Digital Keywords

A Vocabulary of Information Society and Culture

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Digital

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Every digital device is really an analogical device.[1]
—Norbert Wiener

"The days of the digital watch," the playwright Tom Stoppard once joked, "are numbered." The pun may prove prescient: the keyword *digital*—derived from the Latin *digitalis*, from *digitus* or "finger, toe"—has enjoyed a steady rise from almost nothing before the 1950s to a top-2,500 word in contemporary English that applies to everything from electronics (not only the digital watch, but also the camera, clock, computer, disc, video), to social descriptors (digital divides, natives, and revolutions), to emerging fields of inquiry (digital art, humanities, physics, and studies). Given all this, however, its heyday as a keyword may already have passed: a "digital computer," for example, is almost unheard-of today exactly because they are so common, while its presumed counterpart, "analog computers," are now marked historical oddities. (As the **analog** essay notes, the popularity of the *analog* could arise only after the invention of the *digital*.) Likewise *digital photography* and *digital television* are quickly becoming simply *photography* and *television*. And at the same time, innovations in computing, such as quantum computing, are also moving to disassociate *computing* from *digital*. In other words, the sweeping success of digital techniques has rendered the term a quintessentially twentieth-, not twenty-first-, century keyword. As digital techniques continue to saturate the modern world, we increasingly find the keyword *digital*, understood in its most conventional sense, slouching past its prime.

That conventional sense—in which digital is synonymous with discrete electronic computing techniques—is not nearly deep, broad, or basic enough. The second half of the twentieth century, with its attending explosion of computing industry and culture, obviously stands at the dawn of "digital" discourse, but there remains to be recovered a much deeper and more diverse history of discrete signification techniques.[2] Perhaps the most ancient of the predecessors to digital discourse dates back to the Latin source of the term itself—the original digit, or the index finger. This essay takes that origin point—a digit is an index finger—literally. In it I will explore how digits do what index fingers do—namely, count, point, and manipulate. ("Manipulate" of course is a back-formation from Latin for *handful*—a handful of fingers.) Ever since we evolved extensor digitorum muscles, ours has literally been what media theorist Teil Heilmann calls a "digital condition": digital media do what fingers do.

This is not just to say that we use our fingers to command digital media to execute commands, which is obviously the case. Rather, like fingers, digit media carry out at least three fundamental (Lacanian) categories of actions: digits count the symbolic, they index the real, and, once combined and coordinated, they manipulate the social imaginary. Only the first of these categories is commonplace: the flood of digital devices has made it simple to think of digits as counting and computing discretely numbered objects. But digits do much else too: they also point, index, and reference objects at a distance, as well as combine into new tool suites capable of profound acts of social manipulation, handling, and management. The act of pointing to or indexing nonsymbolic elements of reality is fundamental to signifying systems of all kinds, including (but not limited to) digital ones (see **analog**). Once rendered symbolically interoperable, digits combine computational and referential powers in ways that allow the stewards of digital systems to manipulate elements of that social reality. At the same time, that digital systems point to nondigital elements of reality approximately (without computational precision) helps limit or check the mistaken threats and promises of our current digital age, including the now-dated prophecy of a digital singularity and other forms of technomillennialism.

In short, we foreclose against a fuller understanding of the limits of our digital condition (and what those limits make possible) when we understand digits only computationally. By reviewing how digits have long functioned not only as symbolic counters (computers) but also as real pointers (indexes) and social manipulators, this essay seeks to help deflate, deepen, and rethink what is fundamental about the digital.

Counting the Symbolic: The Triumphs of Digital Computing

A recent publication in *Science* claimed that the total computing power worldwide has enjoyed a staggering compound growth rate of 83 percent every year since 1986.[3] The seeds of this exponential proliferation of digital computing power have been germinating at least since 1946, when the mathematician John von Neumann showed at the first Macy Conference on Cybernetics that all signals can be converted into digital format simply through the introduction of a discrete, symbolic threshold: at or above this level, call the signal one; below that level, call it zero.[4] These artificial thresholds abound in the natural world: the meridian that the sun crosses overhead in the sky is the threshold between morning and afternoon, and the medium of the sundial; by contrast, the typed time of the standardized clock suppresses and supplants the real time of the sun overhead.[5] While the history of discrete computing traces back at least to Leibniz, the history of discrete or digital computing took wing after the wartime invention and subsequent industrialization of information science by the academic-military-industrial complex on both sides of World War II.

The point to information science, first articulated by Leibniz and later formalized by the logicians Boole and Shannon, is simple: all real signals can be reduced, with certain loss, into digital symbols. Anything one wants to describe—say, content (sensory experience), space (coordinates), time (intervals), or instructions (programming, algorithms)—can be expressed in the irreducibly countable alphabet of that one binary difference, 0 or 1. As the logician Alan Turing showed in 1937, the most basic digital computer, given enough time and memory, can solve any computable problem.[6] Since then "universal Turing machines," or general-purpose digital computers,

have pioneered the spread of generative digital devices.[7] Supported not only by a global computing industry but by a global computerized economy, modern mediated life now proceeds at the pace of networked computing techniques that render all things countable.

The momentous logic of digital computing, taken to its extreme, leads to the position in vogue among digital theorists that everything that is, is in fact countable. Information physicists, for example, contend that nature has always already been digital, or the real is at base symbolic: magnets have north and south poles, electrons are positively or negatively charged, and quarks spin either up or down. Matter itself appears to follow discrete logics of off and on, 0 and 1. In media theorist Friedrich Kittler's phrase, only that which is switchable can be ("nur was schaltbar ist, ist überhaupt"), or—as the theoretical physicist John Wheeler rephrased the atomist worldview that information is not just what we learn—it is what we *are*: "it from bit."[8]

It is as if in the beginning was the bit, and the computing of bits—from stone coins to Bitcoin—has since become the currency of modern life. The effects of precise computation and copying abound. Writing and programming (from glyphs to ASCII code) reduce thought to the graphism of uniquely encoded symbols; so too does cognitivism seek to distill the vagaries of memory, emotion, and experience into the biomechanics of synaptic firings across neurological circuits. In his monumental *The Culture of the Copy*, Hillel Schwartz has claimed that the defining characteristic of modernity (one fully embodied in the digital age) is its preoccupation with exact copying and its discontents.[9] This then is the first feature of the long legacy of the digital: metadata aside, digits are copied with uncanny exactness. It is hard to overlook the ascendance of this one—but only one—kind of fundamental work our digits do: counting, at scales so large and steps so sophisticated that we name the qualitative change in counting *computing*.

The more digital media spread, the more exacting and consuming our counting regimes appear to become. As early as 1936, critic Walter Benjamin pointed out that the mechanical reproducibility—or computational copyability—of content brings with it a new aesthetics: the work of art since modernism and the interwar period has become increasingly imitable and popular, foreshadowing

contemporary remix, DIY, pastiche, and bricoleur cultures online and off.[10] Our enthusiasms for the spread of digital counting continue: big data are said to scale computing power from sample set to the whole population of data. (Why consult a book when algorithms scour the whole of the Library of Congress?) Democracy enthusiasts too extol the virtues of online voting and debate, where all voices might count equally (see also **activism**, **democracy**). Chess enthusiasts hunger after—and fear—a complete book of moves online. The clean background of the Google search page obscures a messy algorithm that tempts us to imagine that Borges's all-containing catalog of catalogs lies in reach, just a few finger strokes away.

This digital Matthew effect, where the digital gets more digital, meets its culmination in the simultaneous dream of the information theorist, the universal strategist, the advertising executive, and the utopian futurist: the coming digital "singularity," a term coined by Stanislaw Ulam in 1958 suggesting, in light of von Neumann's discoveries, a coming technologically driven paradigm shift in the history of the human race.[11] Since the most fundamental building block of all that we know and are is already the bit of information—these computation enthusiasts contend—the broader the spread of digital media, the more powerfully certain humans will be able to represent and reshape reality itself. In fact digital computation renders more and more of the world visible to those with the tools to compute, index, and manipulate data. Viewed from the perspective of those occupying the commanding heights of computing alone, digital computing promises nothing less than a total convergence, a singular universe in which all bits are known and in play at once—a worldview the rest of this essay seeks to limit.

Indexing the Real: How Digits Point Elsewhere

Digits certainly compute, but they also do far more than that. Like fingers, they also *point*. And, as anyone who has been burned by a misplaced finger knows, pointing is far from an exact science. Just as the internal systems digital media compute are finite, rational, and discrete, so too must the external world to which the same

media point remain infinite, irrational, and approximate, and it is this difference that firmly insures against both the promise and the threat of total digital convergence.

Consider the longer view that emerges once we see digital media as those media that, like our fingers, count the symbolic, point to the real, and manipulate the social imaginary. In this light, digital media include the finger as the original extension of the human body, the coin, the *yad* ("hand" or Torah pointer), the manicule (or "pointing hand," "index," or "digit" in the margins of eleventh- to eighteenth-century typography), the piano keyboard, filing systems, the typewriter, and the electronic telegraph. All these media, among many others, are digital in the simple sense that humans interface with them *digitally*, or with our fingers via manual manipulation and push buttons. Fingers and digital media alike flip, handle, leave prints, press, scan, sign, type. The touchscreens we pet and caress today continue the age-old work of counting, pointing out, and manipulating the literate lines animating every modern media age, including our own. Digital media, such as these, point and refer to real-world objects outside of themselves, and this transducing from the symbolic to the real limits both the computing *and* the indexing power of digital media.

Another name for a digit that points is an index (or its plural, *indexes*). Charles Sanders Peirce, a founding pragmatist and semiotician, divided the world into three types of signs (unlike the Saussurean signifier-signified binary behind the postmodern turn): the icon, which like a portrait resembles the thing it points to; the symbol, which, like the word *couch*, means a place to sit only because convention has taught us to recognize the arbitrary name as meaningful (or as Shakespeare put it, "a rose by any other name would smell as sweet"); and the index, which has a natural connection to the thing it points to but it *not* that thing itself, such as how a symptom points to a disease while not being the disease, or an anthill points to ants without resembling ants. Much work has been and could be done considering how coins, manicules, and files precede digital media in pointing to, without resembling, the semiotic regimes that organize life, such as economic currency (e.g., the head of a leader on a coin), text (e.g., the hand that learns to read by skimming along the line), or bureaucracies (e.g., the

metadata markings on a file that place that file in a larger set of procedural operations).[12] Just this hint at the various ways digital media index the world beyond numbers helps upend a narrow-minded focus on computing as a harbinger of digital convergence. Digital media have long indexed the world.

To be an index is to render approximately or refer to something outside of its own signifying system, and thereby to claim some nonnecessary but useful connection to that thing. Indexes abound: a book index points the reader from outside the body of a text to the right page in the body of the text, but not the exact phrase. The page number in an index reference is not the quotation itself, but it helps approximate its location. The weather vane is not the wind, but it indexes that complex vector field of air into a single well-defined direction. Likewise smoke indexes fire: smoke is not fire, but it signals fire by saying, roughly, "Follow me to an ongoing combustion process." For philosophers of language from Wittgenstein to Austin, this point is basic: all meaningful relationships begin by creating a semiotic structure that excludes something else. (This is true in a romantic sense as well.) For signifying systems of all kinds, the structure of meaning is indexical.

Digital media thus have meaning insofar as they index the world. They point beyond themselves and exclude something significant in the process. Indexical exclusion holds computationally, as Gödel's famous theorems prove that no computational system can be both complete and consistent on its own terms.[13] It is also true socially: our favorite social networking sites reacquaint us with friendly personas and profiles that point to but are not the friends we know in person. Google Maps gives a godlike view of the land surface we both know and do not know by presenting a scalable approximation of it, but it does not give us the land itself. (To represent reality exactly, a map would cost in computing power at least as much as the reality it indexes.)[14] Digitally programmed artificial intelligence, robots, prostheses, 3D printers, and animation serve modern humans because they imperfectly imitate other natural objects. No media copy natural objects exactly: clones, duplicators, alternate realities, perfect memory—this is the stuff of Silicon Valley hype and science fiction dystopia. That original digit, a human index finger, is useful exactly *because* a

finger is not the object it refers to. In other words, it is precisely the negotiable yet natural relationship of all indexes to their referents that makes digital media do more than render the world computationally. Digital media also render the world open and inexactly with a flow of perpetual references elsewhere: that digits (think fingers) can point elsewhere is what grants them their fundamentally analogic character—it is what gives digital work, like all work, the possibility of meaning. As Norbert Wiener remarked, "Every digital device is really an analogical device," although only in a narrow sense (see **analog**).[15]

It is perhaps fitting then that Claude Shannon, Wiener's contemporary and colleague, launched information theory by excluding meaning itself. In his landmark 1948 article that ushered in a strictly computational approach to communication championed in the first third of this essay, Shannon began with this striking constraint: no act of computing (or counting) alone can claim to understand how its messages relate to the real world. *Five apples* means something in the real world, but *five* by itself does not. For him, computing and indexing are functions as distinct as fingers that count and fingers that point. He describes the indexing function thus: "Frequently the messages have meaning; that is they refer to or are correlated according to some system with certain physical or conceptual entities." Then he adds famously, "These semantic aspects of communication are irrelevant to the engineering problem."[16] He is not saying that digital media do not shape our world; rather he is sagely acknowledging that a computational understanding of digits can never speak to such matters. In other words, Shannon, a founder of modern computing, begins by effectively dismissing the premise behind any promise of a digital singularity or computational convergence. He is not saying that digits do not have meaning in the world; he is saying only that the question of meaning is irrelevant so long as we understand digits as only those things that count.

Precise computing and inexact indexing coexist quite happily. Consider probability, the mathematical engine of information theory. Probability is clearly computational, and yet it continuously and uneasily indexes a world that cannot be totally counted. In other words, the modern probabilistic relationship to reality is

foremost indexical, before it is even symbolic. Probabilities do not just count what is. They point ahead, with certain uncertainty, to what could be—to the future or elsewhere. To say, for example, that there's a 42 percent chance of rain tomorrow sounds mundane, but it actually exercises an extraordinarily imaginative license to infer from past data about multiple distinguishable futures—or, given a hundred future tomorrows, forty-two will experience rain. (Perhaps, like the weather, nothing digital about the future is singular or certain.)

In order to be computable, all digital messages must first be treated as if they were part of a possibility index—or, as Shannon puts it, "one selected from a set of possible messages."[17] Even though many messages we send and receive likely have some meaning, the vast majority of mathematically possible messages are sheer spam (Borges's Library of Babel again makes this point). By understanding digits as indexes we return to a familiar point: a finger, like digital media, can point to anything, which means that what we point to is probably meaningless—and at best probabilistically meaningful—most of the time.

We can now see how the digital and the analog are nonoppositional modes of indexing the world. Take the classic analog medium, the phonograph (an early record player named for how it transduces a real-world event of sound, *phono*, into symbolic writing, *-graphy*, and then reads the writing into reproducing the sound). Phonography transforms continuous grooves on a record into continuous sound waves in the air. Both analog and digital techniques, in other words, index the real approximately—and they do so differently and they do so nonexclusively. (There are many other kinds of media.) To imagine the opposite—that digital and analog are in exclusive opposition—is unthinkable: first, imagine that digital media and analog media were in fact the only ways of representing the world. Now suppose somehow there were a total convergence between digital computing and the real world (imagine your smartphone contained the whole world precisely). Even were this to somehow be the case, the end relationship between the digital profiles of the contacts in your phone and the real-world people you know, or between the symbolic and the real, would be—as it always has been—indexical, not computational.[18]

Manipulating the Social: The Discontents of Digital Power

Digits, like fingers, can wag, curl, clench, and deliver crushing blows. The spread of digital computing is no unmitigated good for all, and especially for the disenfranchised many. As Langdon Winner predicted decades ago, the larger the franchise, the more computing power stands ready to serve its interests.[19] Whatever else big data may mean, big data surely means big data brokers. Digital media index not only our world but all known possible worlds—and this means, in practice, those parts of the world that many would prefer not to consider. The cascading collapse of privacy is not only a sweeping narrative of decline—it demotes the status of the modern individual to one on par with most humans in history: we are all again exposed to the elements and subject to powers far greater than ourselves.

This fact sobers digital convergence hype and at once highlights both the true negatives and the false positives behind consequential social problems brought about by digital media. Anyone tempted to believe in the coming computational convergence need only observe how rarely online avatars and dating profiles resemble their users. Symptoms of you and me lurk online. Digital media and real-world actors do not index each other perfectly: they manipulate one another in both directions, although still unevenly. It would not be ridiculous for a Facebook user, for example, to not "friend" other users they have not met in real life. (Social meaning manipulates what exactly is social about social networks.) However, it would be a form of madness to run the relationship between social network and real world in the other direction: strange would be the sociopath who elects to stop being friends with people in real life because their comments are not on their Facebook feed. (How far more frequently do we stop feeling friendly toward them because their comments are!) In other words, our digital registers need not resemble our real-life registers, and vice versa: indexes point in one direction at a time. And yet, of course, Facebook is no dormant register: it is an active institution algorithmically manipulating our social experience (see **algorithm**). These and other social network platforms filter "friends" and "followers" from our view all the time: digits,

combined into corporate platforms, manipulate and promote, fix unseen connections, collapse our many social selves into one persona, privatize our privacy, and flood and flush the marketplace of attention with its wares. It has long been obvious that humans use media to handle modern real life. It remains less obvious how the powers behind digital media handle us.

Consider again how Google Maps, a modest indexing compared to the digital ears and eyes of surveillance states, represents not only the relevant roadsides digital users seek. It also indexes and puts on display images of the homeless, those accused without trial, and all others whose presence and privacy our law, technology, and society do not defend.[20] By indexing all that we send, receive, and process into distant databases, cloud computing techniques force users to exist in a world that can only be "saved," and rarely deleted, with a click of a finger (see **cloud**). Digital databases sometimes index the social with eerie accuracy: a recent study found, for example, that the metadata alone collected in NSA phone tapping have enough inferential power to invade personal privacy.[21] The same indexes risk condemning us with errors, both our own and its own: rumor holds that purchasing a Union Jack and certain soil fertilizers may be enough to automatically place an American citizen on a national terrorist watch list that had swollen by 2013 to include over 875,000 individuals, arguably almost all of them false positives.[22] Digital techniques let those in privileged positions symbolically construct models of the world that index and manipulate it. Digital hands take many shapes: at times the hands of the large and unscrupulous data manipulators take care to caress and palliate those who serve them; at other times the subtle hands of the big data manipulators surgically excise bits from our digital personas and body politic; at others the hands at work paper over and screen from our view the alarming costs of mounting ecological and other social crises; at still other times the hand, curled into the fist of social rage or the martial strikes of cyberwarfare, hovers precariously in the air, threatening to crush its choice target.

In short, digits have never been just computing symbols. Digital techniques—tools ever *in* and *of* our hands—both index the real world and manipulate our many social worlds. Not only has it been obvious since Shannon that digital convergence is a priori

impossible; more important, the necessarily imperfect indexes that confound the relationship between the symbolic and the real, or between what counts and what is, compel us to recognize profound social problems that attend the increasingly rapid, uneven, and worrying concentration of computational power and resources.

Conclusion

Digital media have been counting the symbolic, pointing toward the real, and manipulating lives since humanoids have had fingers, even though the explosion of computing power has swept up the digital to such a degree that the techniques may now be outrunning the term. We can now count down the numbered days of the keyword *digital*, to rehearse Stoppard's jest. To understand our digital age, we must understand not only the numbers—that digits count, compute, construct, and copy internally discrete symbolic worlds—but that digital media can point to or index all possible worlds, not only our real one. This second point helps counterweight, sober, and caution Whiggish enthusiasm for the ongoing digital revolution leading to total media convergence or a technologically determined single future.

The work of digital media can be said to rest at our fingertips. The work of digital computing is similar to counting on our fingers: we think counting is abstract and without obvious real-world unit, and yet counting takes place on the very handy extensions of ourselves—digits, media, and their combination—that permit our bodies to interact with and to manipulate a material world. The human species has always already been born digital: building tools that count, index, and manipulate the world is almost unique to the anthropoid species—those higher primates with digital tools built right into their hands. While counting $1 + 1 = 2$ on our fingers is computationally exact, to do so is to engage in higher abstraction: without a unit or referent, the number "2" remains a quantity without qualities in the real world. Only by indexing our counting to real-world objects do we embody our computational abstractions. Human hands, in other words, are the first digital medium to don real-world units that apply with probabilistic, and never precise, degrees to all possible worlds around us. By pointing or

orienting ourselves to different objects, our digits have long manipulated the world around us. This is nothing new: what is new is the commanding degree and scale to which, in the past seventy years or so, trivially large reservoirs of computing power have begun to be consolidated in the hands of increasingly powerful data-rich institutions—corporation and state alike—and much less so self-organizing groups of people. Socioeconomic privilege continues to scale with digital privileges. (The belief in sousveillance as a viable way of resisting institutional surveillance is most concentrated among affluent technoactivists.)

These trends suggest that the consequences of computational power itself will not converge, and there is no reason to imagine that the institutions that command its powers will (want them to) either. Rather the far more awesome power resting in the hands of our digital species is to point to and manipulate any number of modeled worlds. There remains much to be done to model more equitable and sustainable worlds. Perhaps we can begin by understanding the digit as an openly imitable and probabilistically imperfect index of any thinkable world, including this world, with which there can be no final convergence. The last seventy years have ushered into existence a host of digital devices that now populate our pockets, warehouses, and working models of the world. The lot of these reality doppelgängers, like that of all indexical media before them, is to point to endless and imprecise imitations of their makers.

See in this volume: algorithm, analog, cloud, culture, democracy, event, information, mirror, personalization, sharing

See in Williams: bureaucracy, capitalism, ideology, jargon, mechanical, rational, representative, technology

Notes

1 Quoted in Claus Pias, (ed., *Cybernetics/Kybernetik. The Macy-Conferences 1946–1953*, 2 vols. (Berlin: Diaphanes, 2003).

2 For more on that long history, see Bernard Siegert, *Passage des Digitalen: Zeichenpraktiken der neuzeitlichen Wissenschaften 1500–1900* (Berlin: Brinkmann & Bose, 2003).

3 Martin Hilbert and Priscila Lopez, "The World's Technological Capacity to Store, Transmit, and Compute Information," *Science* 332(6025) (2011): 60–65.

4 John von Neumann gave the first talk delineating analog and digital at the 1946 Macy Conference, and elaborates on how, for example, organisms might be treated as digital phenomena in John Von Neumann, "The General and Logical Theory of Automata," in *Cerebral Mechanisms in Behavior*, ed. L. A. Jeffress, The Hixon Symposium (New York: Wiley, 1951). See also Steven J. Heims, *The Cybernetics Group* (Cambridge, MA: MIT Press, 1991).

5 The psychoanalyst Lacan might say that analog-to-digital conversion seeks to suppress "the real" with "the symbolic," and here I understand, with media theorist Kittler, "the real" as those physical, continuous, material, and analog elements of our world that can be recorded by a phonograph, while "the symbolic" makes up all the artificial, discrete, logical, and digital elements that can be recorded by a typewriter. Cf. Friedrich Kittler's *Phonograph, Film, Typewriter* (Stanford, CA: Stanford University Press, 1999).

6 Alan Turing, "On Computable Numbers, with an Application to the Entscheidungsproblem," *Proceedings of the London Mathematical Society*, ser. 2, 42 (1936–37): 230–65.

7 Jonathan Zittrain, *The Future of the Internet, and How to Stop It* (New Haven, CT: Yale University Press, 2008).

8 Friedrich Kittler, *Draculas Vermächtnis. Technische Schriften*. (Leipzig: Reclam, 1993/2003), 182; John Archibald Wheeler, "Information, Physics, Quantum: The Search for Links" in *Complexity, Entropy, and the Physics of Information*, ed. W. Zurek (Redwood City, CA: Addison-Wesley, 1990).

9 Hillel Schwartz, *The Culture of the Copy: Striking Likenesses, Unreasonable Facsimiles* (Cambridge, MA: MIT Press, 1996). \

10 Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illuminations*, ed. Hannah Arendt (London: Fontana, 1968), 214–18.

11 S. Ulam, "Tribute to John von Neumann," *Bulletin of the American Mathematical Society* 64 (1958): 1–49.

12 For more on C. S. Peirce, see T. L. Short's *Peirce's Theory of Signs* (Cambridge: Cambridge University Press, 2007).

13 For more, see Kurt Gödel, "On Formally Undecidable Propositions of *Principia Mathematica* and Related Systems I," in *Kurt Gödel Collected Works*, ed. Solomon Feferman (Oxford: Oxford University Press, 1986), 1:144–95.

14 John Durham Peters, "Resemblance Made Absolutely Exact: Borges and Royce on Maps and Media," *Variaciones Borges* 25 (2008): 1–23.

15 Quoted in Pias, *Cybernetics/Kybernetik*. See also epigraph.

16 Claude Shannon, "A Mathematical Theory of Communication," *Bell System Technical Journal* 27(3): (1948): 379–423, see 379.

17 Ibid., 379.

18 See Jonathan Sterne, *MP3: The Meaning of a Format* (Durham, NC: Duke University Press, 2012). Also Sterne, "The Death and Life of Digital Audio," *Interdisciplinary Science Reviews* 31(4) (December 2006): 338–48. Eric

Rothenbuhler and John Durham Peters, "Defining Phonography: An Experiment in Theory," *Musical Quarterly* 81(2) (Summer 1997): 242–64.

19 Langdon Winner, "Mythinformation," in *The Whale and the Reactor: A Search for the Limits in an Age of High Technology* (Chicago: University of Chicago Press, 1986), 3–18.

20 Siva Vaidhyanathan, *The Googlization of Everything (and Why We Should Worry)* (Berkeley: University of California Press, 2011), 106–7.

21 Jonathan Mayer and Patrick Mutchler, "Metaphone: The Sensitivity of Telephone Metadata," http://webpolicy.org/2014/03/12/metaphone-the-sensitivity-of-telephone-metadata/.

22 See the "Information Sharing Environment Annual Report to the Congress 2014," https://www.ise.gov/resources/document-library/ise-annual-report-congress-2014.

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