Causality

Thinking about the Function of New Technologies in Terms of Old Ones

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The phenomenon of thinking about the function of new technologies in terms of old ones is often vital to the early technical development of new technologies. The invention process for new technologies, in fact, is generally founded on the social construction of old technologies. New inventions are created to resolve the perceived shortcomings of old technologies or to enhance the functions that old technologies perform. Later technical developments are influenced by the phenomenon of thinking about new technologies in terms of old ones less than invention or early developments because a new social meaning of the new technology becomes established. The development of radio followed the two stage process: old technology functions having great influence, and then little influence. Radio was first invented to allow point-to-point communication untethered by wires. Early technical developments proceeded towards the goal of multiple simultaneous, private, point-to-point communication channels, as in wired telegraphy and telephony. As the meaning of radio shifted towards a broadcast medium, telegraphy and telephony’s influence in its technical development declined considerably. Mechanical, electromagnetic, and electronic computers were invented to increase the speed and accuracy of computation over that carried out by human computers and clerks. In the pre-WWII era, computers were thought of only as replacements for humans; therefore, technical development proceeded only to increase computational efficiency. After the war years, computers gained a new social meaning - machines able to perform advanced scientific computations and eventually communications. As a result of this new social construction, technical development was less constrained by the functions of the old technology, human computers. The histories of radio and computer development are marked by two phases, the initial phase when old technologies exert great influence, and the second phase when they do not.
When radio was invented, telegraphy and telephony formed the electrical communication paradigm. One of the first wireless electrical communications techniques developed actually involved the use of telegraph wires. Granville Woods demonstrated inductive telegraphy, communication through the use of induction between two current-carrying wires, by transmitting messages between telegraph wires and moving trains. Later, Guglielmo Marconi demonstrated an invention that sent dots and dashes through the ether without wires, a true radio communications device. Marconi’s goal was to employ wireless transmission for a commercial system of communication. In the development of his radio device, Marconi incorporated the spark gap transmitter and the coherer detector, which were invented by Hertz and Lodge respectively to investigate and experimentally observe electromagnetic waves predicted by Maxwell’s theory. “Marconi introduced the two components that would transport the system from the laboratory to the commercial world: the Morse Key/Recorder and the earthed aerial…. [T]he key entered by design, the earthed aerial by accident.” By intentionally incorporating the Morse Key into his wireless design, and by using the Morse code as the message coding method, it is patently clear that Marconi was thinking in terms of the telegraph when designing his radio.

As soon as it was introduced, Marconi’s radio was socially constructed as resembling the telegraph, only better. The meaning of radio as a point-to-point communications medium would define it for twenty years after Marconi’s first demonstration. As a result, technological developments during this period were focused on achieving the properties of wired, point-to-point communications with wireless. “Critics [had] charged that wireless offered no more secrecy than semaphores, because anyone with a receiver could pick up the messages.” Additionally, only one transmitter could be located in an area. To move closer to the goal of multiple, simultaneous, private, long-distance communication channels with large transmission rates, numerous
improvements were developed. These improvements included tuning, directional antennas, and faster and stronger transmitters and receivers.⁷

Reginald Fessenden, John Stone Stone, and Lee De Forest developed radio telephony in the time after Marconi’s demonstration. They “regarded wireless telegraphy as a necessary steppingstone to their eventual goal: transmitting the human voice without wires.”⁸ All three inventors initially conceived of radio telephony by thinking in terms of the function of wired telephony as point-to-point communication.⁹ The technical inventions and innovations that these radio telephony proponents developed include the ability to transmit and receive continuous wave signals, techniques to encode sound data in these continuous waves, and methods for tuning wireless transmissions. Stone directly applied wired telephony knowledge that he had acquired at Bell Laboratory to wireless.¹⁰ Radio telephony so mirrored wired telephony that Federal Telegraph’s wireless telephony network, set up in 1912, competed with AT&T’s wired network.¹¹ In this period, no one conceived of radio as a broadcast medium, clinging to the notion of radio as a point-to-point communications technology derived from the phenomenon of thinking about new technologies in terms of the functions of old ones.

After WWI, amateurs changed the dominant meaning of radio from point-to-point communication to a broadcast medium.¹² When the social meaning of the radio changed, the influence of the telegraph and telephone in the technical development of radio diminished. The audion, or vacuum tube, was used as an inexpensive radio wave receiver that could be used by the masses to listen to broadcasts. This early electronic device found application in all facets of radio, including amplification, detection, and transmission through oscillation generation.¹³ Due to its wide availability from WWI surplus, the vacuum tube allowed amateurs to make their own innovations. The Radio Act, which drove amateurs out of desirable parts of the spectrum, forced amateurs to make many technical innovations in order to continue
broadcasting. As the social meaning of radio converted to broadcast, all further technical development was related to broadcast and not to point-to-point communication.

Like the radio, the invention and early development of the computer was heavily influenced by the phenomenon of thinking about new technologies in terms of the functions of old ones. At the time Charles Babbage conceived of his Difference Engine, computation was exclusively the domain of human computers and data processing was exclusively the domain of human clerks.\(^{14}\) The "computer can be said to combine the roles of the human computer and the human clerk."\(^{15}\) De Prony had devised a human computer-based table-making operation using the principles of mass production and division of labor. Babbage designed his table-making machine, the Difference Engine, to mechanize the method of de Prony, using the machine to do arithmetic.\(^{16}\) Undoubtedly, Babbage’s conception of the Difference Engine was based on the functions of old technologies.

Herman Hollerith’s punch card data processing machines were designed to replace the manual data processing that had been done previously. In essence, his tabulating machine was designed to perform the functions of human clerks. "The census of 1880 probably represented a high point in manual data processing in the United States,"\(^{17}\) but took seven years to complete. The unreasonable amount of time provided a strong motive to speed up the census by mechanization. Hollerith developed a mechanical system for census data processing, with electrical tabulation. The basic punch card concept would spawn a wide array of office machinery, all based on the functions of the human clerks.

Analog computers were a third original line of computation devices. These computers modeled the problem to be solved, using electrical or mechanical means. An example is Lord Kelvin’s tide predictor, which used mechanical means to simulate the gravitational forces involved with tides.\(^{18}\)
In general, they were designed to solve a single problem and were not extensible. Vannevar Bush’s Differential Analyzer was a more general machine, capable of solving the entire class of ordinary differential equations. Building models of complex systems in order to understand them and obtain results about their actual parameters is a very common technique throughout history. The analog computers were used in exactly the same way, and therefore stem directly from the functions of old technologies.

Babbage’s Analytical Engine, capable of performing any mathematical operation, was not based on the functions of old technologies, but it was never built and did not lead to any new development. The Analytical Engine concept did not fit into the social construction of computers, and hence was not developed by anyone other than Babbage himself. Only during the development of the Harvard Mark I, were the technical concepts of the Analytical Engine revived. Even though the Harvard Mark I was capable of performing various mathematical operations, it was conceived only to perform calculations for tables, just like the calculators that preceded it. The later ENIAC was also designed to produce tables, ballistic trajectory tables for the war effort. Again, the functions of the new technology were thought of in terms of old technologies. Only in the post-war era was the social meaning of the computer sufficiently changed to allow technical progress to proceed unconstrained by the paradigms of the past.

The radio had the technical potential for being a broadcast medium at the outset and the computer could easily have been developed into a general use computation machine, but development did not advance in these directions because the function of the technologies were constrained by the social meanings of old technologies. The full capabilities of the technologies were only fully employed when new conceptions of the technologies were constructed by various social groups, and the course of technical development deviated from the functions established by the old technologies. The fallacy of the
impact-imprint model of technology is readily apparent by the fact that
development did not proceed in the directions suggested by the capabilities
of the technologies. The phenomenon of thinking about the functions of new
technologies in terms of old technologies was a dominant factor until new
social meanings were constructed.

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