CODING AND REPRESENTATION FROM THE NINETEENTH CENTURY TO THE PRESENT

SCRAMBLED MESSAGES

Edited by
Anne Chapman and Natalie Hume

ROUTLEDGE

1   To Be Connected

Perspectives on Autonomy and Risk from the Electric Age

Manu Luksch and Mukul Patel

Electrification around the turn of the twentieth century occurred within a broad context of modernisation – from innovation in manufacturing and tooling and the rise of the petroleum and chemical industries to medical advances precipitated by the new germ theory of disease. Technological revolution and social reform swept parts of Europe and America, recasting the domestic, public and industrial spheres – though elsewhere, extractive colonialism intensified. The 1870s saw the invention of both the electric telephone and the incandescent light bulb; power stations were established in the 1880s in London and New York, predominantly supplying building and street lighting; and in 1896 Guglielmo Marconi
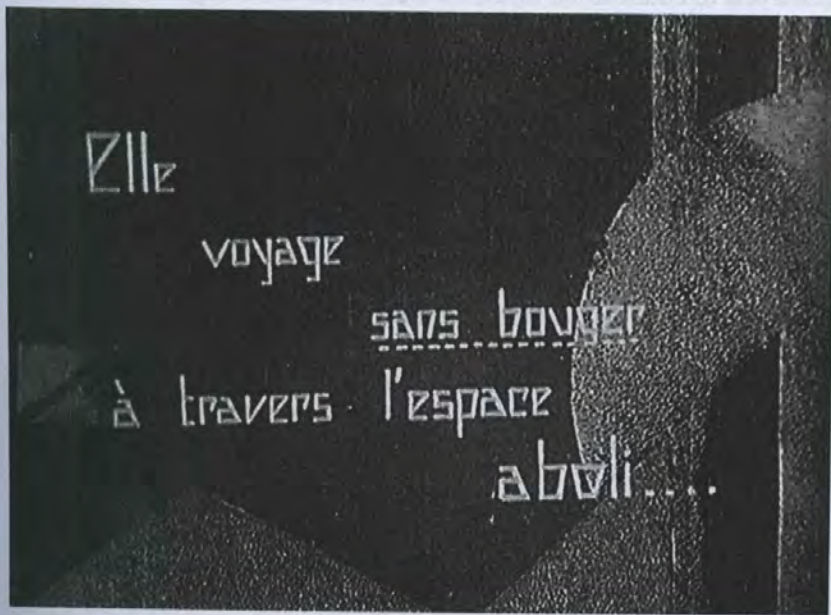

Figure 1.1 Still from *Dreams Rewired* (2015): 'She travels *without moving* across annihilated space ...' Originally from *L'Inhumaine* (dir. Marcel L'Herbier, 1924). Archive: Lobster Films.

patented his wireless telegraph. This technology led to cable-free trans-atlantic communications just five years later.

By promising progress for all, through the proliferation of affordable devices, appliances and communication channels, the 'Electric Age' sparked a fervent utopianism in the public imagination. As early as 1852, one author anticipated

> a future period, when a perfect network of electrical filaments will overspread every civilised land in the world ... destined to consol-idate and harmonize the social union of mankind ... to draw all nations into more intimate connexion, and to convert the whole hu-man race into one society.[1]

The essay film *Dreams Rewired* (Manu Luksch, Martin Reinhart, Thomas Tode, 2015) reveals how the appetites, anxieties and social con-vulsions of today's hyper-mediated world were prefigured in the elec-tric media boom at the dawn of the twentieth century. It is assembled from nearly 200 film clips dating from the 1880s to the 1930s, obtained through several years' research in over fifty archives. *Dreams Rewired* executes a 'double exposure of past (archive footage) and present (con-temporary voiceover)',[2] the diverse footage – from early dramas and newsreels to educational films, records of scientific experiments and ar-tistic adventures with new media – being articulated and interrogated by Tilda Swinton's mercurial narration and a musical score.

This text returns to the pool of archival material that the film's di-rectors worked with, and expands on its thesis. Early electric media promised empowerment in the face of accelerating change, just as our personal smart devices do today. But hopes were curbed by fears – of the erosion of privacy and ubiquitous surveillance, of financial ex-posure and moral hazard – that remain strikingly familiar today. In what follows, we exercise these resonances and induce the historical cinematic record to articulate contemporary desires, capabilities and concerns.

Part 1 introduces the key transformation of the Electric Age – the overcoming of distance – and the moral risks that have arisen with its intensification today. Part 2 explores notions of simultaneity, then and now, particularly with respect to financial risk. Part 3 examines the ma-terial substrate and global political economy underlying electric dreams, while in Part 4, we consider the impact of new technologies in the do-mestic and corporate contexts, and the realities of the 'smart' home and 'intelligent' workplace today. In Part 5, we discuss how the historical enclosure of the electromagnetic commons in the United States is mir-rored in the battle over net neutrality. The concluding Part 6 traces the roots of contemporary surveillance capitalism, characterised in part by the creation of a futures market in human behaviour, back to the early twentieth-century pursuit of efficiency.[3]

1 Towards Distance Zero

By overcoming distance, we overcome difference.[4]

Live connectivity, instantaneous global presence, being everywhere at once – the imminent annihilation of space was clearly envisaged in the newly electrified late Victorian era. Real-time, bidirectional, audio-visual communications would foster empathy, compassion and world peace: a televisual utopia. Although much of the relevant technology was perfected only later in the twentieth century, it was already dramatically imagined in early science fiction such as Albert Robida's *Le Dix-Neuvième Siècle: La vie électrique* (1890).[5] In Robida's novel, the young protagonist Hélène inhabits a gender-equal future transformed by electricity, telephonoscopes and aero-transport.[6] Such radical visions were driven by the no-less radical transformations of everyday life. An incredible vanquishing of distance had been brought about by the establishment of a reliable undersea transatlantic link in 1866. The cable carried an 8 words-per-minute telegraph service, which brought New York and London strikingly close – previously, communication between the two cities took about nine days (this was the duration of a steamer crossing, at a speed of about 25 km/hr).[7] A speed increase of this order – about 10,000-fold – was unprecedented, and would not be seen again until the 1990s.[8]

By the early 1900s, the telephone had brought real-time bidirectional transmission of speech to millions of homes.[9] In the public imagination, it could be only a matter of time before images would accompany sounds over wires. But electrical 'seeing at a distance' remained in its experimental stages through the 1920s. Cinema closely approximated real-time image transmission through newsreels and horse-racing reports. Fiction films furnished convincing, if sometimes wildly speculative, simulations of the televisual. Such visions were often depicted using a fantastic electric variation on the telescope – a 'core optical device in early cinema', according to media theoretician and archaeologist Trond Lundemo – that often incorporated aspects of radio and recording technology.[10] The circular matte signifying a telescopic view became a common cinematic trope to connote seeing over distance.

In spite of their globalising vision, the televisual utopias of early cinema were compromised by their perpetuation of existing hierarchies and prejudices, in particular of race. A vivid example is found in the Danish film *Dr. Ams Tram Grams Kikkert* (dir. unknown, *c.* 1908). While a European inventor awaits a guest to whom he will demonstrate his 'electric telescope', his Asian servant sneaks a look through the eyepiece. Live images from 'exotic' locations stream back to the remote seer, who can also rewind and fast-forward images at will – the instrument is a time machine of sorts. This is a one-way instrument, however, and the evident 'superiority' of Western civilisation is mirrored in the humiliation that the inventor heaps upon his servant on catching him.

Figure 1.2 Still from *Dreams Rewired* (2015). Originally from *Dr. Ams Tram Grams Kikkert* (dir. unknown, *c.* 1907–9). Archive: Sveriges Television AB.

Today's reconnaissance drones and Earth observation satellites take remote seeing – and the surveillant stance – to new extremes. Weather prediction, climate modelling, environmental monitoring (for example, of desertification or sea ice cover) and cartography all depend on remote sensing by satellites. Constellations of these massive satellites, each weighing tons and costing several hundred million dollars, image the globe in near-real time, in the visible and also the infrared and ultraviolet portions of the spectrum. Civilian satellites can resolve details to within less than a metre; the data downlinked to ground stations is accessible within hours of a satellite imaging an area.[11] Rewinding history is as simple as travelling through the archive; on the other hand, fast-forwarding the future is only possible through computer extrapolations that produce, at best, weather projections for the next few days.

> *The globe shrunk to the size of a village –*
> *Neighbours united in electric dreams?*[12]

From its first incursions into the domestic sphere, technology had promised to connect friends and family in diaspora; concomitantly, the trope of the 'telescopic view' evolved to symbolise psychological distance and the pain

Figure 1.3 Still from *Dreams Rewired* (2015). Originally from *Life of an American Fireman* (dir. George S. Fleming and Edwin S. Porter, 1903). Archive: Library of Congress.

of separation. Edwin S. Porter's *Life of an American Fireman* (1903) opens with a scene of a fireman at work dreaming of his wife and child, who will later become the subjects of a rescue operation as their house burns. Such devices have persisted into the internet age: the round matte bounding the fireman's 'mind's eye view' is mirrored in a 2018 ad from Samsung's 'Be Together' Christmas campaign. A flying doctor, en route to an emergency, glances at her smartwatch whose round face frames a portrait of her family. 'If you can't be together,' chimes the slogan, 'be together with Galaxy.'[13]

Some televisual fantasies went far beyond merely connecting friends and family, instead projecting a worldwide community of creators, communicators and consumers of ideas. In Marcel L'Herbier's 1924 film *L'Inhumaine*, the glamorous Parisian singer Claire craves the attention of a global audience and plans an extended concert tour. The inventor Norsen is infatuated with her and desperately seeks to prevent her departure. He develops a wireless system that can broadcast her voice to the world and simultaneously receive live televisual images of audience reactions back in the lab.

Almost a hundred years later, as Claire's desires continue to resonate, today's video-enabled social media platforms promise effortlessly to fulfil such desires. In an economy that is information-rich but attention-poor, visibility is currency. 'Our mission is to give everyone a voice and to show

Figure 1.4 Still from *Dreams Rewired* (2015). Scene showing live televisual feedback from a Middle Eastern audience, originally from *L'Inhumaine* (dir. Marcel L'Herbier, 1924).

them the world,' YouTube claims.[14] No inamorato or Svengali necessary, this is the age of the amateur and the influencer. And as the instruments and objects of this economy become ever more abstract, so audience engagement becomes increasingly frictionless. The Instant Famous Socials Shop sells 50,000 YouTube 'views' and 500 'real likes' for £109.66 (availability: in stock).[15] Twitter Followers Packages ('high-quality followers with lifetime guarantee') have, somewhat mysteriously, sold out at the time of writing.[16] Attention vendors spawn an abundance of online identities, accounts and bots to generate interest, 'favourite' customers and retweet their conversations. The mere semblance of popularity suffices, apparently.

But it would be cynical not to acknowledge the persisting salience of radical social vision mediated through technology. Even as the technology that made television practical was being perfected during the 1930s–40s, the electric communication of data other than sound and images had already been imagined. In Arthur Berger's *Die vom 17er Haus* (1932), commissioned by the Sozialdemokratische Arbeiterpartei in the run-up to elections, three generations exchange knowledge, with the grandfather transmitting an archive over an international data link. And still today, despite the growing instrumentalisation of the internet for commercial purposes, early worldwide web dreams of non-hierarchical

distributed knowledge and communication live on in protocols such as BitTorrent, a P2P (peer-to-peer) file-sharing scheme. BitTorrent declares itself a 'free speech tool' that extends the freedom to publish to those without significant capital or equipment. 'Cooperative distribution can grow almost without limit, because each new participant brings not only demand, but also supply.'[17] Currently, another peer-network-based technology, blockchain, is inspiring activists and entrepreneurs alike. Blockchain allows trust to be distributed transparently among peers – any one of whom can validate a data transaction.[18]

In the public imagination, fantasies of wireless transmission have long included the conveyance not only of data, but also of matter and motion. Louis Seel's *Wiener Bilderbogen Nr. 1* (1925) humorously explored the power of radio to transmit not only sound, but also heat (a Saharan breeze is diverted to warm the elegant woman protagonist) and kinetic energy (a slap, delivered to her husband's lover).

Wireless control of mechanisms over distance would certainly have been plausible in Seel's time. Already in 1897, Nikolai Tesla had famously demonstrated a remotely steered boat in New York.[19] Military applications
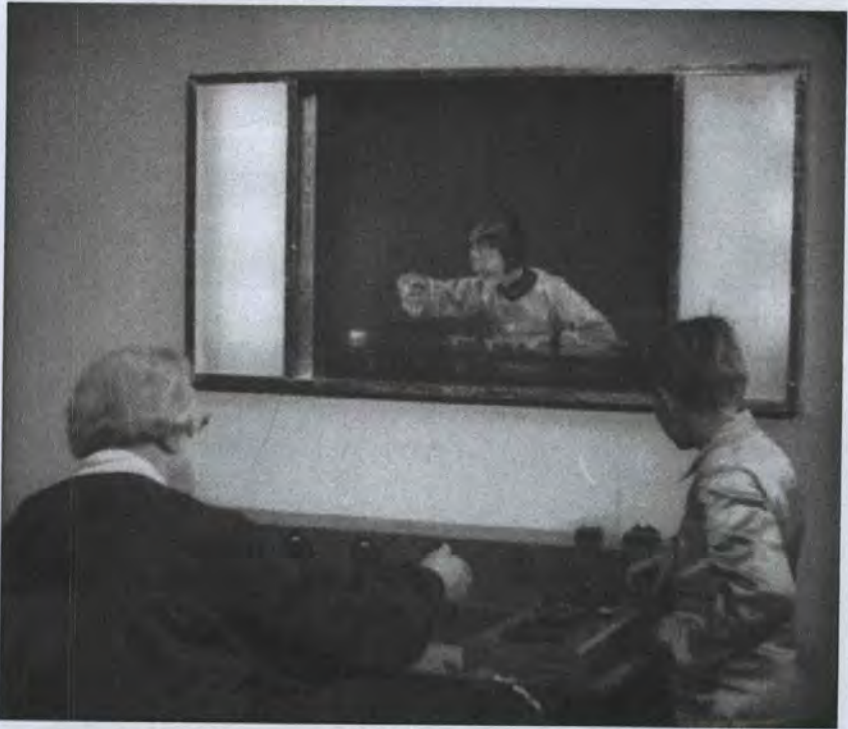

Figure 1.5 Still from *Dreams Rewired* (2015): '"Please accept the transfer." From peer to peer, messages between equals.' Originally from *Die vom 17er Haus* (dir. Arthur Berger, 1932). Archive: Österreichisches Filmmuseum.
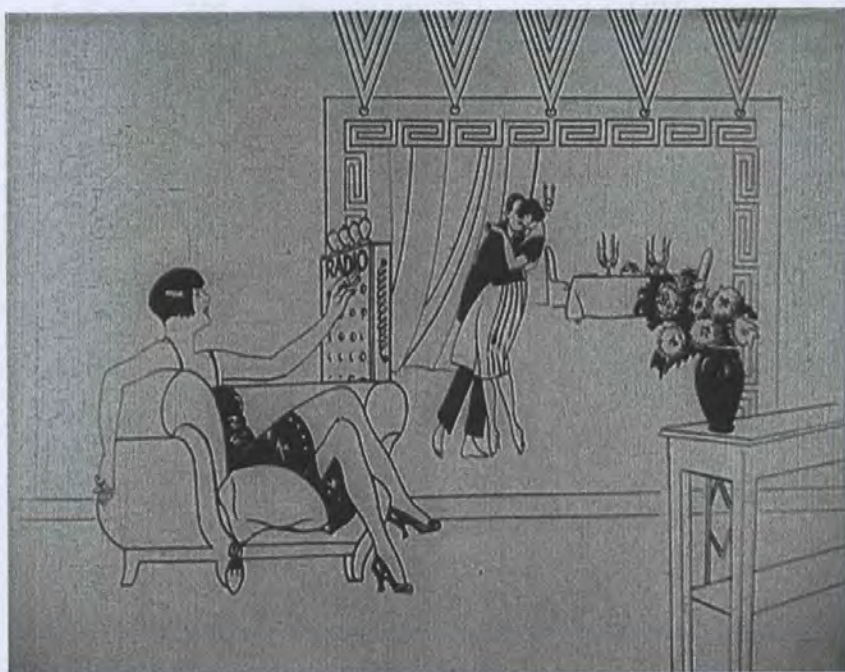
Figure 1.6 Still from *Dreams Rewired* (2015): 'Radio-mechanically, she gets dressed. Radio-optically, she surveys her faithful husband. And radio-mechanically, she strikes her detested rival.' Originally from *Wiener Bilderbogen Nr. 1* (dir. Louis Seel, 1925). Archive: Filmarchiv Austria.

had already been proposed; much early research was motivated by the desire to steer torpedoes to their targets. The slap in Seel's film, simultaneously intimate and remote, finds its darkest contemporary expression in the military drone strike. Remote-controlled and unmanned aerial vehicles (UAVs) have a long and sinister history, beginning with their conception in the mid-nineteenth century.[20] Proponents praise such devices for their 'surgical precision' and 'unprecedented ability' to distinguish between terrorists and civilians – but such techniques visit on their victims an incomprehensible and devastating violence.[21] Twenty-first-century weapon systems make ample use of advancing UAV technology, and not always in the context of war: the US government has deployed armed drones in thousands of 'targeted killings' (extrajudicial assassinations) since 2001, even marking one of its own citizens for 'termination' in 2010.[22] Drone wars are played out in an aggressively asymmetrical theatre, directed by joystick warriors in the ultimate gaming setup, simultaneously amped up and narcotised by screens in windowless rooms far from the conflict zone. The trauma inflicted on the battlefield eventually filters back as moral injury and psychic damage to the operators, inexplicable violence in the

field and post-traumatic stress disorder (PTSD) at home knitted together through telepresence.[23] In a future in which the agents of war are fully autonomous 'killer robots', accountability will be even murkier, and the risks correspondingly more extravagant.[24]

2 Simultaneity

As real-time telecommunication became a reality, cinema faced the challenge of narrating simultaneity through techniques such as the depiction of telephones on screen, using cuts between different locations and split-screen.

> *On screen, and on the phone – tells us: at the same time, but not in the same place.*[25]

Dreams Rewired crosscuts several suggestively named films from early cinema that represented simultaneity through the telephonic experience, including *An Unseen Enemy* (dir. D. W. Griffith, 1912), *The Lonely Villa* (dir. D. W. Griffith, 1909) and *Terrible Angoisse* (Lucien Nonguet, 1906). In *Suspense* (Lois Weber, 1913) a triangular split-screen shows a distressed new mother on the phone to her alarmed husband at work, while a tramp intent on breaking and entering the house saws away at the telephone cable.

Figure 1.7 Still from *Dreams Rewired* (2015). Originally from *Suspense* (dir. Lois Weber, 1913). Private collection.

Once the telephone enabled simultaneity. Today, conversely, accurate synchronisation between locations is a prerequisite for voice and data transmission: digital networks are 'clocked' using standardised time signals from global navigation satellite systems (GNSS) such as the US GPS and the Russian GLONASS.[26] Each GNSS satellite contains several atomic clocks that are synchronised with earthbound clocks; a receiver deduces its own position and the exact time from multiple satellite time signals and information on the satellites' positions. Beyond its application in navigation and communication networks, GNSS time coordination is vital in industries such as energy and finance.[27]

Light, radio waves and other forms of electromagnetic radiation travel at approximately 300,000 kilometres per second in a vacuum, a speed denoted by c. In a groundbreaking 1905 paper, Albert Einstein deduced that c is the 'speed limit' of the universe, applying equally to the movement of matter and information.[28] Because of this limit, information takes time to cover distance, whether across empty space or through a copper cable. In practice, electric signals travel through cables at between 50 and 90 per cent of c. As data has become increasingly time-sensitive in the twenty-first century, so the geographic locations of stock exchanges and data centres have begun to have significant material

Figure 1.8 Still from *Dreams Rewired* (2015). Originally from *L'Argent* (dir. Marcel L'Herbier, 1928). Archive: Marie-Ange L'Herbier.

impact. High-frequency-trading (HFT) algorithms used by financial firms can now exploit nanosecond discrepancies in access to price information for dramatic profit – at the expense of market stability. UK government research following the 2010 'flash crash', which was characterised by rapid, extreme price movement, described HFT 'essentially as an accelerator to … market dynamics such as bubbles and crashes'.[29] A recent paper concludes that although HFT algorithms could theoretically provide liquidity to moderate crashes, they are nevertheless 'responsible for originating and exacerbating flash crashes'.[30]

The negative consequences of financial speculation accelerated by high-speed communications were anticipated and fully played out in L'Herbier's extravagantly produced *L'Argent* (1928), based on Émile Zola's novel of the same name.[31] L'Herbier filmed for three days in the Paris Bourse, flying cameras around the bodies of frenzied traders. Among them is the protagonist, who has a fortune riding on an audacious plan for exploiting natural resources from the New World. The progress of an aviator, crossing the Atlantic en route to discovering mineral wealth, is relayed back to the Bourse by radio. Today financial advantage may be conferred by a few metres' differential in distance to the exchange; for L'Herbier's protagonist, dominance required the bridging of a far greater distance – between colony and metropole.[32]

3 The Material Substrate

Shot in a 'human zoo' displaying colonial subjects imported for the metropolitan gaze, the *Films d'exposition ethnographique de l'Afrique*

Figure 1.9 Still from *Dreams Rewired* (2015): 'It wasn't a free ride – someone had to lift us up.' Originally from *Films d'exposition ethnographique de l'Afrique occidentale au Champ-de-Mars à Paris* (dir. Félix Regnault, Charles Comte and Étienne-Jules Marey, 1889). Archive: La Cinémathèque française.

occidentale au Champ-de-Mars à Paris (1889) brazenly depict differential economic development at the height of the European 'scramble for Africa'. Under colonial rule, occupied territories exported primary commodities for European consumers and raw materials for European industry, often through the use of forced labour.[33] Commodity products of manufacturing were sold back to the colonies, displacing local industry, while newly developed communications and military technologies were deployed by the ruling powers to maintain coercive control.[34] As colonial extraction supported European development, it also exacerbated the technological gap. This history continues to blight the development of African nations.[35]

Telegraphy's development – and apparent mastery over time and space – was firmly rooted in industrial processes and extractive colonialism. From the mid-nineteenth century, there was a boom in demand for rubber and gutta-percha to insulate telegraph wires and undersea cables. Rubber came from plantations in Brazil and vines in the French Congo and the 'Congo Free State', while gutta-percha was harvested from the wild *Isonandra* tree of the Malay Archipelago. Although fast growing, a single tree could yield only a few hundred grams of latex due to the crude extraction methods employed.[36] Insulating the 1857 transatlantic cable required nearly 300 tons of gutta-percha, equivalent to the destruction of about a million trees.[37] By the 1880s, the prodigious demand for gutta-percha threatened to wipe out the tree altogether.[38] The beneficiaries of colonialism – the architects of the new industrial society and early adopters of electrical technology – were for the most part insulated from this environmental degradation, and also from the miserable, often murderous conditions of extraction. Occasionally, though, the material conditions of production did hit public consciousness, as during the 1889 strike at the Silvertown gutta-percha works in East London.[39]

A similar process of hidden environmental plunder has taken place in the Internet Age. Ephemeral and apparently inconsequential, our online actions – searches, tweets, likes and tinder swipes – are realised on an undeniably material substrate. End users are shielded from the provenance of their electronic devices, which are built with the '3TG conflict minerals' (tantalum, tin, tungsten and gold) extracted in the Democratic Republic of Congo,[40] and lithium pumped out from beneath the Atacama desert at huge water cost.[41] These metals end up in microchips and batteries manufactured by enormously complex and meticulous processes that demand corrosive or toxic reagents, including organic solvents, acids, bases and photoresist chemicals, as well as vast quantities of pure water.[42] And the data packets switched by these microelectronics travel through copper cables insulated with today's gutta-percha: polyethylene and polycarbonate, products of a growing petrochemical industry.[43]

At the other end of the life of microelectronics, industrial strategies of planned obsolescence, exercised in the absence of global legal

Figure 1.10 Still from *Dreams Rewired* (2015): By the early twentieth century, the demands of telegraphy and telephony had created an enormous cable industry. Originally from *50 Jahre Fernsprechen in Deutschland* (W. Achsel & Co. Filmproduktion, 1933). Archive: Siemens Historical Institute, München.

frameworks on recycling or the right to repair, result in mountains of e-waste, often accumulating in the regions already scarred by mining of the raw material.[44] Cradle-to-grave design? The US Environmental Protection Agency estimated that in 2012, the country generated 3.4 million metric tons of consumer e-waste (including computer, audio-visual and telecommunications equipment), of which 70 per cent was dumped.[45]

Energy costs are even less tangible to the end user. By Google's accounts, a single search uses on average 1 kJ of energy, roughly equivalent to what a human body burns in 10 seconds.[46] With an estimated 5 billion queries a day, the daily energy consumption of Google search is equivalent to that required for the biological functioning of the entire global human population over 10 seconds.[47] Studies of the environmental impact of other aspects of the information economy are now emerging. A recent life cycle analysis of 'deep learning' neural network models for natural language processing tasks revealed that the carbon footprint of training a single model, involving thousands of algorithmic iterations on massive data sets, could reach several times that of a car over its lifetime.[48]

Life cycle analyses of electronic products can be forbiddingly difficult, deeply involving each of the extraction, manufacturing and service sectors. Rising efficiency – of processors, of manufacturing processes – is not an unequivocal environmental good, as it can drive demand and increase overall consumption.[49] Negative externalities abound; but resource and energy costs and the conditions of labour remain invisible to the average end user. Only occasionally do they surface – for example, when assembly line workers are driven to suicide.[50]

4 Contrivance

Automatic, push-button, remote control.[51]

Things of the future, now in our homes.[52]

An electric future of convenience and leisure through automation was announced at the 1900 World Expo in Paris. Exhibitors promised emancipation from everyday drudgery through the delegation of labour to machines, from moving walkways and electric cars to food-vending machines – an inspiration to filmmakers.[53] Through stop-motion animation in films such as Segundo de Chomón's *El hotel eléctrico* (1908), audiences could imagine a life of leisure, assisted by self-fastening clothes,

Figure 1.11 Still from *Dreams Rewired* (2015). Originally from *El hotel eléctrico* (dir. Segundo de Chomón, 1908). Archive: Pathé.

remote-controlled furniture, autonomous hair-combs and shoe-brushes, and ambulatory luggage.

The 'things of the future' in de Chomón's film are animated as if by magic – their mechanism invisible, like electricity itself. Later cinematic depictions make the motive technology explicit. Buster Keaton's *Electric House* (1922), for example, is similarly populated with animated objects, from a miniature railway for serving meals – anticipating conveyor-belt sushi – and an automatic dishwasher, to retractable beds and motorised bath tubs. The film emphasises the problematics of technology: Keaton is mistaken for an electrical engineer, and much of the action concerns the installation and malfunctioning of machinery.

Today's Smart Home market picks up the promise of convenience through automation and takes it much further: things in our homes will talk to each other, creating an aggregate picture of our behaviour, and ultimately anticipating what we want before even we know it. On first sight, a vision of 'smart things' networked into a 'conscious' home is inviting. Samsung's 'Family Hub' promises to 'organize ... family schedules, entertain, and even see who's at the door' – in effect, to control domestic life, all from the fridge.[54] Self-stocking, it short-circuits the grocery run. Other vendors offer alternative home operating systems in which the command centre is a thermostat or loudspeaker rather than a kitchen appliance. All these versions share the goal of enabling
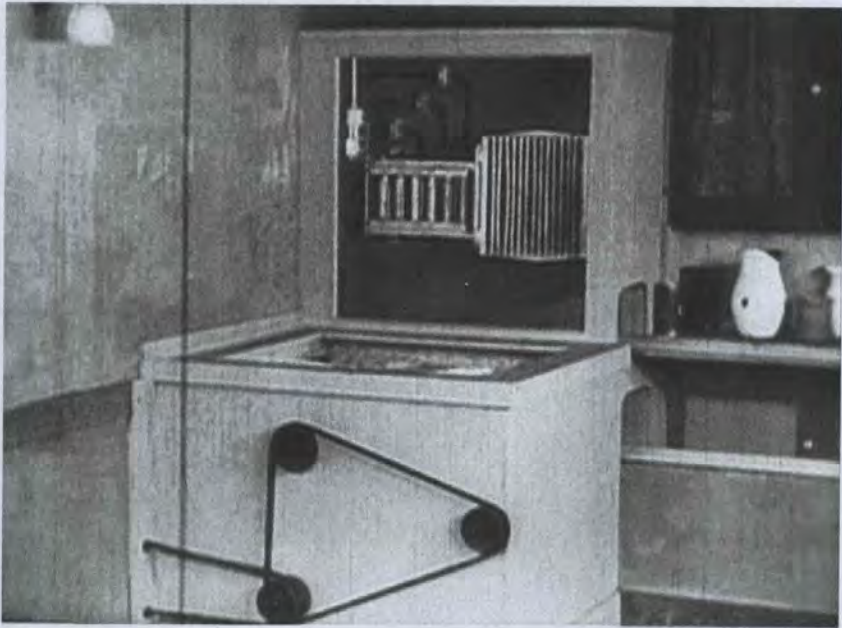
Figure 1.12 Still from *Dreams Rewired* (2015): An automatic dishwasher featured in *The Electric House* (dir. Edward F. Cline and Buster Keaton, 1922). Archive: Joseph M. Schenck.

frictionless consumption through nudging consumer desire. Early cinema tempered the extravagant optimism of the age by warning not only of electricity's corrosive effects on modesty and privacy, but ominously, of dire consequences when reckless humans command automata.

Both de Chomón's and Keaton's films end in chaos wrought by imperfect agents (drunk in the first case, vengeful in the second) in charge of powerful machines, in a way that now seems prophetic. Today, as our machines, devices and objects gain 'smartness', the risks have become deep and systemic.[55] The boons of convenience, choice and service are underwritten by contracts (tl;dr),[56] as our devices deliver intelligence *on us* back to the vendors as monetisable data.[57] Among other freedoms, the pact with 'smart' releases us from legacy notions of ownership, including the right to modify or repair the things around us.[58] Everyday infrastructure is not above suspicion – as the prescient Philip K. Dick exposed in his 1969 novel *Ubik*, when Joe Chip finds himself in a contractual face-off with his 'smart' door.[59]

New versions of the domestic sphere were propelled by social change as well as by dreams of technology. Alice Guy-Blaché, the first director of narrative film, proposed radically alternative futures in several of her works.[60] *Les Résultats du féminisme* (1906) inverts traditional gender roles, daring to imagine the woman of the house putting her feet up,

Figure 1.13 Still from *Dreams Rewired* (2015). Originally from *Les Résultats du féminisme* (dir. Alice Guy-Blaché, 1906). Archive: Gaumont.

drink and pipe in hand, as her manservants frantically sew and iron in the background. Guy-Blaché would later encounter barriers to recognition due to her gender, despite authoring around 700 films and running successful studios.[61]

Indeed, although women had entered the workforce in large numbers in the early 1900s, they primarily occupied traditionally 'female' roles, such as teacher, nurse or secretary.[62] With the outbreak of the First World War and the demand for soldiers, women began to occupy positions in industry and engineering that had previously been denied them, though this trend was partially reversed as men returned from the front lines.[63] And while the advances of the electric age undoubtedly broadened opportunities, roles within the new economy were strongly limited by existing sociocultural attitudes. For example, women were preferred as telephone operators because they were better accultured to be patient and polite when dealing with customers frustrated by poor connections.[64]

A century later, despite unquestionable progress towards gender equality, strikingly similar assumptions about women's capacities prevail in the tech sector: according to Daniel Rausch, head of Amazon's Smart Home division, 'a woman's voice is more "sympathetic" and better received'.[65] Both Alexa and Siri are voiced female by default;[66] sociologist Safiya U. Noble argues that giving AI assistants female voices reinforces

Figure 1.14 Still from *Dreams Rewired* (2015): 'Wanted: young educated ladies.' Originally from *Darstellung des Fernsprechverkehrs* (dir. unknown, c. 1925–6). Archive: Siemens Historical Institute, München.

gender stereotypes.[67] Meanwhile, Google serves ads for executive jobs much more frequently to users it identifies as male, according to a 2015 paper by researchers investigating online ad targeting.[68] The perpetuation of gender disparity in domestic and work contexts through algorithmic management is made all the more dangerous by the invisibility and pervasiveness of the technology employed. The contrivance (device) of the digital assistant needs to be explicitly disconnected from any contrivance (scheme) to entrench existing socioeconomic inequity.

5 Enclosure

Dziga Vertov's *Kino Pravda no. 23: Radio Pravda* (1925), the last in a series of newsreels that documented Soviet life and provided instruction, shows amateur radiotelegraphers constructing and operating basic equipment. Vertov valued new technologies for their power to overcome the limits of time and space. He wrote extensively on the crucial role of filmmaking and the use of sound in creating an ideal society of newly conscious humans.[69] Radio remained a predominantly open,

Figure 1.15 Still from *Dreams Rewired* (2015): 'Simple enough for a child to build: an electrical circuit generates sparks, sending bursts of radio waves across oceans and mountains.' Originally from *Kino Pravda no. 23: Radio Pravda* (dir. Dziga Vertov, 1925). Archive: Österreichisches Filmmuseum.

bidirectional, P2P technology into the early twentieth century, maintaining a promise of empowerment and connection for all; television too was first imagined in the P2P form of the videophone, a natural extension of the telephone. P2P is an example of a many-to-many model of connectivity, in contrast to a broadcast or server-client (one-to-many) model. Many-to-many models allow each node in a network to be both a transmitter and a receiver of data, encouraging end users to be both publishers and consumers, whereas broadcast models imply a hierarchical authority and the consumption of centrally produced data.

In 1910, radio amateurs dominated the airwaves, with commercial and military use accounting for less than 25 per cent of traffic. Large metropolitan areas in the United States such as Boston, New York and Baltimore each had several hundred amateur stations.[70] A major commercial application of radiotelegraphy was ship-to-shore communication. The radio rooms of luxury liners were designed primarily to serve wealthy passengers, with emergency communications a useful by-product. The market was dominated by the Marconi Company, which supplied ground stations, ship-borne equipment and radio operators; its

Figure 1.16 Still from *Dreams Rewired* (2015): The ship's radio room. Originally from *Atlantis* (dir. August Blom, 1913). The film, which depicts the sinking of the transatlantic ocean liner *SS Roland*, was based on Gerhardt Hauptmann's 1912 novel that had been published just before the *Titanic* sank. Archive: Det Danske Filminstitut.

main competitor was Telefunken. Rival companies refused to carry each other's messages, except in an emergency – despite efforts at the 1906 International Radiotelegraph Convention of Berlin to mandate interconnectivity and avoid monopoly.[71] Regulation was minimal.

The controversial role played by radiotelegraphy in the 1912 sinking of the *RMS Titanic* and subsequent rescue operation shored up arguments for expanding the regulation and licensing of radio. Distracted by commercial traffic, the *Titanic*'s radio operator ignored a critical ice warning from another steamship in the vicinity, the *SS Californian*.[72] Of the numerous responses to the distress signals transmitted by the *Titanic* one from the *SS Frankfurt* was met with outright hostility by the *Titanic*'s operator[73] – a hostility that has been attributed to an interoperability squabble, the *Frankfurt* being equipped with a Telefunken radio.[74] There were credible accusations that land-based radio amateurs had disrupted vital communications: in the pre-voice era of radiotelegraphy, the combination of spark transmitters and receivers with poor selectivity inevitably caused interference.[75] Further, radio amateurs were accused of misinterpreting signals and propagating misinformation.[76] Legislation inevitably followed, establishing new standards for radio – both maritime and land-based.[77]

By the end of the First World War, electronic valve (vacuum tube) technology had developed sufficiently to enable practical sound and music transmission, eventually leading to the broadcasting boom of the 1920s. Transmitters became both more numerous and more powerful, and the problem of interference grew. The 1912 Act did not deny new stations access, but as radio advertising grew, existing stations had no interest in sharing valuable airwaves with newcomers. While most countries declared the electromagnetic spectrum national property, in the United States it was (and still is) considered part of the public domain. Despite this, pressure from major broadcasters and growing interference led to the restrictions on access arising with the 1927 Radio Act.[78] Although the Act could not create property rights in the spectrum, its effect was to allow stations to be traded 'at prices that reflected the market value not just of their buildings and equipment but also of their frequency assignments, power levels, and authorised hours of operation'.[79] In the ensuing decades, the explosion in demand for bandwidth from radio and TV broadcasters, cellular providers and wireless computer networks has been matched by technological advances enabling more efficient use of available spectrum, with spectrum scarcity eliminated via a de facto market mechanism. Elimination of scarcity has not, however, prevented the increasing commercialisation and consolidation of the media.[80]

Tim Wu has observed parallels in the evolution of the internet and that of radio. In *The Master Switch: The Rise and Fall of Information Empires*, he characterises the history of information systems as cyclic, with open structures becoming consolidated and closed over time, possibly reopening only after disruptive innovation.[81] Interconnectivity between radiotelegraphy companies was primarily a commercial and legal issue, and not a technical one to do with equipment interoperability;
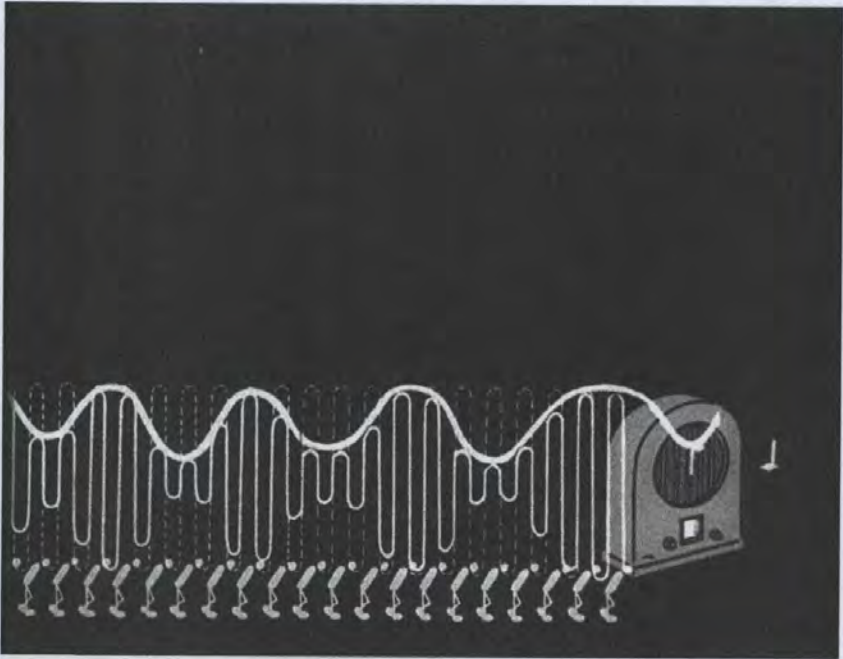
Figure 1.17 Still from *Dreams Rewired* (2015): The electronic valve made it possible to carry sound over continuous radio waves; in AM radio, the amplitude (volume) of a high-frequency carrier wave is modulated by an audio signal – here, the thicker line. Originally from *Unsichtbare Brücken* (dir. unknown, 1932). Archive: Bundesarchiv/Transit Film.

further, at least in the United States, the spectrum has been seen as part of the commons, though regulation has effectively delivered it to commercial interests. Similarly, the internet is built on shared open technical standards, but commercial and legal superstructures now threaten to create differential regimes of access. P2P and open models have again arisen with digital networks and computing, but the overwhelming tendency at the consumer device and services level is towards the proprietary and the broadcast model. Most domestic internet users are connected asymmetrically, achieving far greater speeds for downloading than uploading data, and internet service providers (ISPs) often prohibit domestic users from hosting servers and publishing their own content.[82] This favouring of the downloading user-as-consumer over the uploading user-as-producer mirrors tendencies in the broader economy towards closed, 'black-box' models of technology, which also discourage – if not prohibit – creative acts.[83]

Asymmetrical connectivity runs counter to the principle of network ('net') neutrality introduced by Wu,[84] and currently being battled over in

the United States.[85] Net neutrality requires that ISPs treat all traffic equally, regardless of source, destination or data type, in the interest of promoting an evolutionary model of innovation.[86] In general, computer scientists, consumer interest groups and human rights activists tend to gather under a pro-net-neutrality banner, arguing that tiered access schemes championed by ISPs permit a harmful concentration of power, and even commercial censorship. The consequence: the enclosure of the internet, in the same manner that the radio spectrum has been effectively captured from the commons. Hugh Aitken, in his study of radio regulation, reminds us that

> fears and anxieties that shaped communications policy in the past ... were concerns about concentrated economic power, about control over the creation and movement of information, and about equal access to the means of communication by all members of society ... There may .... yet persist some residue of the sentiment that the electromagnetic spectrum is a special kind of natural resource ... not to be treated as just another kind of real property.[87]

While political progressives uphold many-to-many models as exemplars of distributed authority and embodiments of the empowering and

Figure 1.18 Still from *Dreams Rewired* (2015): A scene in the boardroom of a television corporation. 'We've got to fight to maintain our position with any weapons we can utilise ... Remember – he hasn't even protected himself with patents.' Originally in *Murder by Television* (dir. unknown, 1935). Courtesy Cameo Pictures.

democratising visions of the early internet, these models can be deployed for reactionary ends too. Consider the use of Twitter and Facebook by the ostensibly populist and anti-elitist campaigns in the UK Brexit referendum and the 2016 US election for the unmoderated distribution of emotionally targeted disinformation.[88] Hierarchical structures are essential to the construction of knowledge in science, humanities and the law. In their 2018 book *Network Propaganda*, Benkler, Faris and Roberts trace the parlous state of the US online public sphere to structural issues already existing in the broadcast radio and TV spheres. Drawing on extensive empirical studies, they describe distinct media infrastructures on the right and the left of American politics, characterising the former as more vulnerable to fake news, clickbait and echo-chamber effects, and the latter as preserving valuable editorial norms associated with traditional journalism.[89]

6 Heteronomy

> *A screen in every home – and electric eyes spanning the globe.*
> *But ... wouldn't that mean that anyone could look into our rooms, into our lives?*[90]

Although television had initially been imagined as a P2P videophone,[91] by the time it became a practical reality in the late 1920s, it was in the form of the broadcast model.[92] Pre-war audiences for broadcasts remained relatively small, however, due to restrictions in the range and duration of transmissions and the expense of receiving equipment.[93] A new wave of fiction films inflamed the public imagination with radical technologies and outrageous plots. A. Edward Sutherland's 1933 film *International House* featured a Chinese scientist's invention of a televisual 'radioscope' that could direct its eye to any remote location. In *Murder by Television* (Clifford Sanforth, 1935), an inventor who develops a way of transmitting to the entire globe is murdered in the middle of a broadcast by corporate spies who aim his powerful ray at him. *Things to Come* (William Cameron Menzies, 1936), based on the work of H. G. Wells, features massive, semitransparent public TV screens and the casual use of videophones.

The invasion of the private sphere and the consequential corrosive effects on morality were common fears of the Electric Age, as vividly portrayed in Harry Piel's 1934 movie *Die Welt ohne Maske*. It features hapless inventor Tobias Bern and his associate Harry Palmer attempting to develop a television technology to compete with that of the large electronics corporations. They unwittingly invent a device that can see through walls, offering X-ray-like vision into private lives. Apart from (inevitably) facilitating voyeurism, the device reveals where a tax fraudster hides his money.[94] The potency it bestows is not lost on the pair: "'Not only can we see over distance, but we can see through everything!'/ 'What uncanny power we hold in our hands!'" (Figure 1.19).

Figure 1.19 Still from *Dreams Rewired* (2015). Originally from *Die Welt ohne Maske* (dir. Harry Piel, 1934). Archive: Filmmuseum Düsseldorf / Beta Film GmbH.

While fantasies of seeing through walls continued to be presented in the cinema well into the 1930s, authentic X-ray images had been directly incorporated into film very shortly after their discovery by Wilhelm Röntgen.[95] Pioneering Glaswegian radiologist John MacIntyre's eponymous film of 1896 depicts a beating heart and the passage of a bismuth meal. Dramatic and transformative as these direct imaging techniques were, other abstract forms of penetrating vision – into processes rather than matter – would facilitate the analysis and administration of the body both as biological entity and as economic factor.

In his research into movement and change, the physiologist Étienne-Jules Marey invented various instruments and techniques, including a method of high-speed serial photography using very fast shutters. Marey's 'chronophotography', while often described as 'pre-cinematic', was motivated by a very different impulse to that of cinema.[96] At the movies, a rapid succession of still images is synthesised into illusory movement by exploiting the persistence of vision. Chronophotography, on the other hand, is an analytic technique. The superimposition of the still images in a sequence creates a graph of a process – expanding human vision by

revealing what is too quick for the eye to see, rather than tricking the eye as cinema does.

The chronophotograph series *Chat. Chute avec retournement* (1890) laid bare the double rotational movement that a falling cat uses to right itself in mid-air – and answered a long-standing puzzle in feline dynamics. Studies of human locomotion such as *Marche jambes seules* (1893) not only exposed the underlying biomechanics, but also suggested the possibility of control and enhancement. The French Army was an early client of Marey's. Chronophotographs of soldiers handling rifles suggested ways to optimise their movements – in battle, a few seconds could mean the difference between life and death, victory and defeat. Twenty years later, engineers and pioneers of ergonomics Frank and Lillian Gilbreth drew on Marey's work to develop film-based analytical techniques in their pursuit of efficiency in the workplace. By attaching small lamps to workers' hands and filming their motion, then constructing three-dimensional wire models of the captured light traces, they determined the 'value, time, and sequence of motions for producing the greatest results in the least time with the least effort and fatigue'.[97]

Data-driven analysis found another early, though highly specious, application in forensics. In its mission to modernise in the early 1920s, the Vienna Police Department began to collect moulds of body parts for the purposes of criminal identification, under the guidance of Austrian doctor Alphons Poller.[98] Following a model established by criminologist
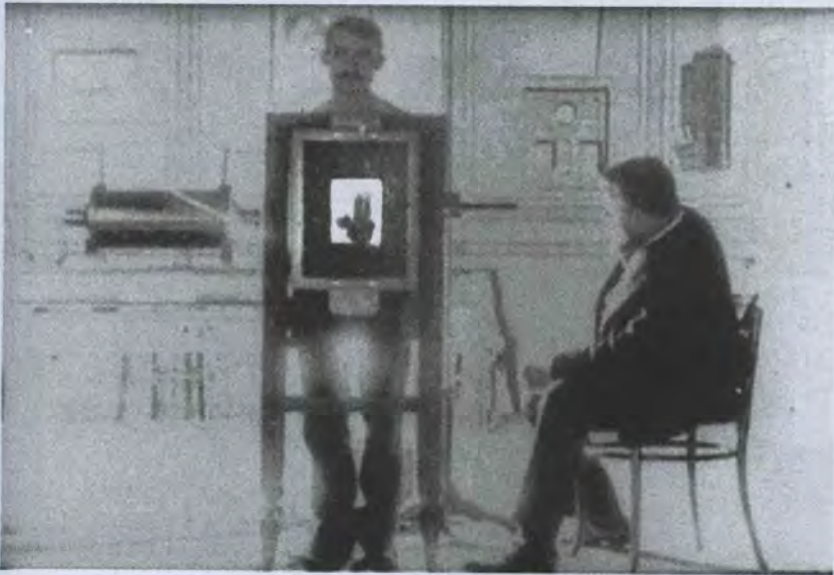
Figure 1.20 Still from *Dreams Rewired* (2015). Originally from *Dr. MacIntyre's X-Ray Film and X-Ray Cabinet* (prod. John MacIntyre, 1896). Archive: National Library of Scotland.

Adolf Lenz, the Department embraced physiognomy as a science, incorporating a section on criminal biology in 1929 to 'examine certain designated persons ... for the better understanding of the personality, and the more intelligent adaptation of punishment'.[99] Inspired by Poller's work, the police in Alfred Deutsch's 1930 film *Die Tat des Andreas Harmer* employ a biometric data set – here, casts of ears – to apprehend criminals.

The development of ubiquitous, networked sensing and computing, together with advances in algorithm design, have revolutionised the potential of data beyond optimisation, ushering in an age of 'predictive analytics'. Through statistical inference and machine learning,

Figures 1.21A and 1.21B Stills from *Dreams Rewired* (2015). Originally from a chronophotographic sequence by Étienne-Jules Marey, *Marche jambes seules*, 1893. Archive: La Cinémathèque française.
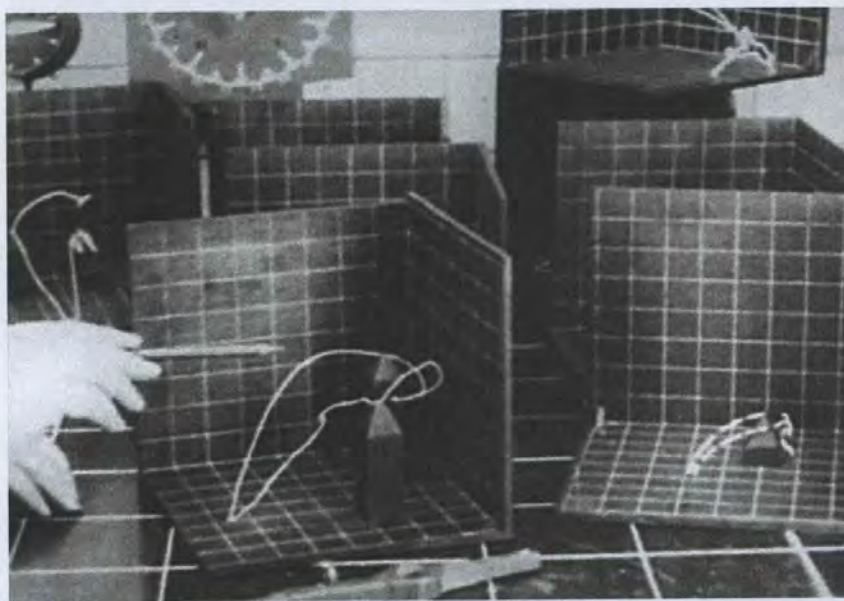
Figure 1.22 Still from *Dreams Rewired* (2015): 'Track, record, freeze the trace. Analyse it. Then – tune, control, accelerate.' From *Original Films of Frank B. Gilbreth* (prod. Frank B. Gilbreth, 1910–24). Archive: Purdue University Libraries, Karnes Archives and Special Collections.

Figure 1.23 Still from *Dreams Rewired* (2015): 'Gepollerte Ohren' ('Poller's
Ears'). Originally from *Die Tat des Andreas Harmer* (dir. Alfred
Deutsch, 1930). Archive: Filmarchiv Austria.

algorithmic decision-making (ADM) systems deliver predictions about
how someone might behave, what they might buy, when they might
die. Contemporary predictive policing models use police departmental
data on crimes recorded – which are, importantly, distinct from crimes
committed – to apportion policing resources by neighbourhood. In
their investigations into racial bias in predictive policing models, Wil-
liam Isaac and Kristian Lum observe that 'if a police department has a
history of over-policing some communities ... predictive policing will
merely reproduce these patterns in subsequent predictions'.[100] As ADM
becomes increasingly widely deployed, controlling access to education,
employment, finance and health care, it also increases risks presented
by the amplification of historical bias, or errors in conceptualising and
specifying objectives.[101]

> We can engineer the context around a particular behaviour and force
> change that way ... We are learning how to write the music, and then
> we let the music make them dance.[102]

Figure 1.24 Still from *Dreams Rewired* (2015). Originally from *Hände: Das Leben und die Liebe eines zärtlichen Geschlechts* (dir. Miklós Bándy and Stella Simon, 1927–8). Archive: Filmarchiv Austria.

Uncanny power today belongs to the agents of what Shoshana Zuboff has termed 'surveillance capitalism' – the specific contemporary mode of economic activity in which network intelligence corporations, in the guise of information and service providers and media platforms,[103] trade financial instruments derived from predictive analytics in a 'behavioural futures market'.[104] Underwriting this rampant gambling on human behaviour is an even more malignant trend – in behavioural 'nudging'.[105] Informed by neuroscientific research on perception and cognition, and fed by data harvested from smartphone apps via highly asymmetric and opaque terms of service, the agile vendor of products and services effectively manages user desire and actions. Prediction is much less hazardous when a user, confronted with an explicit and limited set of options, feels that she is choosing freely. And seemingly insignificant changes in the framing of options may lead to dramatically different behaviour.[106] The consequence is a grave and urgent threat to the dignity of human persons compelled into an outlandishly heteronomous future. It is no small irony that the technological wonders of the Electric Age were originally sold to the public as vehicles of autonomy.

Notes

1 Michael Angelo Garvey, *The Silent Revolution: Or, the Future Effects of Steam and Electricity upon the Condition of Mankind* (London: William & Frederick G. Cash, 1852), 103–4. He continued, 'Is this consummation to be looked forward to as a good, or to be dreaded as an evil?'

2 Bodil Marie Stavning Thomsen, '*Dreams Rewired*: Disembodying Data and Rematerialising Technology', essay in booklet accompanying *Dreams Rewired* DVD (Icarus Films Home Video, 2016).

3 For surveillance capitalism, see Shoshanna Zuboff, *The Age of Surveillance Capitalism* (London: Profile Books, 2019).

4 *Dreams Rewired*, directed by Manu Luksch, Martin Reinhart and Thomas Tode, 2015.

5 Translated by Philippe Willems as A. Robida. *The Twentieth Century* (Middletown, CT: Wesleyan University Press, 2004).

6 The 'telephonoscope' was Robida's term for a videophone.

7 M. Schwartz and J. Hayes, 'A History of Transatlantic Cables', *IEEE Communications Magazine*, 46/9 (September 2008): 44, doi: 10.1109/MCOM.2008.4623705. See also transportgeography.org/?page_id=2135.

8 Nine days is 12,960 minutes, so for any text longer than about 100,000 words, a ship would still be faster than telegraphy at 8 words per minute. Given a realistically short message, however, the telegraph was faster than a ship by a factor of about 10,000. A communications rate 10,000 times that of the early telegraph would be 80,000 words per minute, which is very approximately 400,000 characters per minute, or about 50 kilobits per second. Such a rate would become publicly available in the late 1990s via V.90 standard modems.

9 In the United States alone there were over 2 million telephone subscribers in 1902. Department of Commerce and Labor, *Telephones and Telegraphs 1902*, Bureau of the Census, Special Report (Washington, DC: Government Printing Office, 1906), 5.

10 Trond Lundemo, 'The Dissected Image: The Movement of the Video', in J. Fullerton and J. Olsson, eds, *Allegories of Communication. Intermedial Concerns from Cinema to the Digital* (Rome: John Libbey, 2004), 105–21, 109.

11 For civilian satellite imaging, see, for example, euspaceimaging.com/products/image-specs/. See also Chang-Chien Liu, Ryosuke Nakamura, Ming-Hsun Ko, Tomoya Matsuo *et al.*, 'Near Real-Time Browsable Landsat-8 Imagery', *Remote Sens*, 9/1 (2017), doi: 10.3390/rs9010079. Commercial services include 'FarEarth Observer', live.farearth.com/observer/.

12 *Dreams Rewired* (dir. Luksch, Reinhart and Tode, 2015).

13 But note: 'wireless network and pairing with compatible Samsung Galaxy required. Requires SmartThings App, smartbulb/outlet and SmartThings Hub'. 'Be Together: Even if You're Working Christmas', Samsung commercial, 2018, youtube.com/watch?v=G8Et86NhGuo, accessed 20 December 2019.

14 YouTube Mission statement at youtube.com/intl/en-GB/about/, accessed 28 April 2020.

15 'Instant Famous Social Shop', instant-famous.com/products/10000-youtube-views, accessed 20 December 2019.

16 'Instant Famous Social Shop', instant-famous.com/collections/twitter-followers, accessed 20 December 2019 and still sold out on 28 April 2020. Mysterious because there is evidently no scarcity; another vendor, Insta-Followers has in stock both 'real Twitter followers' and 'realistic-looking

high-quality followers': instafollowers.co/buy-twitter-followers, accessed 28 April 2020. Unlimited reproducibility with perfect fidelity – together with precisely controllable mutability and signal encoding that permits access control and error correction – is characteristic of the networked digital realm. Scarcity of digital goods must be created artificially, through technical mechanisms. See, for example, John L. Sullivan, 'Software and Artificial Scarcity in Digital Media', *Political Economy of Communication*, 4/1: 66–84, available at polecom.org/index.php/polecom/article/view/64/254; and also R. O'Dwyer, 'Limited Edition: Producing Artificial Scarcity for Digital Art on the Blockchain and Its Implications for Cultural Industries', *Convergence: The International Journal of Research into New Media*, doi: 10.1177/1354856518795097.

17 As a torrent user downloads data from available sources across the network, so they also republish it. 'BitTorrent.org For Users', bittorrent.org/ introduction.html, accessed 20 December 20 2019.

18 A non-technical introduction to blockchain can be found in Antony Lewis, *The Basics of Bitcoins and Blockchains* (Coral Gables, FL: Mango, 2018).

19 Benjamin Franklin Miessner, *Radiodynamics. The Wireless Control of Torpedoes and Other Mechanisms* (New York: D. Van Nostrand Company, 1916), 83–4.

20 See en.wikipedia.org/wiki/History_of_unmanned_aerial_vehicles; see also Sarah Simonovich, 'The History of Unmanned Vehicles, Part 1', 14 November 2016, available at aviationoiloutlet.com/blog/the-history-of-unmanned-aircraft-part-1-wwi/, accessed 18 July 2020.

21 Quotes are from John Brennan, President Barack Obama's former chief counterterrorism advisor and now director of the CIA: publications.parliament.uk/pa/cm201314/cmselect/cmdfence/772/772vw08.htm#footnote_7. 'Surgical' is an apt and convenient description of drone operations, and such terminology has been in use for decades: writing in 1986, William Safire defined a 'surgical strike' as 'precise, quick, clean, incisive'. W. Safire, 'On Surgical Strike', *New York Times*, 4 May 1986, available at nytimes. com/1986/05/04/magazine/on-language-on-surgical-strike.html, accessed 5 May 2020.

22 Greg Miller, 'Muslim Cleric Aulaqi Is 1st U.S. Citizen on List of those CIA Is Allowed to Kill', *Washington Post*, 7 April 2010, available at washington post.com/wp-dyn/content/article/2010/04/06/AR2010040604121.html, accessed 20 December 2019.

23 Eyal Press, 'The Wounds of a Drone Warrior', *New York Times Magazine*, 13 June 2018, available at nytimes.com/2018/06/13/magazine/veterans-ptsd-drone-warrior-wounds.html, accessed 20 December 2019. For differing perspectives on the mechanisms of psychological and moral harm caused to drone operators, and the legitimacy of diagnoses of PTSD, cf.: Chris Woods, *Sudden Justice: America's Secret Drone Wars* (London: C. Hurst and Co., 2015), 169ff.; and Grégoire Chamayou, *Drone Theory* (London: Penguin, 2015).

24 For a pithily humorous assessment of the feasibility of autonomous weapon systems from a mathematician, see Kevin Buzzard, 'Killer Robots: What Computers Can't Do', Royal Institution Lecture, January 2017, available at youtube.com/watch?v=jQPb7DRMoZY, accessed 28 April 2020. For a book-length discussion, see Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: W. W. Norton & Co., 2018).

25 *Dreams Rewired*, 2015.

26 A comprehensive description of GNSS technology can be found in B. Hofmann-Wellenhof, H. Lichtenegger and E. Wasle, *GNSS – Global Navigation Satellite Systems* (Vienna: Springer, 2008).

27 Official US government information that summarily describes GPS applications can be found at gps.gov/applications/timing/. For an economic assessment of the role of GNSS in critical infrastructure that discusses applications in more detail, see the UK government-commissioned report: London Economics, 'The Economic Impact on the UK of a Disruption to GNSS', June 2017, available at assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/619544/17.3254_Economic_impact_to_UK_of_a_disruption_to_GNSS_-_Full_Report.pdf. On financial markets' dependence on GPS-derived time signals, see T. Humphreys, 'GPS Spoofing and the Financial Sector', University of Texas at Austin Radionavigation Laboratory White Paper, June 2011, available at radionavlab.ae.utexas.edu/images/stories/files/papers/summary_financial_sector_implications.pdf. All accessed 28 April 2020.

28 This is one key result of the special theory of relativity that he described in the 1905 paper, 'On the Electrodynamics of Moving Bodies', *Annalen der Physik*, 17: 891–992.

29 Government Office for Science, 'Crashes and High Frequency Trading', 2011, 4, available at assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/289016/11-1226-dr7-crashes-and-high-frequency-trading.pdf, accessed 20 December 2019.

30 Mario Bellia, Kim Christensen, Aleksey Kolokolov, Loriana Pelizzon and Roberto Renó, 'High-Frequency Trading during Flash Crashes: Walk of Fame or Hall of Shame?', Leibniz Institute for Financial Research SAFE Working Paper No. 270, 2018, 4, doi: 10.2139/ssrn.3560238.

31 For a survey of the challenges posed by high-frequency trading, see W. Mattli, ed., *Global Algorithmic Capital Markets. High Frequency Trading, Dark Pools, and Regulatory Challenges* (Oxford: OUP, 2018).

32 See M. Zook and M. H. Grote, 'The Microgeographies of Global Finance: High-Frequency Trading and the Construction of Information Inequality', *Environment and Planning A: Economy and Space*, 49/1: 121–40.

33 Ewout Frankema, Jeffrey Williamson and Pieter Woltjer, 'An Economic Rationale for the African Scramble', 14 July 2015, available at voxeu.org/article/economic-rationale-african-scramble, accessed 1 May 2020.

34 Gareth Austin, 'African Economic Development and Colonial Legacies', *International Development Policy*, 1 (2010): 11–32, doi: 10.4000/poldev.78.

35 For a searing indictment, see Walter Rodney, *How Europe Underdeveloped Africa* (London: Verso, 2018).

36 Bruce J. Hunt, 'Insulation for an Empire: Gutta-Percha and the Development of Electrical Measurement in Victorian Britain', in Frank A. J. L. James, ed., *Semaphores to Short Waves* (London: RSA, 1998), 85–104, 92.

37 Charles Bright, *Submarine Telegraphs: Their History, Construction, and Working* (London: C. Lockwood & Son, 1898), 35.

38 This was intimated by Eugene Obach in his Cantor Lectures. E. F. A. Obach 'Gutta Percha' (Cantor Lectures: Lecture I), *Journal of the Society of Arts*, 46/2353 (1897): 110, available at jstor.org/stable/41334332, accessed 26 April 2020. John Tully foregrounds the environmental impact of gutta-percha harvesting in 'A Victorian Ecological Disaster: Imperialism, the Telegraph, and Gutta-Percha', *Journal of World History*, 20/4 (December 2009): 573–4.

39 Tully, 'A Victorian Ecological Disaster', 565.

40 UN Security Council Resolution 1291 of 2000 made an association between armed conflict and resource extraction in the DRC – an association that is acknowledged in US law. Section 1502 of the US Dodd–Frank Act (2010) requires companies to exhibit 'due diligence' and produce independent audits of their use of conflict minerals.

41 For a summary article, see Ben Heubl, 'Lithium Firms Depleting Vital Water Supplies in Chile, Analysis Suggests', *Engineering and Technology* (21 August 2019), available at eandt.theiet.org/content/articles/2019/08/lithium-firms-are-depleting-vital-water-supplies-in-chile-according-to-et-analysis/, accessed 28 April 2020. For a more technical treatment, see W. Liu, D. B. Agusdinata and S. M. Myint, 'Spatiotemporal Patterns of Lithium Mining and Environmental Degradation in the Atacama Salt Flat, Chile', *International Journal of Applied Earth Observation and Geoinformation*, 80 (2019): 145–56.

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44 Particularly for contemporary technology platform providers, planned obsolescence of hardware may be a vital part of a strategy that includes management of scarcity in the realm of software (data formats or operating systems). For an analysis that tempers this business model (using Apple as an example) with the qualities of one based on service contracts, see Tim Kessler and Jan Brendel, 'Planned Obsolescence and Product-Service Systems: Linking Two Contradictory Business Models', *Journal of Competence-Based Strategic Management*, 8: 29–53, available at 10.1688/JCSM-2016-01-Kessler, accessed 28 April 2020.

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47 'Google Now Handles at Least 2 Trillion Searches per Year', Search Engine Land, available at searchengineland.com/google-now-handles-2–999-trillion-searches-per-year-250247, accessed 20 December 2019.

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50 'Foxconn Suicides – 2010', Business and Human Rights Resource Centre, available at business-humanrights.org/en/foxconn-suicides-2010, accessed 20 December 2019.

51 *Dreams Rewired* (2015). Quotation from The Last Poets, 'Mean Machine', from *This Is Madness* (Douglas Records, 1971).

52 *Dreams Rewired* (2015). Quotation from 69, 'Filter King', from *Sound on Sound* (Planet-E, 1993).

53 Looping around the Expo site was a 3.5-km-long *trottoir roulant*, depicted in *Paris Exposition Reproduced from The Official Photographs* (New York: R. S. Peale Co., 1900), 30–1. Swift, clean transport was promised by the Lohner-Porsche electric hybrid car: bie-paris.org/site/en/component/easyblog/entry/a-to-z-of-innovations-at-expos-electric-car?Itemid=1009. For food-vending machines, see A. Chandler, 'The Paris Exposition Universelle of 1900', expanded and revised from *World's Fair* magazine, 7/3 (1987), available at arthurchandler.com/paris-1900-exposition. Both accessed 28 April 2020.

54 'Samsung.com Smart Fridge Freezers', available at samsung.com/uk/refrigerators/family-hub-fridge-freezers, accessed 20 December 2019.

55 O. Halpern, M. Robert and B. D. Geoghegan, 'The Smartness Mandate: Notes toward a Critique', *Grey Room*, 68 (2017): 106–29. The authors characterise smartness as 'inextricably tied to the language of crisis'; it provides 'opportunities to decentralize agency and intelligence by distributing it among objects, networks, and life forms' (p. 108). Available at kclpure.kcl.ac.uk/portal/files/93233599/2017_Hapern_Mitchell_Geoghegan_Smartness.pdf, accessed 9 May 2020.

56 Too long; didn't read.

57 See J. A. Obar and A. Oeldorf-Hirsch, 'The Clickwrap: A Political Economic Mechanism for Manufacturing Consent on Social Media', *Social Media and Society* (19 July 2018), doi: 10.1177/2056305118784770.

58 In the United States, the 'right to repair' movement has gained significant support from farmers prevented from repairing equipment by manufacturers deploying the Digital Millennium Copyright Act (DMCA). The battle is ongoing: 'Farmers Fight John Deere over Who Gets to Fix an $800,000 Tractor', Bloomberg (5 March 2020), available at bloomberg.com/news/features/2020–03–05/farmers-fight-john-deere-over-who-gets-to-fix-an-800-000-tractor, accessed 28 April 2020.

59 Philip K. Dick, *Ubik* (New York: Doubleday, 1969). Chip is held up by his own front door – a door that is aware of its contractual rights.

60 The profession of film director – as distinct from filmmaker – emerged only through specialisation and separation of tasks. Alice Guy-Blaché explicitly restricted herself to a directorial capacity, delegating cinematography and lighting to others. However, film historians didn't acknowledge her as a *director* for many decades, as it was common practice to credit only the production company.

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79 Ibid., 709.

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89 'Liberal audiences do not trust their partisan commentators at rates even approaching those that typify conservative audiences.' Yochai Benkler, Robert Faris and Hal Roberts, *Network Propaganda. Manipulation, Disinformation, and Radicalization in American Politics* (Oxford: OUP, 2018), 311. The authors locate the origins of this asymmetry of trust in a series of technological and institutional changes beginning in the 1970s, one effect of which was the emergence of socially and economically conservative televangelists who preached the prosperity gospel and affirmed the views of the religious right (319 ff.)

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91 Media theorist Doron Galili notes that 'late nineteenth-century commentators regarded moving image transmission devices as complements to the telephone'. Doron Galili, *Seeing by Electricity: The Emergence of Television, 1878–1939* (Durham, NC: Duke University Press, 2020), 23. Video-telephony was a keystone of Robida's comprehensive vision (Robida, *The Twentieth Century*, 50 ff.).

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