set up a display of potato chips next to the disposable diapers and increased snack sales by 17% (11).

At the time, that was a breakthrough in the monitoring of consumer behavior. Today, every time we buy something on the Internet or download a computer program or a piece of music, we leave a trail of information about ourselves and our consumer preferences. By tracking our purchases over time, and by sharing information about our buying behavior across Web sites, market researchers can now develop ads that are targeted at individuals. Recently, researchers at the retail chain Target were able to determine, by tracking habitual purchases, who among their customers was pregnant—before the women made that fact public. The women received coupons in the mail for things like diapers and infant clothes together with coupons for wine glasses and lawn mowers so that they would not think they had been spied on (12). Scientific marketing is another spectacularly effective social science-based technology.

Management

Modern management is another social science-based technology that influences our lives every day. In 1832, Charles Babbage (inventor of the mechanical computer) determined that it should take exactly 7.6892 h to make a pound of number 11 straight pins (5,546 of them) (13). This was the forerunner of modern operations research, but there were other significant steps along the way.

In 1895, Frederick W. Taylor presented a paper titled "A piece-rate system" before the American Society of Mechanical Engineers, ushering in the scientific study of management (14). Frank Gilbreth did detailed research on where masons set up their pile of bricks and how far they had to reach to retrieve each brick (15). From these studies, Gilbreth and his wife, Lillian, made recommendations on how to lessen worker fatigue and raise productivity through conservation of motion. Before Gilbreth, the standard in the trade was 120 bricks per hour. After Gilbreth published, the standard reached 350 bricks per hour (16).

Gilbreth's method was an instant hit—at least among people who hired bricklayers. Innovations in management—the assembly line, supply chain management, operations research—trace their origins to the work of Taylor and the Gilbreths. These methods of scientific management produced spectacular gains in productivity and profits—and, sometimes, spectacular gains in worker alienation as well. Just as in the natural sciences, the application of scientific knowledge can produce results that are held by different constituencies to be desirable or undesirable.

There can be no doubt, however, about the impact of the early advances in time-and-motion study—an impact that is still felt today. In a recent billion-dollar overhaul of a Fiat auto plant, new machinery was installed that makes it unnecessary for workers on the assembly line to bend and stretch to work on the cars rolling by. The increased productivity will probably result in the need for fewer workers, with projected savings of millions of dollars per year (17). It is commonly recognized that the same knowledge about atomic structures that brings us nuclear medicine can also bring us nuclear winter. The same knowledge about operant conditioning can bring relief from terrifying phobias or, as with advertisements for tobacco, it can kill. The same knowledge about efficient use of time and motion can bring us technological outcomes that we may not like.

Insurance

In 1662, John Graunt published an analysis of what were then recently collected demographic records in London. Among Graunt's discoveries was that the ratio of boys to girls at birth in London was 14:13 (18). Graunt accounted for the fact that there was parity in the observed number of men and women by noting that men married later and were more likely than women to die at work, at sea, and at war. He also found that 36% of children died before age six (18)—approximately three times the under-five mortality rate for sub-Saharan Africa in 2010 (19). Thus was born the social science of demography.

Edmond Halley studied the life tables of Breslau (Wroclaw today) for the years 1687–1691 and produced a formula for computing the "just value to be paid for an Annuity during the whole term of the Lives" of people in that city (20). This combination of demography and the management of risk based on probability theory was the beginning of another social science-based technology that pervades modern life: the $4.34 trillion dollar global insurance industry (21).

Public Health

We may not often think of it in these terms, but, as Virchow wrote in 1849, "Medicine is a social science in its very bones and marrow" (ref. 22, p. 66). He was referring to public health policy rather than to biomedicine and, indeed, many of the advances in longevity and decreases in mortality over the last 300 y have been based on the applied social science of epidemiology. The great smallpox inoculation debate of the 1760s in Paris marks the emergence of epidemiology as a social science, and again the possibility of applying probability theory to risk management was the focus.

The principle of inoculation was known in China no later than the 11th century (23). In 1717, Lady Mary Wortley Montagu, wife of the British ambassador to the Ottoman Empire, had her son inoculated against smallpox in Turkey. She had her daughter inoculated in England in 1721, and, a year later, despite opposition by physicians and members of the clergy, the Princess of Wales had her own daughters inoculated. The method was approved by the Royal College of Physicians in London in 1754 (24).

Opposition was stronger in France. Voltaire (ref. 25, p. 81) exhorted his countrymen to adopt the practice, noting that the "twenty thousand persons whom the small-pox swept away at Paris in 1723 would have been alive at this time" had they all been inoculated. He would not prevail. In 1760, Daniel Bernoulli and Jean Le Rond d'Alembert argued the two sides publicly in letters to the Royal Academy. Presenting the case for inoculation, Bernoulli calculated that a child inoculated at birth would expect an increase of 2 y and 2 mo in life expectancy. With a risk of 1 in 200 of dying from the inoculation, Bernoulli proposed universal inoculation (26).

D'Alembert spoke for the opposition. "The risk of death induced by inoculation," he pointed out, "concerns the two following weeks, with a maximum of one month, while the risk of dying from natural smallpox is spread over all the life which means that the probability of contracting smallpox during the rest of life decreases with age" (ref. 27, p. 432). Angelo Gatti, an Italian physician, supported d'Alembert: "An immediate risk, no matter how slight," he wrote, in 1767 "will always make a greater impression than a very great, but distant and uncertain one" (ref. 26, p. 2329).

In other words, human beings do not make life-and-death decisions solely on the basis of rational calculations by scholars (see ref. 28 for a review of risk perception as a function of time horizon). Even though the risk of dying from inoculation was one half of 1%, unlike Britain, few people in France wanted to take the personal risk. This is an early example of something we take for granted today: public debate, grounded in social statistics, in the making of public policy.

These debates continue. The Global Polio Eradication Initiative was stopped in northern Nigeria in the fall of 2003 because of mistrust about the motives behind the program, with sadly predictable results (29, 30). In the United States, public debate continues about whether to use the HPV vaccine (31). In 2011, 22% of college-educated Americans in a national poll said they believed vaccines can cause autism (32). Just as in the 18th century, scientific evidence is necessary but not sufficient for public health policy.

Probability Theory and Statistics

None of these pervasive technologies would have been possible without the development of probability theory. Probability theory was applied social science from the start. The breakthrough came in correspondence between Blaise Pascal and Pierre de Fermat in 1654. Pascal had been asked by Antoine Gombaud, chevalier de Méré, if Pascal could help solve some mathematical problems associated with gambling. In one of those problems, two players agree to play a game of chance until one player wins all of the money on the table. If the game ends unexpectedly, how should the money be divided, assuming the players do not have an equal number of wins? Pascal (in Paris) solved the problem, which had vexed mathematicians for several hundred years, but, unsure of himself, he corresponded with Fermat (in Toulouse) and found that Fermat had arrived at the same solution (33, 34).

In fact, many of the statistical and numerical methods used today across the sciences were developed in the social sciences. Factor analysis was developed by Charles Spearman (35) and L. L. Thurstone (36) in psychology. Factor analysis is used so widely today across all of the sciences as to warrant no special notice. Cluster analysis was developed by anthropologists (37) and psychologists (38–40) and is now used across the sciences. Conjoint analysis originated in psychology (41). Its practical use was developed in research on consumer preferences (42), but it, too, is used now in research across the sciences. The quadratic assignment procedure originated in economics as a problem of resource allocation (43). It was developed in mathematical psychology (44) and is finding application in all fields where comparison of relational matrices is required. Cultural consensus modeling originated in anthropology and psychology (45) and is now used in many fields to evaluate the distribution of knowledge.

The top medical journals today are full of social science research. Gawande et al. (46), for example, studied 54 cases of patients who had sponges or instruments left in them after surgery and 235 controls. People who had emergency surgery were nine times more likely to experience this problem than were patients whose surgery was scheduled. Around the same time, Gawande et al. (47) interviewed surgeons to identify sources of errors in surgery. This led to the development of the Surgical Safety Checklist, another effective technology based on social science. When implemented in a large study, it was associated with lowering complications in noncardiac surgery from 11% to 7% (48).

The information-packed visualization methods we take for granted today across the sciences got their start in social science. Multidimensional scaling was developed in psychology (49, 50) for visualizing patterns in matrices. By turning quantitative data (similarities or dissimilarities) into qualitative data (pictures), the method facilitated analysis of very complex data (see ref. 51 for a review). Visualization methods were advanced significantly when biochemists produced software for looking at molecular structures in three dimensions and in color (52, 53). In turn, the software was picked up in the social sciences for analysis of human networks (54). Social network analysis was developed in the social sciences (see ref. 55 for a history), with lots of input from mathematicians. My own work on network analysis was with Peter Killworth, a geophysicist and applied mathematician (56, 57), and network analysis has been an expanding topic of research in physics (58), with physicists bringing the findings of network analysis to mass audiences (59–61).

Science and Social Science

It is nothing new for physical and biological scientists to be involved in social science research. In 1835, Adolphe Quételet, the Belgian astronomer invented what we would properly call today the social sciences: the application of rigorous scientific method to the study of all human phenomena. From 1827 to 1835, Quételet collected statistics on "drunkenness, insanity, suicides, and crime" and looked for associations with what we would now call predictor variables. In 1835, he published "Sur l'homme et le dévelopment de ses facultés, ou essai de physique social" ("On man and the development of his faculties, or an essay in social physics") (62).

Of note is that audacious subtitle, "social physics." Indeed, Quételet extracted some very strong generalizations from his data. He showed that, for the Paris of his day, it was easier to predict the proportion of men of a given age who would be in prison than the proportion of those same men who would die in a given year. "Each age [cohort]" said Quételet, "paid a more uniform and constant tribute to the jail than to the tomb" (62).

The social, physical, and biological sciences are part of a common enterprise that began just 400 y ago—an enterprise whose goal is to acquire objective knowledge about nature and to use that knowledge to meet human needs. Those needs sometimes involve the making of money and sometimes the making of war, sometimes the saving of lives and sometimes the taking of lives. The decision to use or to ignore scientific knowledge is a political event, as is the choice of how to use scientific knowledge—to hurt or to heal. Smartphones and prostheses and Mars rovers are all of the outcomes of physical and biological science. The outcomes of social science are less visible and tangible, but they continue to contribute technologies that affect our lives every day.

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Correction

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CORRECTION