Binding time: Harold Innis and the balance of new media

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Introduction

Much has been made of the impacts of digital media on the experience of space: new modes of perception and action at a distance: accelerating globalisation; shifting boundaries between work and home life; and so on. It is less common to read about the impacts of digital media on the experience of time. Yet, the digitisation of cultural practices and artefacts has significant implications for structuring our relationships with both the future and the past.

In the theoretical traditions concerned with technology and time, the work of Harold Innis, a Canadian economist and communications theorist, offers an approach to understanding the social significance of all kinds of media. He analysed how different media relate to space and time: space-binding media extend influence and meanings over distances, helping to build empires and develop cohesion across space; while time-binding media influence cultural patterns in duration. For Innis, civilisations can be measured by their balance between managing time and controlling space. If this remains the case today, how has the computer changed this balance in our own culture?

This paper examines the extent to which Innis's concepts about media still apply today. Since his death in 1952, computers have transformed the mediascape, so his claims and approach must be entirely re-evaluated in the light of these changes. Innis's methodology cannot be applied as easily to computers as to earlier media. His analysis of communications places great emphasis on the material features of particular media: from ancient tablets to modern broadcasting. The material status of computers is more complex, and might escape Innis's methods. For instance, digitised artefacts can seem to be largely virtualised. In fact, their existence is split between several sites of inscription in computer storage and memory, and events of expression through outputs: a hypermateriality, and not a virtualisation. I argue, therefore, that Innis's emphasis on the materiality of media remains a key question for theorists of new media. In this paper, I will revisit Innis's approach to the relation of media to space and time and his intellectual transition from

economic geographer to media theorist, and, in the process, will note some resonances that his work has with contemporary media studies, philosophy, and science and technology studies. I will also evaluate his arguments about the significance of media to cultural change, in relation to the history of computers and networks.

Innis on media, space and time

Innis was among the first scholars to argue that social change is closely associated with media change. His later works in particular, *Empire and Communications* (1972b) and *Bias of Communication* (1991), cast modes of communication as central agents of transformation of civilisations. He analysed civilisations in the *longue durée* by tracing changes in the materials and techniques used to organise social activities, communicate over space, and pass knowledge down through time. He compared and assessed these civilisations according to how well the dominant media of each balanced command across space and dominion over time.

> We must appraise civilization in relation to its territory and in relation to its duration. The character of the medium of communication tends to create a bias in civilization favourable to an over-emphasis on the time-concept or on the space concept and only at rare intervals are the biases offset by the influence of another medium and a balance achieved (Innis, 1991, p. 64).

Innis saw a dramatic and destabilising imbalance in the dominant media of the mid-twentieth century in their bias towards space, and their neglect of time. He saw European imperialism, United States expansionism, and the centralisation of commerce and politics as strongly related to the dominance of centralised space-binding media such as newspapers, commercial printing, the telegraph, and radio. By comparison, he saw a neglect of objects and practices with enduring value, such as archives, universities and books.

Innis is likely to have considered the introduction and rapidly changing roles of computers as highly disturbing to the balance of media. Computer design tended to prioritise control over territory and populations, supporting centralised monopolies of knowledge as evident in the first users of computers; the Census Bureau, Air Force, Atomic Energy Commission, Army and Remington Rand Sales Office (Ceruzzi, 1998). Computer databases are also time-binding media, but only within limits, which will be explored later in this paper. Innis's assessment that 'sudden extensions of communication are

reflected in cultural disturbances' (Innis, 1991, p. 31) can certainly be applied to digital media, and he had great suspicions about modern technology, expressed in a polemical 1948 paper 'The mechanisation of knowledge'.

> The conditions of freedom of thought are in danger of being destroyed by science, technology and the mechanisation of knowledge (Innis & Drache, 1995).

Innis's analysis of the relationship between communication technologies and cultural change only extended until the age of newsprint and radio. The first commercial computers were becoming operational towards the end of Innis's life but there is nothing published to suggest he knew about these developments. Innis's legacy provides an alluring gap in the understanding of media in its lack of explicit attention to electronic computing.

Innis's attribution of agency to material objects and their properties remain contentious in media studies today. He has often been critiqued, or dismissed, as a technological determinist (Burnett & Marshall, 2003). However, recent work in philosophy and social studies of science has challenged the fixed boundary between human and non-human action. Innis's lack of distinction between objects and human ideas and actions can be read alongside Guattari's concept of the asignifying semiotic: signs operating below the threshold of meaning (Guattari, 1995). Innis's approach also anticipates posthumanism and actor-network theory and their analyses of the imbrication of non-humans in human affairs. The work of Friedrich Kittler on discourse networks and contemporary media also clearly draws from Innis's legacy (Kittler, 1990, 1999; Kittler & Johnston, 1997). Derrida's conception of cultural inscriptions emphasises the cultural / material dimensions of archives: '…the technical structure of the *archiving* archive also determines the structure of the *archivable* content even in its coming into existence and in its relationship to the future' (Derrida, 1996, p. 17 italics in original).

Innis's influence has always been strongest in Canada. Library and Archives Canada recently put up a website on the legacy of Innis and McLuhan that includes short essays from several contemporary scholars on the theme 'Archives as media'. The site raises the question:

> To what extent is historical knowledge not merely preserved, but shaped by the archive and its means of selecting, storing, and presenting information? (Libraries and Archives Canada, 2007, pp. index-e.html)

Archives necessarily accumulate through ongoing interplays between

human and non-human components. What is archived is conditioned by the material constraints of space, informational architectures of indexing systems, and the personal and collective choices of archivists.

For Innis, the various time-binding media available to any community are qualitatively different, as each retains impressions over time in different ways. Government records, personal letters, and published poems are preserved in different ways. Each civilisation has a different orientation towards time.

To understand Innis's distinctive reading of time-binding media it is relevant to briefly follow his transition from social scientist of space to self-styled Humanities scholar of space, time and media. Innis began with an interest in the technologies that build empires, conducting detailed research into the development of the economy and infrastructure of Canada. He wrote histories of the Canadian Pacific Railway and of the fur, cod, and dairy industries (Innis, 1940, 1962, 1972a). Each of these industries was structured very differently. For example, the fisheries were established in scattered independent settlements along the eastern coast of Canada and, by contrast, workers in the fur trade were dependent on the Hudson's Bay Company which ran a command economy from London (Di Norcia, 1990). The differences between the fish and fur industries emerged from the material properties, behaviours, and environments of the commodified animals themselves. The beaver's sedentary nature and its inadequate defences against humans contributed to the rapid growth of the trade in its fur. The dispersed distribution of fish stocks allowed fishing boats to operate more independently, and therefore the communities to adopt a more democratic ethos (Watson, 2006). Innis read cultures from the ground up, seeing spatial and economic patterns emerging from the properties of agents, environments and lines of movement at various speeds.

In his later work, Innis's attention increasingly turned towards the problem of how civilisations relate to time through different media. Time is harder than space to study empirically, so he switched methods from the notoriously detailed fieldwork and statistical analyses to the accumulation of facts from a huge array of secondary sources. Collegial relationships with classics scholars such as Charles Cochrane, Edward Thomas Owen and Eric Havelock at the University of Toronto (Heyer, 2003) helped him take an increasingly interdisciplinary approach. He came to consider himself as much as a philosopher, historian and sociologist as an economist (Innis, 1991).

Innis combined his understanding of the economy and materialities of

building empires with his new interest in time to propose a theory of history based on the extent to which the dominant materials and modes of communication of a civilisation are biased towards space or time. When Innis refers to 'media bias', he is not talking about the political slant of journalists but biases emerging from the very properties of materials used in communication. He theorises that media bias in a particular civilisation emerges from the interactions between three interdependent layers: properties of media substrates; encoding conventions; and social and political arrangements using media for particular purposes. The computer will present complications at each of these three levels.

1. Media materiality

At the first level of media materiality, Innis argues different substances have distinctive properties that support different styles of communicating and, most importantly, each tends to have a bias towards either space or time. For example, papyrus is light and portable in scrolls, can be made cheaply from water plants, and can be written on with rapid strokes of a brush. However, papyrus deteriorates quickly and is, therefore, biased towards extending communication across space, building, extending and maintaining empires. By contrast, carvings in stone last for centuries but are expensive and time-consuming to produce, and cannot be transported easily. So, as papyrus is biased towards space, stone is biased towards time.

The dominant media of a civilisation reflects the materials available to that community, either from local sources or through trade routes: stone in Egypt; papyrus in the Nile Delta; clay in Babylonia and Assyria; parchment in the Carolingian dynasty; and paper, from China to Europe via the Middle East. The materials established the limits of communication in weight, durability, malleability, reflectivity, and other technical limitations and capacities. The expense, complexity of manufacture, and all other features affect how it can be taken up, and by whom.

The most lightweight medium for communication is speech. This is the dominant medium in oral cultures where face to-face conversations, and the cultivated memories of citizens, are the main means of transmitting culture over space and time. Innis favours the Greek oral civilisation, as a model of a balanced regime of communication, because he believed it did not constrain thought in the same way that writing did. As writing is introduced, thought becomes limited:

> Writing with a simplified alphabet checked the power of custom of an oral tradition but implied a decline in the power of expression and the creation of grooves which determined the channels of thought for writers and readers (Innis, 1991, p. 11).

Innis was not the only scholar of his time writing about media change and, particularly, the significant historical transition from oral to literate cultures. Classicist Eric Havelock (1963) emphasised the transformations in thought with the emergence of writing in Ancient Greece. Walter Ong (1988) analysed the changes in consciousness and personality with the expansion of print. Most famously, Marshall McLuhan (1994) saw media as extensions of the human nervous system. McLuhan was a strong advocate of Innis' work, undoubtedly helping to sustain Innis's influence. However, McLuhan's reading of media was quite different from Innis's predominantly due to his disciplinary origin in literary theory in contrast to Innis's training in social science. Where McLuhan's reference points were surrealism and New Criticism, Innis's were economic staples, trade routes and modes of transportation (Watson, 2006). For McLuhan, mediated memory devices such as writing, printing, videotape, or computer disks are prostheses of human faculties—extensions of individual human memory. In contrast, Innis sees these devices in terms that are more materialist and historical, as 'time-binding media'. Whole societies carry knowledge into the future in distinctive ways, forming time-binding systems that are always bound up with centralised or decentralised social power and traded against immediate goals. Innis regards thought not so much as a property of active individual subjects, but as a pattern that emerges across an entire civilisation, grounded in changes in the materiality of media. Innis's work is distinctive in developing a materialist approach across entire civilisations.

Computers complicate media materiality

Alan Turing's (1936-7) famous thought experiment demonstrated that any universal computing machine could simulate any other Turing machine, with time and memory being the only limits. In principle, computing components could be built from any suitable substances, and in any valid form, making media materiality more complex than with other media. Where print and radio were relatively bound to their embodiments in pulp and the radio spectrum, computers would always be manifest as interconnected components comprised of many different materials—metals, paper cards, magnetic

surfaces, semiconductors, radio, and optical wavelengths.

Turing's mathematical approach to media was the opposite of Innis's, because, for him, the material expression was irrelevant. Turing's proposed machine, which would displace paper as the dominant media material, included an imaginary infinite 'paper tape' as an immaterial prop in his mathematical proof. While paper could never do this particular job in actual machines (even if cards and paper tapes did feature in some designs), some kind of time-binding component was central to Turing's abstract design for an automated computing machine. This design concept called for entirely new materials for automatic memory, which could be written, read, erased, and rewritten automatically.

Maintaining Innis's emphasis on materiality highlights the unprecedented integration of different interconnected material components required in the engineering of computers. The time-binding components of the earliest commercially available computers were notoriously difficult, unreliable and limited. For example, one early memory device used in the UNIVAC-1 in 1951 was the acoustic delay-line (Grey, 2001). It worked by sending carefully tuned vibrations through the substrate of long hot columns of mercury, using techniques developed for radar. Information in the delay line was held in the precarious form of vibrations in the liquid cycling between opposing transducers at either end of the tube, which would then amplify and retransmit the same information. The toxic mixture inside the delay-line had to be kept at a stable temperature to maintain a uniform speed of sound that would keep the memory traces in synch with the machine cycles. Even with such a complex apparatus of seven units, each with 18 delay columns, the system could store only 1000 computer words. Fast memory would remain a prohibitively expensive computing component for several decades.

The engineering of the computer, and the design attributed to Von Neumann, manifested a new form of 'present-mindedness' (Innis, 1991) in its pyramidal memory structure. Changes occurred from the top of the pyramid, in the central processor, and in the register flip-flops that store the information states for immediate use. The processor steps from one instruction to the next at high speed in a digital 'stream of consciousness', making decisions that trickle up and down, and to and from, lower levels of memory and storage. The slower main memory is connected through a memory bus and supplies data and instructions as required. Larger amounts of data tend to be stored in other slower and less expensive components lower in the pyramid, or even off-line. This design, along with the extremely high cost of the fast memory components operating close to the processor, required a distinctive separation between main memory and storage, which persists in today's

computers.

UNIVAC's long-term storage was as cumbersome as its random access memory was volatile. UNISERVO was a magnetic tape system that used extremely heavy reels of half-inch wide strips of nickel-plated phosphor bronze to input, output and store information. The metal tapes zipped past the heads at over 2.5 metres per second, delivering 7,200 characters per second (Gray, 2001). However, tape drives gave only linear access to archival data, which meant that records were accessible at different speeds depending upon their position on the tape. Many tapes were stored off-line making much of the data relatively difficult to access.

Since the 1950s, there has been a proliferation of different materials and designs for computer data storage, with a trend towards cheaper and faster systems. These have included: paper tapes; paper cards; magnetic tapes of several widths (three quarter inch, half inch, quarter inch, eighth inch, eight millimetre); compact audio cassettes; floppy disks (eight inch, five and a quarter inch, three and a half inch); IBM's hypertapes; stringy floppies; holographic systems; laser discs; and the 'millipede' probe storage. Few of these storage solutions have been engineered for the long term. Most of them are now superseded by 'solutions' with far superior capacities and performance. However, replacement systems are rarely compatible with previous standards. Data is often lost in the move to new standards.

In the 1990s, a number of commentators began to warn of the short-life span and vulnerability of the media holding much of today's cultural information. They said that this trend risked making ours a 'digital dark age' in which most of the data stored on computers would be lost. Future historians will not be able to find the records to piece together accounts of our times, lives and experiences (Brand, 1999; Hillis, 1998; Kuny, 1997). These critics pointed out that physical storage media deteriorate quite quickly making data unreadable within only a few years. Floppy disks are unreliable after five years, hard disks after twenty or thirty years, and optical media such as CD-Rs and data DVDs not much longer than that. Meanwhile, computer equipment becomes obsolete within eight years, often to be replaced with improvements that are incompatible with older standards: think zip drives, SCSI and so on. Many documents prepared with the older standards become unreadable without that lost software version or hardware platform. Through this combination of entropic forces the apparently immutable promise of perfect digital copies is broken by the inherent instability of the digital medium. As Rothenberg wrote in 1995,

digital information lasts forever—or five years, whichever comes first. (Rothenberg, 1995)

A recent study of the computer records of Bronze Age excavations in North East London from the mid 1990s found that the computer records had deteriorated more in one decade than the relics had in thousands (BBC News, 2000).

The cultural effects of these changeable storage standards are compounded by the perceived immateriality of data storage devices. A sense of magical distantiation from information is epitomised in the hard disk, which has gradually become the dominant solution for storing almost all data. Matthew Kirchenbaum (2004) argues that the hard disk has driven a 'sea-change in the production and recording of knowledge' (107) and, unlike previous media, is a black boxed inscriptive technology where writing is displaced to a hidden, invisible magnetic substrate, distanced from the user's hand and eye. Further, its platters are in constant motion, allowing it to access data at random and its constant error checking effaces imperfections during copying. The capacity to store and make unlimited perfect copies of images, sounds and programs, as well as writing, have unleashed an insatiable drive to capture and make available the cultural archive. Many of the changes to computer culture over the past half century can be attributed to changes in the materials and economics of production. The complexity of cultural changes associated with the proliferation of digital media is a manifestation of the material complexity of computers as physical devices, as much as by their complexity of information.

2. Languages and genres

Innis examines a second level in the patterning of media in the languages, scripts, and genres of content. For example, he observed that hieroglyphics carved into stone monuments and pyramids of Old Kingdom Egypt tended to be square, upright, decorative, and pictographic. This style emerged partly from working with chisel and stone, but was also connected with the religious and political environment in which this medium was being used, the third level of Innis's analysis. The rigid styles and the use of durable media were closely associated with a centralised society that venerated religious authority in which knowledge was monopolised (Innis, 1972b).

After 2000BC, hieroglyphics came to be written by brush onto papyrus

more often than chisel on stone. This writing was simplified, less like pictures and more like a flowing cursive script. These changes in materials and style were associated with new social arrangements and modes of thinking.

> By escaping the heavy medium of stone thought gained lightness… A marked increase in writing by hand was accompanied by secularisation of writing, thought, and activity. The social evolution between the Old and New Kingdom was marked by a flow of eloquence and a displacement of religious by secular literature (Innis, 1972b, pp. 16–17).

Alphabetical and phonetic scripts are more efficient than pictographic systems. With fewer characters, such scripts are quicker to learn and to use, and so tend to favour traders, rather than centralised groups protecting religious texts. Because simplified and democratised language allows the production of texts to become decentralised, vernacular texts become more common and the dominant forms of knowledge and belief in a culture tend to change.

ii. Divergent languages and temporalities

Developments in computer operating environments and languages helped digital electronics shift from being the exclusive domain of specialists in the 1950s and 60s to becoming everyday artefacts of popular culture by the late 1980s. Early programming languages generated exclusive social groups based on mastery of FORTRAN, COBOL, and other specialised languages. Programmers could make full use of the computer's power, where end users were bound to work within the capabilities of programs provided by programmers. Languages and applications of computers established what Innis (1991, p. 11) referred to as 'grooves', which channel thought and action, leading towards what Deleuze (1992) refers to as the 'control society'. The complexity of computing standards and the high initial costs of hardware over three decades helped centralise power over these forms, similar to how monopolies of knowledge once gave power to the priesthoods that commanded arcane scripts and languages, such as hieroglyphics and the cuneiform. Like the ancient masters of writing, programmers' power was moderated by their relationships to powerful actors such as government, military, commerce, and education.

After microcomputers made hardware more accessible in the 1970s, control over standards became an even more influential force. Institutions such as Microsoft, Apple, Adobe, and so on acquired power by controlling the standards millions of people use to encode and interact with media content. Control over proprietary standards has major implications for the future accessibility of cultural records and means not only monopolising knowledge but also, effectively, owning the environments in which people actually generate new knowledge. There have already been struggles between institutional wills over the control of such standards and communities of users. At the same time, cheap equipment and networks have made open source models of software development viable and possible if the social dynamics of a distributed radical meritocracy can be resolved (West, 2003).

Today, the computer's capacity to bind time is conditioned by the dominant encoding standards for capturing symbolic and sensory data: ASCII text; GIF and JPEG images; MP3 and WAV sounds; MP4, WMP and MOV video; VRML spatial information and so on. The proliferation of standards within the same devices is commonly called convergence and yet these standards are also divergent, as they support different sensory modalities, textual forms and regimes of access. For example, encryption and security schemes limit access to information while networking standards, such as Ethernet and TCP-IP, open up channels of connection. There are also unintended conse-

quences from this range of standards and the frequency of upgrades, which are major culprits in the 'digital dark ages' scenarios.

Software opens up communication to a diversity of dynamic environments such as gaming engines, e-commerce and social software, establishing and framing spatial and transactional spaces for cultural practices. These tools and standards, and the rituals associated with them, condition what will be remembered and how. For instance, as Manovich (2001) observed, there has been a conflict between narrative and database forms. Whereas the narrative drive is to put sequences into order, the database gathers entities but refuses to give them any final order. Another key computer form, the bitstream, reimposes the narrative's logic in streaming media and podcasts. Online applications such as YouTube offer a huge databases of bitstreams, finding their own resolution of the narrative / database clash. Just like computers, comprised of a wide range of materials in complex arrangements, the huge variety of data standards and computer languages make media determinist accounts such as Innis's more difficult to apply. The implications of every command, file type and application are quite specific and often contradictory. Each device, mode of connection and software application has its own signature temporalities and spatialities. There clearly are cultural consequences for this unprecedented diversity of media platforms.

3. Media and civilisations

Innis argued that the predominant media of a civilisation both cause, and so provide evidence of, the distinctive character of that society. Each medium is selected and developed because it suits particular interests within that society. These choices of media reinforce, and sometimes transform, that society. Some civilisations become tied to one medium, while others are subject to constant change. For example, Innis attributed the limited capacity of Egypt to build empire in part to 'the inflexibility of religious institutions supported by a monopoly over a complex system of writing' (25). This contrasted with the Roman Empire where a 'written tradition dependent on papyrus and the roll supported an emphasis on centralised bureaucratic administration' (107).

Changes in materials and techniques of communication contribute to, if not bring on, crises that produce wider transformations in cultures. When new trade routes or inventions bring new techniques for communicating, social changes invariably follow. Innis reads conflicts between or within cultures as struggles over media. He sees the First World War as a conflict be-

tween British newspapers and German books and the Second World War as a confrontation between German radio and British newspapers (Innis, 2004, p. 89).

Innis perceived a significant and growing imbalance in the world media space, in favour of space over time, since the modern European empires emerged in the 1700s. These empires gained power from their use of paper, print and, later, the telegraph, and radio. These media afforded centralisation of national authority, with printed documents helping to establish uniform laws, education, and administrative infrastructures. At the same time, portable and durable communication allowed the administration to decentralise and accelerate throughout the nation. Market and time pressures that tended to favour the most recent content largely drove the output of this printing industry.

> Constant depreciation – new books drive out old books – publishers concerned with depreciation in publishing new books but also concerned with monopolies in building up their lines. How far printing essentially based on controversy perhaps centring around price system and philosophical books became by-product of excess capacity in quiet periods – Descartes in Holland centre of printing industry for Holland? Printing meant mechanical reproduction of images – consequent deterioration in value and closer adjustment to goods – advertising. (Innis & Christian, 1980, p. 130)

This entry from 1947-8 in the *Ideas file*, a collection of transcribed research notes kept by Innis, illustrates how Innis's method was to connect and interrelate phenomena: economics (declining value of book titles), technology (printing of images), cultural forms (advertising), and ideas (excess production allowing production of philosophical books). For Innis, levels of communication are infinitely inter-woven and not a hierarchy where lower levels determine those above. Innis' writing is notoriously dense, packed with detailed historical and economic facts, lacking discursive flourish or argumentation, betraying his earlier training in economic geography. An Innis biographer observes that his collections of writing on index cards anticipate computer databases in their non-linear structure (Watson, 2006). Innis's work did not follow the conventions of analysis, dialectic or narrative so much as perform pattern-matching.

Innis identified an accelerating tendency of knowledge to lose value almost immediately as it is displaced by something newer. The inflated value of information from the present is evident in publishing, newspapers, and the centralised live broadcasts on radio and television. These media have extended control across space at the expense of considered reflection on the

past and care for the future. They also establish and sustain monopolies of knowledge by regulating access to it, imposing selective delays on its release, and developing arcane technical systems that control it.

The trend towards present-mindedness, centralisation, and proliferation of media technologies accelerated in the twentieth century. Innis directly experienced it as a signalman in the First World War, as a witness to the industrialisation of war in the Second World War and in the gathering clouds of the Cold War (Watson, 2006). He saw that the west privileged only immediate goals at the expense of past and future. This was not only apparent in leaders' statements, the increased cultural dominance of advertising, and the decline of the university, but more fundamentally in media bias in the dominant material modes of communications. The book trade, newspaper journalism, and radio were conditioned by the material properties of pulp, paper, and the radio spectrum. Consequently, they supported cultural forms that increasingly prioritised the present.

Projecting Innis into the digital society

There is little doubt that computers have accelerated many of the trends that Innis identified, particularly in supporting corporate and government command over space and populations. In the early years of computing, these systems operated exclusively to sustain and enhance highly centralised monopolies of knowledge. More recently, though, the cultural impacts of computers became more ambivalent and contradictory. PCs, networks, and other digital devices became broadly accessible and the contexts in which they operate have become increasingly diverse.

Today computers operate according to a multiplicity of temporalities usually slanted towards the present. Just as radio news bulletins or newspapers leads with a top story, news websites typically list the top story in the prime position at the top of a web page, privileging newsworthy stories. Some news sites however, have an alternate view of 'breaking news' where the most recent story appears at the top. A further alternative to this ordering is a search-driven or customised news listing where another system of value operates and only the stories that are most relevant for that search, or that user, appear. This multiplicity of possible orderings by computers makes it difficult to equate media features with specific cultural practices or mentalities. Although search engines and archival databases make distant events and historical texts present in everyday life, web search databases still tend to privilege the present by over-writing records of earlier versions of indexed

websites (Hellsten, Leydesdorff, & Wouters, 2006). Internet web pages tend to have a limited lifetime and site redesigns, closures, corruptions, broken links and crashes can degrade the contents of the web over time.

Other websites and internet applications privilege the present in their own ways. Facebook and the web application 'Twitter' ask users to write what they are doing right now, and make this short text available to others who have registered with the site. They archive these entries, forming a kind of narrative record of past presents. Internet chat clients such as MSNChat, AOL Chat and ICQ also ask users to enter their current status to signal their current availability for chatting. Users conduct conversations in text (or as an audio or video bitstream), and automatically generate transcripts. The longer form of the weblog, or blog, orders all posts reverse chronologically, so that the most recent post is at the top. In each case, while there is present-mindedness, there is also a time-binding record of the present being created.

Perhaps even more important than archiving features are the changes to cultural practices associated with adopting particular computer applications. Some of the earliest evidence of this trend was with word processors running on personal computers. Writers began to change their everyday habits, as the electronic environment changed their capacities to compose and organise their texts (Heim, 1987, 1993). The general fluidity of composition, and organisational devices afforded by word processors encouraged changes in habits of textual production. This has contributed to a general growth in the texts and versions of texts being produced and distributed.

Conclusions

The dominant time-binding media of our 'civilisation' operates paradoxically to both diversify and homogenise cultural patterns over time. Since the mid-twentieth century, the complexity of computer-based communications has complicated Innis's reading of media materiality as the key driving force of history. Computers and computer networks are comprised of complex interconnected material components. The constant substitution of cheaper and more efficient materials and manufacturing methods has allowed regular substitutions of these materials. Alongside improving hardware and software designs, the trajectory towards mass customisation allowed digital technologies to access wider and different communities and increasingly diverse application domains. Cultural practices such as calculation, writing, photography, play, and moving image were gradually appropriated by digital media.

These changes emerged alongside, and formed relations with, an already complex analogue mediascape.

The digitisation of many cultural records has made many archives ubiquitously accessible. All these translations, however, are subject to the limits and thresholds of digitisation: bit size; sampling rates; encoding schemas and so on. They are all subject to the threat of deterioration, peculiar to digital media, which make artefacts readable only through machine. This diversity of digitised 'assets' is matched by the ubiquitous relative homogeneity of computer devices and the commodification of the databases, whether by subscription or advertising. While the approach to media history, taken by Innis, becomes much more complicated with computer media, many of his argument are still valid. The monopolies of communication maintained by search engines, software standards, and silos of copyrighted content, are different from those created in other media but have generated their own sites of struggle.

In many ways, the invention of computers has been a response to concerns about the neglect of time, as expressed by Innis and others, and the outcome has been a heterogenising of temporalities with a diverse range of digital media including many different bitstreams, databases and software environments. Conversely, digitisation has increased the risk of data loss. Innis's key contribution to communications theory, linking cultural patterns to the materials of dominant media, remains surprisingly important on re-examination. The proliferation of computers has been sustained by the globalisation of production and the mass consumption of microelectronic components and programming. The diversity of cultural forms associated with digitisation draws on this pattern of trade as much as the material and informational complexity of the devices themselves.

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