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WALTER PITTS

NEIL R. SMALHEISER*

Introduction

The movie *Forrest Gump* made the point that the greatest, most heroic Americans are people of extraordinary character who flicker briefly into public consciousness and are quickly forgotten. Walter Pitts was pivotal in establishing the revolutionary notion of the brain as a computer, which was seminal in the development of computer design, cybernetics, artificial intelligence, and theoretical neuroscience. He was also a participant in a large number of key advances in 20th-century science. Yet while his contemporaries Alan Turing, Ludwig Wittgenstein, and John von Neumann entered the pantheon of fame, Pitts remains a shadowy folk hero. Stories about Pitts have circulated among the cognescenti for years, but almost nothing has been written about him. Here, I have collected reminiscences from his friends and associates to provide a unique insight into a remarkable life; if some exaggerations and embellishments have crept in, they only underscore the basic truth that Pitts was a man with Gumption.

Early Life (1923–1943)

Walter Harry Pitts, Jr., was born in Detroit on 23 April 1923, the son of Walter and Marie (née Welsia). His father and brothers were rough, uneducated characters who regarded Walter as a freak. At age 15 he ran away,

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and from that time he refused to speak of his family. For the duration of his life he had no contact with them except for sending an anonymous Christmas present home each year. The story is told that, at age 12, Pitts ran into the public library to hide from some bullies, found a copy of *Principia Mathematica* by the 20th-century philosophers Bertrand Russell and Alfred North Whitehead, and proceeded to read it cover to cover in the next few weeks [1]. Pitts experienced a metaphysical insight that logic rules the universe, and as a corollary he felt that ego—and his ego in particular—needed to be erased in order to achieve an understanding of the world. This insight, and his living up to it, was a cornerstone of his personality:

That is the peculiar truth about Pitts, whom all of us loved and protected. We never knew anything about his family or his feelings about us. He died mysterious, sad and remote, and not once did I find out, or even want to find out more about how he felt or what he hoped. To be interested in him as a person was to lose him as a friend. [1]

Seeking a place where a 15-year-old intellectual would not look out of place, Pitts arrived at the University of Chicago:

Walter was just 15 when he ran away from home, turned up in Chicago and there met a fellow who called himself Bert. Now, this Bert talked with Walter for some time of philosophy and mathematics, and came to realize that this was no ordinary youngster. Bert was impressed. He told the boy that Carnap, then Professor of Philosophy at the University of Chicago, had written a book that would interest him, and urged him to go and speak to the grand old man. So, Walter got himself a copy of Carnap's book and read it. Later, Carnap was to recount the meeting thus: "This young boy came in to see me and said he had read my book and that a certain paragraph on a certain page was not clear to him. Now when I say that something is not clear to me, I mean that that thing is nonsense. So we took down my copy of the book and opened it to the page in question and carefully read the paragraph . . . and it was not clear to me either!" [2]

Though the story of meeting "Bert" in this manner may be apocryphal, it is true that Pitts sat in on Bertrand Russell's course when the latter visited Chicago in 1938, and that he walked into Rudolf Carnap's office with a marked copy of his book filled with corrections and suggested improvements. After his initial contact with Carnap, he disappeared, and almost a year went by before Carnap was able to contact him again, supervise some of his studies, and help him secure a student job.

Having the appearance and demeanor of a newsboy, Pitts attended classes from 1938 until 1943. His adolescent playfulness and facetious sense of humor are illustrated by a story describing how he demoralized an entire class by sitting in the front of a classroom during a exam of true/false questions, conspicuously flipping a coin for each question, and then coming out with a perfect score [1]. Pitts's closest friends were Jerry Lettvin, then an 18-year-old premedical student, and Josephine Semmes, an intelligent, 20-year-old divorcée who kept those two around rather as mascots.

Besides his studies with Carnap, Pitts wrote several early papers on neuronal network modelling [3–5] and was a regular attendant at Nicholas Rashevsky's seminars in theoretical biology, which included Frank Offner, Herbert Landahl, Alston Householder, and the neuroanatomist Gerhard von Bonin from the University of Illinois. The theoretical biologist Wilfrid Rall, who took Pitts to be a Ph.D. student rather than an undergraduate, recalls that he was “an oddball who felt compelled to criticize exam questions rather than answer them” [6]. This perhaps explains why Pitts never completed his degree (in fact, he never held degrees of any kind), despite the efforts of his exasperated professors.

It was von Bonin who, in 1940, introduced Lettvin to a new professor of psychiatry at Illinois, Warren McCulloch. McCulloch's piercing eyes and “swashbuckling” yet kindly manner proved a magnet for Lettvin and Pitts, and by 1942 they had moved into McCulloch's home alongside his own four children. The discovery of inhibitory synapses by Lloyd in 1941 [7] was the key finding that led McCulloch and Pitts to envision what are now called McCulloch-Pitts neurons: model neurons that receive a set of mono-synaptic excitatory and inhibitory inputs and that fire whenever the net sum exceeds a threshold. In this environment, Pitt's knowledge of Boolean logic and neuronal networks and McCulloch's knowledge of neurophysiology found a fertile mix. In several months of intense collaboration, they realized that the firing of such a neuron could be taken to represent an assertion that a given logical proposition is true, and in a tour de force, Pitts proved that a network of such neurons could calculate any logical propositions that can be computed by a finite automaton.

The resulting paper, “A Logical Calculus of the Ideas Immanent in Nervous Activity,” published together with a related note, showed that the brain could be understood as a computing device, and it was cited by the mathematician John von Neumann as a major influence in his own pioneering effort to design modern digital computers [8–10]. The enduring impact of this paper has been discussed on many occasions [10–14]. (In particular, the interested reader should consult the companion paper by Arbib in this issue of *Perspectives*, which gives a fascinating description of McCulloch's and Pitts's scientific contributions [15].)

Few realize, however, that in the same issue of the *Bulletin of Mathematical Biophysics*, following McCulloch and Pitts's classic paper, was a paper by Lettvin and Pitts written as a practical joke. As a fourth-year medical student, Lettvin was rotating as night resident in the Neuropsychiatric Institute and had gone to live there. Pitts split his time between Lettvin's room, McCulloch's home, and his own shabby apartment in Hyde Park. One of the psychoanalytic residents complained of Pitts's visits, accused him and Lettvin of being homosexual, and insisted that Pitts not stay over. Pitts's idea for revenge was to “explain” that he and Lettvin had spent so much time together because they had been working on a brilliant scientific paper.

In their paper, “A Mathematical Theory of the Affective Psychoses,” Pitts defined two mathematical variables to represent “intensity of emotion” and “intensity of activity,” and showed that the spectrum of affective disorders could be represented by differential equations of these two variables having stable or unstable solutions [16]. The paper, presented first at an Institute seminar, was widely praised: for example, the psychiatrist Franz Alexander proclaimed that this model at last gave psychoanalysis a formal footing. Lettvin insists that the paper was entirely facetious, and Pitts was certainly capable of such behavior: Oliver Selfridge recalled him making a straight-faced, fanciful presentation at the Math Club at MIT. On the other hand, such psychiatric modelling continues to be pursued seriously by many workers today.

Pitts was a polymath. Besides his logical and mathematical side, he had equally intense and encyclopedic interests in music, arts, poetry, geology, and history. Whatever his friends were interested in, he became absorbed in, too, and he could expound in depth on subjects as diverse as the coins of ancient Rome, sheep-raising and wool-dyeing, wild flowers, or the nutritional theories of Adele Davis. He joined his friends on long sailing voyages in the Atlantic Ocean and on mountain-climbing expeditions in New Hampshire and Grand Tetons, and he took up various musical instruments, including cello and oboe.

However, as Robert Gesteland recalls, Walter said he felt like a “mutant” who was virtually incapable of asking someone to dance at a party—he could lecture, but not converse. This aspect of his character had an unfortunate backlash, for some people could not accept that they could never top him at anything. Once, at supper with the literary critic Edmund Wilson, Pitts told him that he had wrongly interpreted a particular historical point; after 45 minutes of lecturing, Pitts was finally thrown out of the house. Pitts also had a lifelong fear of librarians, and he would steal books from the library rather than face the librarians across the check-out desk.

The War Years (1943–1946)

In 1943, Jerry Lettvin graduated medical school and moved to Harvard Medical School, where one of the residents mentioned that the mathematician Norbert Wiener at MIT was looking for a new student to supervise. Lettvin sent for Walter Pitts:

Walter’s meeting with Wiener at MIT was characteristic and beautiful. Wiener didn’t greet us as we entered but said, “I want to show you something interesting about the ergodic theorem.” We followed him to the blackboard. After about five minutes Walter interrupted with an objection. The board extended over two sides of the small classroom. By the end of the hour they were deeply immersed on the second wall. I left, because there was no question about what had happened. [1]

Pitts and Wiener became like son and father, in contrast to the more collegial relationship Pitts shared with McCulloch.

When the draft intervened, Lettvin went to Bellevue Hospital as an Army psychiatrist. Pitts was given a pre-induction psychiatric examination by A.A. Brill (famous for his editions of Freud's *Collected Papers*). Pitts wore a goatee at the time, and when Brill asked, "Young man, why do you wear a beard?" he replied, "Old man, why do you?" Pitts was declared 4F, labelled "pre-psychotic," tapped to join the Manhattan Project, and given a top-secret security clearance.

Pitts was assigned to work at the Kellogg Corporation in New York City, where he calculated breakdown times of uranium. He detested the authoritarian head of the Manhattan Project, General Groves, and engaged in a series of practical jokes. For example, he would send postcards with "Enclosed Will Find Secret Document" written on them in German. At Kellogg, each room had two wastepaper baskets, a green one for ordinary trash and a red one for documents. Pitts would write Greek symbols on peanut shells and throw them into the red baskets, where they had to be analyzed and documented before being destroyed. He was later transferred to work on radar at the Radiation Laboratory at MIT.

In 1945, Pitts decided to ask Josephine Semmes to marry him. To think the project through, he went for a long walk with Warren McCulloch at his farm near Old Lyme, Connecticut, citing a list of his personal deficiencies, of which McCulloch asked, "Would she care?" Pitts, who had just read Martin Buber's *I and Thou*, meditated on Buber's concept of "care," stopped suddenly, and abandoned the idea of proposing altogether. Though his friends are emphatic that Pitts was neither asexual nor homosexual, there is no record of him actually having any romantic relationships with women. A shy, introverted lost soul, with glasses, bad teeth, a habit of twirling his hair, a slight nervous tremor and a tendency to bump into things, more comfortable with small children than with adults, he appealed rather to women's maternal instincts.

As McCulloch's son David was an avid sailor, so was Pitts; the two spent so much time sailing together that, when David married his wife Jean, it seemed natural that Pitts would accompany them on the sailing voyage that served as their honeymoon. Pitts had a similar close, platonic relationship with McCulloch's daughter Taffy, which lasted many years. Taffy was, in fact, the great love of his life, and his friends say that after she married, something broke inside him. Yet he continued their friendship in the same manner, even at one point sharing the same house with Taffy and her husband.

Post-War Years (1946–1952)

At war's end, Lettvin and Pitts returned to Boston, where they shared an apartment at 139 Beacon Street with Oliver Selfridge (later one of the pio-

neers of artificial intelligence). The historian Giorgio de Santillana, a bachelor popular with the residents of Beacon Hill, used to take them along to tea, and once, when told they must wear ties on such an occasion, Pitts and the others showed up with ties—but sans shirts.

Lettvin's day job as a Veteran's Administration psychiatrist paid the rent on the apartment, and he joined Pitts at MIT as a graduate student in mathematics. When Lettvin flunked out of MIT, he assigned the economist Hy Minsky the task of looking after Pitts and Selfridge. Pitts used to tease Minsky by coloring his food purple, which he found repugnant. Lettvin found a faculty berth at the University of Rochester briefly, then, scrambling to find another position, he joined Manteno State Psychiatric Hospital in central Illinois as one of eight doctors for 8,000 inpatients. With the help of John von Neumann, who arranged a \$5,000 grant, Lettvin proceeded to set up a laboratory and conduct research on cat spinal cords in his spare time. This unlikely spot received an international array of visitors, including Warren McCulloch, Paul Dell, and Patrick Wall. Pitts visited for periods of weeks to months, in between work with Wiener in Boston and visits to Mexico City with Wiener's collaborator Arturo Rosenblueth [17].

As a graduate assistant, supported by a Guggenheim Fellowship, Walter contributed corrections and editing to Wiener's *Cybernetics*, participated in the Macy Conferences on Cybernetics (1948–1952), and was engaged very actively with both Wiener and McCulloch [18–20]. His 1947 paper with McCulloch, "How We Know Universals: the Perception of Auditory and Visual Forms," showed how the detailed geometry of topographically mapped, layered, columnar cortices provided specific relationships among neurons in both time and space that could, in principle, allow them to calculate generalizations and invariances among sensory inputs [21]. Though less famous than the 1943 paper, it emphasized many of the neuronal mechanisms explored currently by theoretical neurobiologists [11–15].

Wiener was worried about Pitts making adequate progress on his Ph.D. thesis (concerning the state functions of neuronal networks arbitrarily connected in two and three dimensions), and tried to separate him from the distracting and corrupting influence of his pals Lettvin and Selfridge, who were engaged in endless scientific and money-making schemes. One of these adventures concerned geology. Pitts became convinced that there should be emeralds in the rocks of Massachusetts, and with Selfridge obtained dynamite to blast at the predicted spot. Pitts broke his arm in the ensuing explosion, though they reportedly did find evidence of emeralds.

Another adventure saw Lettvin and Pitts as fledgling screenwriters in Hollywood. The two had written a play, *The Sixth Kingdom*, about a non-English-speaking man from Poland who visits a doctor to complain about a headache and, through a series of misunderstandings, is eventually committed to an insane asylum. They had showed it to W. H. Auden, who wrote them a letter of introduction to Christopher Isherwood. Just before

arriving in Los Angeles, Pitts had fallen off a mountain ledge and had fractured several vertebrae. He lay in a body cast for eight weeks, while Lettvin got a job as assistant writer at Warner Brothers and was assigned to work on *Rebel Without a Cause*. Pitts and Lettvin suggested putting *Darkness at Noon* into an American gangster setting, and brainstormed the idea until Jack Warner squashed the project.

One comedy of errors nearly led to Wiener rupturing his connections with Pitts and the others. Pitts had been given a copy of a manuscript of Wiener's to return to him, but he had checked it in the cloakroom in Grand Central Station in New York and had given the claim check to Jerry Lettvin—who, after a fortnight, gave it to Oliver Selfridge to pick up. Selfridge failed to find the case at the checkroom. Several months later, when Lettvin was next in New York, he inquired about the case, and eventually found that it had been sent to Chicago as unclaimed property, requiring several more months to be recovered. The team's road trips among Boston, Chicago, and Mexico, and their frequent and extended diversions along the way, have some faint echoes of the "On the Road" exploits of the Beats in the same era [19].

The MIT Years (1952–1969)

Jerome Wiesner, then president of MIT, recruited McCulloch, Pitts, Wall, and Lettvin to the Research Laboratory of Electronics as part of a larger communications group assembled in Building 20 that included Noam Chomsky and was notable for its free-wheeling intellectual atmosphere. Ironically, McCulloch, Pitts, and Lettvin were gathered together physically just as they were beginning to drift apart scientifically [1], and just as Norbert Wiener made a sudden, irrevocable break with the others over an alleged slander involving one of the members of his family.

At about the time of the break with Wiener, and arguably because of it, Pitts destroyed his thesis and all of his papers, felt unable to become interested in anything new, and began a long, slow decline. He did not simply begin to drink—as befitting a man of his talents, he synthesized novel analogues of barbituates and opiates in the laboratory and experimented on himself by ingesting long-chain alcohols. In June 1954, *Fortune* magazine included Walter Pitts in its list of Ten Top Young Scientists in U.S. universities (Fig. 1), alongside Richard Feynman, James Watson, Harrison Brown, Allan Sandage, Joshua Lederberg, Leon Festinger, Julian Schwinger, Robert Woodward, and Andrew Gleason [22]. In 1955, Wiesner and McCulloch had arranged for MIT to award a Ph.D. to Pitts without requiring a thesis, but he refused to sign his acceptance [19].

It was during this period that Lettvin and Pitts made a number of fundamental experimental discoveries, including the use of source-sink mapping of extracellular potentials to infer the existence of presynaptic inhi-



FIG. 1.—Photograph of Walter Pitts which appeared in *Fortune*, June 1954 [22].

bition in the spinal cord [23]. A student, Robert Gesteland, worked closely with Pitts on pioneering studies of sensory coding in the olfactory system [24], and the two constructed a library of smells. Ironically, their most famous experimental study, “What the Frog’s Eye Tells the Frog’s Brain,” on sensory coding in the frog retina [25], devastated Pitts because it showed that retinal ganglion cells were not simply acting as logical devices, thus appearing to shatter his dream that logic could be used to explain the nervous system [1].

Pitts did some unpublished studies on Lie groups, lectured on stochastic processes, and uncovered evidence that pointed to Leibnitz as the father of automata and computation theory. With Giorgio de Santillana, he wrote a paper on the Pythagoreans, crafted a tongue-in-cheek profile of Norbert Wiener as might be constructed by a classical scholar of the future, translated a work by Descartes, and worked on a novel interpretation of the writings of the pre-Socratic logician Parmenides (never fully published) [26–29]. He also engaged in many discussions with Herte von Dechend, who in *Hamlet’s Mill* put forth the unorthodox proposal that early myths encoded astronomical observations [30].

In the late 1950s, Pitts moved in with Jerry Lettvin and his family. After having several episodes of seizures and unconsciousness related to drink-

ing, which terrified Lettvin's children, he moved out of both his home and his laboratory. Taking refuge from the pressures of being expected to perform as the resident "genius," Pitts took extended camping and mountain-climbing trips with Franklin Axelrod and Jerome Wiesner's son Steve. He always brought books along on these trips, ripping out each page as it was read to lighten the load.

Through the 1960s, back in Boston, Pitts sat in working-class bars quietly reading and nursing a beer, changing his venue frequently so that his friends would not find him. He became unable to take care of his dog, a Newfoundland. He hadn't realized that he was still lecturer in electrical engineering at MIT, since he did not, as a rule, open his mail; when he found several years' back pay accrued to him, he used the money to buy a brand-new Oldsmobile. Pitts had once said, "Next to Mozart, other kinds of music are not music at all." After his death on 14 May 1969 from bleeding esophageal varices, Mozart sonatas were played at his memorial service [31].

Coda

Some of the seemingly unusual attitudes represented by McCulloch and Pitts are echoed in the current generation of inventive artificial intelligence buffs and computer hackers. . . . Consequently, McCulloch and Pitts may be regarded as members, nay founders, of a whole clan. [19]

Certainly, Walter Pitts had some things in common with hackers. His naive aphorisms—"Dress from the waist up" and "Ignore bureaucrats and they will ignore you"—reveal the same lack of concern for the world at large. Yet though he and McCulloch worked closely with some of the pioneers of AI, they never felt attracted personally towards the quest for machine intelligence. Ultimately, both of these men were humanists, interested in the fundamental nature of man rather than of machines. Pitts liked to say, "A problem is either trivial or it is insoluble." The same can be said of a man like Walter.

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