Information **2012**, *3*, 442-471; doi:10.3390/info3030442

OPEN ACCESS

information

ISSN 2078-2489

www.mdpi.com/journal/information

Article

Counting Electric Sheep: Understanding Information in the Context of Media Ecology

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Received: 29 August 2012; in revised form: 5 September 2012 / Accepted: 7 September 2012 / Published: 18 September 2012

Abstract: In the field of media ecology, defined as the study of media as environments, *media* and *medium*, and *ecology* and *environment* are key terms, while *information*, although commonly employed, is generally used without reference to a specific definition. This article examines the mostly implicit assumptions about and understandings of the term *information* in the context of the field of media ecology. Information can be seen as a synonym or subset of *content* or *message*, can be divided into different orders or levels of content/communication and relationship/medium, and on both levels is dependent on and altered by changes in technology, code, and form. Although sometimes discussed as if it were a substance, information is best understood as a function of communication, which in turn is a function of mediation. As a function of mediated communication, information is closely associated with news and control. Information is also considered the defining characteristic of our contemporary period, but is best understood as a product of electricity, electric technology, and the electronic media. As we have moved from orality to literacy to electricity, so too has the emphasis shifted from wisdom to knowledge to information. Despite popular celebration, this evolution is not an unmitigated good, and what is needed is a balanced media environment.

Keywords: media; medium; information; form; code; relationship; electricity; technology; media ecology

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1. Introduction: The Meaning of Information in the Field of Media Ecology

Media ecology is a field that has been defined as the study of media as environments [1], and it should come as no surprise that the key terms in this field are *media* and *medium*, and to a lesser extent, *ecology* and *environment*. *Information* is a term that is commonly used within the field, occasionally drawing on the precise, scientific definition put forth by Claude Shannon more than half a century ago, based on probability theory, grounded in the Second Law of Thermodynamics and the property of entropy, and tied to the phenomenon of uncertainty [2]. For the most part, however, *information* is employed without reference to this or any other specific definition, relying on popular assumptions of what the term represents. The aim of this article is to examine our understanding of the term *information*, and the phenomena it refers to, in the context of the field of media ecology. To this end, I will discuss the meaning of the term as it is used within the field in this introductory section, then how the concept of information is used in the analysis of media environment in the second section, followed by a discussion of how information is understood as a function in the third section. In the final section of this article, I will emphasize the idea that our current "information age" is a product of electronic media, concluding with some thoughts on how the concepts of wisdom, knowledge, and information respectively can be connected to orality, literacy, and electricity.

1.1. The Medium Is the Message

Central to the field of media ecology is McLuhan's famous aphorism, "the medium is the message" [3], and while the saying has a number of different meanings [4], and may seem in some ways to conflate *medium* and *message*, its foundation is the distinction between media and the messages they carry, also framed as a distinction between *medium* and *content*. The term *information* is sometimes used in ways that are somewhat synonymous with content or message, as that which is contained, preserved, and/or shared by a medium. It follows that, like content or a message, information can be transferred from one medium to another, but cannot exist independently of any medium, in some abstract realm of its own. Media ecology is grounded, in part, in the materialism of modern science, and it follows that information cannot exist outside of the parameters of the physical universe. Information is produced by energy (which can also take the form of matter), Shannon defined it as the opposite of entropy [2], but the key point is that information as content or message must have some kind of material form. It cannot be present in a vacuum as it were, devoid of situational context or physical environment. Within the study of media as environments, information can only be communicated by a medium, can only be produced through the agency of a medium, can only emerge out of a medium as system, can only exist within a medium as environment [4].

1.2. Form and Information

The term *medium* includes the material, but also incorporates the methodological, the technique as well as the technology. This would include the *code* that is used to communicate information, as it is commonly understood that messages are *encoded* and *decoded* [2]. The code may be a language such as English, German, French, Hebrew, Hindi, or Mandarin; it may be a writing system that is logographic, syllabic, or alphabetic; it may be smoke signals, talking drums, semaphore flags, or

Morse code; it may be C++, HTML, Java, Python, or Perl, *etc*. Codes are also sometimes referred to as symbol systems, and more generally as symbolic form [5]. Thus, for example, Postman states that, "because of the symbolic forms in which information is encoded, different technologies have different intellectual and emotional biases." [6] Symbolic form itself may be equated with form in general, or it may be seen as a special case of form as a more general phenomenon. Either way, in being typically distinguished from content, it follows that form is the equivalent of medium. Apart from the code, other formal elements that may be identified within a message include style, tone, arrangement, treatment, pattern, *etc*. While the word *form* is present within the larger term *information*, the meaning of *information* can be understood to refer to that which resides within *form*, inside *form*, as that which is *given form*, that which is placed *in formation*.

1.3. Information and Remediation

The term *information* is commonly employed as a near synonym for *content* and *message*, but it can also be used to suggest something subordinate to the other two phenomena, as something contained within or carried by the content or message. Moreover, while *form* is in one sense an aspect of *medium*, it can also be regarded as part of the message. Formal elements such as the aforementioned style, tone, arrangement, treatment, pattern, *etc.*, whether understood as aesthetic, poetic, or rhetorical, are sometimes viewed as aspects of a medium's content that in turn take information as their content. As Marshall McLuhan observed, a given medium can become the content of another medium [7], as for example, spoken language becomes the content of written texts, the manuscript becomes the content of print media, print media become the content of electronic text. A motion picture broadcast on television becomes the content of the television medium, while a television image incorporated into a cinematic film becomes the content of that movie. Jay David Bolter and Richard Grusin refer to this process as *remediation* [8], and when a physical medium is remediated by another medium, it loses its material quality and becomes a code or style, as for example when handwriting is transformed into a choice of typefaces or fonts. The process of remediation is the equivalent of the nesting of systems within systems, so that the single cell as a system is part of the larger organism as a system, which is part of the larger ecosystem. Along similar lines, McLuhan noted that when a new environment is introduced, the older environment becomes part of its content [7] (and recall here the definition of media ecology as the study of media as environments).

1.4. Relationship and Meaning

McLuhan has been wrongly accused of claiming that content does not exist, which is absurd given that his argument is, in part, that content is influenced and shaped by the medium that is used [4,7]. What his observation does suggest, however, is that there are some instances when content may in fact be entirely reducible to medium. For example, the content of a given message can be said to be pure style or aesthetics, or it may be encoded in a language not known by the receiver, or the message may be nonsensical or so garbled as to be unintelligible (but in both cases still recognizable as a message). In such cases, we may rightly conclude that there is a message, but no information is present. Similarly, a message may be said to hold no information, for example if the same message is repeated over and over again, or if it is so entirely expected as to contain no *new information* (an obviously

problematic phrase, in that *new information* is redundant, and *old information* oxymoronic, except in the sense that information that is old to one party may be new to another, hence the expression, *that's news to me*).

Messages that contains no information can include those associated with ritual, including the everyday rituals of phatic communication (e.g., *hello, how are you? fine, how are you?*). Paul Watzlawick, Janet Beavin Bavelas, and Don D. Jackson separate communication into two levels, content and relationship [9]. Information can be exchanged on the content level, but only after channels of communication are established on the relationship level. Moreover, it is on the relationship level that instructions are provided on how to interpret information exchanged on the content level. Parallel to the content and relationship level of communication, Watzlawick *et al*. discuss the differences between communication and *metacommunication*, the latter being defined as *communication about communication*. The relationship level of communication, along with metacommunication, insofar as they stand in contradistinction from content, are the equivalent of medium (and therefore of environment, system, context, and situation).

Content and messages lacking in information can still have meaning. Like information, *meaning* is a term that has a great deal of significance within the field of media ecology. But unlike information, which is associated with novelty and situated within the message, meaning requires familiarity and is situated within individuals (and groups) [10]. Information is a type of stimulus, while meaning is understood to be a response to a stimulus, and can take the form of behavior (for most organisms) or thought (itself a form of behavior) [11]. Because meaning is in the eye of the beholder, so to speak, it does not require the presence of information, but rather can be said to be based on recognition and recall [12], and to a certain extent projection [13,14]. Meaning is not the opposite of information, but to the extent that meaning is based on familiarity, and information on novelty, the two can be said to exist in inverse relationship to one another. Meaning is generated, in part, by the grammar, rules, structure, *etc.*, of the medium, all of which are aspects of the code or form, and all of which place constraints on the information that can be transmitted or stored, thereby providing the needed redundancy to allow information to be meaningful, rather than being reduced to noise [15].

1.5. Information, Medium, and Environment

Postman notes that, "because of the accessibility and speed of their information, different technologies have different political biases." [6] Holding aside the effects, in addition to accessibility and speed of information, different media can be distinguished by the amount or volume of information that the can produce, contain, preserve, and transfer, by their capacity for information storage, information retrieval, information transmission, and information dissemination. In other words, *information* in various ways can be used to characterize a given medium. McLuhan goes so far as to declare that, "the electric light is pure information. It is a medium without a message." [3] In this instance, the concept of information is neither equivalent nor subordinate to that of content or message, but independent of them, much in the same way that the concept of medium is understood to be its own message, independent of any actual content. Similarly, information is used in a manner parallel to that of medium when it is combined with the term environment, so that the phrases *information*

environment and *media environment* are essentially interchangeable. For example, in *Teaching as a Conserving Activity*, Postman argues:

> Every society is held together by certain modes and patterns of communications which control the kind of society it is. One may call them information systems, codes, message networks, or media of communication. Taken together they set and maintain the parameters of thought and learning within a culture. Just as the physical environment determines what the source of food and exertions of labor shall be, the information environment gives specific direction to the kinds of ideas, social attitudes, definitions of knowledge, and intellectual capacities that will emerge [16].

Similarly, in *Take Today: The Executive as Dropout* coauthored by McLuhan and Barrington Nevitt, we find the following:

> Hypnotized by their rear-view mirrors, philosophers and scientists alike tried to focus the *figure* of man in the old *ground* of nineteenth-century industrial mechanism and congestion. They failed to bridge from the old *figure* to the new. It is man who has become both *figure* and ground via the electrotechnical extension of his awareness. *With the extension of his nervous system as a total information environment, man bridges art and nature* [11].

The use of *information environment* as an alternative to *media environment* has been irregular, but not uncommon, and the phrase *information ecology* has even made an appearance [17]. This suggests that understanding information as the equivalent or a subset of content or message is at best incomplete. Here, Watzlawick *et al.'s* view that content and relationship constitute different levels of communication can be helpful [9]. As noted, metacommunication messages provide instructions on how to interpret information, and following Boolean logic, instructions can be coded in the form of information, as a form of metainformation. To a computer, basic data such as a series of numbers, and instructions such as a command to add the numbers together, both take the form of binary code, the language of the machine. In human terms, establishing a relationship as being hierarchical (I'm the boss!) or egalitarian (Treat me like an equal!) provides information that helps to interpret content level messages (e.g., Can you get me a cup of coffee?). Following this model, we can distinguish between information on the content level (the message is the message), and information on the relationship or medium level (the medium is the message).

2. Information as a Variable in Media Ecology Analysis

Information on the medium level is most typically associated with *transmission*. In the well known Shannon-Weaver Model of communication, an *information source* encodes a *message* which is then sent out as a signal by a *transmitter*, over a *channel* to a *receiver* that decodes the message and sends it on to its *destination* [2]. It is important to note that this model is based on electronic media such as the telegraph or telephone, and not on, say, face-to-face conversation, or public speaking. In the case of the telegraph, the information source is the telegraph key, which is used to tap out a message in Morse Code, the message being sent as electrical impulses through wires, which are the channel (or in the cases of wireless telegraphy, the electromagnetic spectrum and the airwaves constitute the

channel), to be received at the other end where the electrical impulses are turned into a series of long and short beeps (which the telegraph operator translates from Morse Code to written alphabet). In the case of the telephone, the microphone is the information source, encoding sound as electrical impulses that the transmitter sends through telephone lines, the channel, where the receiver turns the signal back into sound played on a speaker.

The Shannon-Weaver Model reflects the close connection between information theory and the introduction of electronic communication technology, and serves as an adequate representation of the technical aspects of information transmission via electronic media. When it has been overgeneralized and used to represent communication in general, however, the model becomes easy to criticize as simplistic and inaccurate. Problems with the model include the fact that it does not allow for the complexities of human communication, which involve the use of numerous channels simultaneously; that it represents communication as one-way, not allowing for the fact that much of human communication entails interactions and transactions, and that these too occur over multiple channels simultaneously; and that it only represents dyadic communication, leaving out triadic situations, group contexts both small and large, and public and mass communication. Broadly, the model can be faulted for describing human activity by way of a mechanistic, technological metaphor, leaving out such vital concerns as meaning, purpose, and motivation. In the field of media ecology, the transmission or transportation view of communication that underlies the Shannon-Weaver model has been criticized and rejected in favor of metaphors emphasizing ritual and communication over time rather than space [18,19], transformation and the effects or message of the medium itself [20], and resonance and communication as the sharing of meaning [12,21].

Reducing the role of the medium to the narrow notion of *channel* suggests that messages can exist independently of a medium, that the sender somehow creates a message and only then decides which channel to use in sending it. In other words, the model does not recognize the prior existence of the channel or physical medium, which has much to do not only with the creation of the message, but in the decision to send a message in the first place [4]. Moreover, while the activities of encoding and decoding are sometimes included in the model, the prior existence of the code itself goes unmentioned, as if the message could be created without a code, rather than created by choosing units from the code itself (e.g., words, numbers) [4]. Messages are created by working with materials as well as by following formal, grammatical, structural patterns [22], so that the division between channel and code is somewhat artificial, a form of elementalism [14], and this is also true of the divisions between source, message, channel, and receiver, not to mention the fact that noise can be present at any point in transmission, not just in the channel. Moreover, the communication that is represented by the model is without context or situation, which is to say that it is without environment.

Given the inadequacies of the Shannon-Weaver Model for representing something other than the electronic signaling, it is still possible to consider the transmission of information as a medium-specific phenomenon. For example, the way in which information is transmitted via telegraph differs from the way in which messages are transferred via telephone, and from communication by way of wireless technology. Information shared via speech can be distinguished from information shared through writing. The kind of information transmitted through images is not the same as the type of information disseminated by words. Receiving information when alone and in the comfort of one's home is not the same as receiving the same information as part of a crowd in a public place.

One of the main tenets of media ecology is that different media have different kinds of biases (one of the meanings of *the medium is the message*). To analyze the biases of different media, it is useful to break down the concept of *transmission* into more specific characteristics, such as communication over space or distance, speed of transmission, dissemination or relationship between sources and receivers, conditions of attendance for the audience, accessibility of information to the audience, access to and control of the transmission process, information storage, volume or amount of information, and the form that information takes or the code that is used [6,23–26]. Each of these characteristics can be examined in their own right, but it is essential to remember that they are all interrelated and cannot truly be isolated from one another.

2.1. Space

The human species is believed to have originated in Africa, and spread from there to the four corners of the world, so that information can be carried along with human migration. That is, at least *in theory*, given enough time, information can be transmitted over almost any distance, even if the messenger travels on foot. In practice, information remains confined to local areas and the small networks of the clan, tribe, and village, as long as communication is conducted entirely by word of mouth. The game of telephone, originally developed to investigate the oral transmission of rumors, is a poor representation of communication within oral cultures, as it does not take into account mnemonic techniques adopted to increase redundancy and otherwise reduce noise in the transmission process. But there is no doubt that the invention of writing vastly increased our capacity to deliver messages over distance with complete fidelity. Writing is associated with the growth of settlements from small villages to the cities of the ancient world, and lightweight, easily transportable writing surfaces are closely connected to the rise of the empires of antiquity [19]. The invention of paper and its diffusion during the medieval period, and the development of the printing press with moveable type in the early modern period, each in its own way extended the reach of human communication. Both oral and written communication across space was entirely dependent on physical transportation up until the 19th century, so that improvements in our ability to travel over land (e.g., Roman road building, and the building of railroads) and water (e.g., the introduction of carracks, caravels, and clipper ships) extended the distance over which information could be disseminated with relative ease and reliability.

More recent progress in transportation is not without significance, but has been vastly overshadowed by the electronic media's ability to transmit information instantaneously. The telegraph was the first medium to split apart information transmission from physical transport, translating material objects (*i.e.*, a written message) into energy (*i.e.*, electrical signals), and in this sense presages the splitting of the atom, with similar explosive effect on human life. While the telegraph was said to have transformed the vast continental spread of the United States into a single neighborhood [18,27], space was more broadly conquered by Marconi's wireless. Satellite communications extended information's reach to the entire planet, giving us what McLuhan termed the *global village* [28–30], with the internet and mobile devices filling in the gaps. Electricity truly marks the turning point in this regard, so much so that the *transmission* view of communication originates in the 19th century with the advent of telecommunications [18,31]. In response to this historical development, Postman echoes Thoreau's famous criticism of telegraphic communication in suggesting that the instantaneous

transmission of information is characterized more often than not by irrelevance, and given our inability to act on the information, a sense of impotence [32,33].

2.2. Speed

Much of what has been written in the previous section applies to the speed of transmission as well as the ability to cover distance, as the two are very closely interrelated. McLuhan placed a great deal of emphasis on the significance of electric speed, which in turn speeds up human activity in general [7]. Instantaneous transmission of information challenges the ability of the receiver to process information in a sequential manner, so that linearity, the idea of taking things one step at a time, is severely undermined. This is manifested in the loss of logical thought, need for consistency, sense of history and progress, and narrative plotting. McLuhan noted that longstanding linear frameworks and approaches are giving way to pattern recognition as a means of making meaning out of simultaneous multichannel messaging. Multitasking likewise appears as a response to the speeding up of communications, albeit not necessarily an adequate response. Speed-up is a significant factor in the problem of information overload, and to an overall sense of incoherence in culture and communication [32,34,35].

2.3. Dissemination and Conditions of Attendance

The Shannon-Weaver Model represents what in technical terms would be called point-to-point transmission. In human face-to-face communication, this most closely resembles dyadic situations such as conversation and dialogue, albeit minus the back-and-forth. Such interpersonal communication can also occur in the context of small groups without much altering the essential quality of one-to-one transmission. It is also possible to have communication on a one-to-many basis, such as we associate with public address and oratory (as well as other forms of oral performance). In ancient Greece, where the written word had given rise to both a larger, more complex form of social organization in Athens and its neighbors and colonies, and a more sophisticated form of public speaking through the development of rhetoric (the use of writing to review, edit, and study oratory), the conflict between the philosophers and sophists represented a contrast between the two types of relationships, one-to-one and one-to many. And while dialogue emerged as the generally accepted ideal form of communication, public address remained highly significant in politics, law, and religion [36].

The printing press with moveable type introduced by Gutenberg in the mid-15th century, in mechanizing the act of copying written works, provided unprecedented possibilities for the mass production of messages. This new ability to communicate from one-to-many eliminated the noise introduced via scribal corruption, and made the mass dissemination of information a reality. Speed of dissemination was limited, however, by the fact that the press was for the most part powered by human muscle until the introduction of steam powered printing in the early 19th century truly ushered in the age of mass communication. By the end of the century, Marconi's wireless telegraphy opened the door to broadcasting, a new kind of mass communication, and commercial radio became commonplace during the 1920s. Mass dissemination of information is not easily separated from mass opinion, advertising and public relations, and propaganda—indeed, the term *information* is used as an euphemism for propaganda in the United States and elsewhere (e.g., the United States Information Agency).

While steam-powered printing and broadcasting are similar in their potential for the mass dissemination of information, they differ in that printing requires physical transportation from the point of production out to the mass readership, reinforcing the center-margin relationships that can be traced back to the first empires of the ancient world, made possible by the written word and lightweight writing surfaces. Broadcasting, on the other hand, does not disseminate a fully formed message in the way that printing does, but rather sends out a signal that is transformed into a message at the point of reception, by the user's radio or television set. In this, the electronic media follow the bias towards decentralization associated with electricity and electric technology more generally, as Lewis Mumford first observed [37]. For McLuhan, this meant the dissolution of center-margin distinctions, so that anywhere and everywhere is potentially a center, at least as long as it is in range of broadcast signals [7,29–31,38]. This shift is further realized by computer networks and mobile devices. Moreover, electronic communications facilitate many-to-many communication in a manner never before possible. The potential was first glimpsed in the early days of radio, when the medium was still dominated by amateurs, and continued in the relatively narrow part of the spectrum reserved for citizen's band and ham radio operators. It was the internet, however, that revolutionized many-to-many communication, so that information now is seen as distributed, to a large extent, through decentralized networks, along with being shared through one-to-one interactions, as well as disseminated from one-to-many.

The relationship between sender and receiver is connected to the conditions of attendance by which information is received and decoded. Oral communication is communal in nature, whether it is the bond formed by dialogue between two individuals, or the fact that the audience for public speaking and oral performance form a unity, linked by the fact that they are receiving messages simultaneously in addition to their co-presence in time and space. Whereas listeners come together as a unified audience, readers must isolate themselves, at least psychologically, in order to decode written messages. Listening to a book read out loud, therefore, constitutes an entirely different experience than reading a book silently, and this affects and alters the decoding process. The cinema, appearing as an adjunct of live performance in the late 19th century, weds mass communication to the communal experience of the audience as large co-present group. During the 20th century, sound amplification create two quite distinct situations: The speech or oral performance before live audiences of unprecedented size made possible by the addition of public address systems (Leni Riefenstahl's 1935 Nazi propaganda film, *Triumph of the Will*, offers a chilling portrait of this communication context), and the radio broadcast heard at home by isolated individuals or by families and other small groups. Further, even in the privacy of the home, radio and television transmission differs markedly when attended to with others or alone, and changes dramatically when received in a public setting. Similar contrasts can be made between information received while listening with headphones or through speakers, whether indoors, in a car, or on the street. McLuhan believed that the difference between images projected onto a screen and from behind a screen made a great deal of difference in how they are decoded [39], and we may similarly consider the proliferation of screens today via smart phones, tablets, and digital TV and computer displays as providing a variety of new conditions of attendance for individuals.

2.4. Access

Conditions of attendance have some bearing on the accessibility of information to audiences and receivers. Access to information via the spoken word is relatively open among individuals who speak the same language, albeit limited in reach and breadth of dissemination. Reliance on the written word changes patterns of access, extending accessibility in some ways, but creating significant barriers with the addition of the prerequisite of learning how to read. Complex systems of notation such as logographic writing (e.g., cuneiform, hieroglyphics, Chinese ideograms) tend to limit access, leading to the creation of what Innis referred to as *monopolies of knowledge* [20]. Other barriers include the use of learned languages for written documents (e.g., Latin, classical Greek, ancient Hebrew), scarcity of written documents and/or writing materials, and even heavy use of calligraphy, which slows reading and detracts from legibility. Increases in accessibility associated with the introduction of simplified writing systems, especially the alphabet, and mass production of texts and publication in the vernacular, as occurred during the printing revolution in early modern Europe, have resulted in the disruption of hierarchies and shifts in favor of democratization. In the modern world, for example, printing set the stage for the Protestant Reformation, breaking the monopoly of knowledge held by the Roman Catholic Church in western Europe, and for the rise of nationalism which was accompanied by the decline of the aristocracy in favor of the middle class, transitions towards various forms of democratic governments, and other manifestations of populism [20,29,40,41].

Printing led to a proliferation of images as well as writing, and it was the 19th century that saw the onset of what Daniel Boorstin referred to as the *graphic revolution* [42], a vast expansion of our ability to produce and distribute visual images. Through a variety of technologies for the mass production of print graphics, the invention of photography and the motion picture, and in the 20th century the invention of television, the western world became, in many ways, an image culture. Visual communication, amplified by electronic transmission, vastly increased the accessibility of information, as it bypassed the barriers of literacy and education. Unprecedented access to information has disrupted the stability of social roles based on gender, race, ethnicity, religion, age, and socioeconomic class, and undermined authority relationships [25]. Computers and the internet have made information even more accessible than previously thought possible, eradicating almost all vestiges of privacy and secrecy. While some concern has been raised about the digital divide, the cost of access has been steadily reduced, and options for free access increasing. And while new media have relied on text-based forms of communication, as the technology evolves, increasingly more emphasis is being given to more accessible forms such as podcasts and online video. Moreover, McLuhan's argument that the electronic media eliminate center-margin distinctions is evidenced by the potential to access information from any location via mobile devices, most of which now incorporate screens and cameras.

Access to information is of great significance, and can be represented by the act of reading, which begs the question, what of writing? For typical individuals, speaking and listening are inseparable aspects of spoken language. And for the most part, we learn to read and write at the same time, although it is possible to teach reading without writing, and it has been done at times in the past. The printing revolution introduced a read-only emphasis, in that typography relies on heavy and expensive machinery, and the various forms of mass communication introduced in the 19th and 20th centuries

have tended to amplify this disparity. The introduction of new media in the final decades of the 20th century opened up new possibilities for access to the transmission process, the ability to send as well as receive information. The shift from read-only to read-write set-ups means greater audience control. Increased access to information facilitates democratization, but that trend can be mitigated through restricted control over the source of information. Power disparities are more readily eliminated when the transmission process is open and easily accessible.

2.5. Time

Transmission of information is generally discussed in regard to space, and the speed at which distance can be bridged, but transmission can also occur over time [20], a process otherwise known as information storage. In a sense, information needs to be stored for at least the length of time required for its transmission, even if it is just an instant, but it is not speed, but rather duration and durability that is the concern here. Languages store information in the code itself, by identifying what phenomena in the environment are worthy of being named and therefore need to be attended to, and by providing the grammar to properly interpret messages [43–45]. Symbolic communication provides a unique potential for what Korzybski referred to as time-binding, the ability to communicate information over time, from one generation to the next [14]. The spoken word, being ephemeral, is a poor medium for storage, however, and collective memory is required to preserve language and its contents. Oral cultures clearly have limited capacity for information storage, and fidelity is likewise limited in transmission over time, although this has the virtue of providing flexibility [20] and aiding in homeostasis [22,46].

Notational systems, and especially the written word vastly increase our storage capacity, which is why they are intimately associated with the shift from tribal society to what has traditionally been termed civilization. Durability is an important factor in storage capacity, so that monuments and architecture can be highly effective forms of information storage, and writing on stone and clay tablets, and parchment manuscripts, all of which Innis termed heavy media, help to transmit information accurately over time, albeit at the cost of reduced flexibility, increased rigidity of culture [20]. Copying of written texts provides new forms of flexibility and new sources of noise in transmitting information over time, in the form of scribal corruption. Printing, in producing multiple, identical copies of a text, aided in the storage of information and eliminated the multiformity of oral and scribal transmission [40]. By the 19th century, information storage led to an unprecedented historical consciousness in the western world, further enhanced by new capacities to store visual, audile, and audiovisual information. Although broadcasting is exceedingly ephemeral, technologies for electronic recording have proliferated, and digital technologies coupled with computer databanks represent the possibility of *total recall*, a prospect at once exciting and worrying for its surveillance implications [47]. Digital archives promise unprecedented access to stored information, but concern exists that changing formats may make older archives inaccessible. Even data stored in digital form is dependent on certain types of software needed to read the files, a form of metainformation, and there already are many instances where new versions of programs cannot read the files produced by older versions of the same program.

2.6. Volume

All of the above variables contribute to the volume or amount of information that exists within a culture at any given time. Innovations in communications have generally resulted in increases in information volume, as we have moved from oral cultures to literate cultures, from scribal cultures to print cultures, and now to electronic cultures and digital cultures. As the volume of information has grown, we have seen shifts away from material objects and towards pure information, e.g., e-mail and text messaging, electronic monetary transfers, e-books, *etc*. In this sense, we have become aware as never before that we live in an information environment, and we have come to characterize our time as an age of information (a point I will return in the concluding section). While there are times when insufficient information is a problem that needs to be remedied, over the past century we have reached the point where information overload has become a more commonly voiced concern. Postman argues for the need to restore barriers to information, warning that we are *informing ourselves to death*, and noting that information will not solve the basic problems associated with the human condition [35,48]. In recent years, others have written popular works offering advice on how to cope with the deluge and work effectively with the new media [49,50]. And while we may celebrate the demise of gatekeeping as imposing unnecessary barriers on access to information, this change comes at the cost of a loss of editorial function, of professional expertise that aids in the evaluation of information. The tragedy of 11 September provides a case in point, as sufficient information was gathered to warn of the attack, but intelligence analysts were unable to put the pieces together, to engage in the synthesis needed to understand its meaning and implications.

2.7. Analogical and Digital Codes

From the perspective of Shannon's information theory, the only variable that matters in regard to the code used to transmit information is quantitative, the number of units, possible messages, signals or symbols within the code [2]. This allows for the measurement of the information contained within a series of messages, based on the probability (the larger the number of units within a code, the less probable the message, the greater the amount of uncertainty reduced by the message, the more information that it carries). This in turn allows for a measurement of the degree of complexity within a given system, but provides no insight as to the meaning of whatever is being transmitted. Moreover, such measurement is only possible if the code is digital, that is, if it is made up of discrete units. It is difficult if not impossible, however, to apply any form of measurement to analogical communication, such as images. While it is possible to digitize images in order to store or disseminate them electronically, the digital file is not itself an image, and tells us nothing about the information associated with the image itself. The image, as a picture, cannot be broken down into discrete units, but must be understood as a continuous whole, based on its resemblance to what it represents.

The fact that digital codes such as spoken language (for the most part), writing systems, and mathematical notation consist of discrete units whose meaning or value is more or less arbitrary, conventional, and clearly defined, while analogical codes such as images, most forms of nonverbal communication, and most forms of art and direct perception are relatively continuous and cannot be broken down into discrete units (in a picture, what line or bit of color constitutes one unit clearly

separate from the next?), is itself a significant different between different types of media. As Susanne Langer notes, digital or as she terms it, *discursive* forms, while being propositional in character (able to form statements that can evaluated as true or false, or at least open to falsification), make up a small portion of the symbolic forms used by human beings (Langer does not use the term code herself, but the concept of code and symbol systems are essentially the same). Most of our codes, or more accurately, most of our art forms, are analogical in nature, or in Langer's terms *presentational*, and are associated with the inner world of feelings and emotion, rather than factual descriptions about the outer world [5]. Thus, as noted above, Postman argues that when information is encoded in different symbolic forms, it will have different intellectual and emotional biases [6]. Although it is not possible to measure analogical form, Meyrowitz intuits that much more information can be communicated by pictures than by words, and in a manner much less under the control of the information source (in this sense, control is related to measurement), and this has much to do with the disruptive impact of television [25].

The distinction between analogical representation and digital coding of information can be seen as rooted in the difference between nonverbal and verbal modes of communication, and between direct perception of reality and the use of symbols to mediate between thought and perception (this is, admittedly, an oversimplification of a complex process). Human communication is distinguished from that of all other species, more or less, by the use of symbols, as exemplified by language, and scholars such as Gregory Bateson consider symbolic communication to be the basis for all other digital coding that humans beings employ:

> Verbal language is almost (but not quite) purely digital. The word "big" is not bigger than the word "little"; and in general there is nothing in the pattern (*i.e.*, the system of interrelated magnitudes) in the world "table" which would correspond to the system of interrelated magnitudes in the object denoted. [51]

Language as a code may be essentially digital, but in practice the spoken word mixes the digital code with analogical forms of communication such as tone of voice and other paralinguistic cues, not to mention the equally analogical use of gesture, posture, facial expression, touch, and other forms of nonverbal communication. Symbolic communication, a creation of the mind, may allow for digital representation, but the body is hopelessly analogical by its very nature, and where human presence and face-to-face communication is involved, the digital cannot be isolated from its analogical context. Some of this is carried over into written communication (e.g., handwriting and penmanship as analogical form), printed documents (e.g., font and layout, not to mention illustrations), and electronic communications (e.g., the mixture of language and image on television).

The difference between digital codes/discursive form and analogical codes/presentational form is one of the most significant in the field of media ecology, but it is also acknowledged that, within these categories, different forms or codes have different biases. Edward Sapir, Benjamin Lee Whorf, and Dorothy Lee are most often associated with the position that different languages codify reality in different ways, utilizing different grammars as well as vocabularies, and that these differences influence the way individuals view the world [43–45]. Edward T. Hall extends this idea to culture in its entirety, arguing that each distinct culture is in its own right a symbol system or code [52].

Edmund Carpenter extends the idea to media, arguing that every medium has its own grammar, its own biases, and therefore its own worldview [53].

2.8. Orality and Literacy

Along with the distinction between word and image, and more generally the digital and the analogical, within the field of media ecology great emphasis is placed on the distinction between orality and literacy, that is, the difference between speech and writing as linguistic codes. Rather than the spoken word and the written word being two parallel symbol systems, however, writing is defined as a secondary symbol system [22], used to encode the primary symbol system of speech. As previously noted, the content of writing is speech, and this form of remediation represents the digitization of one digital code by another. The result is that the written word is a more abstract symbolic form that the spoken word, one that involves a process of decontextualization, as language is removed from the context of co-present communicators, and also from the rich accompaniment of nonverbal communication that also acts as a form of metacommunication (as tone of voice facial expression, gesture, posture, *etc*., all are cues that can help the receiver to interpret the information associated with the verbal message).

In addition to decontextualization, the encoding of spoken language into written form involves a translation from one sensory mode to another, from hearing to vision. This is a qualitative shift, with a variety of implications, as previously noted, including much improved fidelity in messages transmitted over space, the ability to evaluate messages more effectively by allowing for their review and objective analysis, an enhanced ability to formulate messages given the potential for editing and rewriting, and the enormous expansion of our capacity for information storage. All of this contributes to a great increase in the volume of information in societies with writing, especially as writing systems becomes more efficient through the development of phonetic writing, and in particular the alphabet. Again, as previously noted, this sets the stage for the information explosion resulting from the printing revolution that began in mid-15th century Europe, and that has been further extended by the many innovations in communication technology of the past two centuries.

While our present era is often referred to as *the information age*, Michael E. Hobart and Zachary S. Schiffman argue that it is simply the most recent in a series of *information ages* that begins circa 3500 BCE in Mesopotamia:

> The invention of writing actually gave birth to information itself, engendering the first information revolution. Writing created new entities, mental objects that exist apart from the flow of speech, along with the earliest, systematic attempts to organize this abstract mental world.... [54]

Writing, as a code that encodes a code, extends the digital quality of language, but what Hobart and Schiffman stress is writing's decontexualization of the word, as it removes language from the context of a specific time and place, while providing discourse with a degree of permanence previously inconceivable. In doing so, writing also gives us the ability to take words out of their natural context of human dialogue and oral performance alike, for example, as Goody notes, in the very basic activity of making lists, one of the first uses of the written word [46]. In a list, we can have subjects without

predicates, for instance, 12 chickens, 7 cows, 20 bushels of wheat, but in conversation, such utterances would make no sense, prompting the listener to respond, "What about them? What are you trying to say?" Writing even establishes the concept of words as separate things, each word represented by its own character or group of characters, whereas in speech words can be strung together without pause as a single vocalization or utterance. As Hobart and Schiffman explain:

> Information came into being at the cusp between orality and literacy, a singular moment that cannot itself be understood unless we first consider the nature of the oral culture that literacy would transform. In this oral world, memory functioned in sharp contrast to the way we literates conceive of it, not as a container for information but as a participatory act, commemoration, serving to maintain social consensus. The emotional power and immediacy of this activity prevented its participants from distinguishing between the context and the experience of commemoration in any consistent manner. Only with this distinction did the mental object we call information come into being, and only then could memory become a container for them. The information revolution born of literacy is all the more stunning and revolutionary when seen in stark relief against an oral world where information did not exist. [54]

Hobart and Schiffman stress that the accumulation of information following the introduction of writing eventually leads to a situation of information overload, and necessitates new innovations for managing that overabundance; this is a process that Paul Levinson refers to as *remedial media*, newer media invented to remedy the problems introduced by older media (for example, the invention of windows led to the remedial medium of window shades or curtains, the invention of the telephone eventually led to the telephone answering machine, and television to the VCR and DVR) [55]. The remedy for the information overload brought on by alphabetic writing was Aristotle's methods of classification, and the logic used to govern their use, and Hobart and Schiffman make the case that this Aristotelian approach, with some modifications, was sufficient for the volume of information characteristic of chirographic media environments, that is up until the printing revolution in early modern Europe. Moreover, Logan aptly explains how the solutions to the problems posed by the information explosion resulting from the alphabet were inherent in the alphabet itself as a medium of communication [56]. And while Hobart and Schiffman emphasize the techniques of logical analysis, it would also follow that the material innovation of the parchment codex also provided a means for improved management of information, providing greater accessibility by storing more information in one volume than scrolls are able to, and allowing for random access (flipping through pages) in a way that scrolls cannot.

In regard to the information explosion occurring in the wake of the invention of the Gutenberg printing press, the remedy that Hobart and Schiffman identify is numeracy, and Descartes' dream of mathematical rationality, leading up to the development of calculus. Here too, we can identify other efforts such as the consistent use of alphabetical order, page numbers, table of contents and indexes, footnotes and bibliographies, references and citations, not to mention the production of reference works such as dictionaries, thesauri, and encyclopedias, and more ephemeral items such as almanacs, catalogs, and calendars. Elizabeth Eisenstein notes the importance of printing in the production and distribution of the visual display of information in the form of tables (e.g., multiplication, sine, cosine,

tangent, logarithm, *etc*.), graphs and charts, *etc*. [40] Even the simple outline as a form of visual organization does not become commonplace until after printing, and is related to the educational innovations of Peter Ramus, as Walter Ong explains [57]; in this, we also see the origins of the school textbook as a medium for the collection and organization of information. Of course, dating back to antiquity, schools themselves along with libraries were also methods developed for storing and managing information, and both received significant impetus in the typographic era.

The communications revolution of the 19th century, which began with the application of steam power to the printing press, producing the first mass circulation daily newspapers, led in turn to the development of Boolean logic, the 19th century foundations of computer technology (e.g., Charles Babbage's unfulfilled plans for a difference engine, and the actual Hollerith punch card machines used to tabulate data), and the actualization of computer technology during the 20th century (e.g., Alan Turing, and the first electric, digital computers such as ENIAC). Currently, computer databases, hypertextual interfaces such as the World-Wide Web, and search engines such as Google, all are means for coping with information overload, albeit not always completely or successfully. The key point that Hobart and Schiffman introduce, that new information technologies lead to other new technologies and techniques for organizing information, returns us to the two levels of content/communication and relationship/metacommunication. In other words, as the introduction of new media results in increases in information on the content level, this in turn requires innovations on the medium level to assist in providing second order information, information about information.

3. Information as Function

In his popular book, *Being Digital*, published in 1995, Nicholas Negroponte famously set up a polar opposition between atoms and bits to illustrate the transition from print media and other material products (e.g., film, records, tapes, disks) to digital media [58]. In doing so, he implied that the two types of "particles" are in some way comparable, that matter and information are both different types of *substances*. But from the perspective of the physical sciences, the counterpart of matter is energy, and it would make more sense to contrast atoms with electrons (and photons), or with electricity and the electromagnetic spectrum. With this understanding, it becomes clear that media ecology scholars such as McLuhan and Mumford were correct in identifying electrical energy, electric technology, and the electronic media as the key turning points in technological evolution [7,38], with digital technology simply being a further elaboration of the main shift.

Understanding that energy is the appropriate equivalent to matter helps to clarify the fact that information represents another type of phenomenon altogether. We discuss information as if it were a substance, as something contained within and/or transmitted by a message or medium, and we do so as a matter of convenience. This kind of usage often is associated with popular and commonsense discourse, where the term itself is not subject to precise definition. A more nuanced approach would be to define information not as a substance, but as a *property* of a substance, *i.e*., a property of a signal or message, or a property of a stimulus (which presupposes an organism that receives it) or a property of energy. Like other properties, such as weight and size, information can be measured, so this view is consistent with information theory, within which Shannon placed information into direct relationship with the measurement of entropy [2].

From a communication theory perspective, though, information is best understood as a *function*, as a function of form (returning us to the earlier point of being in-*formation*), and therefore as one of various different functions of communication (e.g., to inform, to persuade, to educate, to entertain, *etc*. [59,60]) As a function, it also relates to purpose (the intent to inform, whether successful or not), and to effects (the effect of having been informed, whether that was intended or not). This process, then, is nested within the process of communication, which itself can be understood a function of a larger process, which can be referred to as *mediation*, by which I mean the function carried out by media, within a media environment [27]. The general function of communication, which includes the specific function of information, can be understood as part of an even more general function of mediation (which can occur among individuals and between individuals and their environments). In this way, understanding information helps us to frame communication and mediation as kindred concepts. Information, communication, and mediation represent three orders or levels of function, corresponding to information, message/content, and medium/relationship, each one a subset of the next.

3.1. Information as News

Gregory Bateson emphasizes the fact that information is essentially about *differences*, including and especially second order differences, that is, *differences that make a difference* [51]. The function of information constitutes an alert about changes or differences in the environment of an organism, or in its own internal workings. As he puts it:

> When I strike the head of a nail with a hammer, an impulse is transmitted to its point. But it is a semantic error, a misleading metaphor, to say that what travels in an axon is an "impulse". It could correctly be called *news* of a difference (emphasis added). [61]

The discernment of difference can be seen as a form of cognition, or information processing, and it is a function that can be carried out by a variety of different systems, be they biological, technological, or sociological. Systems at the very least must maintain a boundary against their environment, in order to maintain their integrity and identity, their very existence as systems separate from their environment. This closing off from the environment is associated with the process termed *autopoiesis* by Humberto Maturana and Francisco Varela, the self-organization of the system [62,63], and while their focus is biology, the concept can be generalized to other types of systems, including social systems [64–66]. Establishing a boundary between system and environment, self and not-self, is essential, but that boundary must, to some degree, be permeable, open enough to allow the system to absorb whatever materials and energy it needs to maintain and renew itself, and the ability to differentiate between what in the environment is safe and nourishing to absorb and what is not, also involves information processing, and therefore a form of cognition. If we use the metaphor of information as substance, we might say that, first and foremost, what the organism is open to is information about the environment, or as Bateson would put it, news about the environment (for this reason, I like to say, as a variation on McLuhan, that *the medium is the membrane*). From a functional perspective, gathering and processing news about the environment is one of main tasks of the system's boundary, along with maintaining the integrity of the system itself.

The sociological function of surveillance of the environment [60] is considered universal to the human species (and to other social species as well), and the internal dissemination of information about the environment, and about other parts of the system, is what we commonly refer to as *news*. Mitchell Stephens, in his *History of News*, notes that in oral cultures, news was transmitted by word of mouth, by messengers, criers and singers, and by such media as smoke signals and talking drums [67]. The introduction of writing allowed for more formal approaches to news to develop, for example news sheets such as the ancient Roman *acta* and Chinese *tipao*. The printing revolution resulting from Gutenberg's mid-15th century invention gave rise to various forms of pamphlets, letters, broadsheets, *etc*., that functioned as news media, and eventually to the newspaper itself beginning in the 17th century. The innovation of the printed newspaper as a periodical published frequently and according to a regular schedule established the media environment within which the modern concept of news could begin to emerge. Printing gave us the first form of mass communication, allowing for the mass dissemination of information, but whether and to what degree mass media actually transmit information about the environment as opposed to manufacturing news in their own image is a matter of some debate [33,66,68,69]. It is certainly the case that the content of news media is shaped by the technologies and codes used to disseminate it, which in part is what McLuhan meant in saying that the medium is the message [4,7].

News as we understand it today would not be possible without the printing press, but it is also the product of further technological developments occurring during the 19th century. One of the earliest and most important was the application of steam power to the press, which was previously operated largely by hand. This innovation represented a giant leap in mass production capabilities, giving rise to the first mass circulation daily newspapers, while economies of scale allowed for the papers to be sold at much cheaper prices than previously possible (e.g., the penny press in the United States). The need to fill these papers with news led to the regular employment of reporters, and with it the separation of reporting from editorial functions; at the same time, in search of content for these media, newspapers turned for the first time to covering crime on a regular basis [70]. It also inaugurated the shift from simply gathering the news to manufacturing the news, through innovations such as the interview, the publicity stunt, investigative reporting, and eventually the press release, press conference, and such phenomena as background briefings, trial balloons, and leaks [68].

While publishers and editors felt free to express their opinions and endorse political candidates and initiatives, the ideal of objective reporting gained momentum over the course of the 19th century [70], with opinion relegated to the op-ed pages, in part in an effort to appeal to a broad and heterogeneous readership. Objectivity in reporting, with its stress on the propositional character of language as a discursive symbolic form, had much to do with the popular conception of news reporting as pure information, *factual information*, so to speak. In this sense, *information* might be distinguished from *ideas*, which originate from human beings and therefore are inherently subjective in nature. The notion of a *free marketplace of ideas* is based on the assumption that competition among them will lead to the discovery of truth. There is no comparable sense of a *free marketplace of information*, because objective descriptions are assumed to be true in that they are propositions or statements of fact that can be checked for accuracy, much like scientists can test each others' findings. It would follow that news should remain essentially the same no matter which reporter or newspaper it originates from, as the reports would or should contain essentially the same information. Complementing this rational conception of news, the

development of various methods of printing images, and especially incorporating photographs into print media, gave information a new form, later to be complemented by motion pictures and television. As noted, the resulting flood of visual images constitutes a new, unprecedented kind of information explosion, unquantifiable, seemingly objective but in a form that appeals to the emotions rather than to reason [25,33]. While in some ways counterbalancing the rationality of objective journalism, ultimately the result are two extremes of irrationality and hyperrationality [27].

Perhaps no technology more radically changed the concept of news than the telegraph. As previously noted, it transformed material, written documents into electronic signals for instantaneous transmission, and in this sense helped to form the modern idea of information, as well as news. As McLuhan observed, telegraphic news was associated with the breakdown of linearity in newspapers, as the storyline gave way to the dateline, a loss of narrative form that helped to give the impression of news as pure information [7]. In place of a linear progression of events, the inverted pyramid format was introduced, where the article begins with the most important information in the first paragraph, the *who*, *what*, *where*, *when*, *why*, *and how*, followed by information of lesser importance in each succeeding paragraph. In this way, editors would still have the main news "story" even if transmission broke down before the full report was transmitted. And they could easily shorten the articles to fit them into the available space for a particular edition of the paper. This speed-up also led to a change in the face of the newspaper, from a relatively linear display to the *mosaic* (to use McLuhan's term) of the modern front page, with its hypertextual mix of different, unrelated articles.

The telegraph, which gave rise to the wire services (e.g., Associated Press, Reuters), also had the effect of turning news into a commodity to be bought and sold [19,20], independently of any given newspaper. By 1870, telegraphic printing systems, popularly known as ticker tape machines, disseminated financial information directly to business offices. By the end of the 19th century, Marconi's wireless technology had demonstrated that information could be disseminated through the airwaves, truly giving us *news from nowhere* (the title of a late 19th century utopian science fiction novel by William Morris). With the introduction of radio, and especially following the end of the First World War, news had become more fully decontextualized than ever before, and broadcasting signaled the beginning of information overload in the 20th century, marked in Postman's estimation by irrelevance, incoherence, and a sense of impotence on the part of the audience [33].

3.2. Information as Control

News relates to information on the content level, and various efforts to analyze news would constitute metainformation on the relationship or medium level. As noted earlier, information overload gives rise to new methods and technologies that organize, analyze, and synthesize, and otherwise perform the function of control. Indeed, Norbert Wiener believed the function of control to be so central to the concept of information that he coined the term *cybernetics* to refer to a new science of control [71,72], paralleling Shannon's information theory [2]. Wiener went so far as to declare that *communication is control*, by which he meant that the transmission of information into an environment has an influence on that environment, and therefore serves to control that environment in certain ways. Note here that we are no longer referring to metainformation used to control information on the content level, functioning internally within an information system, but rather to information used to

control some aspect of the external environment (which could be viewed as an information system in its own right). As opposed to *news*, which corresponds to information on the content level, *control* corresponds to information on the relationship or medium level (but can constitute a response to news as feedback, or feedforward).

In military circles, the function is referred to a *command and control*, and indeed, any medium of communication can be used for the purposes of control. Innis notes that the ability to communicate over space is necessary for control over territory, so technologies of transmission and transportation are essential to organized force [20]. Writing is a key technology for organizing armies as well as massive labor projects in the ancient world, as Mumford makes clear [73], and Innis particularly stressed the relationship between light media such as papyrus used as a writing surface, and the expansion of power from the settlement of cities to the conquest of empires in the ancient world. Heavy media can also be seen as performing the function of control, in this case over time, but information storage is a one-way form of transmission, and therefore lacks the ability inherent in two-way systems to receive feedback and adjust accordingly. Wiener argues that feedback is the key to enhanced control, and writing, as a medium that allows for messages to be sent back and forth, provides that cybernetic function.

Although Mumford's discussion of the mechanical clock [38] precedes and therefore does not use Wiener's terminology, it is clear that this innovation, invented in 13th century Europe, was a form of information technology, a forerunner of the computer and a cybernetic technology [47,74]. The mechanical clock produced no physical product, but rather functioned only to disseminate information. Its multiple, identical units (e.g., hours, later minutes, and seconds), while evolving out of the digital technologies of writing and the alphabet [7], set the stage for mechanization, mass production, and eventually industrialism. But most important of all, as Mumford argues, the main function of the mechanical clock was to control and coordinate human activity [38]. First developed in monasteries as a means of getting monks to pray at the appointed times of day, the technology was quickly adopted by towns, where its ability to synchronize action was put to commercial use. The metaphor that time is money originates from this point of transition.

Printing represented a further extension of mechanization, and while lacking an effective feedback mechanism (although the exchange of written messages could still be employed), its potential for mass dissemination of information made it a very powerful blunt instrument of control; that the messages were identical in form introducing an unprecedented homogenizing force into human culture that was instrumental in establishing the modern nation-state, and its colonial empires [7,20,29]. According to Innis, telecommunications in the 19th and 20th century for the most part further extended the emphasis on control over territory, and the drive to empire, whether it involved military control, political hegemony, or economic power [20].

Again, the introduction of telegraphy stands as a watershed moment in the history of information, extending control over space, and opening the door to the nationalism movements of the 19th century, and increased centralization of authority [19,20]. An excellent example of the cybernetic function of the telegraph was its use to solve the problem of railroad accidents. With the introduction of the steam-powered trains in the early 19th century came a significant speed-up in transportation, but no way to control railway traffic. Not only did the telegraph provide a means of communication that could easily outrun a speeding locomotive, but it introduced the possibility of homogenizing time. Clocks,

while serving a cybernetic function locally, could not be synchronized from one city to the next, and trains likewise could not be coordinated, until the telegraph introduced instantaneous transmission. With the newfound ability to set the time simultaneously at different locations, the railroad companies in the United States established the first time zones, whose administration was soon taken over by the federal government, an innovation that then spread across the globe. In this way, trains travelling from different locations would be travelling according to the same time settings, and this new form of synchronization drastically reduced collisions between locomotives heading in opposite directions.

Additionally, telegraph and telephone together provided the control needed for organizations to develop horizontally, with offices in different locations, creating the foundations for the modern corporation. In the 20th century, Marconi's wireless provided a measure of control over ships at sea that had previously been unthinkable; for this reason, governments took control of the airwaves following the outbreak of the First World War, and retained control (directly or, as in the US, by maintaining ownership and leasing spectrum to private interests) after the armistice was signed. Of course, the digital computer technologies that were developed during the mid-20th century and continue to evolve gave us new forms of information processing, and has come a long way towards fully realizing Wiener's vision of a cybernetic future. Coupled with wired technology, especially the internet, and wireless technologies that stretch from satellites orbiting overhead to handheld cell phones and mobile devices, we have gained new powers to control and coordinate our own activities, at the same time that we have become increasingly more subject to control and coordination through and by our devices. We become enveloped by a new media environment characterized by new forms of networked organization, and systems of increasing complexity, both technological and social.

In his outstanding scholarly study, *The Control Revolution: Technological and Economic Origins of the Information Society*, James R. Beniger argues that the speed-up of society due to the invention of the steam engine and the ensuing industrial revolution led to a crisis of control throughout western societies, and this crisis in turn led to the development of new technologies and techniques to help restore control [75]. In addition to inventions such as the telegraph, Beniger points to the extension and formalization of bureaucracy and the institution of rationalized procedures in government and other organizations, new methods of data processing such as Hollerith's punch card tabulator, the development of new accounting techniques, Taylor's scientific management, Ford's assembly line, and various techniques related to advertising, public relations, sales, and marketing. This *control revolution*, as he terms it, has its origins in the 19th century, and to the extent that control is a function of information, this shift represents an *information revolution* as well. Hobart and Schiffman make a similar argument [54], as discussed earlier, but they confine their consideration to information and media, whereas Beniger extends his analysis to the social system as a whole, the contents of the media environment as well as the media system by itself [75]. His specific argument concerning the 19th century can be extended backwards, following the earlier work of Innis [20], so that, for example, the evolution of writing can be understood as a control revolution that occurred in response to increased production due to the innovations extending out of the agricultural revolution.

4. Conclusions: Media Ecology's Implications for "the Information Age"

That we are now living in the *age of information* is undoubtedly a statement that many would take as a given, would accept without question as the best way in which to characterize contemporary life. And it no doubt would be easy enough to justify this appellation by pointing to the plethora of digital devices, computer technologies, and forms of wired and wireless connectivity that dominate our activities, and our thoughts. But in contrast to the *age of typography*, which begins with Gutenberg's invention of the printing press with movable type in the mid 15th century, or the *industrial age*, which begins with James Watt's invention of the steam engine in the late 18th century, identifying the origin of the *information age* proves to be highly problematic. After all, *information* is not an invention, nor is it a phenomenon that is anchored to any particular type of technology. Indeed, information can be present in all forms of communication, in animal communication from the songs of whales to the dances of bees, in the transmission of electrochemical impulses within animal nervous systems, and in the self-replicating strands of DNA and RNA that form the basis of all known biology. The concept of information can even be applied to purely physical phenomena such as the energy output of stars. From the point of view of digital physics, the age of information could be said to begin with the Big Bang, the moment when the ultimate computer that we call the universe was turned on. Such speculation aside, it is possible, as we have seen, to argue that the information age begins with language, or with writing, or with printing, or with the revolution in communication and control that began in the 19th century. Moreover, as has been noted, it is possible to argue that there has been not just one, but several different information ages.

Having earlier noted that matter and information, atoms and bits, are not parallel phenomena that can be compared to one another, it follows that the same holds true for machines (e.g., the printing press, the steam engine) and information. So, when we speak of our time as constituting *the information age*, it is not the presence of *information* that we refer to, nor even its abundance. Instead, it might be argued that what is being referred to is the collective phenomenon of *information technology*, which more and more is part of an integrated network of *information systems*. But references to the *information society* and an *information economy* based on *information capitalism* and brought on by an *information revolution* predate the rise of the internet as a popular phenomenon during the 1990s, and have their origins in discussions of a *postindustrial* society and economy during the 1950s and 1960s. During the 1960s, computer scientists adopted the phrase *information science* to refer to a field of study closely related to their own, while simultaneously, social critics first voiced concern over the problem of *information overload*, a phrase popularized at the end of the decade through the publication of Alvin Toffler's *Future Shock* [76].

But we can push the point of origin back, as some would no doubt argue that Shannon's introduction of *information theory* in 1948 [2] signals the beginning of the information age, and there is certainly rationale for viewing this new era as a postwar development, although the first modern computers were introduced during the late 1930s and early 1940s. Indeed, information can be seen as a phenomenon closely connected to 20th century modernism, and the anxiety associated with it was famously expressed by T.S. Eliot in 1934, in the opening stanza of "Choruses" from his play entitled, *The Rock* [77]:

> The Eagle soars in the summit of Heaven,

The Hunter with his dogs pursues his circuit.
O perpetual revolution of configured stars,
O perpetual recurrence of determined seasons,
O world of spring and autumn, birth and dying!
The endless cycle of idea and action,
Endless invention, endless experiment,
Brings knowledge of motion, but not of stillness;
Knowledge of speech, but not of silence;
Knowledge of words, and ignorance of the Word.
All our knowledge brings us nearer to death,
But nearness to death no nearer to God.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
The cycles of Heaven in twenty centuries
Brings us farther from God and nearer to the Dust.

The target of Eliot's faith-based critique is not computation, however, but communication, specifically mass communication. Although the mass production of messages can be traced back to Gutenberg, and the phenomenon of mass communication is frequently said to originate with the introduction of steam powered printing presses in the early 19th century, actual awareness of mass communication coalesces during the early 20th century. The propaganda (aka mass persuasion) campaigns of the First World War played a role in this development, as well as the beginnings of modern advertising and public relations that followed the end of the Great War. But more importantly was the advent of broadcasting, which served as an alternative to printing. With broadcasting came the realization that there are *media of mass communication*, a phrase eventually abbreviated as *mass media*. What is significant is the plural form, *media*. Earlier use of the term *medium* tended to be in reference to the materials of expression, paint or clay as an artist's medium, language and literature as a writer's medium. By the time Eliot wrote *The Rock*, the idea that newspapers, magazines, paperback books, radio, and movies (which were formerly considered a form of exhibition, akin to stage performance) constitute a single category of *mass media* had become firmly embedded, with television soon to be added to the group. Three decades after *The Rock*, McLuhan, an admirer of Eliot, would drive home the point that media are not a singular, unified phenomenon, that all media are not mass media, and that significant differences exist between different media, hence his pithy observation that the medium is the message, and his special emphasis on the distinction between electronic media such as radio and television, and the older forms of print media [7].

The sudden popularity of *information* and *media* within public discourse is contemporaneous in its origin, and their relative absence in intellectual discourse prior to the 20th century is conspicuous. Consider, for example, that the First Amendment to the Constitution of the United States, adopted as part of the Bill of Rights in 1791, reads, "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of

grievances." There is no mention of *freedom of information*, a phrase that does not enter popular discussion until after the Second World War, when the United Nations General Assembly declared it a fundamental human right in 1946, and included in its Universal Declaration of Human Rights, adopted in 1948, Article 19 of which states, "Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers." In the US, the Freedom of Information Act of 1966 established that citizens have a right to access information about their government, and the phrase *freedom of information* was adopted by other nations as well during the postwar period.

Rather than information or media, the First Amendment guarantees freedom of speech and press, which corresponds to the two primary modes of verbal communication highlighted in the title of Walter Ong's best known work of media ecology scholarship, *Orality and Literacy* [22]. The right of assembly can be seen as an extension of freedom of speech, as the whole point of assembling a group of people together in one place would be to serve as an audience for public address, or otherwise engage in oral discussion, debate, and deliberation. And the right of petition can be seen as an extension of the freedom to engage in written communication, as petitions are typically written or printed documents delivered, in this case, to government officials. As for the freedom of religion clause, religion as it is understood in western culture, revolves around a sacred text, and therefore requires freedom of the press; it also entails oral expression and ritual performance, thereby relating to freedom of speech and assembly.

What sets the 20th century apart, then, is the growing use of the term *information*, as opposed to terms such as *news* and *intelligence*, as well as the growing use of the terms *media* and *medium*, as opposed to *press* and *speech*. The same period that has been dubbed *the information age* has also been referred to, on occasion, as *the media age*. Of course, *media age* is just as problematic as *information age*, in that in all previous ages, human beings relied on types of media as well (speech and language, and even the human body being considered media within the field of media ecology [7,26,27]). It is here that a media ecology approach helps to clarify matters by specifying that ours is an age of electronic media, and within that age, we have entered a later stage of development characterized by digital media.

Peter Drucker characterized the postindustrial period as one in which knowledge workers would operate within a knowledge economy in the context of a knowledge society [78], but his terminology did not catch on. While increased complexity does require knowledge for effective management, continued progress in the technologies of control require less knowledge on the part of workers—witness, for example, the automatic scanning of products by cashiers today as opposed to the basic arithmetic skills required in the past. And note as well the implication that information has displaced knowledge in Eliot's query, *Where is the knowledge we have lost in information?* In regard to economics, the one rival to *information* as the appropriate designation for the postindustrial society is the phrase *service economy*. But service is, arguably, a by-product of information technologies and systems, of the control and coordination of human activity, whether it is in retail sales where traditional interpersonal, oral skills of salesmanship are no longer utilized, or in fast food where cooks and chefs are reduced to the status of servomechanism, or in the high end financial sector where information technology and the

technological imperative of efficiency [79] outstrips all human judgment, resulting in 2008 in the worst financial crisis since the Great Depression.

The title of this article, "Counting Electric Sheep", is meant to serve as a metaphor for the idea that information in its contemporary sense, is a numbers game, a reference to digital technology based on binary code, and Claude Shannon's mathematical theory of communication [2]; measurement also serves as the basis for evaluating efficiency, and therefore for the technological imperative. The title is also intended to signal the fact that information in its contemporary sense is very closely connected to electric technology and the electronic media, a point I have endeavored to stress throughout this article. Of course, the allusion is to Phillip K. Dick's 1968 science fiction novel, *Do Androids Dream of Electric Sheep*? [80] Interestingly, Dick never answered the question posed by his unusual and intriguing title, and perhaps that is why Ridley Scott avoided the problem altogether when he directed the film adaptation of Dick's novel; the first movie to be associated with the cyberpunk genre, it was released in 1982 under a title borrowed from William S. Burroughs, *Blade Runner*. Both the novel and the film ask us to consider the difference between the technological and the biological, the artificial and the authentic, the simulated and the real. Both suggest that as technology advances, such distinctions blur, and perhaps disappear altogether. Perhaps this should come as no surprise, given that information has emerged as a common denominator between computation and cognition, and perhaps even consciousness, not to mention communication in all of its forms, from whale songs to the dance of DNA molecules. Certainly, Dick's question provides us with a compelling metaphor for artificial intelligence, as AI could also be said to stand for *autonomous information*. But Dick's metaphor is a bit askew, as sheep are commonly associated with the period before, not after falling asleep, with insomnia rather than dreaming. The traditional remedy for sleeplessness is counting sheep, and from that my title, *counting electric sheep*, is a link to the point McLuhan made half a century ago, that our technological innovations have a numbing effect, turning us into sleepwalkers blissfully unaware of the effects they are having upon us [7].

4.1. Information, Knowledge, and Wisdom in the Context of Media Ecology

Eliot's poetic linking of *information* to *knowledge* and *wisdom* set off a flurry of speculation on the relationships between these three concepts (as well as others, e.g., data) that I do not intend to take up here. I do wish to note that I have emphasized the concept of information in the discussions leading up to this point, and have not been especially concerned with the distinguishing it from those of knowledge and wisdom. But by way of conclusion, I would suggest that the relationships between the three can be properly contextualized within the field of media ecology. Wisdom is a characteristic of the human person, whether it is regarded as an innate sensitivity and intelligence, or a product of hard won experience. Wisdom is an understanding of relationships, of relationships among people, of people's relationships with their environment, and of one's relationship to oneself. And I would argue that wisdom is intimately associated with nonliterate, oral culture and the media environment with which it is associated. Speech cannot be separated from the speaker, and memory cannot be separated from the persons who remember and commemorate. As Ong explains, in an oral culture, you can only know what you can recall, and if you cannot bring it readily to mind, in what sense do you really know

it? Words of wisdom, in a traditional sense, later to be collected and referred to as wisdom literature, are proverbs, mnemonically formed sayings and aphorisms [22].

Writing, on the other hand, in separating the knower from the known [81], turning a process, a verb, *knowing*, into a thing, a noun, *knowledge*. Knowledge becomes something that you find in a book, that you look up when you need to know something. And whereas wisdom involves understanding relationships, which is to say that it operates on the medium or relationship level, knowledge is about content, and works on the content level. Note that wisdom does not disappear when writing appears, and neither does speech after all. But the characteristic of wisdom becomes more distant the more fully immersed we are in literate culture, more mysterious and elusive. We look for it in books, but there we find only knowledge. And in tying knowledge to writing and literacy, I do not mean to imply that knowledge does not exist in oral cultures, but simply that there is no such thing as a *body* of knowledge, there is only knowhow, the practical ability to do things, which can be learned as an activity, and that includes the ability to remember and recite. The only body of knowledge is the human body, and as Edmund Carpenter notes, this is symbolized by the fact that we talk about learning things *by heart* [82].

If wisdom resides in the person, and knowledge in a book, where do we find information? In signals transmitted through wires and airwaves, bouncing off of satellites, stored on magnetic and optical media, in computer memory and databanks. Knowledge takes time to acquire, and wisdom is the fruit of a lifetime, but information appears instantaneously, dematerialized and decontextualized, its function to reduce freedom and establish control. While popular discourse treats information as a basic human need and an unmitigated good, media ecology scholars warn that its benefits do not come without costs, and have expressed concerned about the devaluation and loss of human judgment, and liberty. The danger is in an unbalanced media environment where knowledge becomes the property of the privileged few rather than of the population as a whole, and wisdom all but disappears in the noise and clutter of information overload. At the same time, our new information technologies do have the potential for helping us achieve a more complex and ecologically sound social system, one where information serves human needs and purposes, and is used to create a sustainable and humane environment. The potential is there, if information can be harnessed through knowledge, and if it can be applied with wisdom.

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