Information Loss from Technological Progress

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Abstract. Progress in electronics and optics offers faster computers, and rapid communication via the internet that is matched by ever larger and evolving storage systems. Instinctively one assumes that this must be totally beneficial. However advances in software and storage media are progressing in ways which are frequently incompatible with earlier systems and the economics and commercial pressures rarely guarantee total compatibility with earlier systems. Instead, the industries actively choose to force the users to purchase new systems and software. Thus we are moving forward with new technological variants that may have access to only the most recent systems and we will have lost earlier alternatives. The reality is that increased processing speed and storage capacity are matched by an equally rapid decline in the access and survival lifetime of older information.

This pattern is not limited to modern electronic systems but is evident throughout history from writing on stone and clay tablets to papyrus and paper. It is equally evident in image systems from painting, through film, to magnetic tapes and digital cameras. In sound recording we have variously progressed from wax discs to vinyl, magnetic tape and CD formats. In each case the need for better definition and greater capacity has forced the earlier systems into oblivion. Indeed proposed interactive music systems could similarly relegate music CDs to specialist collections.

The article will track some of the examples and discuss the consequences as well as noting that this information loss is further compounded by developments in language and changes in cultural views of different societies.

1. Survival of technology
Throughout history there has been a steady increase in understanding and use of technology, from manufacture of stone and metal tools to glass, and the plastics, metals and semiconductors of the present day. It is therefore very tempting to believe that we are acquiring not only more data and information, but also a deeper level of knowledge and perhaps some wisdom. Unfortunately this is not true as the new technologies exist because they have displaced, or made obsolete, the earlier alternatives. In general that means that many of the former skills and understanding of the relevant science and production methods have been lost. It is also disconcerting to realise that the expertise to generate and innovate technological progress resides in a very tiny fraction of the population. The reality is that a smaller percentage of the population now understand our key technologies. Trivial examples are that 50 years ago most families had members who could undertake many of the repairs on a car engine or equipment in the home. Now it is rare to even recognise the components of the engine and most home devices have electronics and electronic chips which are only amenable to experts with complex monitoring systems.

Knowledge has never been permanently retained so loss is not a new phenomenon. Our brain certainly has limited retention and reliability but we assume that we can always have secure tangible
records available to deal with important data such as bank accounts, photographs, letters and personal or family matters. Such items, when committed to paper or photographs can certainly survive our life span and many archives have historic documents and family records that have survived many hundreds of years, plus family photos even from the 19th century. Technological progress has modified this as instead of pen and ink, or typewriters, we have advanced to sophisticated word processors on our computers and electronic data storage in a range of formats and on numerous types of storage system. Similarly black and white photographs moved into colour film and then to digital cameras (and mobile phones). Acquisition has therefore speeded up very rapidly, image processing to edit images, and corrections and mass production of text for storage or electronic communication have become the norm. Indeed many people probably keep no hardcopy records and correspondence is solely by email etc. Writing, correction, mass production and transmission have therefore greatly speeded up. This is 21st century progress.

Associated problems are now emerging. For example the improvements in computer speed, software and storage have taken place, not by improving earlier designs but by leaping into new structures and software which almost invariably are incompatible with earlier versions. Therefore if we had our correspondence and private information on early systems and stored it on floppy discs as used on older computers then we will now have a problem. Once we replaced the computers and bought new software and word processing packages much of the prior information is inaccessible. Further, we need upgrades to receive documents in the new formats. As I will emphasise later most software becomes obsolete or unsupported after around 10 years, and similarly the storage improvements and new formats are rarely accessible after 20 years. These are time scales that are shorter than our human memories and definitely give a situation where we will never pass on information to future generations. The other key factor is that storage on commercial systems (or even home computers) is far from secure in terms of device failure, deliberate malicious access to destroy, change or use the data, and certainly in terms of any network communications of the data it is likely to be monitored both by government agencies and an ever increasing band of criminals. Cyber crimes are a boom industry with profits now measured in the range approaching a billion dollars a year.

2. Reasons for information loss

Skills, data, information and knowledge are often acquired laboriously over long periods of time therefore it may seem unfortunate that they are lost. The reasons are diverse and broadly fall into the following categories of (A) natural disasters; (B) human generated disasters such as wars; (C) religious and political doctrine; (D) failure of the storage media by loss or decay and (E) loss of the language and culture in which the information was written. In addition we may not accept knowledge when it has been acquired or offered because of (F) instinctive rejection or blinkered precondition viewpoints; (G) cognitive dissonance (that means we do not accept ideas which are far from our experience); or (H) religious and ideological dogma.

2.1 Natural disasters

These are inevitable and although we may have little control over avoiding and predicting them the majority of events such as earthquakes, volcanoes, tsunamis or small meteorite impacts tend to be localised. Although they may destroy a local region they rarely have long term global effects. Historically, a major volcanic event at Santorini not only destroyed the Minoan civilization but the consequent disruption in global weather patterns also caused collapse of other regions, including the dynasty in China at that time. The large scale examples of major meteor impacts and ice ages are clearly different and if they are repeated we will be content with survival, even if most of our technology vanishes. Nevertheless some natural events have caused unexpected problems in manufacture of technological items, for example parts of laser printers were made at a single factory that was destroyed in an earthquake. Other equipment examples may emerge and certainly key materials, such as the minerals providing rare earth ions, tend to originate from rather few sources so political restrictions could have major world wide impact.
A more critical natural problem exists as the result of particle emission from sunspots. The clouds of ions and disturbance of our magnetic field would previously have offered beautiful examples of the Aurora Borealis but, prior to any electronics; the only effects would have been psychological or interpreted in terms of an act of the gods (i.e. in the same way as solar or lunar eclipses). Nevertheless geological ice records show that major sun spot activity happens relatively frequently with patterns of major events every few hundred years. A modest event in 1859 disrupted the telegraph system in America. If we realise that this was the simplest of electrical pulse technologies using Morse code then it is clear that electrically it was a significant electrical storm. In recent years there have been several occasions when electrical grids have failed because of solar activity. Of far greater concern is that when the next major sunspot emission takes place we are extremely likely to be catastrophically affected, not just because of our total reliance on electronics, but more importantly that the electrical grid network could be destroyed. This means total loss of all facilities such as electricity, water, gas, petrol pumps and food supplies. Even for smaller events there is the potential danger of the loss of satellites plus substantial interference with ground based electronics. Destroying satellites would have impact on many areas from communication, satellite navigation, radio and TV as well as all the military defence systems, and not least, communication via mobile (cell) phones. Aircraft would be grounded and many computers and electronic networks could potentially be destroyed. The damage would probably include access to internet and media storage systems.

Electronic interference is inevitable but the consequences have probably rarely been considered in the depth that is essential for survival of society as it currently operates, however a recent international group considered a scenario comparable with the modest 1859 event and suggested low cost safeguards that should be implemented now [1, 2]. Without such precautionary measures power failure could exist for several years, with insurance predictions in trillions of dollars, even assuming that governments could operate.

A further example of disasters that are outside of our control is the spread of disease and plagues. These are an inevitable part of evolution with an average of about 3 pandemics per century. In former times, when many people were illiterate and information or music were passed by personal contact, then a plague could curtail this route and all the prior knowledge of a region could be lost. Previously we were cushioned from such situations as transport speeds were low and diseases spread relatively slowly. For example in the Black Death of the Middle Ages land transport was typically spreading the disease at less than 5 km per day. By contrast, at the end of the 1914-1918 war the influenza epidemic travelled far more rapidly and killed more than 20 million people (i.e. more than in the fighting) and this was the result of better transport. By contrast every major city and country is now linked by air travel so a new virus can be disseminated across the world within a 24 hour period (i.e. often faster than symptoms can develop). We need therefore to be aware that widely held knowledge and information may survive the next major epidemic, but in many areas of technology the skills are highly localised and one could imagine a scenario where all the world experts in a topic were struck down at a conference in an exotic location either by disease, tsunami or a plane crash.

2.2 Human generated disasters
Here one could write volumes but in terms of knowledge loss, or suppression, the major villains are wars, religious fanaticism and fear of knowledge which would undermine particular beliefs. Persecutions motivated by racism and religion have, and continue to destroy countries and kill or exile specific groups of people so the knowledge and diversity of culture of the countries involved then suffer. There are many political examples of invaders destroying all literature of the country that has been invaded, and also killing those with knowledge. From the viewpoint of the invaders this is a sensible strategy as it removes dissent and makes it easier to impose the new regime. Religious persecutions and enforced conversions of an invaded nation are similarly viewed as standard practice. Scientific knowledge can easily be seen as undesirable by those who base their ideas on faith, not quantifiable repeatable observations, and a familiar historic example came with the difficulty in accepting that we are just a planet circulating the Sun, not the centre of the Universe. The reality
downgraded the faith that we are the epitome of all creatures. Further, the current astronomical observations that many other stars have planetary partners are likely to cause religious problems if there is evidence of other life forms on those distant planets.

Accidental fires have also destroyed documents and information that were stored in major collections. One such was the loss of the Ancient Library of Alexandria. This site, of library plus research institution, accumulated many thousands of key documents from all over the Mediterranean region from its founding in the 3rd century BCE. It was the greatest centre for study in the region. One, or more, fires destroyed it and the irreplaceable contents. Several of these fires were related to warfare or religious intolerance.

2.3 Intuitive rejection of new ideas

Somewhat surprisingly information is often unconsciously rejected or distorted as part of our normal signal processing. Our instincts, honed for rapid response and survival, mean we make instant decisions as to a danger or situation. All subsequent evidence is then processed to support our initial view, even if it is wrong. There are classic examples of this over zealous decision making. One such is found in the courtroom where juries tend to make an instant initial assessment of the person on trial, and then ignore or re-interpret evidence that disagrees with this first view. Such a subconscious error is equally a common feature of research where we have a scientific model, and then bend our interpretations to make data agree with it. This is not dishonesty, but an inherent human response. A third well documented example is seen in analysis of X-ray images to detect cancer. If the analyst sees a definite cancer site in one region then this will become a primary focus and, despite efforts to look at the rest of the image, the eyes and brain will return to the first site and not recognise secondary ones elsewhere.

We are also more likely to accept new ideas that are close to facts or ideas that we already understand or believe, and reject anything that is too radical (independent of the evidence). The degree of acceptance will increase if the presenter is particularly famous. This effect, called Cognitive Dissonance, is very unfortunate for outsiders to a field who arrive with no preconceived prejudice and clearly see facts that the members of the topic area cannot recognise because it is not in their training or would conflict with senior figures in the field. A classic example was the case of Wegener who, although a meteorologist, noted that maps of South America and Africa had close similarity as though they might have been joined. He then made studies of fossils and rock strata in equivalent matching regions and found a close match. Consequently he proposed the continents had drifted apart. His work was totally rejected because he was of the wrong discipline and the idea was too radical, and it was nearly 50 years before his model of plate tectonic movements became widely accepted.

2.4 Information loss from changing language and material decay

Writing has existed for several thousand years with examples from the Middle East of simple Cuneiform lines made in soft mud that was then hardened, to various styles of picture coding such as Egyptian hieroglyphics or the forerunners of Chinese calligraphy. Both these Western civilizations eventually faded from prominence, their languages changed and new styles of writing evolved. This resulted in the existence of many examples of the writing but without any memory of the language or how to interpret the signs. Decoding such scripts has therefore been challenging. Hieroglyphic analysis was helped by discovery a stone in 1799 with the same information from 196 BCE written in Egyptian Hieroglyphics, Greek and Demotic with a decree from Ptolemy V. This was called the Rosetta Stone. Other lost languages such as the Minoan Linear A and B were decoded by inspired imaginative analysis. For factual writing and records we therefore have a gained a moderate understanding when such examples exist. Records of victories or justification for invasions may be clearly written but they are invariably produced by the victors, so here the knowledge lost may be the truth. Interpretation of more subtle texts of opinion, philosophy or comments are far more difficult because not only do we not know the nuances of the phrases used, but just as in modern language, these can change dramatically with time. We are also totally guessing at the cultural and religious
implications of text written in earlier periods. The situation has not changed as languages are now evolving extremely rapidly because of easy modern communication. For example viewing films or TV programmes from 50 years ago (or less) offers insights into a different world, and the content often seem so dated that it almost inconceivable that they were the norm of that period. This changing situation is obvious for many people still alive today. Listening to teenage slang and the way words can alter, or reverse in meaning within a year, underlines that language and context are incredibly transient. The speed of the changes has been exacerbated by faster communications.

Survival of text and pictures is equally determined by the long term stability of the materials used and here we move from philology into more clearly defined chemistry and materials science. Writing on clay tablets or stone carvings may have been slow and tedious to produce but the materials have survived several thousand years. Indeed the numbers that exist are remarkably numerous once we realise that the early populations were extremely small, and most of the people were illiterate. There is no way that our generation will leave an equivalent fraction of the words that we have written. Progress to papyrus, vellum and later writing surfaces certainly speeded up document production but the materials have had a progressively shorter life expectancy. Materials such as papyrus and vellum could mechanically crumble, be burned or reused for other purposes, and in many cases depended strongly on the climate. For example the Dead Sea Scrolls are some two millennia old but have survived because they existed in dry desert conditions. The inks available at the time have also faded although in some cases infrared reading can reveal early writing, and sometimes later work written on the same parchment. Nationally important archival material has often been preserved but this is invariably because the parchments etc have neither been in a war zone, fire or poor climatic conditions.

Survival of paintings shows identical problems and one can contrast the pictures of the Last Supper painted by Leonardo da Vinci around 1494-8, with the Raphael School of Athens painted in ~1500. The Last Supper was a fresco on a damp North facing wall next to kitchens, in a room that was later used as an army barracks. The original may have been magnificent but by 1642 it had virtually vanished and all the current reproductions are based on copies and the very different attempts at restoration. Hence colours have changed or people face in different directions according to the restorer. By contrast the School of Athens is in excellent condition. We have not lost the painting but almost totally lost the hidden meaning. Art experts will offer opinions as to the symbolism of the statues and central figures, and identify the faces as images (real or imagined) of the various key faces displayed. This is lost knowledge for most viewers and the art literature suggests that there is far from universal agreement among the experts. The key theme here is that even if we have an ancient painting or text in good condition we invariably fail to recognise all the encoded information of the mythology, references to events at the time, or symbolisms of dress, gems, flowers and hand gestures etc. Basically we can never understand the work of earlier generations with the same mind set as those for whom the work was created. Similarly many people enjoy music written several centuries ago and play it with reproduction instruments at the pitch used at the time of composition. Undoubtedly pleasurable, but it is from our perspective, not that of the earlier time. Indeed this is a universal situation over all musical genres from all periods whether Baroque, early jazz or the hits of 20th century pop.

2.5 Recording of music and images

Rather than move directly to modern electronic technology it is informative to trace the way music and pictures have been recorded and broadcast. In the mid 19th century sound was used to mechanically imprint patterns of wax drums. It needed an intensely loud volume, the playback sound quality was poor, and playback damaged the recording. Nevertheless it showed potential. Improvements moved the method consecutively to wax discs and then, with the advent of triode amplifiers and microphones, on to shellac records offering some 4 minutes of sound. This was long enough for dance music with a wide public appeal and it triggered developments on to longer playing vinyl discs which eventually ran for about 30 minutes per side. Attempts to make more compact and/or portable systems used
magnetic tape; this was followed in the mid 1980s by the introduction of the CD which could record up to 80 minutes per side. Sound quality steadily improved as did all the associated electronics of amplifiers, speakers and headphones. More important than the actual progress is to recognise that each new technology had a lifetime of around 20 or so years before it was overtaken. Further, the progress was enabled by totally new systems which made the old equipment obsolete. Commercially this was also desirable as it opened an expanding sales market for equipment and the need to rerecord music with the modern methods so even the older records etc were outdated. It also appealed each time to new younger audiences and was not limited to any specific style of music. Later recording may exist on versions of MP3 or computer files as these have enormous storage capacity. However, the format is not necessarily of the same sound quality as the CD but for the mass market this no longer seems critical either because of the style of music that they are used for, or as they merely provide background sound.

Image capture followed a similar pattern in that the earliest photographic emulsions emerged in the 1820s. Their speed and fidelity improved and moved from glass plates to more flexible cellulose supports etc and expanded into the silent cinema images. By the 20th century resolution and film speed increased (plus movie sound tracks). The cinema further drove a move into colour (and stereo sound). Video tapes competed with film and several alternatives battled for 20 years until they were in turn superseded by DVD formats. On-line viewing of films has even displaced these for many people.

A related set of developments has occurred in TV broadcasting from the tiny low resolution screens of the 1930s to a variety of line formats and signal encoding which have increased the size, colour and picture quality. A comparison of the original TV with modern high definition images is remarkable. Further, the response speed for action events and signals encoded for stereo viewing are still lively topics. The new systems are of course unable to play older recordings. Not surprisingly when we analyse the survival of each format the lifetime is still decreasing and modern TV systems have lifetimes of probably 10 years before they are replaced with new models.

3. Progress, obsolescence and information loss with electronics and communication

In the 21st century we may be justifiably proud of the technological achievements, especially from the last 150 years. In long range communication in the 1850s this was by digital electrical pulses with Morse code at a few letters per second. The move to optical pulse coding and glass fibres required a major technological effort in the production of transparent materials, electronics to encode pulses, laser sources compatible with fibres, switching and wavelength multiplexing to send many channels down the same fibre at different wavelengths. Receivers, decoders and in-line optical fibre amplifiers were all developed to maintain a steady improvement in capacity times distance (i.e. a measure of the fibre performance). As the user we did not appreciate that each new advance was made with new technology that replaced earlier ones that had reached their limits. However, from our viewpoint the performance is now some $10^{12}$ times better than the ancient Morse code (i.e. a phenomenal advance in 150 years).

More obvious to the public have been the improvements in electronics for faster computer chips, CCD cameras with more pixels at lower cost, and smaller and ever larger electronic storage systems. Initially computer chip density was doubling in under ~2 years (popularly known as Moore’s law); computer speeds were therefore increasing; CCD “pixels per dollar” increased logarithmically, for example by 100 times during the period between1994 to 2004; and hard disc capacity has been rising at a similar rate. Marketing of computers, cameras and stores strongly advertised such progress as it encouraged purchase of new state of the art equipment with totally new software. Unfortunately more transistors per unit area imply they are smaller and so eventually the advances have hit minimum size limits, and the logarithmic improvements with time have currently ended. Instead the commercial focus is on mobile phones with applications and new models released annually (invariably incompatible with some features of earlier ones).
4. The emerging pattern
The pattern is always the same. Once a technology has a mass market it evolves by innovations that are rarely compatible with earlier versions. The time taken to obsolescence depends on the sophistication. Simpler items, such as equipment for playing music probably lasted 20 years, in part because there is a new generation that will purchase it, even if it is a large investment. More high technology examples of computers, software, CCD cameras or mobile telephones have progressively shorter half lives before they need to be replaced with times ranging from say 5 years to one (in order to have the fashionable mobile phone). Almost always the innovations come from young engineers who are also among the prime market for the products. So to them the associated obsolescence is irrelevant as they want it and can afford it, plus they understand how to use it. They fail to recognise that not only does this induce obsolescence of equipment and older stored information but it progressively isolates and undermines the sections of society who cannot afford the changes, or perhaps because of ageing, cannot comprehend how to use the new items. Therefore many retired people still prefer hand written correspondence and “real” people on a telephone help line. The computer driven society is both alienating them and undermining their self esteem. Indeed trying to find a state of the art modern mobile with a keypad readable and workable by a pensioner is almost impossible (except for very basic telephone functions).

Increasing wealth and new electronics generally speed up both the progress and the rate at which earlier systems become obsolete. The consumer who is content with the original system often has no choice to keep it as for example the costs of replacements and repairs favour the new purchase. In some cases, such as TV, no signals are broadcast which match older receivers. Information loss from obsolescence of earlier storage media is inevitable.

The pattern equally predicts that current items, such as CDs, are definitely approaching the end of their favoured position and for music the opportunities for interactive CDs merely require some new electronic processors so that we can adjust the sound to suit our home audio systems and room acoustics, or alter the balance between the various performers on the disc. These are highly desirable features and within the scope of current technology.

5. Estimating information survival lifetimes
Future historians will have major problems finding access to correspondence and ideas or journals that have become solely electronic as most will either be in obsolete formats, encrypted, corrupted or erased. Major data archives and libraries away from the security of access to the internet will be fewer in number. Whereas those items connected to the outside world via the computer, or stored on “cloud” systems are remarkably vulnerable to failure of the provider, malicious attack or, in the event of a political strategy have reduced access. Indeed it is predicted that in the next major world conflict the first attacks will be corruption and destruction of the electronic communications of the opposing side. (NB One major power recently invested 50,000 euros in electronic typewriters so as to minimise computer espionage). Note also that “cloud” service providers have not yet been in business for long periods of time and storage may require payment which will cease when a person dies and bank accounts are frozen. This will cause deletion of material. Home items on CD (or later systems) will need frequent backup to state of the art access and this is precisely the type of task that will not (or cannot) be done by the elderly, so family records and photos will vanish very rapidly.

One also assumes that access will continue whereas in reality fibre optic overloads will occur as links are used even more extensively for social networking, advertising, spam etc. For long distances most fibre optic links are under the seas and there are many regions where systems are channelled in clusters. This makes them vulnerable to natural, accidental or terrorist interference (e.g. near the Suez canal there have been two recent events where some 60% of the East-West capacity was temporarily lost).

In the early development of computer chips the speed of competitive progress resulted in an identifiable logarithmic pattern of improvement (Moore’s ‘Law’) so one can ask if there is an equivalent description which predicts how fast information will be lost. Not least because of the
technological advances. To avoid Cognitive Dissonance I will offer a model in terms of familiar science of Thermodynamics (Zeroth plus three laws), Exponential decay (as for radioactivity) and the Heisenberg uncertainty principle (i.e. a trade off between different factors).

There is an equivalent of a half life in the survival of storage media. The constant will differ between say stone tablets and CD storage but the pattern is that technology is the driving force producing a shorter survival time. By contrast the speed of writing and communicating is expanding phenomenally (e.g. social networks of Facebook, Twitter, blogs etc commit facts and trivia to the internet at ever increasing rates and Facebook rose from zero to a billion users in 10 years). So with my model of a Thermodynamics pattern of laws I have:

A zeroth assumption as:

- The speed at which information was written or prepared is the inverse of the survival time.

This offers a Heisenberg equivalent first law as:

- The (writing speed) x (the quantity stored) x (the survival time) is a constant (S).

A second law is in the style of radioactive decay:

- Information and storage media decay, or become lost, exponentially with time. The half life depends on the media.

A third law matches the non-attainability of absolute zero:

- All information is eventually lost.

This is good thermodynamics.

One can guess at numbers to add for the decay constant but in principle my first law has a sensible pattern relating writing speed, information content and half life survival time. As a simplistic attempt one might compare copyist from different epochs, such as those writing on clay tablets, the high sped scribe of the Doomsday Book and a good 20th century copy typist using an electric typewriter. My examples are adjusted for a year output as though there were a 24 hour working day and half lives are defined as from production to present.

Clay tablets at 365 pages per year have survived 5000 years gives S of ~1.8 million.

Doomsday scribe 2000 pages with books that exist 900 years later gives S of ~ 1.8 million.

20th century electric typewriter copyist at ~9 pages per hour with paper and print fading after 25 years offers an estimate of S around 2 million.

The pattern is encouragingly consistent. As a final test we might consider the writing of a doctoral thesis but here it is necessary to account for all the preparation time, experiments, calculations and graphics production. Since the work will involve a computer many aspects will be speeded up by a factor of say $10^4$. With this major assumption we can then predict the half life for a thesis which took a year to prepare and had 150 pages. The first law offers $150 \times 10^4 \times (\text{half life}) \approx 2 \times 10^6$. Hence the thesis survival time is a little over a year. This is probably true since key items will be published and after the viva the thesis will be consigned to a library and mostly forgotten. Whilst such numbers are unimportant in detail they nevertheless support the pattern of advancing technologies causing an ever shorter survival time for the output.

6. Social isolation and loss of creativity

The preceding examples are tangible and often quantifiable but of at least equal significance are the negative social effects of new technologies. These appear in many guises. For example one often sees small children in push chairs or playgrounds being totally ignored by the parent who is concentrating on chatting on a mobile phone. Instead of stimulating creativity and socialising most children now play ready made computer games in isolation from the family (often with games that have a highly violent content). Similarly there is an essential need to conform to peer group pressure and so they speak incessantly with other children by phone, Facebook, Twitter etc. This means this generation has lost the time to daydream and have reflective self assessment of what they want from life, and it undermines their future creativity. For many, family meals, or even those in cafes with friends, are not focussed on the immediate people but on banal phone usage. One can only guess at the consequences of this social pressure and subjugation of private and original thinking. Further, lack of exercise and
overeating is causing obesity and subsequent medical problems, so this is the first generation where the children are less fit than their parents were at the same age.

At the other end of the age spectrum both the elderly (and poor) are severely disadvantaged if they do not have ready access and capability to operate on-line communication for searching for bargains, finding out vital information from local governments and/or understand how to use on-line banking and simultaneously recognise scams and viruses. These are daily problems that are more serious and immediate than losing old correspondence or photographs. Other difficulties now arise during travelling, for example in London the buses do not accept money but require pre-paid electronic cards or bank cards; one of the major bridges needs pre-booking by mobile and card instead of a toll booth. For those without mobile phones and computers (roughly 10% in the UK), or visitors and travellers, these are highly inconvenient.

Overall advancing technology is both undermining creativity and serious face-to-face social interactions and progressively isolating both the poor and the elderly.

7. Summary
The aim was to emphasise that improvements in technology offer some advantages for our lives but invariably former skills are lost and equipment becomes obsolete. This has the major consequence that storage media are progressively more transient and less secure. Our reliance solely on modern technology is equally hazardous as in the event of international conflicts, or even major sunspot emissions, many of the communication and storage systems will either fail and/or be disrupted. Corruption and unwarranted access to data is similarly an increasing hazard, not only from monitoring by Governments and industries, but also from malicious and criminal activities. Indeed computer crime is a boom industry.

Virtually all aspects of my comments are in the public domain with internet access. In the spirit of ignoring hard copy, and relying on modern technology for fast access, minimal references are provided (e.g. from tectonic plates to paintings of Raphael) however internet sites will offer considerable detail in every case. The development of recording is covered by [3, 4] and [5] includes future ideas for CD recording and obsolescence of earlier instruments.

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