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Cultural Consequences of Computing Technology

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Abstract

Computing technology is clearly a technical revolution, but will most probably bring about a cultural revolution as well. The effects of this technology on human culture will be dramatic and far-reaching. Yet, computers and electronic networks are but the latest development in a long history of cognitive tools, such as writing and printing. We will examine this history, which exhibits long-term trends toward an increasing democratization of culture, before turning to today's technology. Within this framework, we will analyze the probable effects of computing on culture: dynamical representations, generalized networking, constant modification and reproduction. To address the problems posed by this new technical environment, we will suggest possible remedies. In particular, the role of social institutions will be discussed, and we will outline the shape of new electronic institutions able to deal with the information flow on the internet.

Keywords

technology and culture, cognitive tools, electronic networks, knowledge management, social institutions, collaborative systems.

Introduction

We are currently witnessing a technical revolution based on the widespread use of computers and electronic networks, but this will most probably prove to be a cultural revolution as well. The ubiquitous presence of personal computers in almost every home and place of work, the spread of various mobile devices, the increasing computing capacity and accessibility of servers, combined with the explosive development of the internet and its numerous applications (notably e-mail and the web) have fashioned a technical environment in which we all have easy access to huge computational power, numerous personal contacts and practically boundless information. This technical environment is essentially new in the history of mankind, and our main point is that it cannot but have important cultural consequences.

Comparable inventions in the past, such as writing systems or the printing press, have had profound consequences on human culture (Innis, 1951; McLuhan, 1962, 1964; Lévy, 1997). We will examine the influence of these information techniques in history, discerning long-term trends toward an increasing democratization of culture, but also toward a fragmentation of knowledge.

We will then try to analyze the effects of computing technology on today's culture within this historical framework. It will be shown that recent techniques constitute a continuation of older trends, while also presenting new opportunities and challenges. In particular, data processing can be used to manage some of the very problems it might bring about in the first place.

We will also argue that social institutions remain more necessary than ever to manage and evaluate the flow of information on the internet. There is simply no obvious alternative to social consensus in order to filter relevant information and knowledge. After discussing the role of classical institutions (such as the press or universities), we will outline the form that novel internet-based institutions might take in the near future to fulfill similar functions more efficiently. This would obviate some of the destabilizing effects of computer technology.

In short, we will consider computer technology within the historical framework of intellectual tools in general, in order to better understand its present and future effects on human culture. This will help us suggest new ways to manage today's information flood.

1. A brief history of cognitive tools

Before examining computer science, we would like to review the history of cognitive aids so as to put recent developments in perspective. Cognitive tools facilitate and enhance our cognitive processes. As it happens, computing technology is but the latest development in a long line of cognitive tools: natural language, writing, mathematics, printing, and more recently audio-visual media. We will briefly review some of those in turn, without attempting an exhaustive survey. Our goal will be mostly to highlight the main stages of a long history, so as to discern long-term cultural trends.

Natural language

Natural language is not really a technique, as it was not deliberately designed, but appeared spontaneously sometime about 100,000 years ago. The origins and emergence of human language is the subject of much debate, but language remains probably our most important cognitive tool to this day. Higher cognitive processes, such as reasoning or planning, are inseparable from language, which also enables us to communicate our thoughts with others and to elaborate common plans and cultural constructs. In short, natural language is essential to individual and collective thinking (Vygotsky, 1962; Carruthers & Boucher, 1998).

Yet, spoken language is a poor medium to transmit knowledge at a distance or through time. Transmission by word of mouth is inaccurate, highly dependent on social links and vulnerable to social collapse. Traditional societies had devised ways to improve transmission by means of ritualized forms (poetic style, myths and sagas, cultural schemata…) but such forms constrain and slow down the production of cultural content. Human societies have then experimented with various other formats of representation, but the main one is undoubtedly writing, i.e. a systematic graphical representation of natural language.

Writing

The invention of writing systems is relatively recent (about 5,000 years ago) but clearly represents a major cultural development, as writing made possible the organization of centralized states and empires as well as the transmission of culture through time (Innis, 1950). The history of writing is fairly complex, showing a gradual evolution from ideographic systems to various

alphabets (Gelb, 1963; Sampson, 1985). Writing also allowed the development of specialized formal languages such as number systems and mathematics. We will not go into this history here, but the invention of the alphabet (about 3,000 years ago) was a turning point because it made reading and writing much more accessible to a larger proportion of the population.

In spite of the recent development of audio-visual media (such as radio and television), writing remains our principal representational medium for organized knowledge. Textual documents are still our main source of useful information, and computing techniques have by and large been developed on top of textual representations. In fact, the use of textual information has been enhanced rather than replaced by computing, and writing is more important than ever.

Writing systems are abstract coding techniques, but they should be seen in conjunction with their material support, which has been highly variable: clay tablets, stone, papyrus, bamboo slats, parchment and paper. Different support materials have proved more or less durable and easy to use (more durable materials tend to be more cumbersome) but paper has gradually become the support of choice, because it is cheap, fairly easy to produce and easy to use. Paper also made possible the next big invention: printing.

Printing

The Chinese probably invented paper in the 1st or 2nd century AD, and have experimented with printing techniques as early as 800 AD, but their ideographic writing system (containing thousands of different characters) made it difficult to compose texts with movable type (they tended to use block printing instead). It was only in late medieval Europe that the conjunction of paper, alphabetical writing and the printing press made it possible for independent craftsmen to print all kinds of written document, at little cost and outside official institutions. Printing greatly lowered the cost of reproducing and disseminating ideas and knowledge at a crucial moment in European history (Eisenstein, 1983).

The result was the cultural explosion of the Renaissance, a period that saw the production of thousands of different books on a diversity of subjects, by an increasing variety of authors, reaching an ever larger public. Because printing was decentralized, it proved difficult for traditional institutions (church, state or university) to control the output of books, and this technique was an important component of the development of modern European civilization. It fostered habits of intellectual freedom that have become an integral part of our modern culture.

Printing is thus a very good example of the cultural consequences of a technology. Although it consists in a combination of fairly simple techniques (paper, ink, movable type, the printing press and book binding) the effects of printing on modern culture have been profound and long-lasting (McLuhan, 1962). We may now surmise that electronic data processing will probably have effects just as important, but the history of past cognitive aids should help us appraise recent developments.

2. Long-term trends

When we look at the history of cognitive aids and techniques, long-term trends can be observed. A few general tendencies seem to be at work throughout the centuries, and appear to be reinforced by each new technological advance. Technological changes take place within a wider culture, which they influence in turn, but often along well-worn grooves… These trends form a coherent cluster, which could be analyzed in the following way:

Explicitation and diffusion

With each new representation technique (notably language, writing and printing) human beings have represented a larger part of their environment, physical and social, as well as a growing world of beliefs and norms. More efficient representation techniques have also made it easier and easier to disseminate information and knowledge to larger groups of people both through space and time. Because the availability of better techniques makes it easier to produce and to use documents, it becomes more profitable to represent more and more information for a wider public. Such a tendency proves self-reinforcing, as this textual world calls for ever more written commentaries, developments and debate.

Democratization and decentralization

The evolution of representation techniques has increased the proportion of the population able to make use of them. For example, the invention of the alphabet and the development of printing have put written culture within easy reach of wider social groups. Generalized schooling is also a factor, which is itself facilitated by easier writing techniques. Similarly, the availability and lower cost of representation techniques have gradually put an end to the monopoly of official institutions on the production and circulation of knowledge. Book printing proved much more difficult to control than copying manuscripts by hand in monasteries. Freedom of expression is then as much a consequence of technical change as a social and cultural evolution.

Fragmentation of knowledge

Because it has become very difficult to enforce a central control of information and beliefs, all kinds of opinions and ideas can be expressed. This freedom of expression proves highly beneficial when it serves critical thought and intellectual debate. But it may also lead to a bewildering jumble of unrelated, unsubstantiated allegations and beliefs, which range from useless to downright harmful. Even in the more serious world of scientific or intellectual thought, the sheer mass and increasing specialization of knowledge make it very difficult to follow the evolution of ideas outside of narrow domains. The ensuing fragmentation of knowledge counteracts the benefits of a wider diffusion, and useful knowledge may actually become truly accessible to fewer people instead.

We have just seen that this long-term evolution may entail risks as well as increased opportunities. Let us consider again the impact of the printing press on European society during the Renaissance, as described in (Eisenstein, 1983). Printing made texts easier and cheaper to reproduce, hence much more available than when they had to be painstakingly copied by hand. And because printing was also a fairly simple technology that could be mastered by independent craftsmen outside of big institutions, many more people could now disseminate their texts and ideas.

Combined with a whole cluster of social and economic changes (Burke, 1998; Johnson, 2000), printing fostered the explosion of cultural creativity that jumpstarted the rise of European civilization to world dominance. But the consequences were not totally felicitous: with increasing intellectual freedom, the ideological monopoly of the catholic church and medieval universities collapsed, ushering in the Reformation movement. Although part and parcel of European modernization, the spread of Protestantism also led to protracted religious wars, which tore through European society for more than a century.

3. Consequences of computer technology

In the same way that printing consisted in a cluster of tightly related techniques, computer technology is a (much more complex) cluster of interlocking techniques. The two main components would be computers (including hardware and software) and electronic transmission networks (especially the internet). Fixed-line and mobile phones are now being rapidly integrated within this technological cluster, offering yet more access points to the global digital network. Because of the growing integration of computer technology with transmission networks, one could speak of *telematics* rather than *informatics* (Nora & Minc, 1978).

Telematics has important consequences for cultural and cognitive processes. These effects can be attributed to three main phenomena: dynamical representations, information networking, and ease of reproduction. Although they are interrelated to some extent, we will examine each one in turn, showing the opportunities as well as the problems involved. We will at same time suggest potential remedies to the problems posed by technical advances.

Dynamical representations

Traditional representation media are static and passive. Once written, drawn or printed, manuscripts, images and books are stable and permanent. Indeed, the main motivation for writing systems is to make permanent records possible. This is how we can still learn about Egyptian beliefs, the Bible, Greek philosophy, Buddha or Confucius. The stability of traditional media has given rise to the notion of immutable sacred texts, which once fixed should not be tampered with lightly.

Computers too constitute a representational medium, and we would contend that keeping (and transmitting) textual or numerical records is their most frequent social usage. In this respect, computers are amazingly versatile: they can represent texts as well as images, sound or video because anything can be coded as numerical data. But computers can of course also compute, i.e. process representations, and this is totally new in the history of representations. Representations of all kinds may then be transformed, reformatted, compressed, expanded, translated, recombined… It would be tedious to review all the possible transformations that are now being commonly applied to computer representations, but we will just give a few examples.

To begin with, translating representations is commonplace in computer science itself: high-level programming languages are compiled into machine code, textual documents (such as this text) are represented internally by character codes but displayed through a graphical interface (or a printer). More generally, texts can be annotated or translated, photos can be touched up, maps can change scale, databases can be merged… Decisions that might have required a lot of thought in order to choose the right scale or format have become superfluous, because representations can now be modified at will, very quickly and at little cost.

One cannot stress too strongly *the novelty and the importance of this flexibility*. It really ushers in a new age in the long history of representations, which is likely to have serious cultural consequences, even if few people seem as yet fully conscious of this.

The notion of a canonical text (or the original version of a work of art) has probably become obsolete, because documents or paintings are no longer unique material objects and can be easily modified. Mechanical printing had already made reproduction easier, and photography even more so. Modern artists such as Marcel Duchamp or Andy Warhol have not failed to notice this change

of status, on which they have often played more or less ironically, but computers are now dealing the final blow to the traditional status of cultural objects.

Of course, we are constantly interacting with the real world, updating our internal representations all the while to perform our daily tasks. To be now able to quickly modify complex external representations as well is an important advance that promises to speed up many of our cultural tasks, from art to science. The risk, however, is to thrash around impulsively within a superficial culture consisting of a mishmash of incoherent versions, forgetting the very notion of basic reference texts.

Possible remedies:

How could we alleviate the risks we have just outlined? The versatility of computers might also be used to address the very problems they have caused. For instance, it is perfectly feasible to set up and lock in canonical versions of texts or images in digital storage, but this must be a social decision, because the technology does not encourage it. It must also be observed that the very multiplicity of representational formats requires general norms and standards to allow processing and transmitting digital representations.

The history of computing in the past two decades has indeed seen an increasing standardization in file formats (such as PDF or Word) with an emphasis on portability between different systems. Thanks to a few common formats, it has become much easier to share files between users without worrying too much about specific hardware or operating systems. Compatibility between file formats, however, is simply not sufficient to ensure the transmission of reference texts. The choice and preservation of works of reference can only be done by social institutions.

Textual and social networks

Another striking novelty is the generalized networked structure of digital information, on at least two levels: texts are interrelated by hyperlinks, and individuals (or groups) are increasingly linked by electronic media (such as e-mail or social networking). Of course, social relations have existed as long as human society, and scholars have always tried to organize knowledge into coherent domains. But textual and social links can now be made explicit and can be easily followed with a click of the mouse.

These new technical possibilities have given rise to a number of current metaphors: *browsing* web pages, *navigating* or *surfing* the web's structure, *following* social links… What they have in common is the availability of a structure that can now be exploited at little cost. Again, there is nothing new in the very notion of social or informational structure: men have always tried to use social contacts for trade, ambition, politics or the pursuit of knowledge, and encyclopedias have long exhibited indices and cross-references. Yet, following electronic links is so much easier and quicker that this constitutes a dramatic leap.

As a result, we now have easy access to an enormous and practically unlimited quantity of documents and knowledge. This is like living in a giant public library, with instantaneous access to all the shelves and reserves… The potential for learning new and maybe unforeseen information is mind-boggling, but how could we possibly manage, absorb and digest so much data? Our cognitive capacity has most probably not changed much in such a small time-span (a few decades), so there is a glaring mismatch between the information available and our ability to take advantage of it.

Worse still, the discrepancy between the amount of information and our capacity to process it tends to encourage a particular cognitive style, which might be called the *zapping* mode: exploratory but with a short attention span, curious but impatient, superficial and intellectually lazy. We have already witnessed such a tendency in the mass media, most notably with the television public, and the internet age threatens to make it even worse.

The wealth of information and easy navigability thus leads to a dispersal of attention and a fragmentation of content. Without strong integration mechanisms (whether cultural or technical), one is faced with a jumble of information of little useful value. To pursue the navigation metaphor, this would be like sailing haphazardly without map or compass. As a matter of fact, maps and compass were crucial to the voyages of discovery at the beginning of the Renaissance. Appropriate navigation tools would then be in order on the internet as well.

Possible remedies:

Navigational aids have then been devised to help us follow a course and reach a goal: search engines and social networking software have already become indispensable. Search engines work by continuously indexing as many web pages as possible, making retrieval from user queries more or less easy. Google's main contribution has been to exploit the structure of web links to recommend the most widely cited pages. Yet the retrieval performance of search engines is far from satisfactory: in so far as it can be ascertained, recall and precision hang around 50% (for the first 10 or 20 sites proposed). And it may be difficult for a novice user to formulate an appropriate query.

Social networking software and recommendation systems can then be used to tap into collective expertise to find, evaluate or recommend information and knowledge. Social networks (e.g. Facebook) build explicit links between users, while recommender systems (e.g. Amazon) compute a similarity between user profiles to recommend the same products to similar users. Google's ranking algorithm may also be seen as a first step in this direction (the hyperlink structure of the web is fundamentally a social construct). However, using social relationships (whether explicit or implicit) to retrieve information is still an open research domain.

Modification and redistribution

The network structure we have just been discussing, together with the processing ability of personal computers, makes it very easy to copy or modify documents and to redistribute them on the internet. *Duplication* is essentially costless, and *collaborative production* has become technically so much easier. A text can be reworked repeatedly, going through successive versions between several authors, by e-mail or by means of a shared wiki. The final result can then be posted on the web or disseminated on the internet at no extra cost.

The consequences of such an apparently innocuous technical capability are in fact dramatic. From an economic point of view, electronic duplication invalidates the traditional model in which one paid for cultural goods item by item (be it a newspaper copy, a book, a movie or a piece of music). Because the cost of producing a new copy is now essentially nil, paying for each copy doesn't make much sense any more, and repressive copyright laws will be hard to apply in the long run. New business models must be found to finance the production of cultural goods (e.g. taxes on internet access), but firms and lawmakers are still struggling to find and enforce adequate financing formulas.

Collaborative production of free software is then an interesting model, in which various participants contribute to a common software project without explicit retribution. The

phenomenon of free and open-source software is important, because it shows that, under certain conditions, people (and firms) are perfectly willing to work toward a common goal for free, producing excellent software in this way (see Feller et al., 2005).

From an informational point of view, the processing capabilities available to every computer user have greatly increased the production, modification speed and diffusion of documents of all kinds. Each user is now a potential producer and disseminator of information or knowledge. This represents a serious alternative to traditional top-down publishing or broadcasting systems, where information was sent by a few to the many. Information production is now potentially interactive, from many to many.

This is obviously a new world, but also the continuation of long-term trends. The possibility for generalized and interactive production of information is but the latest step in the long march toward the democratization of culture. Ever since the invention of writing 5,000 years ago, successive advances have made knowledge available to an ever wider proportion of the population: easier writing systems such as various alphabets, cheaper and simpler writing implements (e.g. paper rather than clay or parchment), the printing press, and nowadays the computer and electronic networks.

But with increased democratization and productivity comes again the danger of information overload and fragmentation of knowledge. The wealth of information provided by electronic networks is augmented for better and for worse by the increased number of possible contributors. A world in which everybody writes their own regular blog could turn into a cacophony of futile voices, or at best to a collection of unrelated little niche domains.

The increased productivity and capacity for expression made possible by electronic networks could be a cause for cultural confusion and disarray as much as for creativity. A healthy society maintains a dynamic balance between integration and renewal, cohesion and innovation. For the time being, it seems that the balance has shifted toward innovation and disorder, and we might require appropriate methods to try to organize the mishmash of documents which is flooding the internet.

Possible remedies:

Content democratization seems much more difficult to manage than dynamical representations and networking effects. We are witnessing an explosion of user-created content, but without any obvious means to organize such an outpouring. Technical norms and standards are irrelevant at the textual level, and search engines help retrieve information, but cannot organize or synthesize knowledge. The computer tools we have do not yet reach up to the semantic level. User tagging of documents (*folksonomy*) and the Semantic Web movement (annotating documents with structured descriptions) are steps in the right direction, but we are still a long way from automatic reasoning about texts.

For the time being, it looks like the only realistic approach is to resort to old-fashioned social institutions to try to make sense out of the present explosion of content. We still have to rely on newspapers and other mass media, universities and publishing houses to decide which information to filter, relay, publicize, interpret, criticize or reframe. The quality of this process and the time required are highly variable (quicker but more superficial for newspapers, slower and more thoughtful for universities for instance), and the diversity of relevant institutions is probably a healthy thing.

On the other hand, we could use available techniques in order to help organize this flood of documents. For example one might encourage the emergence of more or less standard patterns

for blogs and wikis, in the same way that scientific articles or books have assumed with time highly standardized forms. Systematically linking electronic documents with other relevant documents is another way to alleviate the fragmentation of public debate. In fact, many blogs regularly include textual and social links to related documents or persons. But a systematic reflection on this point should now examine the function of social institutions.

4. The role of social institutions

No society leaves cultural production to chance alone. In the realm of culture (as well as in other domains) social institutions have emerged to foster, develop, evaluate and control production. Culture has been variously associated with temples, schools, churches, monasteries, academies, universities and publishing houses. These institutions have been in turn beneficial, benign, harmful or irrelevant, but rarely absent from the cultural scene. At the best of times, a productive society manages to keep a precarious balance between order and disorder, innovation and conservation, repression and freedom. The role of social institutions is to try to maintain this balance.

More generally, an institution could be defined as a relatively stable pattern of social practices and conventions, fulfilling some social function and giving structure to social life. Institutions may be associated with formal organizations, but not necessarily. Historically, institutions often emerge more or less spontaneously from collective behavior in a given domain, to then become the conventional social reality framing individual behavior (see Berger & Luckmann, 1966).

Classical institutions

Universities are a good example of cultural institutions. An invention of medieval Europe (there were precursors but no exact equivalents to be found in classical Antiquity, China or the Muslim world), universities combined teaching, intellectual debate and cultural production in a novel way (Verger, 1973; Rüegg, 1992). By spreading organized knowledge and habits of critical thought to a wider urban population, they have had a hugely beneficial effect on European culture and society, first in the Middle Ages and again from the 19th century onward.

But universities also became more conservative in the 16th and 17th century (probably because of a gradual loss of autonomy and subservience to political power). For a couple of centuries, they contributed little to intellectual progress, which was mostly taking place elsewhere in more informal circles. Apart from the teaching role of universities, their influence on culture was mostly irrelevant, or even harmful when churning out solemn condemnations of anything new in philosophy or science. And even at the best of times, traditional universities tended to ignore technical crafts.

If social institutions can act as a damper on intellectual progress (as is often the case in periods of rapid change), why do we still need them? Why not be content with the raw, unelaborated cornucopia of knowledge offered by the internet? Well, let's imagine a big warehouse where merchandise would be stored at random, and where each article would be of dubious provenance and quality. It would then be very difficult to find a particular article and almost impossible to compare similar articles for price, quality and style. Such a store might be picturesque, but essentially useless for serious shopping. Similarly, unorganized, unevaluated knowledge is of little useful value.

So, what would be the relevant institutions today? In increasing order of their reaction time, but also in their cultural productivity and depth of critical thought, we could list the following social institutions:

- the mass media (TV, radio, newspapers)
- specialized magazines and journals
- publishing houses and libraries
- universities and research centers

Even in our internet era, these are still the main institutions which filter, evaluate, discuss, criticize and make sense of the flood of information that reaches us every day. And they do not function separately, but constitute a global system. They form a huge network, representing a hierarchy of levels with different reaction times and complexity of thought. Information and knowledge flow both ways, going up from the mass media to universities, but also trickling back from research laboratories to the general public through the mass media.

Now can these classical institutions deal with the information flow on the internet? Are changes necessary for this purpose? Or should we envision new institutions better adapted to electronic networks and their free-wheeling spirit? And what could these new institutions look like? Firstly, "classical" institutions will have to adapt to some extent to deal with electronic networks. But we may also imagine new electronic institutions to be more natural and efficient in cyberspace.

The adaptation of classical institution to the internet can only be gradual and will take time, because it basically requires a new literacy. New techniques must be learned, and more important still, new habits must be acquired to evaluate the wealth of information to be found on the internet. Once the basic techniques have been mastered (e.g. e-mail, web surfing, social networks…), one must learn how to evaluate semantic content (e.g. whether a web site is credible and reliable).

It is indeed amazing how quickly many traditional institutions have caught on. Newspapers and publishers in particular have learnt to peruse blogs and social networks to gather news, and then to post information on their web sites. Everybody has learnt to use search engines to check facts and to find information. And the web has radically changed the way scientific research is done, because it allows scientists to share results much more quickly and on a much larger scale.

Yet, these new practices seem quite superficial, compared to the size of the potential task. They touch on a very small proportion of what could be found on the internet, and have little effect on its content apart from a few islands (newspaper web sites for example). The internet is still very much a dark continent, with insufficient communications with the rest of the world. It is ironic to observe that this huge communication medium represents a different universe, which has in fact little intercourse so far with classical culture.

A possibility that has hardly been exploited yet would be for newspapers and magazines to publish regular criticism about chosen web sites or themes, in the same way critiques are published about books or movies. It is true that readily identifiable genres are yet to emerge on the internet, but regular criticism and the publicity it entails might hasten the development of more structured production formats. It might turn out, however, that classical institutions are simply inappropriate to deal with the internet, so that newer approaches would be needed.

Electronic institutions

Traditional institutions are probably inadequate in their present form to cope with the electronic information flood, which might be too rapid, too diverse and too decentralized for them. New electronic institutions should be based on the internet, working in relatively novel ways, and there already exist some very interesting attempts pointing in this direction. We would cite in particular Wikipedia (the electronic encyclopedia), the free software movement, and the tagging mechanism used on sites such as Delicious or Flickr. The recommendation systems (used notably by Amazon) represent another, somewhat different route for collaborative interactions, with indirect and implicit contributions by system users.

Wikipedia is an online encyclopedia, which has developed (and is still evolving) as the result of the work of thousands of anonymous contributors. Articles are collectively rewritten till they stabilize. Similarly, free and open source software is developed without pay by online communities of programmers, often producing excellent publicly available software (Feller et al., 2005). Tagging (i.e. labeling) documents by many individual contributors results in a common vocabulary that can be very useful to retrieve documents (Cattuto, 2006; Golder & Huberman, 2006), as a common semantics emerges from impersonal collaboration. Recommender systems exploit previous choices made by online users, giving advice based on behavior similarity among users (Adomavicius & Tuzhilin, 2005). For example, if you buy books on Amazon, the system will recommend other books bought by users with similar tastes.

These various attempts aimed at solving specific problems and had limited goals. But in so doing, they suggest a more general common model, which could serve as the basis for a new type of social institution operating by electronic means. The central feature of this common model would be *collaborative consensus-building among virtual groups*, made possible by the speed and low cost of electronic interactions. This is also necessary because virtual rules and conventions can only be enforced by consensus. And contrary to classical institutions, virtual communities do not require office buildings, meeting schedules or physical transportation. Neither do they require face-to-face contacts or stable personal relationships. Virtual interactions can be quick, cheap and impersonal (Memmi, 2006).

Another attractive feature of electronic collaborative work is that many people accept to contribute without payment or retribution. This was not obvious in a capitalist economy, but recent experience (notably with Wikipedia and free software) has shown that such a "free" model is both realistic and efficient. Whereas the mass media or universities must hire specialized staff in order to function, electronic institutions can be set up without having to pay wages. In fact, close analysis of the free software movement has shown that a majority of contributors are employed by universities and software firms, so that the ultimate cost is borne by classical organizations. But the point is that these organizations are willing to contribute in this manner to common projects.

To sum up, electronic institutions would have the following characteristics: consensual collaborative work, free contributions, rapid and practically costless interactions, mostly impersonal relationships. Collective agreement can emerge in this way quickly and at little cost.

This picture is too general, however. Some specific conditions must be met for such a system to work in practice. Recent experience of electronic collaborative work has shown to some extent what works and what doesn't, while more traditional institutions have had centuries to attain some measure of stability and efficiency.

Based on experience and common sense, we believe particular conditions to be necessary for electronic institutions to be successful. These conditions are about the same as for classical institutions, but are even more important because they cannot be enforced formally:

- a specific domain or task
a virtual community must be gathered around some central interest or task.
- clear ground rules
a group can only function if clear rules are followed, explicit or implicit.
- central management
successful groups are managed or moderated by an inner core of experts.
- durability of results
collaboration results must persist in time for collaboration to continue.
- visibility of purpose
aims and results should be publicly visible to motivate contributors.
- economic sustainability
participants must have sufficient resources to contribute freely.

These features might not be all needed at the same time, but most of them should be present for a system to have a chance of durable success. For instance, only a minority of free software projects are completed and fewer still pass the test of time. But institutions such as Wikipedia have already shown staying power.

Conclusion

We have seen the profound effects of technology on human culture. In the course of history, cognitive tools such as writing and printing have fashioned techno-cultural environments in which representations and knowledge have become more and more accessible to a wider proportion of the population. Computing technology and electronic networks are the latest development in this long-term democratization, and will have equally far-reaching consequences. We are obviously faced with a cultural revolution, which has only just started and which deserves serious thought.

We have examined the probable effects of electronic technology, due notably to dynamical representations, generalized networking and rapid, interactive modification of content. These phenomena increase cultural productivity, but also threaten us with a flood of fragmented, incoherent information. We have therefore suggested various technical remedies to address this concern. However, social institutions (such as universities and the press) probably remain the best means to try to deal with this massive flow of information. But virtual communities of purpose, i.e. an electronic version of social institutions, could be more efficient and cheaper to operate on the internet, provided some reasonable conditions are met.

Electronic institutions operating on the internet would possess some novel characteristics, because the medium allows and encourages collaborative work and free individual contributions. Pioneer efforts such as Wikipedia or free software have shown how efficient can be a model based on free contributions. Developing this promising model further is probably the best direction to follow so as to deal with the new internet culture.

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