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Model World: The Hidden Ingredient and Nature vs. Nurture

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The Hidden Ingredient

When I taught undergraduate and MBA courses in operations research at the University of Maryland, I covered the basic topics and included an extra dose of linear and integer programming. Because I taught in the school of business, I felt the need to demonstrate how the subject matter had some relevance to the students' daily activities and interests, and, hopefully, would be of value in their post-college work environments. This was not an easy task. I used my notes with a backup text (I am not a fan of case studies). For linear programming, in particular, the usual classical applications of allocation, scheduling, blending, and production/inventory—the standard set found in any text—seemed not to be sufficient. They were interesting, but so what? I think I came close to achieving a reasonable level of relevance with take-home, computer-based, team projects that challenged the students to find and discuss solutions to problems stemming from the major OR topics. One project that I thought helped to coalesce many ideas and concepts was how to desegregate a school system—our campus was located in a county that was under a court order to do just that. However, the importance of these projects and applications seemed to fade over time.

To make the case for OR, I would schedule the showing of videos from the Edelman prize competition. (I usually scheduled them during the week that I attended an ORSA/TIMS/INFORMS national meeting.) I would supplement these with five additional videos that the Committee on Mathematics and its Applications (COMAP) produced under the heading of "For All Practical Purposes." These five COMAP videos are titled Management Science—Overview; Street Smarts; Trains, Planes, and Critical Paths; Juggling Machines; and Juicy Problems (COMAP 2006). The mathematician Solomon Garfunkel ably hosts each video. "Juicy Problems" illustrates, among other applications, the use of linear programming (LP) in mixing fruit drinks. After showing how LP can be used to combine juices in an optimal way, Garfunkel picks up a bottle, reads the ingredient label, and notes that LP is not listed. "It is a hidden ingredient," he says.

I always felt that this statement goes beyond LP. It should be the OR profession's slogan: "OR—the hidden ingredient." It should be printed on all OR application reports; it should show up in OR articles that appear in the popular press; and, it should be used whenever we explain the question "What is the OR profession?"

I must admit that when I find myself in (non-INFORMS) social affairs, I still hedge when a new acquaintance asks, "What do you do?" I usually reply with the "professor thing" and my association with the University of Maryland's Smith School of Business. As I do not want my questioner to think I am in accounting or finance or marketing, I add that I teach the mathematics of decision making as applied to business problems. Sometimes, in the past, I would even say that I teach management science, because those two words have a flair about them that causes most people to nod understandingly or back off from further questions. However, because operations research is now the official INFORMS name for what we do, I refrain from mentioning management science and speak only of OR, followed by hidden-ingredient examples that most people can appreciate, e.g., the scheduling of airline crews, why banks and post offices now use a single first-in, first-out waiting line and, of course, juicy problems. This is my way of spreading the OR story and its accomplishments. Maybe, if we all recount what we do by using hidden-ingredient tales, our professional activities will find approval by the FDA (Full Disclosure Administration) and be listed on the labels. Do join in.

Nature vs. Nurture: How Do You Recognize an OR Person?

Few in my generation of OR professionals were academically trained in OR. Back then, OR degree programs were rare, but relevant college courses in linear programming, game theory, queueing theory, and simulation were beginning to appear. Many of us were first exposed to OR on the job. I was hired into the US Air Force group in which George Dantzig and his associates developed and set the initial direction of LP. Others found jobs with governmental organizations such as the Navy's Operations Evaluation Group or the Army-sponsored Johns Hopkins Operations Research Office. During that time, OR consultant groups were being formed, notably, Arthur D. Little, Inc., Melpar, Inc., the Corporation for Economic and Industrial Research (CEIR), and the independent, nonprofit Rand Corporation. The same was true for the early generation of OR analysts in the UK (e.g., Vajda, Rivett, Goodeve, and Beer) who found positions in the government's Admiralty Research Laboratory, the National Coal Board, the British Iron and Steel Research Association (BISRA), and in-house corporate OR groups such as United Steel Companies (USC), Imperial Chemical Industries (ICI), and Courtaulds (Fortun and Schweber 1993, Kirby 2003). I always wondered what made the early OR analysts feel that they were the "OR type" of person who could make a living "doing" OR and, maybe, even make a contribution to the field. Speaking for myself, I found OR interesting; it was fun; there were jobs; and the pay was reasonable. However, the questions remain: What characteristics do OR people exhibit that make them candidates to pursue OR as a profession? Does someone take to OR because of nature (genes and DNA) or nurture (real-world experiences) or some mysterious mix? To shed some light on the discussion, I will briefly discuss some individuals and their activities. However, first, for the purposes of this article, this is what OR is all about:

> The underlying theme of OR is the need to accomplish current or proposed activities in an effective and efficient manner as measured by appropriate criteria (cost, time, labor, goods, and services): effective in achieving desired results and efficient in accomplishing the results with minimum effort and resources.

Prior to any formalism of the field, many people were doing what we now consider to be OR. My favorite pre-OR people are Frederick Taylor and Frank Gilbreth. Both were active in the late 1800s and into the first decades of the 20th century.

Taylor (1856–1915) is considered "the father of scientific management." His approach to the resolution of industrial production and management problems is still referred to as "Taylorism." As stated in Kanigel (1997, p. 7), a definition of Taylorism can be confused with a slightly restricted definition of OR:

> The application of scientific methods to the problem of obtaining maximum efficiency in industrial work or the like.

How did Taylor become the guru of scientific management? In 1874, he took the admissions exam for Harvard, passing with honors. However, because of poor eyesight, he decided against Harvard and the possibility of a law degree. With his interest in science and mathematics and "orderly habits of thought," he was drawn to mechanical engineering (Kanigel 1997, p. 101). Because engineering schools, at that time, did not have much to offer, Taylor took the "customary" job-entry approach by working as an apprentice patternmaker for a machine shop (Kanigel 1997, p. 108). Finishing his apprenticeship in 1878, Taylor joined the Midvale Steel Company as a laborer in its machine shop. He soon advanced to foreman and eventually became Midvale's chief engineer in 1887. Taylor's nickname was "Speedy Taylor," and he was not one to indulge himself in "... any period of relaxation ... there was always something to study, consider or plan" (Kanigel 1997, p. 7).

At Midvale, Taylor initiated his seminal time studies on metal-cutting operations. He was guided by the interlocking questions of "Which is the best way to do a job?" and "What constitutes a day's work?" A famous time study, conducted after Taylor moved to Bethlehem Steel in 1898, led to new shovel designs that enabled the workers to shovel $21\frac{1}{2}$ pounds of the different types of coal—a three- to four-fold increase in productivity. Taylor's famous 1911 book, *The Principles of Scientific Management*, was translated into over 10 languages (including Esperanto!) and set the world's manufacturing on a course of applying his principles (Kanigel 1997).

Were there any inherent forces that propelled Taylor into scientific management? Kanigel (1997, p. 104) offers a few observations by one of Taylor's teenage friends: Taylor's obsession with precision in his marking off a playing field in feet and inches; his hiking excursions in which he tried to "discover the step which would cover the greatest distance with the least expenditure of energy; or the easiest method for vaulting a fence [or] the right length and proportions of a walking stick." His inventive side is illustrated by the sleep harness he constructed to wake him when he rolled over on his back—when he had a nightmare, he awoke on his back from the nightmares. Taylor earned a degree in mechanical engineering from Stevens Institute of Technology in 1883; he was a "phantom student" in that he did not attend any classes; he was fully occupied at Midvale Steel (Kanigel 1997, p. 182).

At age of 17, Gilbreth (1868–1924) started work as a bricklayer's helper for a construction company. He noticed that workmen doing the same job of laying bricks did not adhere to any one sequence of motions, varied in the time they took to do the same job, and used different levels of energy to accomplish the task. He concluded that there must be "one best way," the motto for all his future work. Gilbreth's study of bricklaying, his seminal motion study, reduced the motions per brick from 18 to 5; the bricklaying rate, measured for a particular type of wall, increased from 120 to 350 per hour. He also invented an adjustable scaffold "so that the correct posture and motions could be maintained as the job progressed" (Barnes 1968, Larkin 1969, p. 9). Gilbreth's oldest son, Frank, tells the story of how the senior Gilbreth, on visiting one of his company's construction sites, would taunt the bricklayers (who did not know who he was) on how easy it was to lay bricks. He would accept their challenge to "try it or shut up." This led to his taking off his coat and tie and "the bricks and mortar would start to fly" (Gilbreth 1970, pp. 103–104).

Along with his wife, Lillian Moller Gilbreth (1878–1972), who was called the "First Lady of Engineering," Gilbreth evolved the concept of motion studies, "the science of eliminating wastefulness resulting from ill-directed and inefficient motions" (Larkin 1969, p. 7). Their work, combined with the essentials of Taylor's time studies, led to the powerful concept of time-motion studies. Gilbreth was the first to use a motion-picture camera in such studies; his classic study was a film of the Giants versus Phillies baseball game at the Polo Grounds on May 31, 1913. Gilbreth determined that it would take $1\frac{1}{2}$ seconds for the ball to be relayed by the catcher to second base after it left the pitcher's hand. He calculated that a runner on first, who was intent on stealing second base and had an eight-foot lead, would have to run at a speed faster than the world's record for the 100-yard dash (Barnes 1968). (One wonders how Gilbreth's analysis holds up against today's 90+ mile-per-hour pitchers. In 1930, the world's record for the 100-yard dash record was 9.4 seconds.)

Frank never went to college. Lillian received B.A. and M.A. degrees in literature from the University of California, Berkeley and a Ph.D. in psychology from Brown University. She was a pioneer of ergonomics. In the book, *Cheaper by the Dozen*, written by two of their 12 children (Gilbreth and Carey 1948), there is a description of what I would classify as an extreme example of an OR person. Although I could not find any effectiveness and efficiency stories about Frank's childhood years, this provides a telling description of how Frank organized the Gilbreth household:

> Dad took moving pictures of us children washing dishes, so he could figure out how we could reduce our motions and thus hurry through the task. Irregular jobs, such as painting the back porch or removing a tree stump from the front lawns, were awarded on a low-bid basis. Each child who wanted extra pocket money submitted a sealed bid saying how much he would do the job for. The lowest bidder got the contract.

> Dad installed process and work charts in the bathrooms. Every child old enough to write—and Dad expected his offspring to start writing at a tender age—was required to initial the charts in the morning after he had brushed his teeth, took a bath, combed his hair, and made his bed. At night, each child had to weigh himself, plot the figure on a graph, and initial the process charts again after he had done his homework, washed his hands and face, and brushed his teeth (Gilbreth and Carey 1948, p. 2).

For both Taylor and Gilbreth it was their nature, innate talent, and inclination to search out ways to improve the effectiveness and efficiency of industrial (and other) work tasks. I believe that they would have exhibited such a disposition no matter what age they lived in or what profession they entered. They were true OR types. One wonders what careers they would have had if their first jobs were, say, assistant professors.

But, what about the founders and early workers in OR, say Patrick Blackett (1897–1974) or Philip Morse (1903–1985)? Were they primed at birth?

Blackett and Morse were highly trained and well-established physicists by the time they came to OR during World War II. In the formative days of OR, as we noted above, it was mainly by chance that one landed in the "right job" that led one to consider the concepts of effectiveness and efficiency in operational problems. A reading of Morse's autobiography, *In at the Beginnings: A Physicist's Life* (Morse 1977), does not indicate that he had a flair or interest for improving effectiveness and efficiency either in his personal activities or work prior to his World War II involvement with antisubmarine warfare. The same can be said of Blackett (Nye 2004, Ormerod 2003).

While still a youngster, Blackett attended two naval schools; when he was 16, he joined the navy and took part in the Battle of Jutland. In 1919, he left the navy to attend Cambridge and graduated in 1921 with a physics major. His subsequent research in nuclear physics and cosmic rays in the 1930s earned him the 1948 Nobel Prize in physics. He began his pioneering work in OR in 1940 when he joined the Royal Air Force's Anti-Aircraft Command as a scientific advisor. In the spring of 1941, Blackett moved to the Royal Navy's Coastal Command where he and his staff (known as Blackett's Circus) became involved in submarine warfare. In his account of his World War II activities, *Studies of War* (Blackett 1962), Blackett states (p. 177):

> One obvious characteristic of operational research, as at present practiced, is that it has, or should have, a strictly practical character. Its object is to assist the finding of means to improve the efficiency of war operations in progress or planned for the future.

It is interesting to note that Blackett and Morse, two highly acclaimed physicists and academics, were both attracted to the operational concerns of how to reduce the impact of German U-boats on supply and troop convoys. Blackett was six years older than Morse; they had met in 1930 when Morse was on a postdoctoral fellowship visit to German and British physics research centers. In 1942, Morse was asked by Navy Captain Wilder Baker to join a newly formed US Navy operations group called the Antisubmarine Warfare Unit. Located in Boston, it was part of the Atlantic Fleet. Baker had met Blackett in England and was impressed with Blackett's description of how "scientists in the field" had contributed to making the then embryonic early-warning radar system fully effective (Morse 1977). An earlier note by Blackett, written in December 1941, *Scientists at the Operational Level*, was widely distributed within the military services of the UK and the US (Blackett 1948, pp. 27–29). Blackett (1962) and Morse (1977) detail accounts of the World War II activities of Blackett and his associates, and Morse and his Antisubmarine Warfare Operations Group (ASWORG). It was their scientific training (nurture) that enabled them to address the operational needs of the military and to later promulgate what they had accomplished as the new science of operations research.

Taylor and Gilbreth made their important advances and impact on industry with little or no formal higher education. It was in their genes. For Blackett and Morse, without the exigencies of World War II, we can assume that they would have continued their academic careers and been recognized, as they were, as outstanding physicists. The OR world was fortunate in having them in place at that time and for their insight in recognizing that their experiences should be channeled beyond the military.

In contrasting Taylor and Gilbreth against Blackett and Morse, I did wonder where I fit within the nature versus nurture dichotomy. I trust that the reader has also given this some thought. Today, with respect to OR, the nature versus nurture dichotomy is rather blurred; it is a continuum and is heavily weighted toward the nurture (education) side. This raises some questions: How do you recognize an OR person? Are you an OR person and why? Did you ever have any notions of bringing efficiency to your chores and other activities when you younger?

As I look back on some of my activities, I see embryonic ideas of efficiency that would shape me for a life of OR. In my teens, I worked in the hat and coat checkroom for a wedding caterer. By experiment, I learned that the coats should be hung in a row so the buttons all faced to the right. In that way, in one smooth motion, I could slip the coat off the hanger so it was in a position to present it to the customer in just a few seconds. My motion study probably garnered me a few extra tips! I also helped the caterer in the kitchen. I was charged with drying the silverware. It did not take me too long to learn to separate the utensils by type, pick up a handful of stacked spoons, and zip through the drying. (I still apply my results when I help my wife do the dishes.) When I was 16, I worked for a watch-repair shop in downtown Boston during the summer. In the morning, before I went to the shop, I had to make the rounds of a number of jewelers and pawnshops to collect any watches needing repair; before I went home at night, I had to return any repaired watches. After a little experimentation, I found the "best" route that enabled me to make the rounds on a single 10-cent streetcar/subway fare, plus a judicious use of transfers. It minimized my out-of-pocket cost without any backtracking. I believe I was primed at birth for a life of OR. Do you, the reader, have any similar stories?

It would be nice if we had proven and tested psychological and/or aptitude tests for determining what makes an OR person. However, I do not know of any. In the meantime, we can only ponder the following: On what basis would you advise a youngster to consider OR as a profession?

(a) Good in mathematics,
(b) Solves Sudoku puzzles,
(c) Mows the lawn over a shortest route,
(d) All the above.

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