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Reintroducing Wiener: Channeling Norbert in the 21st Century

The arc of Norbert Wiener's fascinating life became clear to us one day in the M.I.T. Institute Archives. In one box of the Wiener collection, we found a yellowed 1906 *New York World* broadsheet headlined, "The Most Remarkable Boy in the World," filled with the image of an adorable little boy standing on a stack of immortal books (1). That little boy was young Wiener, a world-renowned prodigy in multiple fields whose eyes were "almost uncanny in their gaze" (1). In this short space, we want to reintroduce you (or, for some, introduce you) to the adult Wiener's most important contributions to today's science and technology, and to his farsighted concerns for the human impact of the new technologies his cybernetics revolution helped to sire.

Wiener's early work was impressive. Already, in the 1920s, he presented new insight into Brownian motion, Heaviside's calculus, and the mathematical analysis and measurement of electric signals. He took a radical new *statistical* approach to communication engineering, in which he reconceived the communication process as a set of mathematical probabilities. He was the first to describe electronic signals as "data" and "series of data," as he called them in 1930 (2, p. 259). And, in his first stab at quantifying the new commodity of information, Wiener proposed a novel "binary" system, as he called it then, to represent electronic data as a series of two probable choices designated by a 0 or a 1. Other engineers introduced important new technical terms, formulas, and working methods during those years. But the fact remains: there simply was no rigorous science of communication before Wiener applied his groundbreaking work on probability, wave motion, and harmonic analysis to practical problems of communication engineering.

The Second World War brought Wiener's work to the fore. His wartime assignment was to develop an automated, radar-guided fire control system for antiaircraft artillery, a project he completed with M.I.T. engineer Julian Bigelow, though their device never saw combat. But Wiener's war work went far beyond antiaircraft fire. Early in 1942, Wiener sent a report to his overseers in Washington. His monograph, with its daunting math and engineering theories, was promptly classified, bound with bright yellow covers, and dubbed Wiener's "Yellow Peril" (3). In it, Wiener severed the entire practice of control from its origins in power engineering and brought it bodily into the camp of communication. He also described that elusive commodity of information, and the measure of information contained in any message, as the mathematical likelihood of that particular message emerging from a larger "measure or probability of possible messages" (3, p. 4). Wiener's other wartime revelation was feedback, an engineering

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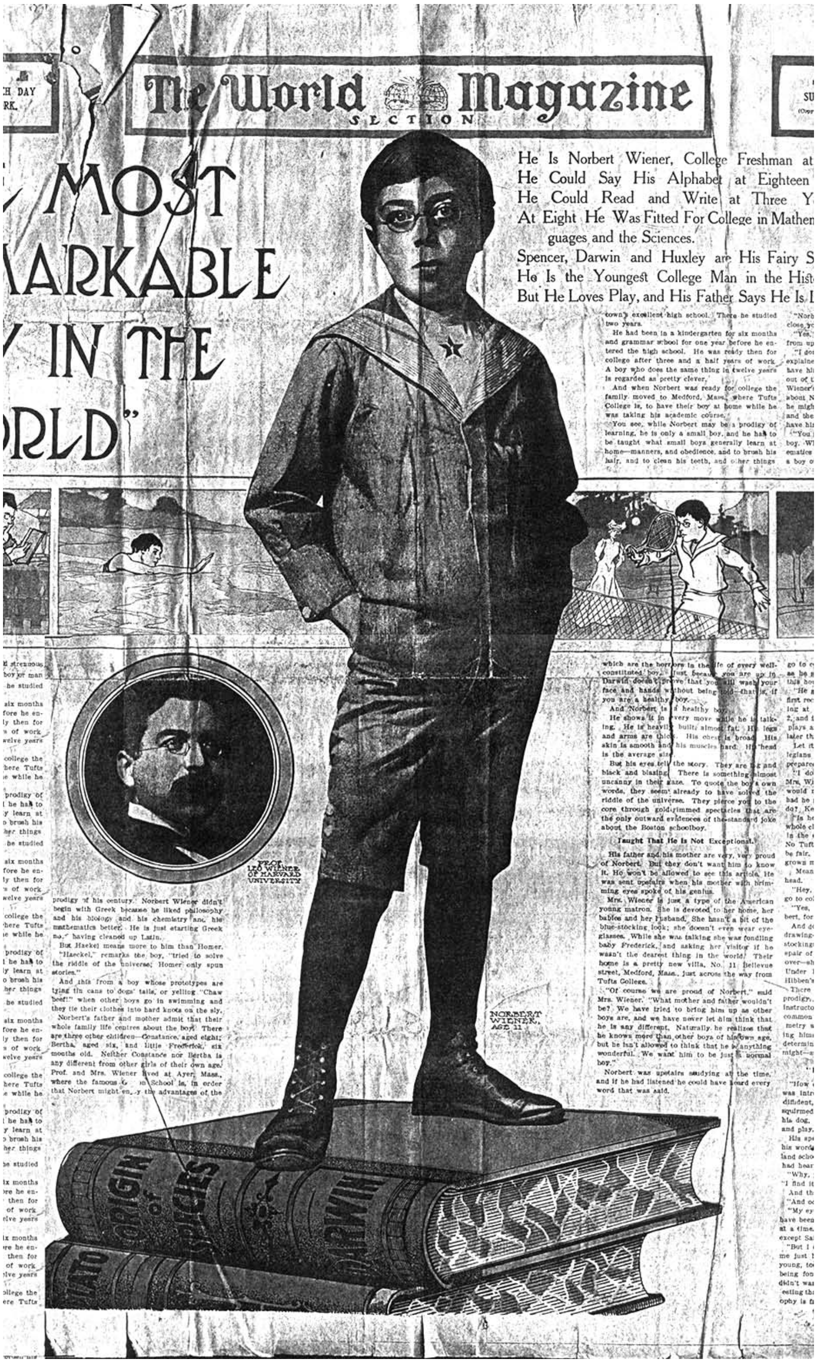

Norbert Wiener, age 11, "The Most Remarkable Boy in the World." From Joseph Pulitzer's *New York World* magazine, October 7, 1906.

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concept he learned about from Bigelow in 1941 and quickly perceived as a universal scientific principle (4). His war work solving basic feedback problems of self-regulation and human sensorimotor response drew Wiener back to his first love, biology, and to his good friend Dr. Arturo Rosenblueth of Harvard Medical School. Together, Wiener and Rosenblueth applied Cannon's physiological concept of "homeostasis" to control engineering, and made the first explicit connections between feedback in the technical sense and the feedback loops wired into the human nervous system's living electrical networks.

Wiener's work came together with the publication in 1948 of *Cybernetics*, his new science of "control and communication in the animal and the machine" (5). But Wiener was just getting started. With the dropping of the atomic bomb, Wiener worried deeply about the direction of all the war's new knowledge and technical developments. In an article in the *Atlantic Monthly*, "A Scientist Rebels," he declared he would no longer allow any of his work to be used by "irresponsible militarists," to create bigger and more lethal weapons, and he urged other scientists to join him (6). Later, he took his growing concerns about postwar science and technology to the wider public. In *The Human Use of Human Beings*, he explained cybernetics and its far-reaching social implications in layman's terms and expressed his dire concern about the coming impact of automation on labor and human workers (7). His final popular work, *God & Golem, Inc.: A Comment on Certain Points where Cybernetics Impinges on Religion,* addressed sensitive questions of ethics that had begun to churn at the center of the cybernetics revolution (8). The mythical figure of the Golem provided a timely metaphor for the new age of self-acting intelligent technology. Without perfect programming and tireless human oversight, Wiener warned, that technology would become "a two-edged sword, and sooner or later it will cut you deep" (8, pp. 53-56).

Wiener's work speaks profoundly to the twenty-first century. As Bigelow said, Wiener was always working on "the problem after next" (4). No doubt he would view today's technical innovations with both fascination and dread. He would love today's technology that's brilliant, helpful, and playful like he was. He would jump for joy to see the new artificial limbs, sprung from his prototype Boston Arm, which have restored wounded warriors to mobility and enabled Paralympic athletes to go for gold.

But he would surely despair at the accuracy of his more dire predictions. In 1950, he posited that the advent of intelligent machines would "produce an unemployment situation" that would make "the depression of the thirties … seem a pleasant joke" [7, p. 220]. The statement was considered overblown at the time, and many insist it still is, but "the trend and the bearing," as Wiener put it, is turning in his direction [5, p. 29]. M.I.T.'s Erik Brynjolfsson and Andrew McAfee report that, after decades of robust technological job creation, advances in computing, robotics, and automation software are now destroying jobs faster than they are creating them [9]. Significantly, today's robots embody exactly those kinds of autonomous learning and self-programming capacities Wiener worried about most. Manufacturing jobs are also vanishing at a greater rate, as a percentage of the U.S. economy, than during the Great Depression [10]-[11]. So maybe Norbert wasn't so far off after all!

Wiener would hate *cyber*crime. He would be at swords' points with the American military, and every military, over their increasing reliance on intelligent *cyber*warfare weapons systems that have a penchant for tragic errors. As he said, this "compulsion of scientific warfare is driving us pell-mell, head over heels into the ocean of our own destruction" [7, pp. 176-177]. The only solution, said Wiener, was greater moral and social responsibility by scientists and engineers. He drove home his point: the new technologies and the knowledge that undergirds them should be used, not for profit, power or personal gain, but for the benefit of all humankind.

Wiener's gaze was uncanny indeed. He transformed the domain of the natural sciences, and the practices of control and communication engineering, "fundamentally and irreversibly" [12, pp. 15-16]. He laid a new foundation of universal principles that bridged the worlds of physics, living things, human beings, and all the domains we inhabit. He opened the frontiers of science and technology to new dimensions of experience and connected the living systems of the human body, brain, and mind to the technologies we have created in our image.

Let us reintroduce you to Norbert Wiener in the 21st century, the most remarkable boy in the world and, in our view, the most remarkable man of the information age, who gave us the tools and the guidance we need that may yet "help tip the balance toward our continued existence on this earth" [12, p. 213].

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