Communication Shock

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The Rhetoric of New Technology

By

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PREFACE

"We are not," as Carolyn Marvin so thoroughly documented and accurately observed, "the first generation to wonder at the rapid and extraordinary shifts in the dimension of the world and the human relationships it contains as a result of new forms of communication, or to be surprised by the changes those shifts occasion in the regular pattern of our lives." Ever since New York University professor Samuel Morse developed the first commercially successful telegraph and a binary code in the 1830s, humans have experienced awe, optimism, and fear about the potential consequences of electronic communication. Marvin's outstanding scholarly work identified the telegraph as the beginning of the modern communication revolution, aptly calling it "as significant a break with the past as printing before it" and arguing that all subsequent development of electronic communication machines – telephones, radio, television, and the computer — "have simply been elaborations on the telegraph's original work."[1]

The telegraph, however, is neither the beginning nor the end of this story. The human being is an organism dedicated to the concepts of discovery and invention. We have been taught from our childhood to harness our ideas, theories, questions, hypotheses, and put them to the rigors of nature and society. We nudge. We push. We literally experiment with our available materials, surroundings, and environment. And on some occasions, along this path of unknown experimentation, we unleash new discoveries upon ourselves and our fellow creatures. Sometimes, these discoveries have unforeseen natural consequences that could not have been predicted. And sometimes, these discoveries also have unforeseen human and social implications that could not have been forecasted, let alone even conceptualized. Fire, the wheel, electricity, the combustible engine, electronic circuitry, traditional and cellular telephony, radio, air travel, the television, the mainframe computer, the atomic bomb and its

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[1] Carolyn Marvin, *When Old Technologies Were New: Thinking About Electric Communication in the Late Nineteenth Century (*New York: Oxford University Press, 1988): 3.

nuclear offspring, the personal computer, the Internet — all working in some bizarre fast-forward opus toward an unknown grand finale.

Have you ever stopped for a moment to wonder at the vast cleverness of our civilization and the balance at play which knits this fabric of life we have collectively developed? It is all very breathtaking. It is all very challenging, too. Who possibly could have predicted that the waste emissions from our hydrocarbon-consuming vehicles and power-generating plants might be contributing to unfathomed climate change? Who could have predicted that our use and abuse of penicillin would lead to drug-resistant strains of bacteria, which now pose life-threatening health risks for all? Who could have foreseen the phenomenal explosion of the Internet and its hardware accoutrements and paraphernalia? Clearly, we allow scientific discoveries (as "experiments" in and of themselves) loose upon ourselves without fully discerning the vast range of potential physical and human consequences that these innovations may, ultimately, yield. Are we ready — truly and honestly — to take on the magnificent things that our minds are altogether capable of producing? Are we?

The last century has given birth to new scientific relationships between language, mathematics, chemistry, biology, physics, computing, and our love (and indeed lust) for more information. However, information should not be confused with knowledge or wisdom. Profoundly complex mathematical algorithms run gently in the central processing units on our personal computer motherboards. The Internet, once tethered to physical locales by awkward wires and cables, is steadily going wireless; and, moreover, this arena of data (the information which constitutes the Internet) is being used by both governments and dissenters as an urbane battlefield within which to contain and threaten the status quo.

The twentieth century may go down in history as one of the boldest ever taken up by the human race. Science, like a hammer, can be used for good or bad purposes. The hammer can be used to construct homes or buildings; likewise, this hammer can be used to cause these homes or buildings to come tumbling down. By extension, science itself is absent a clear political motive — save the ground of discovery itself. It is the human being, governing these "discovery arsenals" made authentic, which is ultimately in charge of the ethics of innovations and their implementation. By extension, we should be able to conclude that science does not harm; it is purely the application and distribution of scientific applications which is in question. Science, alone, is merely a process of discovery. It is a process of compartmentalization; the labeling and understanding of everything within the reach of our sun and now, certainly, beyond it.

In 1980, merely three decades ago, world-acclaimed author and technocrat futurist Alvin Toffler wrote in his cutting-edge work, *The Third Wave*, about a forthcoming communication technology revolution and how this transformation would impact using and non-using societies worldwide. Toffler noted, "We grope for words to describe the full power and reach of this extraordinary change. Some speak of a looming Space Age, Information Age, Electronic Era, or Global Village."[2] Perceptibly, during the mid-1970s and 1980s, the mainframe computers running George Boole's binary logic were making a modest societal impact. This impact would expand radically over a mere two decades as computers entered the Personal Computing Era. Toffler was but one of many during the1980s to write about the awesome potential of a "bridge" between computing power and information that would change the world as we knew it, forevermore.
We, the beneficiaries of the Computer and Internet Revolutions, have witnessed many of Toffler's predictions come to light.

Our research literature is vibrant with articles and books analyzing Internet systems and their resulting societal influence. Communication scholars quickly understood and argued that naming is framing and that the metaphors we chose to comprehend the new phenomena would shape personal decisions and public policies.[3] Professor Stephanie Schulte's outstanding analysis of the discursive construction of the Internet in global popular culture documents how we have drawn on discourses from satire to popular film to make sense of the Internet and make public policies to advance or control the uses of the technology.[4] Technocratic thinkers like Howard Rheingold, Albert-Laszlo Barabasi, Susan Herring, Sherry Turkle, and Mark Buchanan today write about "wireless" Internet culture and the acceleration and integration of everything occurring because of these Internet communication technologies (ICTs).[5]

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[2] Alvin Toffler, *The Third Wave* (New York: William Morrow, 1980): 9.
[3] Stephen A. Smith, "Communication and the Constitution in Cyberspace," *Communication Education*, 43 (1994): 87-101.
[4] Stephanie Ricker Schulte, *Cached: Decoding the Internet in Global Popular* Culture (New York: New York University Press, 2013).
[5] Howard Rheingold, *Net Smart: How to Thrive Online* (Cambridge MA: MIT Press, 2012); Albert-Laszlo Barabasi, *Bursts: The Hidden Pattern Behind Everything We Do* (New York: Dutton, 2010); Susan Herring, *Computer-Mediated Communication: Linguistic, Social and Cross-Cultural Perspectives* (Amsterdam:

However, one field of science that has been largely overlooked in the general and communication studies literature will, without a doubt, have a striking impact on the future of ICTs: nanotechnology. Often referred to as "tiny tech" or simply "nano" by industry insiders and venture capitalists, this emergent discipline, joining together the fields of biology, chemistry, computer science, mathematics, physics, and telecommunications, is experiencing a surge of scientific fascination worldwide. And, you definitely need to understand the basics of this coming nanotechnology revolution.
Why? Because this paradigm shift is going to alter everything with which it comes in contact — technologically, socially, culturally, and politically. It is going to transform electronics, making the devices we use faster, smaller, more potent, and more integrated with the Internet. It is going to radicalize the fields of medicine, pharmacy, and chemistry, allowing researchers to develop new and interesting molecular structures to benefit the life sciences at their root level. It is going to uncover how the rules of physics function at the subatomic level; thus, inventing an entirely new dimension and means of mass production. A basic understanding of the facts about this technology will be useful in trying to grasp the truth about its potential impact.

The stakes in this "revolution" are colossal, to say the least; but, the insurgency will be most subtle. At stake is your role in industry, your role in a global economy (or not). At stake are the geographic nation-state boundaries to which we have become accustomed, reorganizing around indiscernible technological-economic-state lines. At stake is your means of income, your means of retirement, your means of literally living and dying. At stake is your decision to bring technology into your very body (via intra-media) to live a longer life. At stake are: your religion, your politics, your ethics, your beliefs, and even your values. This technology promises to liberate those who can afford it and make the most fanciful dreams of science fiction real — and to do so with velocity. Don't blink! Be courageous.

COMMUNICATION SHOCK is an exploration of the possible social and human impacts of nanotechnology, especially where new communication technologies are concerned. This book investigates how much the human mind can process — indeed, how much the united social psyche can take —

John Benjamins, 1996); Sherry Turkle, *Alone Together: Why We Expect More from Technology and Less from Each Other* (New York: Basic Books, 2011); Mark Buchanan, *Small World: Uncovering Nature's Hidden Networks* (New York: W.W. Norton, 2002).

before it reaches "crash speed." As humans become more and more networked with communication technologies, and as these technologies inch closer toward integrating with the human body (and perhaps even the mind), we must come to understand and confront the social condition known as COMMUNICATION SHOCK. More importantly, we must wisely choose in embracing or rejecting these technologies and explore how we might do both by striking an appropriate balance.

Our purpose in this volume is to provide you with an understanding of the past developments and the future of technology, but we aim at more than that. We hope to bring some objectivity to the discussion of technology, to map its development, and to encourage a rational conversation about its potential problems and promise. We also want to challenge you to reach your own conclusions – about the future, imagined and unimaginable, and about the fundamental values in conflict and how you wish to contest them.

CHAPTER ONE

FRAMING AND UNDERSTANDING CHANGE

Before we fully explore and engage the concept of Communication Shock, two basic prerequisites are (1) a useful theory for framing and understanding the rapidly changing environment of modern technological change and its discontents, and (2) a thorough situating of the historical technological developments and changes that brought us to now and that will morph exponentially in the uncertain future. In this chapter we survey the theoretical framework that we believe most useful for making sense of the rapid technological change that is transforming our global culture and our role in that drama. First, we will review the work of Everett M. Rogers and his now classic Diffusion of Innovations theory, then we will turn to the more recent gloss and adaption of Rogers' work by Larry Downes and Paul F. Nunes, which they term Big-Bang Disruption.

I. Diffusion of Innovation Theory

University of New Mexico Communication Professor Everett M. Rogers was one of the discipline's foremost theorists. Similar to Canadian communications theorist Marshall McLuhan, the nomadic Rogers was considered a "futurist." His sagacious understanding of societal issues and his calculating statistical expertise provided him with an unparalleled methodological vista into the human uses and gratifications of communications technologies. His work can serve as a disciplinary guide as we wade into the future of a robust new technological landscape.

Rogers is best known for his work on a highly utilized body of communication theory called diffusion of innovations. Generally described, diffusion of innovations theory examines the absorption and adoption of new ideas or new technologies into the mainstream of a given society or communications system. Diffusion of innovations, first theorized by Rogers in 1962 and most recently updated by a fifth edition in 2003, is a highly abstract theory in nature and is useful in analyzing and (in many cases) prognosticating *how* societies will adopt innovations over time. To truly understand how diffusion of innovations theory serves as a foundational model for our communication shock theory, we must first dissect Rogers' treatise *Diffusion of Innovations*. The legendary book has gone through several editions and updates over the years, evidence of the enduring importance of the work.

Remember, we are looking at Rogers' diffusion of innovations theory as a foundational model for communication shock theory. As a tried and tested model for explaining how ideas and technologies become adopted in social systems, it serves us well as a foundation before we unpack the apex argument of this book. Correspondingly, this chapter examines the basic building blocks of diffusion of innovations theory.

The Basics of Diffusion of Innovations Theory

Candidly, then, what is a *theory*? It is a well-established set of hypothetical propositions. More distinctively, a theory is a way (or even a refined method) of explaining something that remains speculative. Theories help us consider possible means to understanding issues that defy easy explanations. Accordingly, diffusion of innovations *theory* is a way of understanding *how* technologies and ideas (as innovations themselves) move through social systems to become adopted as part of the norm. Rogers' conceptual definition for the term *diffusion* as a process is of paramount importance in understanding "the process by which an innovation is communicated through certain channels over time among the members of a social system." Rogers asserts in this definition that there is both rhyme and reason as to how innovations move throughout social systems and that this movement follows and explainable process. It is this *diffusion process* that we now consider in detail.

Diffusion of Innovations Theory: Four Foundations

1. The Innovation

Rogers wastes no time in identifying what, specifically, an innovation is: "An *innovation* is an idea, practice, or project that is perceived as new by an individual or other unit of adoption." In this light, an innovation is anything *perceived as new* by the social system that encounters it. The idea or invention could be a new one, or, quite to the contrary, it could be something very old. For example, penicillin (while known to the civilized world) could be perceived of as "new" to Indigenous Australian Aborigines

— so, it would be considered an innovation by their social system definition. The "newness" aspect is directly tied to the first three steps of the innovation-decision process. Different social systems will perceive different ideas or inventions as either "new" or "old." In the end, "newness" is social system dependent.

2. The Communication Channels

The second major foundation of diffusion of innovations theory rests with the communication channels used to convey the perceived innovation. Rogers tells us that communication is a process in which "… participants create and share information with one another in order to reach a mutual understanding." Typically, this genre of communication happens through some type of channel. Furthermore, humans must be involved in the communication encoding (creation) and decoding (assimilation) process. Very simply put, Rogers states that "a *source* is an individual or an institution that originates a message. A channel is the means by which a message gets from the source to the receiver." Interestingly, Rogers also asserts that diffusion is a highly specific genre of communication, which is ultimately about the conveyance of new ideas. This type of communication includes three communication elements: (1) the innovation itself, (2) two people or "units of adoption" to negotiate meaning, and (3) a communication channel. Rogers is so explicit with his analysis of what constitutes a channel, in fact, that he divides them between two camps: mass media channels and interpersonal channels. Obviously, mass media channels have to do more with mediums like television, radio, newspaper, magazines, and even the Internet. Conversely, interpersonal channels have more to do with individual human discussion. Likewise, it is also true that some elements of influence can follow either channel system; people are sometimes moved by more than one message, and through more than one channel. Many innovation campaigns, like those common to health information movements, for example, use a multipronged approach to disseminate information.

3. Time

Time is perhaps the most easily understood, but understudied, component of all diffusion of innovations research. Rogers argues that time is the interval through which, and within which, the diffusion of innovations process happens. What is necessary from future diffusion of innovations investigators is more longitudinal analyses of *how* diffusions pervade (or do not pervade, in some cases) within social systems during significant time periods. Suffice it to say that time is an indispensable component to Rogers' diffusion of innovations model, but has received very little attention. The swift empirical studies common to behavioral research models rarely evaluate situations over periods longer than a year or two. Longer scrutiny periods are therefore necessary.

4. Social System

The final building block of the diffusion of innovations model is the social system. Explicitly, Rogers writes that the social system is "a set of interrelated units engaged in joint problem solving to accomplish a common goal." Importantly, Rogers does not segment the credibility of the social system from the authority of the innovation. In other words, because an innovation is to be diffused within a social system proper, the innovation is intrinsically hinged to the way communication is both perceived and practiced by that very social structure. Subsequently, it is highly important to fully understand the social system or culture in which an innovation is negotiating.

The Innovation-Decision Process

Rogers frames the innovation-decision process as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation." While invoking uncertainty reduction theory, Rogers clearly outlines five steps in the human innovation-decision process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation.

I. The Knowledge Stage:

The knowledge stage is where the innovation (as a new idea or a method) is introduced to the target receiver. In this first stage, the person or group seeks to reduce their uncertainty about the innovation by increasing their knowledge of the innovation. Throughout this stage, the person mainly tries to understand "what the innovation is and how and why it works." Per Rogers, these basic questions comprise three types of knowledge sets: (A) awareness-knowledge, (B) how-to-knowledge, and (C) principles-knowledge. It is important to understand each type:

A. *Awareness-knowledge*: This type of knowledge denotes the individual's knowledge of the innovation, by and large. Rogers argues that this knowledge can spur people to learn more about the innovation through self-motivation, and can even lead to adoption of the innovation altogether. Further, this type of knowledge has something of a "halo effect" on the other two types of knowledge (below) in that awareness-knowledge can lead individuals to pursue both how-to-knowledge and principles-knowledge.

B. *How-to-knowledge*: This knowledge is concerned with the proper use and technique of the given innovation. For the innovation to be adopted by the individual or social system, its use must be properly understood before attempting to implement the innovation. As the degree of complexity with the innovation increases, so, too, does the importance of how-to-knowledge. Rogers perceived this aspect of diffusion of innovations theory to be critically important in the overall knowledge acquisition stage.

C. *Principles-knowledge*: The third and final knowledge type has to do with the proper usage and application of the innovation. It is one thing, of course, to know how to use something (how-to-knowledge), but it is another thing altogether to properly use and apply the innovation in action. While it is true that an innovation *can* be adopted without full principles understanding, it cannot be properly wielded.

II. The Persuasion Stage:

Persuasion happens when the individual or social unit forms either a negative or positive predisposition about the innovation, itself. However, Rogers writes that "the formation of a favorable or unfavorable attitude toward an innovation does not always lead directly or indirectly to an adoption or rejection." Thus, one could hold a negative attitude toward an innovation but still adopt the innovation. Predispositions (as attitudes) do not always equate with their behavioral sets. Attitudinal adoption typically occurs after information seeking, which is why Rogers lists persuasion as the second stage or phase in his diffusion model. Interestingly, unlike many behavioral scholars, Rogers believes that the innovation-persuasion stage has more to do with affective (emotional) reasoning than pure cognitive (knowing) reasoning. Of course, as with any persuasion model, the level of social corroboration in adopting the innovation weighs heavily in this stage. People are more likely to adopt a behavior if their social circle (constituted by colleagues, peers, and friends) models that behavior. In sum, the persuasion stage is where attitudes are formed regarding the innovation. However, remember that attitudes leaning one way or another do not always equate to actual behaviors.

III. The Decision Stage:

This stage deals exclusively with the choice to adopt or reject the given innovation. Whereas the adoption or "full use of an innovation" is regarded as "the best course of action available," rejection represents the choice "not to adopt an innovation." Once the knowledge and persuasion stages are complete, sentiments toward the innovation *must* translate into behaviors. Rogers notes that the trialability of an innovation typically leads to a more positive decision to adopt the innovation; in part, because the individual can test-run the innovation and also because the launch of a behavior chain (even when a trial chain) frequently leads to an aligned, positive attitude. Even so, people can still choose to reject the innovation. For example, some people are not used to having cameras in their cellular telephones. Yet, if they try out a friend's cellular telephone with a camera installed, they may not like the application and choose, instead, to have a basic cellular telephone.

For Rogers, there are two types of rejection: (1) active and (2) passive. Defined, active rejection condition occurs when a person tries the innovation out for themselves, and then, decides to discontinue implementation. On the other hand, we have the passive rejection condition (also known as the non-adoption condition), which happens when the individual attitudinally rejects the innovation without having ever tried the advanced idea or behavior. This is outright rejection of the idea, prima facie, without any trial-run. Rogers tells us that these two components — active and passive rejection of innovations — are some of the most severely understudied aspects within diffusion of innovations research.

IV: The Implementation Stage:

The implementation stage is where an innovation is put into play. Nonetheless, please realize that the individual is constantly evaluating the success or failure of the innovation during this fourth stage. Recall, also, that diffusion of innovations research is based broadly upon uncertainty-reduction theory. This means that people encounter new situations with the intrinsic desire to reduce their overall levels of uncertainty; essentially, they seek-out information in order to become more familiar with their context. So, under diffusion of innovations theory, this translates into seeking a renewed knowledge about the innovation at hand (to reduce their anxiety and uncertainty about the innovation). Consequently, the individual may ask questions about the innovation to friends and colleagues from time to time. Or, as an alternative, they may require higher-level knowledge about the innovation and seek a professional's advisement. Fascinatingly, the innovation-decision process officially ends here, since "the innovation loses its distinctive quality as the separate identity of the new idea disappears."

V. The Confirmation Stage:

Confirmation occurs after the adoption-decision has been made. At this final stage of the diffusion process, people search for support to bolster a decision to adopt a given innovation. Rogers notes that confirmation is that stage in which an individual can reverse the adoption-decision if "exposed to conflicting messages about the innovation." Even though persuasion studies have shown that individuals tend to steer clear of contrary information or persuasion, instead seeking sustaining ideas for their choice, one could shift a held attitude toward the innovation, during confirmation. For this reason, the solidity of one's attitude becomes decisively important to sustain the continuance of the innovation.

Rogers also notes that discontinuance of the innovation is a distinct possibility during this stage. There are two means by which this can be accomplished: (1) the current innovation is exchanged outright for a better, alternative innovation [known as replacement discontinuance], or (2) the individual outright rejects the innovation because he or she is not pleased with its overall performance [known as disenchantment discontinuance]. Whichever the case, it is important to recall here that humans can choose to disengage from an innovation if another innovation holds more utility, or, because the innovation doesn't meet expectations.

Adopter Categories

Rogers illustrates the types of individuals prone to certain responses when encountering an innovation. He does so through a common bell curve, dividing the arc into 5 divisions. He terms these divisions "adopter categories" and defines them accordingly, as: "the classifications of members of a social system on the basis of innovativeness." The five classifications are: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. Within each particular division on the curve, people are comparable where their "innovativeness" is concerned. Nevertheless, between these divisions things are entirely dissimilar: "Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system."

►Innovators

Consisting of a mere 2.5% of the general population, innovators are the most daring and experimental lot of all classifications. They are enthusiastic about acquiring new knowledge and skill-sets, while also understanding the difficulty in sometimes doing so. Innovators are best prepared to profit from a new innovation, and are prepared to invest time and energy in a venture that may fail. Rogers tells us that innovators are bold adopters who frequently serve as "gatekeepers" in social systems, acting sometimes as "change agents" to help others adopt an innovation if they are reluctant. Because of their daring, the more conservative members of a social system may not respect them or their ideas.

►Early Adopters

Represented by 13.5% of the population, early adopters are not as enterprising (or overconfident) as innovators. Early adopters are more tied to the politics of the social system they inhabit, but also have an eye for innovations. As a result of their political prowess, they are more likely to hold leadership or authority roles inside the social circle. In reality, members from other group classifications will frequently come to the early adopter for information about all matters of circumstance, including innovations. Because of their perceived authority, Rogers notes that the early adopters' beliefs about the innovation are critical. He writes that early adopters lead by example: "early adopters put their stamp of approval on a new idea by adopting it." In short, the politically astute early adopter is interested in innovations, and will keep a sharp eye on what the innovator is doing — in case the innovation has merit.

►Early Majority

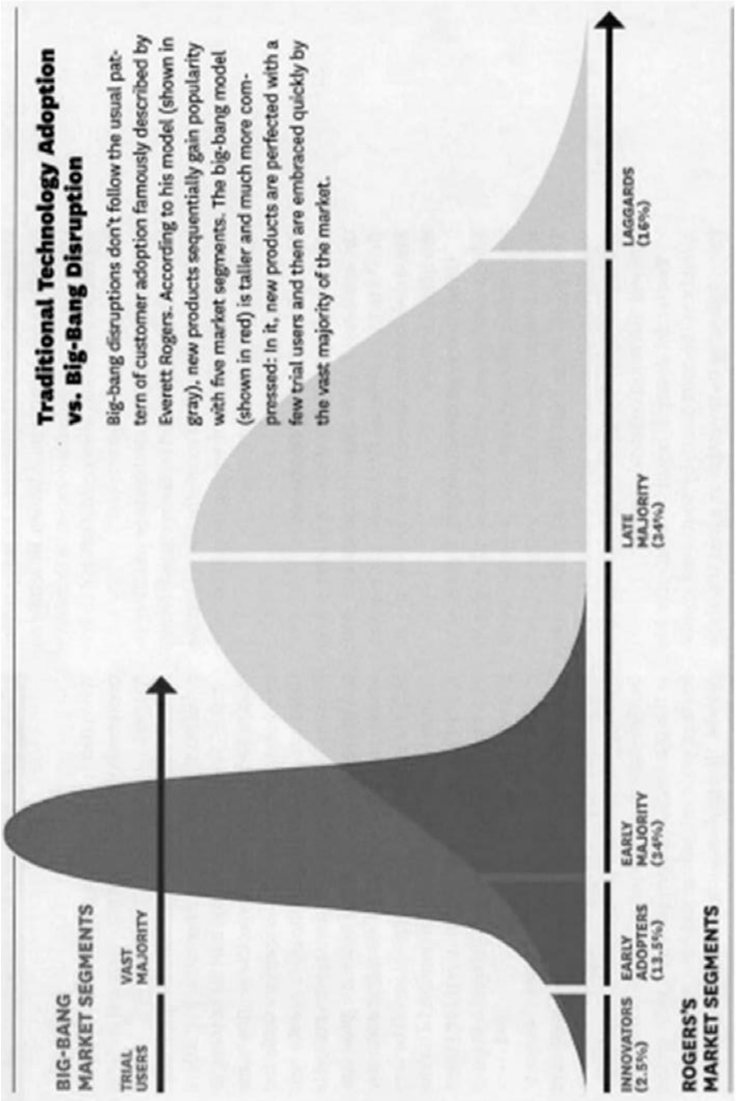
Unlike early adopters, the early majority is more intrigued by following rather than leading (which incurs a certain risk). Certainly, members of the early majority are well-regarded by their peers; these members simply do not desire a pivotal leadership role. Rogers notes that the early majority typically follows the lead of the early adopters, but relies heavily upon interpersonal relationships to achieve their innovation-adoption. To this end, the early majority represents 34% of the general population, translating into one of the two major groups of the distribution.

► Late Majority

The other 34% of the distribution, placed third in curve position, is the late majority. While they are comparable to the early majority in that they are a sizable part of the innovation population, these members generally wait until most of their contemporaries have adopted the innovation before they commit. While these members are at first cynical about the innovation and its promise, the fact that so many peers are adopting the innovation makes it a fiscal and operational necessity. The "peer pressure" to adopt the innovation may, in fact, be so great that they reduce their anxiety about the innovation for long enough to give it a trial period. Rogers notes that to spur innovation-adoption, members of the early majority should seek to actively convince the late majority that the innovation is safe and has benefits and advantages.

► Laggards

Laggards are resolute traditionalists, and these individuals commonly reject new ideas, technology, and the people who advocate them as a matter of both principle and utility. Consisting of 16% of the overall innovation-adoption populace, laggards are highly skeptical and usually hold a localized worldview. Captivatingly, laggards typically associate with other laggards, making them a difficult segment of the population to penetrate with interpersonal persuasion techniques. Besides, before laggards will adopt an innovation, the idea or technology must be fully tested and adopted by many to demonstrate its efficacy. As a result of all this, laggards take a reasonably long period of time to adopt an innovation.


Traditional Technology Adoption vs. Big-Bang Disruption
Big-bang disruptions don't follow the usual pattern of customer adoption famously described by Everett Rogers. According to his model (shown in gray), new products sequentially gain popularity with five market segments. The big-bang model (shown in red) is taller and much more compressed: In it, new products are perfected with a few trial users and then are embraced quickly by the vast majority of the market.
BIG-BANG MARKET SEGMENTS
TRIAL USERS
VAST MAJORITY
INNOVATORS (2.5%)
EARLY ADOPTERS (13.5%)
EARLY MAJORITY (34%)
LATE MAJORITY (34%)
LAGGARDS (16%)
ROGERS'S MARKET SEGMENTS

II. Big-Bang Disruption

The rapid advances in technology and its undisciplined integration in the decade since the last edition of Rogers' *Diffusion of Innovations* have changed the game in significant ways and have required, in many instances, a rethinking of his adoption paradigm. Larry Downes, a fellow at the Accenture Institute for High Performance, and Paul Nunes, the global manager of research at Accenture, have offered an amended interpretation to help explain a radical new kind of innovation and adoption process that they have labeled Big-Bang Disruption. While their perspective in the *Harvard Business Review* has been offered to explain the process to corporate research and marketing executives facing new and dynamic market competition, it is also useful in explicating the current dynamics generating the development of new technologies and the ways in which consumers respond to the shifting electronic realities.

As an example to illustrate their argument in a Forbes.com column, they point to once familiar and widely adopted objects and devices as pinball machines, "address books, video cameras, pagers, wristwatches, maps, books, travel games, flashlights, home telephones, cash registers, Walkmen, day timers, alarm clocks, answering machines, The Yellow Pages, wallets, keys, transistor radios, personal digital assistants, dashboard navigation systems, newspapers and magazines, directory assistance, travel and insurance agents, restaurant guides and pocket calculators" that have been rapidly made redundant by new technologies that are more convenient, less expensive, and better performing.

This phenomenon, of course, is not a new one for communication technologies. The dissolution of the Pony Express only two days after the transcontinental telegraph reached Salt Lake City in 1861 and the demise of Western Union in 2008 as a result of growing email adoption were both victims of new communications technology that were faster, less expensive, and more convenient. Such disruptions, however, are increasingly frequent.

The precipitately evolving environment presents problems for all businesses, as "consumers suddenly and enthusiastically abandon older and even defining inventions for something new and often untested." This impact is intensified for the technology and information sectors, but virtually all businesses are now or soon will be digital businesses. Customers now make decisions to adopt new products in a matter of weeks, and they do so at a rate unanticipated by the old models. Such a dramatic change in adoption of innovation behavior suggests the necessity for a better understanding of the new variables at play in the market and the larger society, and, consequently, a modification of the Diffusion of Innovation model grounded in the technologies of even the recent past.

Downes and Nunes posit three characteristics of Big-Bang Disrupters in the technology markets. First, **unencumbered development**, is represented by the informed, curious, and creative individuals participating in “hackathons” on their own time, exploring the potential uses of technology for fun more than profit. For example, they suggest the creation of Twitter, imagined at a hackathon in 2006, made publicly available in 2007, and boasting 200 million users by 2012.

Second, **unconstrained growth**, by Big-Bang Disrupters truncates Rogers’ gradually progressing five stages to three very quick ones in the life cycle of new products where the old rules no longer apply: development, deployment, and replacement. When combined with the unvetted development process, there will almost certainly be many more failures than successes. However, rather than providing cautionary reticence among the early adopters, Downes and Nunes argue plausibly that “each epic failure feeds consumer expectations for the potential of something dramatically better.” They point to the legal death of Napster and the subsequent rise of iTunes, as one example of this effect, and note that the success of Kindle and other e-book readers to launch after earlier failures by Sony and SoftBook to now account for almost 20% of book sales revenue.

The third, and perhaps most surprising, characteristic of Big-Bang Disrupters is **undisciplined strategy**. Only two decades ago, Michael Treacy and Fred Wiersema's 1993 article in *Harvard Business Review*, elaborated upon in their 1995 book *The Discipline of Market Leaders: Choose Your Customers, Narrow Your Focus, Dominate Your Market,* posited a Value Disciplines Model and suggested that businesses should adopt and concentrate on only one of three goals necessary for market success – operational excellence, product leadership, or customer intimacy. It was taken as gospel by many in numerous industries.

Now, however, Downes and Nunes posit, Big-Bang Disrupters “start life with better performance at a lower price and greater customization. They compete with mainstream products on all three value disciplines right from the start. The faster, cheaper, and smaller computing power predicted by

Moore's Law is still the key driver, but it's now deployable on a global scale and delivered through the cloud to inexpensive mobile devices.” As an illustration of this principle of thoroughly undisciplined strategy, they offer the saga of how the traditional mapmaking industry was impacted by such free online services as MapQuest and the optional purchase GPS devices in automobiles, but the most significant Big-Bang Disrupter was the Google Maps Navigation app, which can today be installed for free on any smartphone.

Conclusion

The phenomena we discuss above have already modified the scale for diffusion and adoption of these emerging and future technologies at a rate previously unprecedented and unimagined. One question to consider is your own mental calculus for making decisions to embrace new communication devices. A second might be where you see yourself along the adoption curve and what this means for your ability to participate in the private market or the public sphere. Another is what will become of the traditional laggards and their ability to engage in the conversation, regardless of the topic or their purpose?

Of course, diffusion of innovations research is not without its criticisms. Some believe that reality is far too complex and dense to explain with Rogers’ oversimplified theory or the more recent revision posed by Downes and Nunes. Some believe that innovations are too commingled now to be properly unpacked as singular entities, therefore giving rise to the argument that *many* innovations are actually being studied by diffusionists. As well, some believe that “disruptive” technologies (e.g., those technologies which intervene as “new” when individuals are already in the innovation-consumption process) create a series of offshoot innovation cycles for which the theory fails to adequately explain. And, of course, some believe that something called “path dependence” can literally secure certain technologies in place. An example of this would be the use of the “QWERTY” keyboard, made apparent on smaller all-in-one devices or, even, the use of specific software programs (because everyone else is using them).

No theory is ever completely sound. Without a doubt, plausible arguments can be created for almost any hypothetical position or counter-position, so it would be remiss not to mention these critiques against diffusion of innovations. Nonetheless, we contend that the Diffusion of Innovations hypothesis is a useful lens for comprehending and understanding the increasingly rapid development and acceptance or resistance to be expected. It now seems obvious, as Downes and Nunes contend, that many consumers are so accustomed to the new environment for new technologies that they now often expect "every product or service to get cheaper and better with each passing day," and this again plays into and implicates our concept of Communication Shock at multiple levels.

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CHAPTER TWO

NANOTECHNOLOGY BASICS

On August 2, 1939, as World War II was brewing throughout Europe, renowned U.S. scientist Albert Einstein issued an urgent letter to U.S. President Franklin Delano Roosevelt, wherein he revealed that Nazi Germany was developing something called an "atomic bomb." In the confidential letter, Einstein argued that this powerful weapon could be deployed against the U.S. and her strategic allies, and would have potentially devastating consequences. In a subsequent meeting with Roosevelt, Einstein and several of his colleagues indicated that such a bomb would produce an enormous energy array, and could be used to destroy entire cities. In direct response to this new intelligence, FDR commissioned the secret "Manhattan Project," which was formed to develop a U.S.-controlled atomic arsenal.

After six years of some rather breathtaking applied physics research, and nearly two billion U.S. taxpayer dollars later, two atomic devices — one nicknamed "Little Boy" and the other "Fat Man" — were readied for deployment. Smaller weapons tests in the Jemez Mountains of New Mexico revealed that the weapons would, indeed, function as theorized. And, on August 6, 1945, U.S. airship *Enola Gay* dropped a 4 and a half ton uranium bomb over Hiroshima, Japan (measuring a 10 kiloton explosion), effectively ushering in the atomic age. At 08:16 that morning in Hiroshima, 66,000 people were instantly vaporized and 69,000 people seriously injured. Nevertheless, Japan would not surrender to the U.S. as requested. Three days later on August 9, 1945, the U.S. dropped its other sole remaining device on Nagasaki, Japan, killing 39,000 and leaving some 25,000 wounded.[1] That next morning, on August 10, 1945, Japan

[1] Interestingly, scientific studies of the atomic blasts over Hiroshima and Nagasaki have concluded that the explosions only reached 1/1000th of their overall potential. By all accounts, while the weapons were strategically and politically successful in reaching their end goal, they did not function to the fullest of their capabilities.

unconditionally surrendered to the U.S., ending World War II in the Pacific Theater.

However, the fixation with the atom and its enormous military and peacetime energy potential would not end with Japan's surrender. If anything, this military event served as a global catalyst for each nation-state's zeal to develop or acquire atomic weaponry. The U.S. immediately began a lofty production program, manufacturing as many weapons as possible. The former Soviet Union tested its first nuclear weapon in 1949, and quickly began making its own stockpile. The United Kingdom developed and tested its first nuclear weapon in 1952; then France in 1960; The People's Republic of China in 1964; and, India in 1974. The number of nations that have had, at one time or another, nuclear weapons research and development programs is far too lengthy to list. Simply know that we, as a world, are well-equipped to annihilate ourselves several times over.

Of course, “safe” nuclear energy programs have provided people with relatively clean electricity since the early-1970s. It cannot be said that our discovery of how to split the atom's nucleus (which was once viewed as impenetrable), is entirely a bad thing. Again, science, like rhetoric, can be used for good or bad ends. The world is not only filled with nuclear weapons, it is also filled with nuclear energy plants conducting highly controlled atomic fission processes. Indeed, if we are sane and rational with our use of atomic material, it may very well liberate us by harnessing the necessary energy to fuel our various energy-dependent civilizations. On the other hand, the Chernobyl disaster of 1986 and the Fukushima Daiichi nuclear disaster of 2011 provided a glimpse of a darker future and calls into question the very idea of safe nuclear energy. Nonetheless, we have now opened “Pandora's Box.” We cannot go back. Nature's secret is now realized and released. It will be up to us humans to decide how this discovery will be implemented and managed.

Clearly, significant scientific research has been conducted on the atom over the past century. The disciplines of physics, chemistry, and biology all acknowledge that the atom is the smallest unit of matter itself; and, that all things — organic and inorganic — are constructed of atoms bound together as both simple and complex molecules. This is not some top military secret. This now-simple fact is taught in grade schools throughout the world, and a popular magazine published an article on the secrets of the hydrogen bomb using information from publicly available sources. However, whereas our past research efforts have traditionally focused on how to release energy from the atom (specifically, how to release energy from the fission process of uranium), our future research efforts are now taking a *completely* different approach. Instead of breaking atomic bonds, thereby unleashing extraordinary amounts of energy, world scientists are now considering ways to proactively construct and reconstruct molecular structures from the atom up. This new discipline, which seeks to bind almost every hard science together under a new rubric, is called: *nanotechnology*. And, to fully understand it we must think small — very small.

I. What is Nanotechnology?

One must understand that nanotechnology deals in the science of matter at an unbelievably minuscule scale. For example, some of the tiny wire-like shafts (carbon nanotubes or CNTs) used in nano-electrical computer engineering are literally 1/1000th the width of a human hair. We are talking about something that is exceedingly tiny. We are talking about something that is *much less* than microscopic. We are talking about something that is on a new scale of science, altogether, called: the nanometer (*nm*). A commonly accepted industry definition for **nanotechnology** would be: *a branch of engineering dealing with the design and manufacture of extremely small electronic circuits and mechanical devices constructed at the molecular level of matter*. To be more specific, nanotechnology is a science where the range of engineering occurs on a 0.1 to 100 nanometer (*nm*) scale. As a result, any scientific or engineering work occurring at the 0.1 to 100 *nm* scale is, therefore, properly nanotechnology.

Seeing the World Below: On Types of Microscopes

To put it simply, nanotechnology occurs at levels of vision considerably smaller than what the human eye can readily see. In fact, the order of the "tiny universe" is as follows [from larger to smaller matter]: (1) millimeters, (2) micrometers, and (3) nanometers. The naked eye has a difficult time discerning things once they go below the 50-60 micrometer range (just below the width of a human hair).

1. Ordinary Microscopes

In 1590, we first began to glimpse into the world of the micrometer when two Dutch eyeglass makers, Zaccharias Janssen and his son Hans, invented a lens tube system that enlarged miniature objects. Shortly thereafter came a refined compound microscope and telescope (invented by Galileo in 1609), both of which revolutionized biology, medicine, and astronomy. But, real advances in the microscope did not occur until Anton van Leeuwenhoek of Holland built some of the most refined microscopes (during the late-1690s and early-1700s), with mirror refractor plates that illuminated the objects under scrutiny. Robert Hooke (during the 1800s) and Charles A. Spencer (during the 1900s) modified these evolving models, producing a crude form of what we know today as the basic lighted compound microscope.

2. The Electron Microscope

A compound microscope can only see so deeply into matter. Ordinary white light blurs objects at a certain downward level, and they begin to be "grouped" through the lens. We must, therefore, use something called an electron microscope to go deeper into the structure of matter, itself. In the early-1930's, the German team of Max Knott and Ernst Ruska developed a microscope that used a vacuum system to "speed up" electrons so that their light wavelengths would become more traceable, and thus, more visible to the electron microscope. This process of "speeding up" electrons allowed researchers to see the electrons' paths better so that they could then take a picture of the electrons on a lithographic plate. Still, researchers were only looking at the electron, not the nucleus. In sum, an electron microscope only goes down to the electron level — known to scientists as 10 *angstroms*. The main benefit of this device is that it allows researchers to see and model molecular structure. All you really need to know for our purposes is that the electron microscope can enlarge objects nearly 1 million times their size.

3. Scanning Tunneling Microscope

In 1981, Gerd Binning and Heinrich Rohver contributed to the "study of the small" with their release of the scanning tunneling microscope (STM). This microscope actually uses a very fine needle to "scan" metallic surfaces (like computer chip semiconductors) for their atomic properties. Computers use very sophisticated software applications to record the smoothness and irregularities in the surface of the object at atomic levels, where three-dimensional charts are then induced and drawn. The STM microscope actually goes below the electron level, and examines the atomic nucleus. The STM microscope is primarily used for electronics research and development, especially when designing newer, faster, and smaller circuits which fit on a computer chip.