AN EXAMINATION OF THE EFFECTS OF DIGITAL MEDIA

ON THE COMMUNICATION OF SCIENCE

by

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ABSTRACT

Science communication has never existed in a vacuum. As communication technologies evolve, so do the strategies of scientists. A historical analysis of this relationship reveals major influences that have filled information gaps left in the wake of new communication technologies. I have identified three such influences that affected 20th Century scientific communication: the corporate, the military-industrial, and the need for 'visibility' in the visible scientist. The cultural framework of the existing communication strategies has always shaped the pursuit of science. To remedy this problem, scientists need to embrace the new media landscape and become the primary communicators of their work. Transparency is the key to the successful dialogue of science.

INTRODUCTION

We live in a spectacular time. Never before has information been so universally accessible and freely disseminated. Researchers and scientists can freely share cutting-edge discoveries instantly across the globe. A global network of high-speed Internet has redefined scientists' relationship to not only their work, but also to the masses as well. Scientific data now, in theory, is accessible to anyone with Internet capabilities, granting them a front row seat to scientific advancements.

Yet, even as information has the unprecedented potential to reach the masses, this increased access comes with its own set of challenges. The sociopolitical shackles that have influenced the works of past scientists have evolved alongside high-speed communication technologies. As a filmmaker, I see the enormous benefit of having scientists take the reins of communication of their work; however, it is also evident that holes remain in the pipeline of communication between scientists and the public. These holes are unfortunately often filled by third parties (government organizations, corporations, institutions) or erroneous claims. The issue with lighting-fast communication is that it can spiral so easily out of control when scientific claims are leaked to the masses before properly peer-reviewed and tested. This has lead to multiple cases of science miscommunication or co-opting by individuals and organizations that wish to manipulate data for self-interested agendas or profit.

Science communication has never existed in a vacuum - and it never will. But allowing the scientist to assume the role of the primary storyteller could catalyze the public's understanding if done properly for both the specifics and the generalities of scientific practice and process. If we, as filmmakers, can sufficiently examine the effects of digital media on science communication - where it excels and where it is lacking - then the translation of information to the public could be more efficient.

HISTORY

In 1963, Thomas Kuhn, a professor of the history of science at the University of California, penned *The Structure of Scientific Revolution*, a thesis where he examines the process in which major changes come about in the scientific field. Kuhn concludes these epistemological upheavals, christened *paradigm shifts*, occurred when revolutions in science come about as the result of breakdowns in the current intellectual systems - when old methods won't solve new problems (Kuhn 10). Kuhn explains that a historical look at scientific practices illustrates this emergent property: "Close historical investigation of a given specialty at a given time discloses a set of recurrent and quasi-standard illustrations of various theories in their conceptual, observational, and instrumental applications" (Kuhn 43). Kuhn claims that while the scientific method may be pure in ideal, the pursuit of science has always been shaped by the cultural framework in which it existed.

While this term *paradigm shift* has since been widely used (and simultaneously abused) in modern discourse, it should be considered with reference to the effects that the advent of digital media has had on the formulation and subsequent communication of scientific achievements. While claiming to be an entirely objective methodology, the scientific method throughout history has accrued cultural baggage, which ultimately influences scientific developments. Though countless scientific papers have been written on the effects of digital technology on scientific practice, it is pertinent to examine how the technology that has changed science is the very same technology that has changed the communication of its investigations and results. For such an examination to be sufficient, we must look at previous paradigm changes that have affected scientific discourse.

Long before the Internet was realized, science communicators - then called *natural philosophers* prior to the 19th Century- dealt with another shift in communication methods in the form of Johannes Gutenberg's printing press in 1450. What was printed by Gutenberg's press could now be distributed and affect otherwise docile citizens or subjects. This allowed scholars to create communities across greater distances than ever before. The increasing availability and ease the press provided also permitted scholars to systematically refine and build upon ideas not only across grand distances, but generations as well (Chase). This was indeed the first form of communication on a massive scale. Furthermore, the printing press represented a pre-digital concept of taking abstract ideas and reducing them to text with the intent of mass dissemination. This embodies the same underlying cultural concepts within digital technology - the method of science communication evolving alongside technology.

The repercussions of this new mass media were powerful. Jeffery Chase, a professor of computing at Duke University, attests that the "power of the press was used simultaneously as a decentralizing force to undermine established elite institutions, and as an instrument of mass influence and control through advertising and propaganda." This in turn catalyzed the idea of ownership of knowledge and the concept of content creation as an industry – manifesting in the growth of intellectual property rights, the idea of the public domain, copyright, and plagiarism. (Chase). Such a cultural shift would start to leverage central agency away from the Church, paving the way for Scientific Revolution and Enlightenment in the 1600's.

Prior to the Scientific Revolution, natural philosophers based their observations on the prevailing Aristotelian method of the *deductive* argument. Yet in the wake of the Enlightenment, these *"divine laws of nature"* were replaced by reasoning and systematic analysis. The inductive argument, as championed by English Philosopher Sir Francis Bacon (1561-1626), became the cornerstone for the modern scientific method (Gregory & Miller 20). Instrumental to this development was Bacon's, *Novum Organum* (1620) (Spier). In it, Bacon outlines his new system of inductive reasoning in attempts to undermine the syllogism of Aristotelian ideas (Klein). Known as the Baconian Method, this was the first step to the development of the scientific method in modern science, leading to the establishment of the prominent research and communication practices that dominated science culture right up to the digital age.

The emergence of the Baconian method, or Scientific Method, was a direct result of the cultural shifts that were instigated by Gutenberg's printing press. The new technology allowed work to be published, distributed, and consumed by more people. The overall realm of scientific discourse grew, and while the Scientific Revolution was nowhere as grand a sphere of influence as the digital revolution, it is an important antecedent to consider when studying the effects of the Digital Age on the communication and *consumption* of science.

COMMUNICATION MODELS OF THE 20th CENTURY

The 20th Century proved to redefine the role of the scientist to a greater degree than any previous time since the Enlightenment. While science at large continued to advance, the coinciding emergence of photography (and eventually film) was there to document it. The masses could now see German Physicist Albert Einstein's theory of relatively explained by scientists in the 1922 film, *The Basic Principles of Einstein's Theory of Relativity*, or perhaps be horrified by photographs from the front lines of World War I and the effects of chemical warfare. The Industrial Revolution of the previous century had established urban-based population centers, and perhaps more importantly, introduced a new type of citizen in the consumer. The newly defined sociopolitical landscapes of the 20th Century, coupled with the aforementioned revolutionary visual communication technologies, set the stage for what I consider the three major influences on science communication; corporate and military-industrial pressures, and increased "visibility" (visible scientists).

The Corporate Influence

In 1933, The President's Research Committee on Social Trends, in commenting on the vacuum cleaner, decreed "The homely broom that has remained unchanged since the time of the early Egyptians is giving way to an expensive piece of electrical equipment"(Hoover 857-858). Consumer literacy was quickly becoming a central concern in the United States at the turn of the 20th Century. For the first time, Americans were now buying the material of their daily life, instead of growing, gathering or making it. Corporations utilized new media technologies and scientific 'truths' to sway consumer opinions (Gregory & Miller 34). The American Medical Association launched a news bureau in 1910 to combat quack remedies, while organizations such as the National Dairy Council, the American Gas Association, the American Chemical Society and the Kellogg Company all pushed for public awareness of their goods (Gregory & Miller 26-27,34). Edward L. Bernays, nephew of psychoanalyst Sigmund Freud and the father of modern public relations, was a pioneer of this technique, writing in his 1922 work Propaganda on the immeasurable sway these reports had on the public;

> Universal literacy was supposed to educate the common man to control his environment. Once he could read and write he would have a mind fit to rule. So ran the democratic doctrine. But instead of a mind, universal literacy has given him rubber stamps, rubber stamps inked with advertising slogans, with editorials, with published scientific data, with the trivialities of the tabloids and the platitudes of history, but quite innocent of original thought. (Bernays 20)

Hindsight is 20/20 when examining these historic cases of information manipulation for financial gain. Yet, what these corporations were doing was merely exploiting cultural “holes” that were left in the wake of new communication technologies and resultant paradigm shifts. Decades after Bernays’ work, corporations would still utilized the power of the 'objective' scientists for personal gain. Frederick Seitz, an American physicist and former president of the United States National Academy of Sciences, was approached in 1979 to run a biomedical research across major universities, hospitals and research institutes across the country, focusing on degenerative diseases including cancer, heart disease, diabetes. The funding agent? The R.J Reynolds Tobacco Company. The purpose of the funding was to develop "an extensive body of scientifically, well-grounded data useful in defending the [tobacco] industry against attacks" (Oreskes and Conway 11).

This all emphasizes the reality that data can be manipulated for specific gain, especially in the wake of new technologies. In the modern Digital Age, one is not hard-pressed to find examples of those who "bank" on misunderstandings or misinterpretation of scientific achievements. Data can and *will* be manipulated for obtuse gain and those responsible for it (scientists and researchers) need to be responsible for the dissemination of the data. Of course, this trend of obfuscation continues in the digital age, where the waters can become even murkier. However, it is pertinent to examine another major influence of communication that emerged during the 20th Century: the military-industrial complex.

The Military-Industrial Influence

While the 20th Century was a time of technological advances, it was also a time of warfare on an unprecedented scale. World War I demonstrated on a global stage the awesome power of science in the prominent manifestation of chemical warfare. This proved to be both a windfall and a curse for the scientific community, as it would continue to be so for the remainder of the century. Chemists in particular had to deal with the moral weight of chemical agents causing many horrors of the war, all the while accepting the money and resources government had now made available for research (Gregory & Miller 27).

This positive feedback cycle of funding and subsequent wartime secrecy continued well into the Second World War. Even though public education through the new media had increased, direct communication from the scientists to the public had all but vanished. At the time, there was simply no *need* for the scientists to communicate to the public directly, as the funding flowed in at unprecedented rates. Howard Simons, a science reporter and former editor of *The Washington Post,* remarks:

> There was always a "gee whiz" element in the reporting of science but this really was the time of hero and heroics… When megabucks were so much the main units of currency that the scientists could never conceive that the faucets might be turned off, the profession did little to develop a correct working relationship with Congress, or with the media, or with the public. (qtd. in Goodfield 3)

The military-industrial complex that was World War II provided the scientists with a *raison d'etre* for unlimited expansion into new realms of science – most notably chemistry and physics. The government funded many of these projects regardless of any presence in the public sphere. Technology became a governmental and military pursuit, seen as a key element in winning the war. The Office of Strategic Service, the predecessor to the CIA, was established in 1942 as an intelligence agency, tasked with "strategic importance of intelligence and clandestine operations in modern war" (Central Intelligence Agency). The public seemed content with this wartime secrecy. After all, the mysterious wartime work of the scientist gave them a heroic image as new technologies, advancement in medicines, transportation and, ironically enough, communications flooded the American public (Gregory and Miller 35 -37). Then, on August 6, 1945, the first bomb dropped on Hiroshima, demonstrating quite clearly the destructive power of those scientific advancements, while birthing a new age of scientific communication and condemnation.

When the United States entered into the Cold War with the Soviet Union, science and the communication of science experienced changes in the economic, organizational and epistemological approaches to science (Schiele, Claeseens and Shi 5). This period exhibited growing political constraints that bound many scientists to the emerging Cold War policies that commonly clashed with interest in public outreach (Wang 325). In the United States, science communication was perceived as a matter of national security and was closely monitored by new government authorities such as the House Committee on Un-American Activities and the Senate Internal Security Subcommittee (Wang 333). The scientist was effectively discouraged to speak with the public about their research amidst the tight-lipped political climate of President Harry S. Truman and Senator Joseph McCarthy. Even non-government scientists were faced with "loyalty" investigations if they became too open with their work. They would risk losing funding or even the right to obtain a passport for travel (Wang 334).

Perhaps no one could speak more to these intrusions on free expression than J. Robert Oppenheimer, arguably the face of the Manhattan Project and the father of the atom bomb. He, like many other atomic scientists of the day, argued publicly against nuclear weapons development on moral grounds. Out of fear of potentially communist ties, his security clearance was revoked in 1953 during a much-publicized hearing and was never reinstated (Gregory and Miller 36). William H. Pickering, head of CalTech's Jet Propulsion Lab, lamented in 1974 "Science and technology changed almost overnight from hero to antihero" (Westwick 11).

As the anti-Communism movement curtailed openness with the public, the institution of science became feared as a totalitarian force (Wang 333). British scientist and novelist C.P Snow remarked "It takes a very strong head to keep secrets for years, and not go slightly mad. It isn't wise to be advised by anyone slightly mad" (Wang 345). The 1964 Stanley Kubrick film, *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb,* captured the public concern of the power of scientists within an insidious government regime (Ebert). Though the film took a satirical look at Cold War policies, it touched on the very real destructive capabilities of science and technology. Science at this point was "as sociopolitical as it was epistemological," postmodernist philosopher Jean-Francois Lyotard remarked. (qtd. Gregory and Miller 67). This sentiment was reflected in Dwight D. Eisenhower's famous warning to the American public that "public policy could itself become captive of a scientific-technological elite" (qtd. in Wang 345). Science historian Jessica Wang wrote: "These Cold War anxieties about science and scientists, however, ultimately had less to do with science itself than the nature of governance in a modern bureaucratic society" (Wang 346). Therefore, it showcased the sense of unease when the conduit of information from the scientists to the public was obscured.

The Visible Scientist

The 20th Century recast scientsts from being faceless writers or distant lecturers; they became moving human beings with voices that could connect to the viewer. Science literature also became a prominent feature in the booming magazine business. (Gregory and Miller 29). The Science Service agency, a national news agency for distributing science news by and for science journalists, was created in 1921. Edward Scripps, one of the founding individuals, claimed that "The service, which offered drama and romance ... interwoven with wondrous facts" explored the "drama [that] lurks in every test tube" (Gregory and Miller 29). This trend would continue throughout the 20th Century: the need for a scientist to captivate audiences, whether for financial gain, professional spotlight, or some other desired self-serving result.

In response to the mounting division between the general public and the scientific community, the post-Cold War years sought to revitalize the popularization of science throughout the masses. Unlike previous decades, concerted efforts were made through the use of television and various works of popular nonfiction. When Carl Sagan stepped in front of the television in 1980 as the host of *Cosmos: A Personal Voyage,* he and his fellow writers (all of whom had scientific backgrounds) launched the highest rated PBS show of the decade. Sagan's *Cosmos* combined elements of groundbreaking special effects and epic soundscapes with cutting edge science to create a narrative for the viewing-audience to follow, even if they lacked formal scientific training (*Cosmos: A Personal Voyage*).

It was not just the television that became a venue for popularizing science. In 1988 Stephen Hawking propelled quantum science to the forefront of the public's attention with his publishing of the best selling popular science book, *A Brief History of Time.* The book became a global best seller and dealt with how science (and particularly physics) could answer some of the questions of our origins that have historically been left to theology. Hawking's publication was far from the only popular science publication, but paved the way for publishers to take on other leading physicists. During the following decade, several publications such as Leon Lederman's *The God Particle* (1993) and Steven Weinberg's *Dream of a Final Theory* (1993), would serve to educate the public and seek to secure public support for funding other scientific endeavors. Rae Goodell, a communication scholar, called these individuals "visible scientists," a title for those acting as a liaison between the mass media (and public at large) and the hordes of invisible scientists in the labs (Goodell 9).

These science-popularizers, according to Goodell in her book *The Visible Scientists*, follow a certain set of "rules": 1) one should popularize only when one's productive research life is over and stick strictly to a specific area of expertise; 2) act only to improve the public image of science; and 3) a scientist must first establish a reputation as a credible researcher before he or she is entitled to communicate with the public. Goodell also lists several qualities that "visible scientists" share: they present either a "hot topic" or a controversial stance often at odds with the establishment; they are "revolutionary" in their scientific work as well as articulate and colorful; and they are passionately involved, a far cry from traditional myth of the scientists' dispassionate objectivity.

The new media technologies of the 20th Century gave rise to this new communication paradigm. As we have seen before, the exploitation of media technologies in previous decades created the dissension in the public that, Goodell argues, gave rise to the ultimate *need* of the: 'visible scientist," who utilized the same communication technologies that once created the rift between the public and the scientists. The rise of the visible scientist, however, did not occur without it's own major pitfalls. Linus Pauling, William Shockley, and B.F Skinner are just a few examples of renowned scientists who had become 'visible' not only for their science but for their public involvement (and sometimes antagonizing tactics) (Goodell 5).

Goodell points out that these "visible scientists" are unhappy with the oversimplification or sensationalism that the mass media communication of information demands. "Scientists exchange horror stories about the press the way laymen discuss their operation scars," Goodell states (Goodell 121). The act of "coming out" to the public with one's findings involves an inherent risk that can tarnish one's reputation in a manner akin to academic suicide. These visible scientists walk a fine line between simplifying science for public reception and distorting the facts (and, therefore, violating academic integrity). This possible jeopardy is why, Goodell attests, that the only scientists who can afford to step out as public figures are the ones who have transcended academic pressure and possess upper-echelon accolades such as a Nobel prize or two.

Many commentators began to wonder if the relatively small number of visible scientists had too much influence on mass media and public opinion. Historically, they represented not only themselves but also the entire community in their discipline, yet they tended to speak on topics outside of their expertise (Goodell 202). This could result in a disproportionate coverage from the media and an inflation of their credibility with the public (Goodell 202). Media attention has traditionally given these scientists advantages, as they are chosen to appear because of their visibility, which increases their visibility, resulting in a classic positive feedback cycle. Though these visible scientists have helped the public take a tentative step towards “a more realistic view of science, a recognition of science's strengths and weaknesses” the information age has proven to give those “still in the labs” the unprecedented ability to become 'visible' in their own right (Goodell 207). What Goodell couldn’t account for, however, was the reflexive result of this method of communication. It was established that ‘visible’ scientists talked to the public, but now the public could respond and comment with emerging communication technologies. Therefore, a new paradigm emerged that was base on dialogue and response, not linear lectures.

A BRAVE NEW WORLD: THE DAWN OF THE DIGITAL AGE

In 1863, Samual Butler (a contemporary of Darwin) spoke of an ideal mode of communication for scientists:

> I venture to suggest that ... the general development of the human race to be well and effectually completed when all men, in all places, without any loss of time, at a low rate of charge, are cognizant through their senses, of all that they desire to be cognizant of in all other places. ... This is the grand annihilation of time and place which we are all striving for, and which in one small part we have been permitted to see actually realized (qtd. in Rzepa).

Although he was referring to the electronic telegraph, Butler's description of a "multi-media" mode of communication for the sciences - a way to index and access information quickly without hassle – prophesied a mechanism that manifested itself the Internet over a century later (Rzepa).

With origins dating back to the late 1960's during the height of the Cold War, the Internet did not develop into a user-friendly interface until the early 1990's. The World Wide Web, a protocol for information distribution, was developed at the *Organisation Européenne pour la Recherche Nucléaire* (CERN) in 1991 as a system base for sharing data across research sites. Because of its primary funding by the US government, the early incarnations of the Internet were solely used for research, education, and other government uses (Leiner et al.). It was not until the early 1990's that the Internet was available for independent commercial networks and subsequently grew exponentially. In March of 2013, 38.8% of the world's population had reliable Internet access, growing from only .4% of the population in 1995 (Leiner et al.).

The Internet brought forth a new method for scientists to collaborate locally. No longer were they confined to a geographic location; furthermore, as data repositories moved online, academic publications became searchable across disciplines. Information now traveled at near-light speeds, allowing global communities of scientists to collaborate. The new data catalogs could now be accessed by a wide array of both academic and non-academic individuals. Jim Gray, an American computer scientist, had come to call this utilization and categorization of 'Big Data' as the “Fourth Paradigm” of scientific exploration. What this Fourth Paradigm has come to represent is a shift in scientists' relationship with data in a similar magnitude to that experienced with the introduction of the printing press or the Industrial Revolution. Scientific data was now, in theory, accessible to anyone with Internet capabilities; however, the unprecedented *amount* of data available had opened up the possibility of gross misinterpretation of the data by irresponsible entities. So, while the vestiges of power that science had so enjoyed in previous centuries was now disseminated into the public sphere via this new method of communication, the 24/7 availability of the public-accessible data further increased the magnitude of communication dangers from those present in the 20th Century.

As this new media frontier expanded, it continued to both redefine ideas of superiority in the scientific community and democratized public access to information. This tendency was exemplified by the onset of what became referred to as “Web 2.0,” a new Internet interface that began in the early 2000's. This movement transcended from the mere broadcasting of information of the early Internet to active participation from users, such as open-source user-generated media, social networking, and blogging (Anderson 4). Blogging in particular proved to be a useful tool for scientists to report the daily happenings of their research. An aspect long ignored by the scientific journalists, the scientists themselves now reported the process of their research. They now had access to report from the front lines and communicate an understanding of the dynamic operations of science.

Sociologists Harry Collins and Trevor Pinch describe science as "a lumbering fool who knows neither its own strength nor the extent of its clumsiness and ignorance" (Collins and Pinch 2). This scientific golem "will follow your orders. But it's clumsy and dangerous. Without control a golem may destroy its master with its flailing vigor" (Collins and Pinch 1). To Collins and Pinch, science is a monster that is equally awkward as it is unsafe, possessing an enormous influence upon the public sphere. "Bad science" is not only erroneous, but also dangerous.

As we have seen, the new media landscape is propelling the dissemination of information to the masses at an unprecedented rate, and the rate is only increasing. I argue that the traditional role of the scientist, as exhibited, needs to evolve in order to tackle the "golem" that is science and the communication thereof. The time-honored role of the scientist has been to disseminate the knowledge to the scientific journalists or the few "qualified" visible scientists, warts and all. Traditionally, the risks of speaking publicly for the scientists have outweighed the benefits, but this is quickly changing. Paul Ehrlich, biologist and author of <u>The Population Bomb</u> expresses:

> I expected [the publicity] would totally destroy my scientific career-not because I expected to get out of research, but because the average scientist is basically toilet-trained to the point where if what he does is comprehensible to the general public, it means he's not a good scientist. That's what I thought. I was wrong. (qtd. in Shortland and Gregory 6)

What scientists have originally feared has not necessarily been a lack of consensus among scientists resulting in a misrepresentation of data, but rather the media misrepresenting the scientific consensus. This issue is one of scientists showing how they know what they know. Dan Kahan of Yale University, who specializes in cultural cognition, stated that a scientist "should tell a story." Science communication "doesn't reflect what they know, it expresses who they are." Scientists need to communicate uncertainty – to explain the process of understanding as well as communicate what is a scientific question or not. The public discourse on climate change, for example, is mostly one outside the scientific realm more one of policy makers, yet it is still seen as a scientific discussion.

One aspect of fallacious science communication is that its claims are based on a singular entity called 'Science.' Postmodernity has seen the deconstruction of this idea of a singularity in science and its hierarchical establishment. Civil mistrust, which has always obfuscated the communication of science (especially after the Second World War), can be alleviated if the public knew of the workings and inherent shortcomings of the scientific process. Professor John Durant, who specialized in the public understanding of science, stated;

> The public needs more than mere factual knowledge. And it needs more than idealistic images of the 'scientific attitude' and 'the scientific method' . . . what it needs, surely, is a feel for the way the social system of science actually works to deliver what is usually reliable knowledge about the natural world (Gregory and Miller 91).

All in all, scientific knowledge is based on a corpus of work within the methods of scientific investigation, discovery, and discourse.

Despite all the factors that seem to work against the notion of the scientist as the principal storyteller, I argue that science adheres to the narrative structure. Traditional stories have conflict. Scientists have an excess of conflicts, which they can use as a central narrative: it is always the search for information or perhaps a more controversial slant such as global warming or the use of GMOs. Scientific papers have traditionally followed the introduction/methods/results/discussion, bearing a striking similarity to a traditional three-act narrative structure (Olson 96). Then there is also the perceived issue of subjectivity vs. objectivity in stories vs. science. From an early age, scientists are taught to adhere to certain rules. As Michael Shortland and Jane Georgy write in their *Communicating Science: A Handbook,* “A good scientist is disinterested and objective – he or she has no personal stake in or feelings about the worked in hand – and is completely committed, intellectually and in time, to research” (5). However, it is incorrect to assume science and the scientific paper are purely objective. The methods of scientific inquiry do not guarantee truth: “objective” research follows criteria that have been agreed upon by a certain group; it is a construct, a mediation, a lingo.

Nobel recipient Sir Peter Brian Medawar argued in his 1963 paper *Is the Scientific Paper a Fraud?* that science held the visage of objectivity, but “scientists and the public are reminded time and time again science is conducted by human beings” (98). The best and most honest science communication is one that is transparent to the fact of its inherent subjectivity and strives to have as much clarity as possible. This model is exemplified by the communication practices of Stephen Jay Gould and other successful science communicators.

The first step is to come to terms with the idea that science and the communication thereof is a construct of the individuals who consider themselves “scientists.” In the past, science was seen as an extension of nature and religion, in which all scientists were merely decoding the divine facts and figures into something that transcended the human experience. There was an idea that there was a 'Truth” and linear direction of progress. In the Postmodern Age, the idea of multi-narratives verses the solo narrative of 'Truth' opens up the idea that science is a construct of the human mind. This is not a negative look at the discipline; as Medawar stated:

> Scientists should not be ashamed to admit, as many of them apparently are ashamed to admit, that hypotheses appear in their minds along uncharted by-ways of thought; that they are imaginative and inspiration in character; that they are indeed adventures of the mind.

The idea of pure objectivity is antiquated. The issues arise when journalists are tasked to observe, investigate, and report, but scientists need to take charge in emphasizing that science is provisional. The desire to be “objective” should be taken with a grain of salt. Scientists need to leave their fears in the lab and step out to communicate the vast intricacies of the scientific process. Educating the public on the process of science rather than its findings will not only increase transparency (and thus trust and subsequent funding) but will also normalize the public's expectations, as they now know the uncertainties of the scientific process. The landscape needs to be broadened with more individuals having omnidirectional conversations and opposing viewpoints. The public needs to understand the essence of data, knowledge, and statistical analysis, in addition to acknowledging how provisional science inherently is.

In the Information Age, the public expects a constant stream of data and instantaneous knowledge, whether it is an op-ed in *Scientific America* or a 140 character Tweet. As we have seen with previous paradigm shifts; the printing press, radio, television, etc., there is always a period of upheaval before the scientific community can settle into a new communication paradigm. During this upheaval, the voids of information are exploited by outside parties. Therefore, it is the responsibility of the scientists to be current with these modern methods of communication, because they are the primary resource. But to do so they must be properly indoctrinated in the methods of public understanding, which is best described in a narrative format. We have been moving in this direction for a while, but with the "Big Data" of today and bidirectional modes of communication, scientists need to take the final leap. They need to hold the reins of the communication of their research and steer it back on track when it (inevitably) goes off course. In short, the scientists who are prepared will provide the most accurate translation, which is for the betterment of both public appreciation and the justification of the science itself.

There are certainly inherent problems with scientific communication. I argue that the sensationalism that is generated from a new scientific announcement will only increase in the new media age. No longer is scientific communication a unidirectional exercise, but rather it is becoming more transparent as now the masses can take part in the increasingly democratic scientific process. Essentially, the information is going to move out into the public even before it has been properly packaged. The scientists need to embrace the chaos and take responsibility. The traditional notion of the ivory tower has crumbled under the weight of the digital age. It is time to adapt.

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