

Chapter 8 Literacy

A few years ago I met a woman in Bombay who was completing her PhD in social anthropology. She had just returned from a field trip to Rajasthan where she had spent time with a group of travelling story-tellers. This particular group went from village to village, unannounced, and would simply start a performance in the village square. Although each story would have a familiar plot –the story telling tradition dates back thousands of years – each event would be unique. Prompted by the storytellers, who held up pictorial symbols on sticks, villagers would interact with the story. They would be part of the performance. I commented to the woman that with that depth of knowledge about interaction, and the combined use of words and images, she could get a job with Microsoft tomorrow."What's Microsoft?", was her reply.

This episode confirmed my prejudice that we still don't know how to design for communication. We know how design messages, yes: the world is awash in print and ads and packaging and email spam. But these are one-way messages. They are the output of a point-to-mass mentality that lies behind the brand intrusion, and semiotic pollution, that despoil our perceptual landscape. We live less in an information society, than in a signal transmission society. We're so flooded by noise that it's hard to understand what's going on. We have learned to filter out noise and distraction, but in so doing we have also lost sight of bigger picture.

Our perceptions of time and process are especially weak. We have constructed a technology-centered social system built on principles of standardisation, efficiency, and the division of labour, that obscures the bigger picture. We depend on human, natural, and industrial systems which interact in complex and dynamic – but also invisible – ways. A change through time is, by its nature, hard to see. Our problems, being cumulative, are easily ignored. Collectively wasteful behaviours seem trivial in themselves: leaving the light on; printing out an email; eating a plate of Kenyan beans. It's the accumulation of such tiny acts which weighs on the planet. As Paul Ehrlich has explained, we are not genetically hard-wired to respond to long-term dangers. Civilization may well be threatened by changes taking place over years and decades – but we don't notice changes over a few years or decades¹. Edward O Wilson makes a similar point:"Reality was not constructed to be easily grasped by the human mind; our species is the product of evolution, not the purpose of evolution"²

In order to do things differently, we need to see things differently – which is why tomorrow's literacies need to be systems literacies. We will need new perceptual aids to understand the state of our systems – to "read" their morphology, their dynamics, their intelligence, how they work, what stimulates them, how and why they change through time. We need to make time and process legible – to design representations of phenomena that, right now, are invisible to us.

So how might we make such aggregate heaviness visible? Many affective representations of complex phenomena have been developed in recent times. Physicists have illustrated quarks. Biologists have mapped the genome. Doctors have described immune systems in the body, and among communities. Network designers have mapped communication flows in buildings. Managers have charted the locations of expertise in their organizations. But these representations have been made and used mainly by and among specialists as objects of research – not as the basis for feedback and sense-and-respond behaviour by wider groups of people.

Representations of energy flows would be a good place to start. We need to reduce the ecological footprint of the cities we live in. Natural ecosystems have complex biological structures; they recycle their materials, permit change and adaptation, and make efficient use of ambient energy. Real-time representations of energy performance in the built world could show us where resource systems are "leaking". Visual feedback on leaky energy systems and behaviours would help us close matter and energy loops drastically. Combined with reduced construction energy and materials costs, most buildings in use could in time export energy rather than consume it.

Sensitivity to changes in their state through time develop best if we learn to use all our senses, not just sight. The dramatic arts of film and theatre, and the metaphors of visual art, can be re-purposed to help us understand – to know – the behaviour of systems. Otherwise stated, our communications need to be more visceral or, as Bruce Sterling puts it, we need to "augment reality, aestheticise all sensors". If carbon dioxide were blood red, our skies would look ominous indeed. He points out. The architect Luis Fernandez-Galiano, in *Fire and memory*, says we need to shift our perceptions "from the eye to the skin – to develop not just an understanding but a feeling of how complex processes work..."³

Natives of the Adaman jungle in India have constructed a complex annual calendar built around the sequence of dominant smells of trees and shrubs in their environment. When they want to check the

time of year, they simply smell the odours outside their door⁴. For most of our time on earth our senses – taste, smell, sight, hearing, touch – have been the main ways we experience a connection between the self and the world. We need to rediscover that communication richness.

Many representations of complex phenomena have been designed. But they don't get used. The purpose of systems literacy is not to watch from outside, it is to enable action.

How might we do that? One way is to make space for other forms of communication than impressive spectacles. Thinking about those storytellers at the village in India, we need to make space and time available for discourse – not just dissemination. Camp fires could replace billboards.

Overloaded, underframed

Although information overload preoccupies the media – who help cause it – our dilemma is not that we receive too much information, but that we lack ways to select what's important. "We no longer have roots, we have aeriels" goes the urban legend. Physiologically, our bodies and brains have not evolved much since shepherd boys sat under olive trees in Biblical times, and watched goats eat grass. They processed a similar volume of data as we do, but were less distracted. Information overload is a misnomer. We don't receive anywhere near the data it takes to overload our neurons. According to Raphael Needleman, the editor of Byte, our mind is capable of processing and analyzing many gigabits of data per second--a lot more data than any of today's supercomputers can process and act on in real time. The reason we feel overloaded is because we're getting information unfiltered, unsorted, unframed. "A lot of our bandwidth is consumed with the boring act of filtering out the junk" says Needleman. The design challenge is making information digestible, not keep it out⁵.

We have a lot of packaged information to choose from. The 545 miles of shelves in the Library of Congress hold over 100 million pieces of literature, including 27 million books and pieces of literature, 1,200 newspapers on file, 100,000 films, 80,000 television and 500,000 radio broadcasts, and a million other sound recordings. The mountain swells continuously: every day of the year a thousand new book titles are published; laser printers churn out 600 million sheets; and copying machines add another 250 million pages. Twenty million words of technical information are published each day by scientists, (95 percent of all who ever lived, are still alive⁶). This milky way of words are packaged scientific papers in peer-reviewed academic journals: more than 5,500 of these are

published daily, too. As a former magazine editor, this last number struck me as fearsome until I discovered (from William Horton's excellent book) that, thanks to the peer review process, fewer than one third of these texts are read by the editor of the journal concerned – and that ten percent of them have not even been read by the professor whose name appears in print as its author, thanks to sterling work by armies of graduate students⁷.

Our technology-filled world generates its own mountain of data. The volume of data needed to understand a technological device has multiplied a thousand times in my lifetime. The pilot of a World War II fighter aircraft could probably fix by consulting its 1,000 page manual. By the early 1950s, the engineers servicing his aircraft had to look things up in a 10,000 page manual. This document bloated to 100,000 pages by the 1960s when avionics and jet propulsion became standard. Today, you would have to read one million pages of documentation to understand how the B2 stealth bomber works; presumably, therefore, no one person does. Moving up a scale, high-tech navy ships were carrying 10-40 tons of paper manuals and forms until the 1980s. Most of this paper was kept above deck for ready reference, but this raised the ship's centre of gravity and thereby reduced its speed, manoeuvrability, and fuel economy. By the time came to build the \$23 billion Space Station Freedom, the only way to measure the amount of documentation required was by cost: \$1 billion for documentation⁸.

Top-heavy warships, and warplanes that could not take off while carrying their own manual, were among the main drivers of the digitisation of technical documentation. But the emigration of technical data from atoms and bits did not slow down its growth. Most new information is stored on magnetic media, not on paper but, unluckily for trees, although the percentage of hard copy is declining, the overall total is exploding. On the contrary, we now produce between one and two billion gigabytes of original information per year – roughly 250 megabytes for every man woman and child on the planet. Over a three year period, we create significantly more information than has been created since the beginning of time⁹. Researchers at the University of California-Berkeley calculate that five exabytes of new information – roughly five billion gigabytes – was created in 2002 alone. Five exabytes is like half a million libraries as big as the above-mentioned Library of Congress print collections¹⁰. And that's just stored media; broadcast media add immensely to the total. The average American is now exposed to 254 different commercial messages in a day, up nearly 25 percent since the 1970s. Advertising people call this the "clutter" problem and solve it, of course, by adding to the clutter¹¹.

Knowledge maps

One way we deal with all this stuff is to surf. Some people change stations as much as 22 times per minute, or once every 2.73 seconds. Some psychologists argue that this behaviour which is a perfectly effective response to the proliferation of channels, but a less sanguine interpretation is that we filter out too much and are navigating through life half-blind. As EL Doctoro put it, "it's like driving a car at night. You never see further than your headlights, but you can make the whole trip that way".

A better way to organise large quantities of data is to make maps. Of the part of the human mind that processes incoming signals, 90 percent is devoted to input from our stereoscopic visual system; presented correctly, we can understand data in multidimensional form extremely well. It is already commonplace to encounter software programmes that take seas of stock market data and shape them into a visual, moving, morphable shapes that make sense to us¹².

At a recent Venice Biennale of Architecture, David Rokeby I presented a work entitled "Seen" which visualized the flows of people passing through and hanging out in Piazza San Marco in Venice. Rokeby used a video camera as a sensing device. A video camera has about 300,000 pixels, and each individual pixel can be considered an individual sensor, so the camera effectively projects 300,000 sensitive beams into the space it is observing. By applying algorithms to each pixel or local set of pixels, Rokeby rendered the results as processed video images, live and in real-time. The resulting image is striking, dynamic and eloquent. The trajectory of every single pigeon and every single pedestrian in the piazza is tracked and leaves a fading trail that defines the direction and speed of their movement. "We have a highly developed visual system that outperforms computers at many tasks involving large correlated fields of data, says Rokeby; "the computer is capable of shifting invisible phenomena into the range of our perception, allowing us to use our own highly refined abilities". This is especially true of cross-temporal phenomena that constitute flow: movement patterns that happen too quickly or too slowly for us to properly register with our eyes¹³.

What would it mean to use techniques like this to monitor our planet's virtual signs in real-time? Would it be feasible to design perceptual aids to help us to understand the invisible natural systems which surround us? The science fiction writer Bruce Sterling asked us to think what it would be like if CO2 was red, and our wasteful emissions turned the sky to the colour of blood; or if we designed the

eco-equivalent of a Geiger-counter, a device with sensors that would click, eerily, whenever we left the tap on. In Germany, a design group called Art+Com has an interface ready-and-waiting. Called T-Vision, the entire face of the earth is generated out of topographical data and satellite images. Using a level of detail to manage scenic complexity, the work presents a model of earth as seen from a million kilometres above its surface, or at the level of an office interior in Berlin.

John Gage of Sun Microsystems talks about sprinkling "smart dust" over the landscape – millions of tiny sensors that would monitor the physical world remotely. Wireless sensors could be dispersed anywhere: tiny thermometers, miniature microphones, electronic noses, location detectors, or motion sensors, all providing information about the condition of the physical world, and converting analogue data about anything physical – pressure, light, gas, genes – into bits and bytes which they communicate wirelessly to a network. The global market for such sensors will reach \$50 billion in 2008, Intecho Consulting, in Switzerland, lists an extraordinary array of devices that is already on the market: Binary Sensors, Position Sensors, Speed/RPM-Sensors, Navigation Sensors, Acceleration Sensors, Force Sensors, Torque Sensors, Distance Sensors, Tilt Sensors, Pressure Sensors, Filling Sensors, Flow Sensors, Temperature Sensors, Photo detectors, Image Sensors, Acoustic Sensors, Current Sensors, Magnetic Sensors, Humidity Sensors, Chemical Sensors for Gases, Chemical Sensors for Liquids, Biosensors¹⁴.

A lot of research into remote sensing is funded by the military, but many applications can be repurposed for civilian applications. A company called BodyMedia supplies a wireless device that, strapped to your arm, constantly monitors your bodily vital signs and behaviours – blood pressure, rest and exercise, and so on. Their technology platform could be repurposed to tell you about the planet's vital signs. Another product, called GammaMaster, proclaims, "Where is Your Radiation Detector When You Really Need it? – On Your Wrist!". A precision timepiece with a built in Geiger counter, the GammaMaster "is ideal for emergency personnel who may have to respond to accidents, incidents or terrorist attacks which could involve radioactive material"¹⁵. Another product, the HazMat Smart-Strip, is a baseball card-sized device that changes colour when exposed to nerve agents, cyanide, chlorine, pH, fluoride, and arsenic – in liquid or aerosol form – at minute levels. A change in colour in any of eight categories alerts users to "get additional gear, decontaminate, or evacuate". "It's not cool to use your nose to detect chemical spills," said Lt. Cris Aguirre, a hazardous materials technician and a Smart-Strip user from the Miami-Dade Fire Department in South Florida. The makers of smartstrip are now developing an information database covering the broad spectrum of

emergency concerns of Suspicious Packages, General Medical, Decontamination, Mass Decontamination, and chemical and biological agents that are potential weapons of mass destruction¹⁶.

Community-based efforts to develop Earth system education are already under way. Students in the US and Europe are beginning to use environmental sensors as an extension of human senses in an environmental context. In the Digital Library for Earth System Education (DLESE), teachers, students, and scientists are working together to create a library of educational materials: lesson plans, maps, images, data sets, visualizations, assessment activities, and online courses.¹⁷ In New York State's Black Rock Forest, a consortium of schools, colleges, and research institutions study topics ranging from tree-rings, to glacial geology, in situ. The forest has been "instrumented" (their word) with environmental sensors which continuously measure and record properties of the air, soil and water. The sensors sense the same phenomena as human senses, but do so 24 hours a day and 365 days a year. "Probably the most important insight you can convey from the real time data is that environmental factors vary across both time and space" says Kim Kastens, at the Lamont-Doherty Earth Observatory. "Thinking about causes leads to questions like: why is it that air temperature goes up and down on a 24 hour cycle? why is it that one site consistently has lower relative humidity than the other?"¹⁸ Another educational tool, Data Harvester, enables students to perceive the ways that data vary through time on time series graphs, and through space are shown on map.¹⁹

Environmental sensing – by humans, by remote sensors, or by both – raises tricky of calibration. Who says where the red line starts? People and cultures evaluate data in different ways. An Eskimo might judge a room to "too hot" that a child from New York would find "just right." The same differences of interpretation occur on a planetary scale. Violent arguments greeted publication of *The Sceptical Environmentalist*, by Bjorn Lombok, because the Danish scientist questioned the way data ecological data had been interpreted. Harvesting accurate data is one thing; deciding what the data mean, and what to do about them, is another; systems literacy is not just about measurement. The learning journey up the ladder of complexity – from quarks, to atoms, to molecules, to organisms, to ecosystems – will be made using judgement as much as instrument. Learning experiences to foster ecological, systemic and scientific literacy need to help young people become reflective actors in the complex world that awaits them. Simulations about key scientific ideas, and visualisations of complex

knowledge, can attract the attention – but the best learning takes place when groups of people interact physically and perceptually with scientific knowledge, and with each other, in a critical spirit.

If the way we acquire language is any guide, and if systems literacy is a kind of language, then we should start teaching the subject when children are very young. Our brains absorb a lot of language – the concepts it embodies, and the culture implied – during our first three years. American researchers counted all the words a child would hear and speak – in every encounter and every interaction with its parent or caregiver – in a large sample of 2,000 children. By the age of four, they discovered, a professional family's child will have had 50 million words addressed to it, and will have had 700,000 encouragements addressed to it (compared to only 80,000 discouragements). "We were awestruck at how well our measures of accomplishment at three predicted language skills at nine to 10" the researchers told the journalist Polly Toynebee. Toynebee concluded: "school had added little value after the age of three; it was already too late"²⁰.

Planetary dashboards

The point of systems literacy is to enable collaborative action, to develop a shared vision of where we want to go. Before-and-after knowledge maps are useful in this regard; they can represent the state of a system now, and its state as we would wish it to be in the future. Many businesses already use spreadsheets in this way for numbers: they're a kind of map that enables 'what if?' scenarios to be re-calculated with different variables factored in. Since they were first designed 25 years ago, spreadsheets have evolved into important tools for the control of complex systems. Gary Reiner, Chief Information Officer of General Electric, has a long-term plan to put all the company's vital processes company's into a uber-spreadsheet, digitising as much of the business as possible. As Ludwig Siegele put it in a profile of the project for The Economist, this not only means buying and selling most things online but, more importantly, "setting up a digital nervous system that connects anything and everything involved in the company's business". The aim is to monitor IT systems, factories and employees, as well as suppliers, customers and products, in real-time, the paper reported; company-wide "dashboards" would compare how certain measurements, such as response times, or sales, perform against goals. "From a distance it (Reiner's "dashboard") looks like a Mondriaan canvas in green, yellow and red. A closer look reveals that the colours signal the status of software applications critical to GE's business. If one of the programs stays red or even yellow for too long, Mr Reiner gets the system to e-mail the people in charge. He can also see when he had to

intervene the last time, or how individual applications—such as programs to manage book-keeping or orders—have performed”.

To advocates of the concept, the real-time enterprise is a giant spreadsheet of sorts in which a new information, such as an order, is automatically processed and percolates through a firm's computer systems and those of its suppliers”²¹.

Vivek Ranadive argues in his book *The Power of Now* that, to become real-time, companies need to create overarching spreadsheets that connect everything they do. In Ranadive's bewitching vision, because users cannot keep track of rows and rows of columns, they will need an "intuitive overview of the information they really care about". Ranadive, who has a vision of what he calls the "event-driven firm", believes that running the company will be rather like running an IT system today: machines monitor the business, solve problems by themselves, as far as possible, and alert managers when something is amiss. Ranadive calls this "management by exception".

Many of the systems required for real-time business already exist: the global spreadsheet is a matter of joining them together. Juice Software, based in New York, helps users to link spreadsheet cells to data sources. Another company, KnowNow, helps firms improve the visibility of critical business information. A company called Rapt provides pricing optimization software based on real-time feedback from markets. Arzoon (which changed its name from "Vigilance") helps multinationals "globally manage your inventory motion". Closedloop Solutions, SeeBeyond, CrossWorlds: the list of players in this vast enterprise is as endless as is the inventiveness of their names.

The design challenge, now, is to develop global dashboards for buildings, cities, and regions. These can surely learn from (and incorporate modules from) the systems being made by companies. Buildings, for example, consume a lot of energy – but we don't 'see' heat flying out of the windows. If we could, our behaviour and use of the building would probably change. (This author did see a building-wide energy consumption metre next to the elevators in a Dutch high-rise). A dashboard to monitor the ecological footprint of a city would also be handy. Real-time representations of energy performance can help us use buildings and places in new and more sustainable (and cheaper) ways.

Visual to sensual

The global dashboard idea is not without its critics. Scepticism of purely visual communication goes back a long way. Saint Augustine, in *City of God*, attacked 'scenic games' as being responsible for the death of the soul. Goethe warned in 1817 that there is always a danger of "seeing, and yet not seeing". More recently Martin Jay, a noted chronicler of the passive role accorded to spectators in Western thought, charged that visual information tends to be "too static... in comparison with other senses; vision still seems tied to the Platonic valorisation of static eternal Being, over dynamic, ephemeral Becoming"²². Another eminent critic, Susan Sontag, memorably alerted us to the danger that photographs – and by implication all visualizations – have a tendency to "shrive sympathy. An image is drained of its force by the way that it is used", she warned; "images shown on television are, by definition, images of which one sooner or later tires. Image-glut keeps attention light, mobile, relatively indifferent to content"²³. The other problem with purely visual communication is that new images, however striking, or apposite, come into a world already filled with signs and ads and a million other competing signals. Matthew Chalmers, a psychologist at Glasgow University, warns that "striking visuals can cause a loss of narrative flow if they obliterate the links and connections that comprise the trail of a story". Understanding is situational, and we live in a society of spectacle wherein a thousand and one other messages vie constantly for our attention.

Visual representations under-value the knowledge we have by virtue of having bodies. In his 1945 book *The Phenomenology of Perception*, the philosopher Maurice Merleau-Ponty argued that perception is a process in which an active body enters into a 'communion' with its surroundings; perception is a continuous interaction that involves the subject's intentions, expectations and physical actions. There is no purely active 'sender' nor purely passive 'receiver', he said; without action, there can be no experience of anything 'external' to the subject. "The body is our general medium for having a world; sight and movement are specific ways of entering into relationships with objects", wrote Merleau-Ponty. For him, and other critics of visuality as a privileged medium of understanding, it is meaningless to talk about perceptual processes of seeing without reference to all the senses, to the total physical environment in which the body is situated. Another philosopher, Martin Heidegger, also argued that the separation of subject and object denies the more fundamental "unity of being-in-the-world" (*dasein*). This view is in opposition to the dominant paradigm in information processing, in which perception is understood as sense data being passively received by the brain. "When

perception is understood as an active process involving the totality of our body, it no longer make sense to see it as a passive reception of information through a medium"says the interaction designer Dag Svaenes²⁴.

Merleau-Ponty memorably counselled us to"move beyond high altitude thinking... towards a closer engagement with the world made flesh". Many ecological thinkers also emphasize that our senses – taste, smell, sight, hearing, touch – are the fundamental avenues of connection between the self and the world²⁵. Luis Fernandez-Galiano, in his book *Fire and memory*, argues that we need to shift our perceptions"from the eye to the skin – to develop not just an understanding but a feeling of how complex urban flows and processes work"– sensual, not just visual, seismographs.

The internet, especially when coupled with sensors and telerobotic devices, potentially enables us to observe and even act on distant objects. But do these techniques provide us with meaningful knowledge? This is the central question of what Ken Goldberg, a professor at UCLA, calls telepistemology, the study of knowledge acquired at a distance."Cyberspace presents us with a dilemma"he says."We are physical beings who experience the world through our bodies. Are we being deceived? What can we know?"These questions in the philosophy are hardly new – they date back to Plato and Aristotle. Now, however, if we are to measure and interpret the state of invisible systems around us, we have to make important judgements about the value of knowledge that is technologically mediated²⁶. Another philosopher, Catherine Wilson, contests the idea that representations are in some way ignoble, and reminds us that much of modern science depends on the use of instrumentation to transform theoretic entities into real ones."With electron microscopes we can now see molecules and viruses – formerly hypothetical entities that are now as ordinary as mailboxes"she argues²⁷.

We cannot wait for philosophers to resolve their differences about the status of different kinds of knowledge before acting. That way lies perpetual inertia. We need ways, now, to think intelligently the consequences of our actions for the health of the planet and, even if we are not certain that one scenario or another is"true", use those reflections to inform our decisions and actions. For Terry Winograd and Fernando Flores, authors of a classic book called *Understanding Computers and Cognition*, the issue is not one of theoretical exactitude."Practical understanding", say Winograd and Flores,"is more fundamental than detached theoretical understanding. Perception should be studied from the inside, not the outside – looking at properties of the nervous system as a generator

of phenomena, rather than a filter on the mapping of reality. We cannot deal with 'organism' and 'environment' as two interacting, independent things"²⁸.

Situations

Understanding is not only embodied. It is also situated. Human activity is not primarily as rational, planned and controlled as we like to think. The anthropologist Lucy Suchman says it is better described as "situated, social, and in direct response to the physical and social environment". Ordinary interpersonal interaction, says Suchman, is highly complex – far more complex than the constrained and choreographed interactions enabled by computers. "Meaning is always created in a situation"- an environment, a context, a social and cultural setting, a "situation in which actors find themselves"²⁹. 'Context independence' and 'anytime, anywhere functionality' are catchy sales slogans – but they are misguided slogans when it comes to the design of ways to understand complex systems. John Seely Brown also says that designers should engage more closely with the social contexts in which information products are used – and with the way that different communities of users interact with technology. Brown tells a famous story about a new photocopier that Xerox engineers were convinced would destroy the competition. They would not listen when colleagues protested that the machine was too complicated to use. At this point, the design team showed the engineers a video in which two middle-aged men were filmed trying, and failing, to copy a document. "The punch line was that both these guys were Nobel Laureates" recalls Brown; "only then did we persuade the engineers that if the smartest guys in the world could not operate it, perhaps their product was not so usable after all".

Hippocrates said 2,500 years ago – in Airs, Waters, Places – that, in order to understand the disorders in any subject, we must study its environment. "Treatment of the inner requires treatment of the outer, said the sage. "The greater part of the soul lies outside the body". In biology it's the same. They describe as chronomic the influence on a process of geographic or regional environment. Chronomy adds value. Even TelCos care about context. "Context deprivation" is recognised as a problem by TelCos – even as their own speed culture obliterates context. So how do we improve the situations in which these all-important people-to-people interactions take place? What kinds of knowledge do we need to bring to bear? And if we don't know, who does?

Designers and architects should be able to help here. After all, they've been designing spaces for thousands of years. Unfortunately, the world is filling up with physical spaces designed for the consumption of spectacles. Concert and exhibition halls, tourist resorts, sport stadiums, shopping malls and cafes, all are designed to help us buy things, not for social interaction. Raoul Vaneigem put it well, back in 1957, when he founded The Situationist International. "The whole of life presents itself as an immense accumulation of spectacles... All that was once lived, has become mere representation".

Voice

At Teyler's Museum in Haarlem, in The Netherlands, there's a magnificent sound synthesizer (by R Koenig, after H Heimholz) used for imitating vocal sounds. Eight chunky resonators, a bit like miniature brass water boilers, are attached to electronic tuning forks that are actuated by clunky copper coils. A keyboard, containing eight white keys, is mounted on an aged wooden plinth. The machine is dated 1859.

Nearly 150 years later, it's still not much fun talking to machines. Microsoft, IBM and other research labs have spent billions of dollars trying to let us talk to computers the way people did to HAL in the movie 2001, but progress is painfully slow. Computer science Ben Schneiderman says the effort is misguided, if only because it's hard to speak and think at the same time³⁰. Speaking uses auditory memory, which uses the same space as short-term and working memory, he explains. "Speech interfaces are difficult to design effectively at the best of times. They best flourish where they employ normal human conversational techniques – but that's terribly hard to achieve". Winograd and Flores argue that natural language is so heavily dependent on shared understanding, a shared knowledge base, and shared cultural experiences, that "there is no evidence that computers will be able to understand human language in the way other humans do. Natural language can never do that because language is so uncertain in human terms". So much of our communication is based on nuance, gesture, and inflection, that although it might be a year or two before computers can recognize our words, it might be decades – if ever – before computers correctly infer our meaning". The upshot is that while speech may help blind and disabled people interact with computers, it's unlikely to become the dominant way we connect with them³¹.

Natural language interfaces may elude us, but other kinds of sound are more promising. Auditory interfaces are most successful when other kinds of signals would be distracting, such as driving a car. The evidence after thousands of person years of research seems to be that voice and sound are best used outside traditional computing environments. The most successful applications involve the use of voice in ways similar to touching pre-set words on a touch screen – only using our voice instead of our fingers to cause the system to carry out a simple task. The interaction can be for control (such as opening a door) or information retrieval (getting a name from an address book)³². Even then, the simplest of tasks can go wrong. I once visited the research labs of Sharp, in Japan, where our host stated "Open!" (in English) to a sliding glass door. It stayed shut, however, until he went behind a curtain, and flipped a switch. "Sorry" said our rueful host, "it was set to Japanese".

The advent of ubiquitous computing has further accelerated interest in sound as a medium of interaction. So although computers may disappear, they are unlikely to go quietly. Research into the "sonification of hybrid objects" proceeds apace; this is the use of sound to display data, monitor systems, and provide enhanced user interfaces for computers and virtual reality systems³³. Researchers say that human ears are sensitive enough to interpret sound, just as our eyes are able to process words and characters. With sonification, applications could be designed to produce a background tone or tempo that increases in pitch or speed as data changes, thus freeing users to perform other, visually-oriented tasks. Sound also provides insight into patterns that may not be apparent on a purely visual interface. "If you're driving a stick shift, you change gears when the engine revs up too high, without thinking," David Jameson, a project manager at IBM's Computer Music Center, and former member of the '70s Irish band Time Machine, told Wired. "You do it without thinking, even while talking to a passenger. You are detecting changes in sounds."³⁴ "Much of the research on sonification focuses on determining what kinds of noises work best to indicate information flow. Thus, a tone tracking the stock market would likely be a pleasant background tone that changes pitch with new data"³⁵.

Could sound be a better way to attract and hold our attention through time, and to alert ourselves to short-term danger? The Futurists certainly thought so. In 1917 the founder of the Futurists, Marinetti, wrote that "noise is the language of the new human-mechanical life... music is closely related to human perceptions of time and its segmentation". For a contemporary critic, Christine van Assche, "electronic music oscillates between technology and ethnography: it is the music of

machines, whose echoes are lost in the digital network; but also the great polyrhythmic of African the pulsing beat of drum'n'bass"³⁶.

The art historian Ernst Gombrich found that in listening to repeated sounds, like the ticking of a clock, the dripping of a tap, or the rumbling of a train, we subdivide and shape the flow of identical impressions by projecting alternative rhythms. In music, it is the performer who sets the accents according to the demands of the score: there is no choice but to follow the auditory patterning."Humans are sensitive to change, but we don't like perceiving too much of it"Gombrich observed."Our mental apparatus is set somewhat like a homeostat indicating"no change"until a break in continuity demands and arouses attention". Think of the Geiger-Mueller counter. Too much change can become so frequent and abrupt that it leads to overloading the perception system."We filter out overdoses of discontinuity", wrote Gombrich,"because we dislike an impression of confusion – or at least of restlessness. The right dosage of continuity and change makes for ease of perception experienced as clarity".

Musicians know all about dosage. In the early seventeenth century, a poet stirred by the rich polyphony of church music declared that it"showed him the way to heaven's door"³⁷.Modern music is different. During the twentieth century, music of all styles documented and celebrated dynamic movement and the technology of high-speed travel – steam train, automobile, flying machine – together with intangible facilitators of long-distance communication such as the telegraph, telephone and radio³⁸. Later, when human beings became increasingly frazzled by acceleration, artists began to search for stillness. Brian Eno's Music For Airports album, in 1978, offered nervous travellers a moment of calm amid the worry and confusion of perpetual motion. Recalls David Toop,"Eno's music offered a kind of glue with which briefly to cement together the fragments engendered by such a fluid, potentially stressful environment"³⁹.

The death of the composer coincides with the resurrection of the listener. Home studio tools and software – the laptop computer, internet databases, the sequencer, MP3, MIDI, the home studio – all these have made it possible for everyone to be equipped with the tools for musical creation. Tools for cutting, pasting, reverse playback, frequency modulation, reverberation, echo, layering, mixing, and spatialisation, make it possible to play with existing sounds: repeat them, juxtapose them, layer them. The do-it-yourself spirit encourages self-management and bricolage: Maurizio's albums contain raw materials or samples conceived specially for re-appropriation – a musical palette, or sound-chart.

The music's pattern is never in the thing itself, designed in advance: it always takes place on the outside, in the ways people put the bits together in different ways in different contexts.⁴⁰

Lewis Mumford once described the aesthetics of middle time – a balance between fast and slow, event time and clock time, up and down time. "We need", wrote Mumford, "to keep time in life as we do in music, not by obeying the mechanical beat of the metronome – a device only for beginners – but by finding the appropriate tempos from passage to passage, modulating the pace according to human need and purpose". Ragtime marked the start of the acceleration of music to match the acceleration of industry: jazz was followed by boogie woogie, rock and roll, disco, punk techno and house – the latter racing along at 200 beats a minute. "Economic and scientific modernisation succeeds when it is accompanied by cultural creativity that revolutionizes the way we see the world", wrote Charles Leadbeater, just as I came across the music of Talvin Singh⁴¹.

Tuning the city

You do not need to be visually impaired to find "non-seen diagrams" useful. Benjamin Rubin studied the use of sound as an information medium in the New York City subway system. This huge system, with its hundreds of stations and thousands of trains, uses three designed signals: turnstile transactions, train arriving, and doors closing. The three sounds are clearly audible, but bear no meaningful harmonic relationship to each other; the train arrival signal, for example, is often masked by the turnstile beeps. This is the predictable result, says Rubin, of using sounds within the same 1/3 octave frequency range. "Despite its use of tonal signals, the mix that results sounds unintentional, technological, and out of tune; the New York City subway system sounds decidedly unmusical". The turnstile bank in particular, with its microtonal pitch variations, often sounds like a badly tuned instrument. Since the pitch variation is random, and carries no information, we perceive it as mildly grating dissonance. Sound in the subway is viewed by riders as entirely utilitarian. Rubin designed a new set of sounds, based on the notion of a wind chime, to improve communication effectiveness by using a wider variety of easily distinguished signals, and to improve listenability through the use of an expanded sound palette and deliberate composition. A variety of timbres, pitches and rhythms were used to create a soundscape that is harmonic, varied, and textured⁴².

Audio feedback has also been used successfully in the field of surgery. In the course of a typical diagnostic surgical procedure, numerous needle placement errors occur – for example, missing the tumour in a biopsy. Ultrasound and imaging techniques are there to help the surgeon concentrate on manipulating the instrument without taking to take his or her eyes off the patient. Audio feedback enables the surgeon to effect a precise placement by enhancing his/her comprehension of the three-dimensional position of a surgical implement with respect to some predetermined desired position within the patient's body⁴³.

In his book *Audio-Vision* the film theorist Michel Chion proposes that one kind of sensual perception influences the other, and transforms it. People have a natural urge to fuse sounds and images as a strategy for making sense of the world, says Chion. "We never see the same thing when we also hear; we don't hear the same thing when we see it as well". His book was about how this tendency extends to our experiences of viewing films, where cinematic and theatrical sound influences our perception of time, including our perception of movement, speed, rhythm, and pacing. Chion explains that "...the eye is more spatially adept, the ear more temporally adept... the eye perceives more slowly because it has more to do at once; it must explore in space as well as follow along in time". People are more capable of acutely tracking the details of motion with the ear, than with the eye; people who possess both sight and hearing can usually understand spoken language faster than they can read⁴⁴.

"Our cities talk to us" says the typographer Paul Elliman. Using just a few words at a time, they speak from the walls and ceilings of buildings, from elevator cars, supermarket checkouts, and subway trains – offering directional advice, even warnings. "It may not amount to a full dialog, but through a range of technology, involving recordings as well as complex language-modeling programs, our movement can now be guided by the voices of audio signage. These spoken forms of public information occupy their own place in the city, an acousmatic space.". The term comes from film, describing characters that speak but remain concealed; "mysterious characters," as Michel Chion describes it, "hidden behind curtains, in rooms or hideouts robots, computers, ghosts." For Elliman these sounds, the voices of audio signage "fall between the scripted characters of both typography and cinema. Like typefaces, they convey distinctive identities. But we also recognize in their tones the lush advertising sirens of *Blade Runner* and *Minority Report*, or the authoritarian chill in the speech of the Wizard of Oz. Certain voices may turn out to have even closer associations with power

and authority than meets the ear". New York subway-car announcements feature presenters from Bloomberg radio, the station owned by the mayor, Michael Bloomberg.

Airports and railway stations were some of the first places to adopt talking signs. Since the 1970s, "Mind the gap" advice (spoken by former radio presenter Peter Lodge) on London's underground has been a sonic landmark for anyone visiting London. In Amsterdam, a public row ensued when a soap actor's voice was introduced to the city's metro. On the Madrid subway, the recorded voices of a man and a woman perform a sequence of short duets just before each station. The man opens with "Próxima estación" and is closely followed by the woman, who identifies the stop: "Plaza de Castilla." With the persistence of a running commentary, the friendly female voice of the Shanghai subway follows you from train to platform, to ticket hall, to street, pointing out safety features and directions, suggesting bars, restaurants, and department stores. Elliman remarks that beyond the messages' vocal friendliness or familiarity, a more significant feature of acousmatic space is that "the spoken words seem to come from nowhere, their infrastructural origins carefully concealed. Rather than being talking ghosts in the machine, these characters are a sequence of repeated speech patterns. The voice, once thought of as uniquely human, is a new benchmark in our relationship with technology – talking and walking us through the acousmatic spaces of the city". In a survey carried out by London Underground, the favourite choice for a "redesign" of its public address system was a voice-impersonation of Marilyn Monroe⁴⁵.

Touch

Interaction that involves physical contact between the user and the computer is referred to as haptic, after the Greek word meaning touch or contact. A surprising thesis: rather than the most difficult of social senses to transmit, touch may well be the easiest. Back in 1993, Ken Goldberg and Richard Wallace connected two simple touch sensors and haptic actuators together to create Datamitt. They were placed inside metal tubes on each coast of the United States so that if a participant in Los Angeles placed her hand inside, and squeezed, the participant in New York would feel the pressure, and vice versa. Datamitt was remarkable for its low resolution, a one-bit sensor actuator. Whether squeeze or no-squeeze with nothing in between. And yet the effect was quite engaging. So while it is true that a true handshake is a highly situated, multisensory experience – complete with eye contact, sweaty palms or otherwise – a low-bandwidth version can do a pretty good job⁴⁶.

Smell

For the Ongee of the Andaman Islands, the universe and everything in it is defined by smell. Their calendar is constructed on the basis of the odours of flowers which come into bloom at different times of the year. When greeting someone, the Ongee do not ask 'How are you?', but 'Konyune onorange-tankka?' meaning 'How is your nose?'. "Natives of the Adaman jungle in India have constructed a complex annual calendar built around the sequence of dominant smells of trees and shrubs in their environment. When they want to check the time of year, they simply smell the odours outside their door"⁴⁷. Smell is probably the most undervalued of the senses in modern Western cultures. Yet cultural historians have shown that this was not always so: the current low status of smell in the West is a result of the 'reevaluation of the senses' by philosophers and scientists of the 18th and 19th centuries. The intellectual elite of this period decreed sight to be the all-important, up-market, superior sense, the sense of reason and civilisation, while the sense of smell was deemed to be of a considerably lower order – a primitive, brutish ability associated with savagery and even madness⁴⁸. The emotional potency of smell was felt to threaten the impersonal, rational detachment of modern scientific thinking.

Although the human sense of smell is feeble compared to that of many animals, it is still acute. We can recognise thousands of different smells, and we are able to detect odours even in infinitesimal quantities. Our smelling function is carried out by two small odour-detecting patches – made up of about five or six million yellowish cells – high up in the nasal passages. For comparison, a rabbit has 100 million of these olfactory receptors, and a dog 220 million. Humans are nonetheless capable of detecting certain substances in dilutions of less than one part in several billion parts of air. We may not be able to match the olfactory feats of bloodhounds, but we can, for example, 'track' a trail of invisible human footprints across clean blotting paper. The human nose is in fact the main organ of taste as well as smell. The so-called taste-buds on our tongues can only distinguish four qualities – sweet, sour, bitter and salt -all other 'tastes' are detected by the olfactory receptors high up in our nasal passages.

The development of more sophisticated technology for synthesising or 'capturing' previously elusive smells appears to be keeping pace with the advances in high-tech noses to detect the ones we already have.' Headspace' technology now allows accurate analysis and synthetic reproduction of

almost any smell. One new fragrance for men allegedly includes both the distinctive odour of a famous New York tobacconist shop and 'essence of racing car'. Another manufacturer claims to have reproduced the scent of financial newspapers. A process known as 'soft extraction', which has been in use for some time in the food industry, is the latest vogue among perfume manufacturers. By passing a special form of carbon dioxide through an object such as a coffee bean, food technologists have been able to extract coffee flavouring. The procedure is now being used to capture the fragrance of flowers which are resistant to more traditional scent-extraction techniques.

"There's more to interaction than meets the eye" quips the designer Bill Buxton. "When compared to other human-centered machinery, such as the automobile, today's computer systems make extremely poor use of the potential of the human's sensory and motor systems". Consider the use of the feet in sewing, driving a car, or playing the pipe organ in a church. User interfaces can be more natural, easier to learn, and be less prone to error, if we pay more attention to the 'body language' of human-computer dialogues. Buxton's thesis is simple: if you can say it in words in a single phrase, you should be able to express it to the computer in single gesture, too. "We have two hands!" he said; "users are capable of manipulating more than one device at a time in the course of achieving a goal. Think of driving a car, or riding a horse"⁴⁹.

There has been a great deal of study of how quickly humans can push buttons, point at text, and type commands. What the bulk of these studies focus on is the smallest grain of human computer dialogue, the atomic task. These are the 'words' of the dialogue. The problem is, we don't speak in words: we speak in sentences. In those sentences, phrasing is a crucial component of speech and music. It determines the ebb and flow of tension in a dialogue. It lets us know when a concept is beginning, and when it ends. It tells us when to be attentive, and when to relax. Why might this be important in our discussion of 'body language' in computer-human dialogue? Well, for the same reason that it is important in all other forms of communication: Phrases 'chunk' related things together⁵⁰.

The key concept is feedback. The art historian Ernst Gombrich knew more than most about the ways our perception of change works. "Our mental apparatus is set somewhat like a homeostat indicating "no change" until a break in continuity demands and arouses attention. But not too much". In any medium, Gombrich explains, change can become so frequent and abrupt that it leads to overloading of the system, an impression of confusion or at least of restlessness. The right dosage of

continuity and change makes for ease of perception experienced as clarity". In listening to repeated sounds like the ticking of a clock, the dripping of a tap, or the rumbling of a train, we feel compelled to subdivide and shape the flow of identical impressions by projecting alternative rhythms. In music, it is the performer who sets the accents according to the demands of the score: there is no choice but to follow the auditory patterning"⁵¹.

Let's talk

Maybe we just need to talk. Stories can be an excellent way to communicate complex ideas."We throw up our hands at a problem phrased in an abstract way"says Malcolm Gladwell, "but have no difficulty at all solving the same problem rephrased as a social dilemma"⁵². Speech is clearly important in our lives; most of us utter as many as 40,000 words in a day. The intriguing point is that most of these are about utterly trivial issues."Most of the time we use language to gossip. It's what makes the world go round"says Robin Dunbar, a Professor at Liverpool University. He worries that if we lose language proficiency, we will be robbed of an ability to follow and sustain complex arguments. If that happens, more and more humans will simply give up trying to understand and influence the world around them.

Ivan Illich warned about this danger thirty years ago. In the 1930s, he discovered, one out of ten words which a man has heard when he reaches the age of twenty are words which were spoken to him – as a member of a crowd, a church, in the military, or at school. Nine out of ten words were spoken to him or overheard by him while somebody whom he could touch and feel and smell was saying them to somebody else. By the 1970s, when Illich wrote about it, the proportion had been reversed: about nine out of ten words were spoken either to a crowd – or, more generally, through a loudspeaker. For Illich there was a huge difference between a colloquial tongue, which is the result of absorbing what people say to each other with meaning; and a language which people get from actors declaiming with phoney conviction what speech writers have written for him."I have seen people in Malaysia, the poorest people, on street corners, sitting there all night composing farungs. You make a verse of two lines, then I do the same. We might go on through a whole moon night that way"⁵³.

Designers, educators and communicators argue endlessly about the merits and demerits of using metaphors to enhance our understanding of abstract ideas. Alan Blackwell, leader of a project called

Vital Signs at Cambridge University in the UK, is critical of over-literal representations. "Most people are able to recognise and process abstractions", he says; "strained physical metaphors can make their job harder". Blackwell's group has studied abstract behaviour over a number of years. How, for example, can the user interface of an appliance, such as a minidisk player, include things we can't touch – for example, when we ask the device to do something in the future, such as recording a programme? Blackwell calls this an "abstraction over time". A second research issue: how shall such abstractions be represented visually: what are the general characteristics of systems of signs we can interact with? Interaction designers call these notational systems. The difficulty with notational systems is not just to do with representing abstract processes in visual form; as they proliferate, it becomes harder for users to remember what they mean. "The debate is unhelpfully polarised and atemporal", says Blackwell; "my own view is that we need both".

The real world, the symbolic world and the fictional world do not have to be alternatives to each other. Philosophers may tell us that direct experience is superior to mediated experience – but what if a story, or a simulation, helps us understand the real world better? What if a vicarious experience brings us closer to the "thingly element of things"? In their classic book *Metaphors We Live By*, Lakoff and Johnson argue that imaginative and creative metaphors are capable of giving us a new understanding of our lived experience. They can give new meaning to our pasts, our daily activity, and what we know and believe. "In all aspects of life, not just politics or love, we define our reality in terms of metaphors and then proceed to act on the basis of those metaphors. New metaphors have the power to create a new reality" they write. Much cultural change arises from the introduction of new metaphorical concepts and the loss of old ones. The creation of new metaphors is as important an aspect of literacy as reading. As proponents of change, we need to invent need to invent new metaphors – and campaign for them⁵⁴. For Lakoff and Johnson, metaphor is one of our most important tools for trying to comprehend partially what cannot be comprehended totally: our feelings, aesthetic experiences, moral practices, and spiritual awareness. In the case of poetic metaphor, language is the medium through which new conceptual metaphors are created. Works of art, too, provide new experiential gestalts and, therefore, new coherences⁵⁵.

Art

Knowledge maps can give us the facts about the condition of the systems that surround us. Information design can make those maps engaging and informative. But the imaginary can also be powerful in shaping expectations. Art, in this context, can be a means of creating new realities – especially when aesthetic experience is not limited to the segregated spaces of official art. Music, the visual arts, and especially time-based or performance art, are crucial components of systems literacy. They create experiences that can bond people together in shared, and alternative, visions of the future. When added to the designer's powerful representations, the artist's critical intuition – especially when used to trigger our own insight – can shift our focus away from the material world and its artefacts towards new concepts of culture and community.

Imagined futures have always been a driver of innovation. During the last quarter of the nineteenth century, the motion picture industry simultaneously gave form to, and was shaped by, artist-driven conceptions of space, and time, and event. Cultural enthusiasm for speed and simultaneity pre-dated the technology of film, together with the telephone and phonograph, that later extended our perception of events and locations beyond their physical and temporal bounds⁵⁶.

Performance art proper was born in a fistfight in 1910 between the Italian Futurist painters and poets, and the Venetian townspeople who reacted in anger when 800,000 manifestoes, "Against Past-Loving Venice" were scattered upon them⁵⁷ Throughout the 20th Century, avant-garde artists' groups such as the Russian Constructivists, the Dada artists, Surrealists, COBRA, Letterist, Fluxus, creators of "Happenings," conceptual and postmodern artists or recent years, have staged site-specific installations. Fluxus – a movement of artists which followed the influence of John Cage – saw so-called traceless art forms – such as dance, music, song, and story telling – as an opportunity to modify the evolution of culture. Their approach was to make unexpected social contact with people and so create a series of chain-reactions, or magnetic waves, above and below art itself. In the 1960s, "Happening" artists made people licked jelly off a Volkswagen. These artists remind their audiences: "there is no artifice here: this is happening now, in real time."⁵⁸ The American philosopher John Dewey said in 1931 that "the only true education comes through the stimulation of the child's powers by the demands of the social situations in which he finds himself". Dewey and the artistic avant garde both fought to bridge the schism in Western thought that separates the creator from the spectator, and bitterly opposed art and literature whose sole purpose is entertainment.

Love of art for its own sake is almost never encountered in the Middle Ages, and when its first symptoms appeared, mixed up with a taste for pomp and precious objects, the common view at first was to consider them aberrations. We find it natural today to speak of "land conservation" in the same way that we speak of the preservation of a work of art. But both ideas would have other eras as inconceivable. It is likely we will start institutions to restore natural beauty just as those for the restoration of works of art, without recognising that such an idea presupposes a radical transformation of our relationship to nature. The inability to penetrate a landscape without spoiling it, and the desire to purify it from such penetration, are two sides of the same coin⁵⁹.

The artist Robert Irwin, who investigated the barriers which keep art from dealing with the universal experience of change, concluded that art should be "knowing in action" and "delegate a major share of the creative act to the observer"⁶⁰. Telepresence art addresses our being-in-the-world through lived experience, not through representation". In his project Rara Avis, the participant (or 'immersant') saw a large aviary as soon as she walked into the room. In front of this aviary she saw a virtual reality headset. Inside the aviary, the viewer noticed a strong contrast between the thirty flying birds (zebra finches) and the large tropical macaw which was perched and immobile. The viewer was invited to put on the headset. While wearing this, she was transported into the aviary. Which she perceived from the point of view of the macaw (combination of macaw and owl because of its eyes~) and was able to observe from a displaced point of view"⁶¹.

In another piece, Masakai Fujihata's Light on the Net in 1996, visitors found a live image of the entrance hall to a building in Gifu Prefecture. And a 7x7 matrix of light bulbs. By clicking on any of them, one can switch a bulb on or off from anywhere in the world. The concept and its implementation are simple and beautiful. Even with something so simple as spelling out "Hi" from a distance, the effect was sublime. In Lynne Hersman's Leeson's Tillie: The Telerobotic Doll, each of Tillie's eyeballs moves slightly as you move the cursor on it. Click on an eye, and an image of a gallery wall appears in a window below. This is what the doll sees in the gallery – the physical space where she sits. The doll's eyeballs have been repped with cameras that send images to the Internet. For Hersman, "voyeurism and surveillance tactics have become extensions of our "I"⁶².

Some media artists celebrate time delays on the internet. For Marina Grznic, the limitations of telerobotic technology – delays in transmission time, busy signals from internet service providers, and crashing web browsers - "can be seen as restoring the aura, and with it our sense of space and

time". When the communication delay between operator action and perceived response is greater than about 250 microseconds, it becomes cognitively apparent to the user. The behaviour of operators under such conditions was first studied by researchers contemplating applications in space: they found that users at first adopted a strategy of "move and wait". The idea that time-delay and distance contribute positively to reflection is not a new one. Aesthetic theories since the eighteenth century have seen distance as a precondition for reflection, self discovery, and the experience of art and nature, writes Oliver Grau. "The result of physical or psychological distance from the phenomenon is a conceptual space – Denkraum. As early as 1927, the philosopher Ernst Cassirer worried that Denkraum was threatened by the telegraph⁶³.

Eighty years later, Susan Sontag questioned how much we really know about the trash heaps, slums and wars depicted by today's imaging technologies. They are supposed to give us a clearer image – but by sanitising the subject, they prevent us from knowing reality itself.

The important contribution of media artists such as Moholy-Nagy, Nam June Paik, Roy Ascott, Douglas Davis, Masaki Fujihata and others, has been to ambiguity and tension between 'here' and 'there'; they have played games with mediation so that the user is both the observer, and the observed. Their work has sensitised us to the need to use media critically, rather than literally. But the best media art is constructive, too. Increasing numbers of artists around the world are working in collaborative mode with telecommunications. Eduardo Kac has chronicled the way that in their 'works', images and graphics are not created as the ultimate goal or the final product, as it is common in the fine arts. Employing computers, video, modems and other devices, these artists use visuals as part of a much larger interactive, bi-directional communication context. Images and graphics are created not simply to be transmitted by an artist from one point to another, but to spark a multidirectional visual dialogue with other artists and participants in remote locations. Once an event is over, images and graphics stand not as the "result", but as documentation of the process of visual dialogue promoted by the participants. This new art is collaborative and interactive. It uses text, sound, image and, virtual touch, to provoke a critical response to the dominant linear model of communication which privileges the artist as the codifier of messages. "Telematics opposes a multidirectional model of communication" says Kac, "one where the artist is creator of contexts, facilitator of interactions"⁶⁴.

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