Compression & Encryption: Information processing and culture

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Abstract

This thesis is an investigation of two information processes: encryption and compression. Epistemically, these are products of 20th c. mathematics, but today constitute core infrastructures integral to digital culture. Compression (coding for efficient storage and transfer) enables a multimedia internet, while encryption (coding to control where/by whom information can be decoded) renders information as a value-form for a capitalist economy.

Technologies are not neutral, but ambiguous and contested: complex, material assemblages rife with contradictions, complications and opportunities. Such complexity demands excursions into codecs: technical devices which enact obscure information processes. Drawing on the methods of media archaeology, historical materialism, science and technology studies, and software studies, I trace the emergence and political-cultural contestation of contemporary techniques of compression and encryption.

As information processes, compression and encryption concern production: of signals, of art, of culture and of subjectivities. Compression, I argue, made possible a historic abundance of 'free' information, at once de facto common, an overstimulating shock to human subjectivity and an over-circulation crisis for capital (outpaced by its own information-commodities). Innovations in perceptual coding have made possible remarkable compressions of sounds, images and video, while also drawing humans into the channel and challenging the ontological basis of information theory. Compression codecs raise questions about our sensory economy: what kind of culture is anticipated in code? What is rendered perceptible? Where and to whom?

Within and against this circulation, encryption – ostensibly a tool of secrecy – has been reinvented as one of property. Cryptographically secured files make possible new accumulative mechanisms, and contribute to digital culture's occult character: opaque, inaccessible, mediated by proprietary interfaces and rights management systems. Against the cryptographic securing of information, I argue the need for a politics and methodology of decryption, alongside a renewed commitment to the socialisation of information.

Contents

knowledge:
another process, finally no different, in its overall form, from the one called stupidity

Samuel R. Delany

Introduction

Information is theoretical; it requires abstraction. It is also demonstrably material.[1]

Though unintuitive, there is no fundamental contradiction between these claims.[2] What we call abstractions are instantiated in, and tend to secrete, materialities: arrangements of electrons in organic tissue or on a circuit board, collections of symbols, idle thoughts, messages transmitted via the internet, movement, action, birth, death, random mutation or mass destruction.[3] In all these cases, abstractions – from banal, to meaningful, to calamitous – mark the coming together of apparently isolated channels, the issuing of determinisms between distinct materialities, conceptual strata or regimes of production.

This thesis investigates information at such a meeting point, between technology and culture. In it, I seek to expand a materialist account of two technical processes in particular, which are integral to our cultures and economies today: compression and encryption. These technologies are products of twentieth century information theory; the work of communications engineers (largely based in the UK and US).[4] Arcane mathematics correspond to complex materialities: in various guises, these technologies also constitute global infrastructures for the circulation of information. We would have no multimedia internet without compression, and it could not circulate information-commodities without encryption. Neither compression, nor encryption would be possible without informatics: the basis of culture's digitization.

Of course, this is a compressed summation of my topic. Technology is not neutral, but ambiguous and contested: compression facilitates excessive accumulation, and encryption is a tool of privation, but they are also more than these things. As complex, material assemblages, compression and encryption codecs are rife with contradictions, complications and opportunities. We should grapple with, not deny, such complexity – undertake, as Adrian

[1] As argued in the mathematical literature: Mahesh Karnani, et al. "The Physical Character of Information", *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* 465.2107 (2009)
[2] Hence, Friedrich Kittler can propose an "information-theoretical materialism"; "Real Time Analysis, Time Axis Manipulation" *Cultural Politics* 13.1 (2017)
[3] See Adrian Mackenzie's semiotics of the atomic bomb: *Transductions* (London: continuum, 2002), p.59; Also, Derrida, Catherine Porter and Philip Lewis who write that "Nuclear weaponry depends... upon structures of information and communication, structures of language, including non-vocalizable language, structures of codes and graphic decoding"; "No Apocalypse, Not Now" *Diacritics* 14.2 (1984), p.23
[4] See, e.g. Bernard Dionysius Geoghegan, *Code: From Information Theory to French Theory* (Durham: Duke University Press, 2023), pp.40-45

Mackenzie writes of codecs, "long excursions into labyrinths of mathematical formalism and machine architecture".[5] The responsibility (and central challenge) of this work is to return to the surface with something meaningful.

This introduction outlines the contours of my interdisciplinary research project – which is also 'undisciplined', in the sense it has no easy disciplinary home.[6] Thanks to a post-disciplinary tradition and supervision, I've had the privilege of working with a variety of materials in a variety of ways.[7] Methodology is therefore a concern, and one function of this introduction is to reflect on it. Frequently this work entails the pulling together of literature, so I have no dedicated literature review chapter. Instead, this introduction orients the thesis within a few distinct theoretical traditions: notably media archaeology, software studies, science and technology studies (STS), posthumanism and historical materialism. These traditions imply a range of methods, which must be worked through within the methodological discussion.

At the intersection of these traditions sits digital culture. Indeed, they offer many definitions for digital culture, all of which (even the most vulgar) must deal with the question of materiality: digital (as a substrate for) culture. A common proposition states that digital culture comprises the cultural activity in or around "the digital".[8] I think digital culture is this and more, but there's a more pressing, grammatical, concern here: "digital" is an adjective, not a noun. To me, "the digital", begs a question: 'the digital what?' Digital infrastructure, network, computer, software, coding, signal, medium? Preceded with "The", "digital" becomes a semiotic black box. This problem, as I discuss here in relation to "the cloud", is of political – not just analytic – importance.

For some scholars and commentators "the digital" handwaves difficult questions about what the things they study actually consist of. But they are gesturing towards something, and that thing is both complex and large. Facing it head-on is not straightforward; I tend to talk about mass networked computing, although the abstract reduction of this phrase doesn't really capture the infrastructural scale of what is being referred to. Metaphors and euphemisms – of which "the digital" is one – obscure as much as they reveal. They also act upon their objects: intervene on them via abstraction. If we cannot banish such figurations, a robust digital materialism should at least hold them to account.

5 Adrian Mackenzie, "codecs", *Software Studies: A Lexicon* (Massachusetts: MIT Pres, 2008), p.48
6 Frédéric Darbellay, "From Interdisciplinarity to Postdisciplinarity: Extending Klein's Thinking into the Future of the University", *Issues in Interdisciplinary Study* 37.2 (2019), pp.91-109
7 Rosi Braidotti and Matthew Fuller, "The Posthumanities in an Era of Unexpected Consequences" *Theory, Culture & Society* 36.6 (2019) https://journals.sagepub.com/doi/full/10.1177/0263276419860567 [09/09/2024]
8 E.g. for the term: Lorella Viola, *The Humanities in the Digital: Beyond Critical Digital Humanities* (Palgrave McMillan, 2023)

Against the cloud, or why we need digital materialism

William Turner, *Clouds and Rain Over Water*

A watercolour study of raincloud. Vague in form, at once light and opaque; fitting as a visual representation of "the cloud".

We call it cloud computing – they should be in a cloud somewhere.

Eric Schmidt, Search Engines Strategies Conference (2006)[9]

Among the most ubiquitous metaphors for digital infrastructure is 'the cloud.' Clouds were being used by engineers as a shorthand for networked communications systems as early as the 1960s.[10] As Patrick Wikström describes, a cloud is "a useful and vague enough symbol"; it gestures to the presence of something complex without committing to any tangible detail and hence functions well as a graphic shorthand for the complexities of networked information.[11] Rather than drawing out the whole system, the engineer can arrange relevant entities around a cloud, which stands in for the network.

"The cloud" is not invoked as an entity in itself until later, however. Likely the earliest such use is a 1993 advert for AT&T's distributed computing service, Personal Link.[12] The advert opens to rolling clouds (fig-0.1) as the narrator announces, "At AT&T we have a vision: a vision of an electronic community where people can easily communicate, get and share information, learn,

[9] "Conversation with Eric Schmidt hosted by Danny Sullivan" *Search Engine Strategies Conference* (April 2006) https://www.google.com/press/podium/ses2006.html [19/01/2023]
[10] Patrick Wikström, *The Music Industry: Music in the Cloud* (Cambridge: Polity Press, 2013), p.3; A genealogy of cloud-like architectures (not metaphors) is offered in Tung-Hui Hu, *A Prehistory of the Cloud* (London: MIT Press, 2015), p.x-xviii
[11] Wikström, p.3
[12] David Hoffman, "What Is the Cloud – By AT&T", YouTube (2013) https://www.youtube.com/watch?v=_a7hK6kWttE [18/01/2023]

play, shop."[13] Shortly after, a cloud-borne cityscape emerges complete with high streets, skyscrapers, ongoing construction, motorways, schools, homes, mailboxes and telephones (fig-0.2). Personal Link is a cloud, the advert suggests: a nebulous assemblage of applications and services, not a material infrastructure. The advert translates the cloud from temporary networking shorthand into a larger and more absolute imaginary. Personal Link was a commercial failure, but "the cloud" has since been resurrected. In 2006 then chairman of Google, Eric Schmidt, made a presentation to an SEO (search engine optimization), launching a "cloud model" in which data services and architecture are migrated from user PCs onto servers belonging to the service provider.

Cloud computing, today's term, consolidated itself around this concept in the following years. The Google Cloud Platform (launched two years after Schmidt's interview) was key to the proliferation of the term, as was Amazon Web Services (AWS), which had launched in 2002 (but only used "cloud computing" later), offering on-demand web services including computation, storage, database operation, analytics, logistics, machine learning and more. Among these is

Figure 0.1
What is a Cloud
(1993)

Peering through the AT&T logo we are shown clouds floating across a blue sky

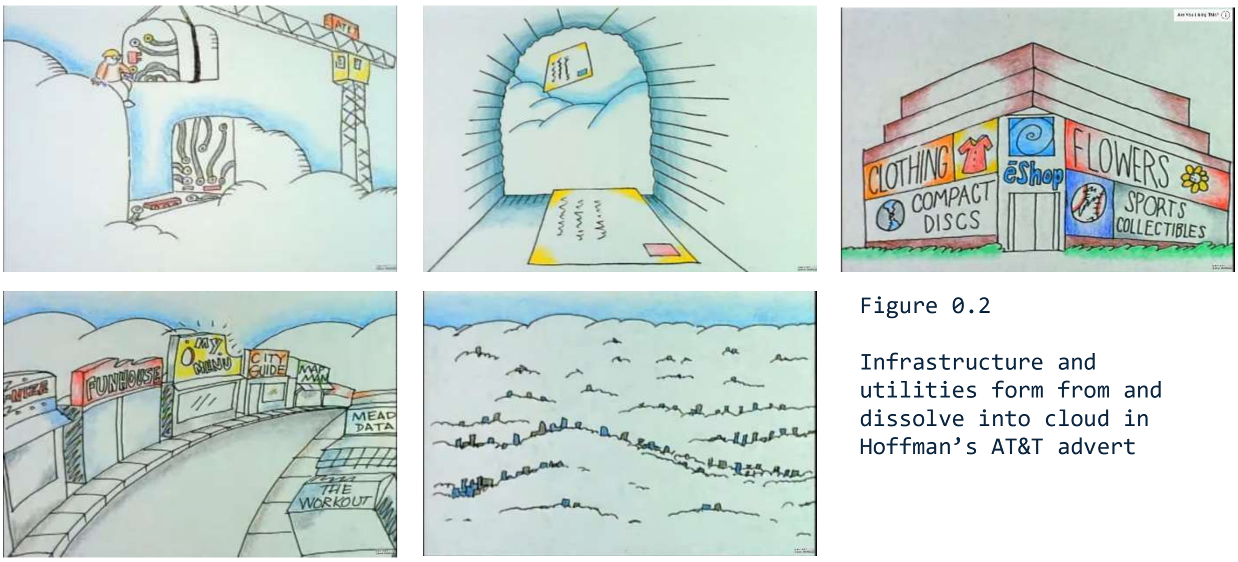

Figure 0.2

Infrastructure and utilities form from and dissolve into cloud in Hoffman's AT&T advert

[13] Ibid.

MTurk (Amazon Mechanical Turk), through which human labour can be purchased and co-ordinated by an application programming interface (API), with workers integrated as machine processes.[14] From a user-perspective infrastructure, architecture, processing power and even labour vanish beyond the mist.[15]

In such cases, cloud computing refers to something more precise than “the cloud” does in relation to Personal Link: a network architecture that seeks to centralise processing power, data storage and system architecture. Schmidt is explicit, for instance, that “cloud” should stand in for “server”. Such architectures obfuscate material processes from the end-user: they produce an imaginary of immateriality (in which architecture has evaporated) which itself justifies that architecture.

But behind this immaterial imaginary exists material infrastructure owned, operated and organised by a small number of organisations in an increasingly centralized manner: the consolidation of computing into hyperscale datacentres. In Schmidt’s speech, the “cloud” is used as a cipher for server; it stands in front of the server, obscuring it. Etymologically, “cloud” derives from the Middle English word “clod”, which refers to a clump of earth or a block of stone.[16] The cloud contains its supposed opposite: earth. To occlude, dabbling in these material idioms, is to block something from view. The apparent abstraction of “the cloud” acts to obscure its intense materiality: the fact that it is a number of servers.

This phenomenon, where the technical operations of our culture and economy appear to vanish behind a vale of mist, into the cloud, is not limited to cloud computing. Matthew Hockenberry and Jason LaRiviere capture it well, writing that: “the idea of the file, itself, is fading. Nearly everything seems to play inside the same sorts of apps, lost somewhere out there in the stream”.[17] In user interfaces, corporate jargon, advertising speak, the public imagination, popular culture and even academic discourse, we are beset by the idea that digital technology and culture have become somehow immaterial. If there is a single motivating factor behind my project then it is this: the pressing need for robust historical materialist accounts of digital technology and culture which defer to neither the impossibility, abstractness nor ephemerality of their task.

One can make political and analytical arguments for this. The cloud has gone hand-in-hand with the privatisation of the internet from the mid-90s onwards and corresponds to the emergence of

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[14] Alluding to the 18th century faux-automaton; See, e.g., Danielle Dean’s video installation *Amazon*, 5 February 2022 to 8 May 2022, Tate Britain, London https://www.tate.org.uk/press/press-releases/art-now-danielle-dean [30/01/2023]
[15] Craig Fowler, et al. “Frustration and ennui among Amazon MTurk workers”, *Behaviour Research Methods* (August 2022), pp.1-17
[16] “cloud”, *Chambers Etymological Dictionary* (1988)
[17] Matthew Hockenberry and Jason LaRiviere, “On the performance of playback for dead devices”, *Hands on Media History* (London: Routledge, 2020), p121

computing-as-a-service today.[18] Politically, when the material infrastructures behind our screens are obscured, it becomes difficult to know who owns, operates and benefits from them. Analytically, it is a problem that accounts of "the digital" are often imprecise; a problem which first and foremost relates to sloppy materialisms.

Full stack materialism

There is precedent for such a materialist approach to digital culture. Feminist histories of computing have been right to stress the importance of the loom, and of weaving (or knotting) in general to the material history of algorithms. Sadie Plant's *Zeros + Ones*, a seminal work of this genre, argues that algorithmic processes predate the digital computer by some thousands of years, culminating in automated looms on which Babbage based his Analytical engine, the first plan of a Turing-complete computer, for which Ada Lovelace composed the first algorithm; computing emerges here as an intensification of weaving.[19] The Quipu, likely the oldest coded recording device produced by humans, is formed from knotted fibres (fig-0.3).[20] Ron Eglash has pointed to hair braiding as an example of embodied mathematical knowledge, and algorithmic practice – in particular as an example which challenges the epistemic centrality of western enlightenment thought to mathematical practice.[21] We know of representations of braiding of around 25,000 years age; an exceptionally early example of compression, containing hair to protect it from damage.[22] Following this thread, it quickly becomes apparent that computing (before and after the digital computer) embodies an intensely material practice, concerned with the complex sequencing and interweaving of materials – be they strands of hair or electromagnetic signals.

My thesis is methodologically and metaphysically committed to the idea that there is no easy binary between the material and the immaterial, as has been promoted in phenomenological distinctions between spirit or mind and body, some limited sociological notions of the social (and indeed, some notions of culture), or even in some post-Marxist analytical categories (such as "immaterial labour").[23] Vilém Flusser's argument that one can recognize culture through the

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[18] Rajiv Shah and Jay Kesan, "The Privatization of the Internet's Backbone Network", Journal of Broadcasting and Electronic Media 51 (2007), pp.93-109
[19] Sadie Plant, *Zeros + Ones* (London: Fourth Estate, 1998), p.61
[20] Marcia Ascher and Robert Ascher, *Code of the Quipu* (Ann Arbor: University of Michigan Press, 1981), pp.2-3
[21] Ron Eglash, *African Fractals: Modern Computing and Indigenous Design* (New Brunswick: Rutgers University Press, 1999), p.114; Ron Eglash, et al. "Culturally Situated Design Tools: Ethnocomputing from Field Site to Classroom", *Anthropology and Education* 108.2 (2006), pp.347-362
[22] Walpurga Antl-Weiser, "The Time of the Willendorf Figurines and New Results of Paleolithic Research in Lower Austria", *Anthropologie* 47 (2009), pp131-141
[23] "Immaterial labour" was coined by Maurizio Lazzarato and notably mobilised by Michael Hardt and Antonio Negri in *Empire* (Cambridge: Harvard University Press, 2000), p.29

apparatus of the camera, which is both part of and "informs" culture, is significant here.[24] Most immediately to "inform" is to affect form, but there is also an echo of "information", manifest through the patterning of material. Within such a philosophy, culture is in large part comprised of technical images; the camera produces an image of society, and subjectivity is a product of this cycle of perception and production ("a collective memory going endlessly in circles").[25] Any claim that culture is technological is intimately linked to another: that culture is material. 'Full stack materialism' is a tongue-in-cheek moniker that I've adopted for the suggestion that materiality runs all the way up (or down) the chain of abstraction and complexity.[26]

Metaphysically, I'm following Gilles Deleuze's reading of Leibnitz' fold within a monad in this assertion.[27] In such a framework, those things conventionally described as 'abstract' – thought, signification, language, data, etc. – are understood as articulations on a single material

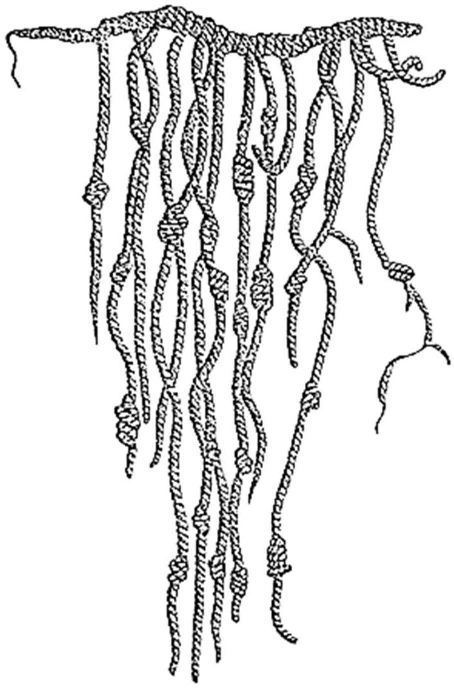

Figure 0.3 Punch-cards for a mechanical loom in the Science and Industry Museum, Manchester (left) and an illustration of a Quipu taken from Asher and Asher's *Code of the Quipu* (above)

Both artefacts point to the interrelation of weaving and computing.

[24] Vilém Flusser, *Towards a Philosophy of Photography* (London: Reaktion Books, 1983), pp.21-32
[25] Ibid., p.20
[26] Credit goes to my supervisor, though the phrase was a joke
[27] Gilles Deleuze, *The Fold: Leibnitz and the Baroque* (London: The Athlone Press, 1993), pp.3-13

substance.[28] Digital architecture is frequently separated into so-called abstraction layers, tiers of operations constructed within and on-top of each other (forming a stack). 'Full stack developers' work on both the front-end (user-facing) and back-end (underlying systems) of application development. Hence, as a full stack materialist, when I discuss an idea, or a protocol, or an embodied codec, or a commodity, or social relations, I understand all these things as equally but differently material – all the way up the stack.

Within the critical theory literature, Benjamin Bratton's *The Stack* is the most extensive engagement with the concept of a stack.[29] Bratton expands the stack into a single (present and future) global infrastructure, accidently emerging out of networked computing systems – one which offers new territories to contest.[30] While my thesis is not in direct conceptual alignment with Bratton's project, I view his turn towards technical systems as architecture as important: digital infrastructures are material inheritances through, with and against which we must act.[31] Bratton's stack is an accidental megastructure; it is not given that it will work for any given set of interests.[32] One 'narrative' of this thesis is the extent to which powerful interests have already begun contesting networked information; McKenzie Wark's *Hacker Manifesto* was already attentive to this process in 1999 – an era from which the internet is now unrecognizable.[33] Practically, opposing the hegemony of big tech requires a commitment not to give up conceptual ground to the "cloud". Massive hyperscale data centres are material accumulations, and their supposed immateriality (as the cloud) is an obfuscation.

This introductory chapter offers an opportunity to expand on possible analytical responses to such obfuscation. The following section intends to situate the methodological and critical disposition of the thesis among existing work. As I've indicated, this is not an exhaustive review, with the discussion of existing literature continued throughout the thesis .

Decoding information & culture

Information and culture are often presented as anathema to one another. Indeed, British cultural (and media) studies has often struggled with the question of technology. Richard Barbrook and Andy Cameron's now classic essay on the topic, "The Californian Ideology", offered an insightful and timely critique of a hegemonic block in technological development – but it also warned of the dangers of "technological determinism", understood as a view that technological development

[28] Deleuze also reaches for Alfred North Whitehead, who is useful for this thesis' articulation of information (and capital) as a process; pp.76-84
[29] Benjamin Bratton, *The Stack* (Cambridge: MIT Press, 2015)
[30] Ibid., pp.3-18
[31] Ibid., p.xvii
[32] Ibid., p.xvii
[33] McKenzie Wark, *A Hacker Manifesto* (Cambridge: Harvard University Press, 2004)

will inevitably make life better (more accurately called solutionism).[34] In reception, this critique has too often become a vulgar anti-determinism, which views any argument which attributes agency to technology or is interested in processes as suspect, or even dangerous.[35] The solutionist and the anti-determinist accounts tend to agree that we don't need to look deeply at technology: to one it is a benign progressive force, and to the other it is an uncontestably malign, oppressive force.

Contrary to such positions, I follow Elisabeth Eisenstein in a view that technologies mark one point of determinism among many – though Einstein has herself been accused of enacting a "technological determinism".[36] It is a key claim of this thesis that information processing often plays a determining role, new techniques in information processing especially so. As Eisenstein argues, this is "as an agent, not the agent, let alone the only agent of change."[37] Contrary to the classic description of technological determinism put forward by Raymond Williams in *Television: Technology and Cultural Form* (technology as discovered independently of social forces, and acting straightforwardly to determine social change) one can view technology as both determined by social forces and itself as determining.[38] That the steam engine, or television, or computing have unalterably changed the course of history in no way precludes that these were themselves products of social forces. Technologies (and especially technical infrastructures) are best seen as the crystallisation of apparently contradictory determinations, including social relations, but also the laws of physics, accident, geography, and a range of interests and activities whose relationship to accumulation is at best ambiguous.[39] One must acknowledge, on the one hand, that technology is often a thing "looked for", as Williams does (I am talking about products of research actively funded by capital and the state, after all), and on the other that, once manifest, technologies may not function exactly as the distillation of social forces that produced them intended.[40]

A vulgar social determinism, which suggests that humans are sole determiners of history, is no better than the vulgar technological determinism identified by Williams. Taking media technology seriously requires being open at least to the possibility that such objects of study can

[34] Richard Barbrook and Andy Cameron, "The Californian Ideology", *Science as Culture* 6.1 (1996), p.56
[35] See e.g. Evgeny Morozov's account of "technological solutionism", which disentangles the solutionist position from the determinist one; *To Save Everything, Click Here: The Folly of Technological Solutionism* (New York: PublicAffairs, 2014)
[36] Elizabeth Eisenstein, The Printing Revolution in Early Modern Europe (Cambridge: Canto, 1984), p.xviii; See: Rodney Mader, "Print Culture Studies and Technological Determinism" , *College Literature* 36.2 (2009), pp.131-140; Also, Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (London: University of Chicago Press, 1998), p.19
[37] Eisenstein, p.xviii
[38] Raymond Williams, *Television: Technology and Cultural Form* (New York: Schocken Books, 1975), pp.11-14
[39] Best conceived as a "fold" via Deleuze; *The Fold*, pp.3-13
[40] Williams, *Television…*, p.14

be historical agents. An understanding that culture is deeply technological, and indeed that technology is cultural (that these things co-constitute one another), has been integral to my research and to the writing of this thesis, as has a view that technology is both political and important to how we relate to the world and each other. This is not a novel position; it appears, for instance, in the cyberfeminist tradition, notably the work of Sadie Plant and the early work of the Cybernetic Culture Research Unit, as well as the posthuman philosophy of scholars like Rosi Braidotti and Katherine Hayles, who all indicate that technology is entangled with the possibilities of the human – of perception and production.[41] There have always been strands within cultural studies deeply interested in technologies as a site of culture, and of technological practice as a form of cultural production; a tendency exemplified in work on sound system culture which documents the DIY production of sound machines.[42] Likewise, I view codecs as sites of immense importance for the generation and circulation of culture, and as articulations of human labour.

Codecs are implicated in questions of perception and subjectivity formation; accessing them is a question of methodological difficulty. In line with philosopher of technology Flusser, I take a view that presenting media as a-technical is a dangerous abstention which leaves them as 'black boxes'.[43] Flusser suggests:

> any criticism of technical images must be aimed at an elucidation of its inner workings. As long as there is no way of engaging in such criticism of technical images we shall remain illiterate.[44]

Flusser's assertion complements a similar claim from Matthew Kirschenbaum that analysis must attend to more than the "event on the screen", and reach towards the technical systems which often evade critical attention.[45] Studies of the "screen" (first in the Screen journal and later "screen theory") conceive of cinema (and other forms) as apparatuses: ideological machines.[46] However, the body of the viewer has tended to overshadow the body of these apparatuses, and the discipline has been overwhelmingly interested in psychological and affect analyses, only occasionally reaching behind the surface image. What Kirschenbaum calls a "forensic" approach is necessary to overcome the screen's deceptive flatness.[47]

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[41] See, e.g. Joan Broadhurst Dixon and Eric Cassidy, eds. *Virtual Futures* (London: Routledge, 1998); Katherine Hayles, *How We Became Posthuman* (Chicago: University of Chicago Press, 1999); Rosi Braidotti, *The Posthuman* (Cambridge: Polity, 2013)
[42] Julian Henriques, *Sonic Bodies: Reggae Sound Systems, Performance Techniques, Ways of Knowing* (London: continuum, 2011), pp.3-4
[43] Flusser, p.14-15
[44] Ibid., p.16
[45] Matthew Kirschenbaum, *Mechanisms: New Media and the Forensic Imagination* (Durham: MIT Press, 2007), p.4
[46] E.g. Laura Mulvey, though she is far more attentive to the technical than other scholars working in the psychological mode; "Visual Pleasure and Narrative Cinema", *Screen* 16.3 (1975), pp.6-18
[47] Kirschenbaum, p.23

The deconstructive process is one methodological touchstone for a forensic reading. Jacques Derrida theorises a technical trace, "arche-writing", as the ur-form of supplementary, according to which all techniques of externalisation (all media) are already mediated.[48] Speech, writing, photography, etc. are therefore all iterations on arche-writing and constitute textual systems. Deconstruction proposes the investigation of such a textual system – which runs through and before any text/screen – and its contradictions. But this always-already-mediateness correlates to an absence of fidelity in signification, one which on the one hand can only be overcome with 'acts of faith', but is on the other productive, allowing readings to transform the ground on which they are founded.[49] While Derrida doesn't strictly call deconstruction a "method" (he understands it as a process, not a program), this mode does suggest certain ways of working.[50] In particular, the primacy it lends "writing" implies a corresponding importance to "reading". Derrida's framework limits neither writing nor reading to texts, and certainly not to literary ones; deconstruction has drawn accusations of disciplinary creep, characterised as extending into areas in which literary scholars are underqualified.[51] Bad readings aside, hostile reactions are typical for interdisciplinary work, with direct corollaries in some literary scholars' hostility to computational "distant reading" methods.[52] At best, I contend, "reading" resists the ossification of analysis into discrete limited categories ("discourse analysis", "content analysis", etc.) and allows for a more lucid and conceptually oriented investigation, drawing work from a number of fields into new syntheses for novel insight. Hayles, a research chemist before becoming a literary scholar, typifies such a productive meeting of literary methods and scientific material; her work on electronic literature is an important reference point for my thesis.[53]

Derrida also enthusiastically appropriates the language of information theory; there are intimacies between deconstruction and post-structuralist notions of decoding. Close reading methods have been appropriated by software studies – well represented in the Computational Culture journal and the Software Studies book series from the MIT press – for the investigation of computer programs. In their manifesto for the discipline, Rob Kitchen and Martin Dodge

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[48] Jacques Derrida, *Of Grammatology* (Baltimore: John Hopkins University Press, 1976), p.60
[49] "The age of the sign is essentially theological", he writes in *Of Grammatology*, p.144; Cf: Bernard Stiegler, "Derrida and technology: fidelity and the limits of deconstruction", *Derrida and the Humanities* (Cambridge: Cambridge University Press, 2001)
[50] Derrida, *Of Grammatology*, pp.161-162
[51] One such (tongue-in-cheek) reaction, from a software engineer: Chip Morningstar, *How to Deconstruct Almost Anything – My Postmodern Adventure* (1993) https://webperso.info.ucl.ac.be/~pvr/decon.html [12/09/2024]
[52] Stuart Hall, "The Emergence of Cultural Studies and the Crisis of the Humanities" *October* 53 (1990), pp.15-16; distant reading was coined in Franco Moretti, "Conjectures on World Literature" *New Left Review* 1 (2000) https://newleftreview.org/issues/ii1/articles/franco-moretti-conjectures-on-world-literature [12/09/2024]; For a rejection of computational methods as "readings", see Joanna Drucker, "Why Distant Reading Isn't" *theories and methodologies* 132.3 (2017)
[53] Katherine Hayles, *Writing Machines* (Chicago: University of Chicago Press, 2005)

describe it as differing from other computational fields in focusing "explicitly on the conceptual nature and productive capacity of software, and its work in the world" – which could be taken directly into my own project, although information processes operate through both hardware and software.[54] Reading, taken in this expansive sense, is a core method of my thesis: in pursuit of clarifying and problematising my core subjects, I offer "readings" of technical documents, specifications, devices, infrastructures, products of information processes, creative works, scientific literature and at least two literary texts. I sometimes find it helpful to adopt an etymological mode in the vein of Raymond Williams' literary studies informed cultural studies.[55] Such interventions can alienate words from their assumed uses and offer new analytical routes. The history of words can also contain traces of cultural (and technical) histories and be suggestive of the social life of things – though etymology alone cannot make ontological claims.

As already alluded to, the post-humanities ask for an "affirmative, expanded" methodology with a renewed relation to science.[56] This cannot just mean commenting on the sciences from the humanities, it also requires taking advantage of what scientific methods have to offer our analyses. Science and Technology studies is a point of methodological reference: Paul Rabinow's *Making PCR: A Story of Biotechnology* attempts to understand the development of the polymerase chain reaction (PCR) (a vital method for DNA analysis through the culture of its production) via an ethnography of those who were involved in its development, which Rabinow identifies as "scientists, technicians and business people", of their culture and their workplaces.[57] Though modest in scope, I adopt a similar method for the first of two chapters on JPEG compression, for which I interviewed six of its surviving committee members comprising scientists, engineers and standardisation professionals.[58]

More substantially, I try to be attentive to the ontological challenges posed by scientific knowledge. Friedrich Kittler has written in favour of banishing the "Geist" (spirit) from the "Geisteswissenschaften" (humanities – literally, 'science of the spirit').[59] Kittler's media theory, heavily influenced by Michel Foucault's archaeological method, suggests we can investigate a culture through its artefacts; at times, this is an explicitly and provocatively determinist project,

[54] Rob Kitchin and Martin Dodge, *Code/Space: Software and Everyday Life* (London: MIT Press, 2014), p.246
[55] Most obviously in *Keywords: A vocabulary of culture and society* (London: Oxford University Press, 1983), though *Culture and Society* is more sustained in its application of the method
[56] Braidotti and Fuller
[57] Paul Rabinow, *Making PCR : A Story of Biotechnology* (Chicago: University of Chicago Press, 1996)
[58] Permission was sought by email and before conversations to use the contents of interviews to inform the thesis.
[59] Quoted in Geoffrey Winthrop-Young, "On Friedrich Kittler's Authorship and Love", *Theory Culture & Society* 32.3 (2015), p.3

"media determine our situation."[60] This is a playful, polemic mode which evidently cuts close to the bone for some; banishing the human from culture has a powerful alienating effect which can trouble hegemonic assumptions and reveal causalities and genealogies that were not otherwise apparent. Kittler is a key influence for media-archaeological methods, notably for Jussi Parikka, who characterises these as "excavating the past in order to understand the present and the future".[61] From Kittler, Parikka derives a view of technology as "a condition of knowledge", one which must be explored if we are to understand the situation of the present (and of "so-called Man").[62] As such, he proposes the examination of technical artifacts, and the genealogy of ideas which underscore their development, as a means of troubling the normative presentation of technology in the present as a neutral progressive force.[63] Indeed, media archaeology tends to demonstrate the highly specific nature of the interests driving technological development. Alongside reading, this genealogical mode is a central method for my thesis, and structures much of my analysis.

One interpretation of the genealogical mode of media archaeology is as an attempt to escape stultifying discussions of "new media" which preceded it. Indeed, new media scholarship was often preoccupied with escaping the "new" – to some extent a product of the processes (conferences, funding, book series, etc.) of academic work – via clever theorisation. Wendy Chun, for instance, deals with the "newness" of 'new media' via "the update": "new as in renovated, once, again… for they are constantly asking/needed to be refreshed."[64] Software is constantly laying down sediment for digital culture: filling our hard-drives, iterating complexity and slowing down in the process (all material to work with).[65] Nonetheless, these are important theoretical predecessors, with which my own work is still in dialogue. Lev Manovich's *The Language of New Media* contains a lexical instinct that rightly suggests analytical frameworks for non-digital media forms are inadequate for analysis of digital culture.[66] But such an instinct is disrupted by a refusal to "return to the structuralist phase of semiotics"; already in the 1990s we were operating with a structural vocabulary some twenty years out of date, and we need a vocabulary which is attuned to the processes of digital culture.[67] As such, I engage in some ambivalent structuralism – notably

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60 Friedrich Kittler, *Gramophone, Film, Typewriter* (Stanford: Stanford University Press, 1999), xxxix
61 See, e.g. Jussi Parikka, "Friedrich Kittler – a media anthropology without the man?", *39th E-Seminar of the EASA Media Anthropology Network* (2012) https://www.easaonline.org/downloads/networks/media/39p.pdf [29/12/2024]; Jussi Parikka, *What Is Media Archaeology?* (Cambridge: Polity Press, 2012), p.2
62 Parikka, "Friedrich Kittler…", p.2
63 Parikka, *What Is…*, p.4
64 Wendy Chun, *Updating to Remain the Same: Habitual New Media* (London: MIT Press, 2016), p.2
65 Chun describes software as a "hardening" of programs; *Programmed Visions: Software and Memory* (London: MIT Press, 2011), p.6
66 Lev Manovich, *The Language of New Media* (London: MIT Press, 2001)
67 Ibid., p.12

in Chapter Two – wherein the claim is always of analytical utility, rather than absolute ontological certainty.

Platform studies has attempted to confront computing through specific infrastructures: mainly via devices, consoles and operating systems. Starting with Nick Montfort and Ian Bogost's *Racing the Beam: The Atari Video Computer System*, such work has attempted to describe the construction of a platform, understood to be some media-technical environment, be that at the level of a system, application, hardware device or service.[68] Platform studies rightly stresses both the importance of technical rigour – actual engagement with the schematics and processes of computer – and an understanding of the wider culture in which they are produced.[69] "The platform" has been articulated in political economy (notably by Nick Srnicek) to describe a joint economic-technical-infrastructural form which predominates contemporary digital economies (Google, Amazon, etc.).[70] These critical articulations of the "platform" differ, and their proponents do not tend to reference each other – though such an encounter might be productive, bringing on the one hand a more thorough encounter with the technical and on the other a more rigorous encounter with politics.

There are registers other than the ubiquitous 'platform'. Jonathan Sterne, in his book *MP3: The Meaning of a Format*, for instance, begins to develop what he calls "format theory" – a pivot, in his formation, from media.[71] Like platform studies, format resolves to examine formats as "technical and cultural problems"; but while platform studies generally positions platforms as locations of culture (which afford this in different ways), format theory tends to suggests formats are consolidations of culture (though in specific, local, not general terms – the culture of and genealogy of audio engineering, for example) which are also themselves determinate.[72] My own focus, on the codec, continues Sterne's pivot towards a category more aligned with questions of processing and production beyond storage. There is also, within media studies, what Lisa Parks and Nicole Starosielski call "critical infrastructure studies".[73] The turn to supporting systems behind and beyond the surfaces of media (which both make possible and affect the content of screens), which they indicate, is an important one; this should encompass not just hardware, but also software infrastructures. Of filing systems within digital computers, Cornelia Vissman has written that "In highly unmetaphorical fashion, files and their techniques organize the very

[68] Nick Montfort and Ian Bogost, *Racing the Beam: The Atari Video Computer System* (London: MIT Press, 2009)
[69] Ibid., pp.vii-viii
[70] Nick Srnicek, *Platform Capitalism* (Cambridge: Polity Press, 2017), pp.1-8
[71] Jonathan Sterne, *MP3: The Meaning of a Format* (Durham: Duke University Press, 2012), pp.1-31
[72] Ibid., p.6
[73] E.g. the collection: *Signal Traffic: Critical Studies in Media Infrastructure* (Urbana: University of Illinois Press, 2015)

architecture of digital machines."[74] Vissman's intervention is useful because it reaffirms not just the need to be attentive to technical systems, but also the extent to which these are organised and conceived according to logics beyond the ostensible bounds of the machine. Maria Eriksson et al.'s *Spotify Teardown*, which stands as the most comprehensive and insightful study of music streaming to date, straddles both platform and infrastructure conceptual modes to bear a creative methodology down on the proprietary streaming platform.[75] That such a study cannot unambiguously break open the proprietary black box probably suggests that more than analytical methods are needed in the face of such opacity; though often inadequate, a variety of commentors and movements are instructive of possible practical orientations, from the free software movement, through radical librarians and online piracy advocates.[76]

In and beyond media theory, my thesis is in conversation with a tradition of unorthodox Marxism, including Walter Benjamin and Henri Lefebvre, who stretch dialectics towards the expression of more complex materialisms, and Stuart Hall, whose conjunctural challenge, that analysis must always be in conversation with and in aid of the political moment, offers an important intervention to theoretical work.[77] In *Spectres of Marx*, Derrida offers an important interjection that, with regards to technology, we must work in the "spirit of Marx", who could not have predicted his technological antecedents (which challenge ontologically those of his moment).[78] Marx occasionally conceives of capital as a "process", a formulation which is particularly useful to the present work, which wants to think about technical and economic processes (including accumulation) as a system; in such moments his writing appears closer to Whitehead than to Hegel – certainly there is enough material to read it as such.[79]

As I write we are in something of a minor resurgence of academic interest in information theory and cybernetics. Bernard Dionysius Geoghegan has demonstrated admirably the importance of information theory to European critical theory – including to Derrida's deconstructive theory.[80] Christopher O'Neill's recent translation of Foucault's "Message or Noise?" is another important contribution to the moment.[81] Nevertheless, the information processes in which I'm interested remain critically underdeveloped, despite their centrality in today's information infrastructures.

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74 Cornelia Vissman, *Files: Law and Media Technologies* (Stanford: Stanford University Press, 2008), p.164
75 Maria Eriksson, et al. *Spotify Teardown: Inside the Black Box of Music Streaming* (London: MIT Press, 2019)
76 Richard Stallman, "Free Software Definition", *Free Software Free Society* (Boston: GNU Press, 2002); Marcell Mars, Manar Zarroug and Tomislav Medak, "Public Library (an essay)", *Memory of the World* (2014) https://www.memoryoftheworld.org/blog/2014/10/27/public_library_an_essay/
77 Jeremy Gilbert, "This Conjuncture: For Stuart Hall", *New Formations* 96 (2019), pp.5-37
78 Jaques Derrida, *Spectres of Marx* (Routledge: New York, 1994), p.66
79 Karl Marx, "Notebook II", *Grundrisse* (London: Penguin, 1993), p.258; see also Anne Fairchild Pomeroy, *Marx and Whitehead* (New York: State University of New York Press, 2004)
80 Geoghegan, p.166
81 Michel Foucault, trans. Christopher O'Neill, "Message or Noise?", *parrhesia* 39 (2024)

As a pivotal form of compression, more JPEGs have been produced than other photographic forms in the history of photograph (including film images).[82] Though hard to demonstrate empirically, a similar claim can be intuited for encryption: that more messages will now have been encrypted by the AES-256 cipher than any other encryption method, including simple ciphers. These exorbitant volumes are made possible by the scale and intensity of networked computing, which itself rests of the effectiveness of these digital information processes.

Sterne's *MP3* represents a major contribution to the history of compression, and leaves MP3 as the most carefully studied media compression format.[83] Beyond MP3, there is literature which touches briefly or adjacently on compression – such as Hito Steyerl's work on poorly compressed images or David Harvey's economic theory of time-space compression – and one function of this thesis is to tie that work together, but (beyond computer science) literature on compression is sparse.[84] To date there has been little historical, cultural or economic engagement with JPEG, for instance, despite its centrality to visual representation today. A notable exception is Rosa Menkman's work on glitch and more recently resolution, which while generally oriented towards practice, develops a historical critique (of photographic test images, for example), as well as Danile Palmer's short chapter investigating JPEG's ambiguous cultural economy; one which he argues remains opaque: "We are literally unable to see the underlying social relations just as we cannot see the data behind a digital image.[85] While I found Palmer's work only late in the process of writing this thesis, one way of understanding my work on JPEG is as an attempt to expose these obscured aspects through close attention to the codec, itself a crystallisation of them.

There are several robust histories of cryptography – notably David Khan's *The Code-Breakers* – which tend to end with the development of the computer and/or the internet.[86] Outside of this work, which is committed to a historical understanding of cryptography as a technology of secrecy, the historical and cultural literature is sparse. There is one helpful account of encryption and aesthetics, Nadim Samam's *The Poetics of Encryption*, along with the exhibition of the same name.[87] Samam's consolidation of relevant artwork is highly useful, though the text tends towards general exploration of "the technocene" (as indicated in its subtitle) over encryption specifically.

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[82] Graham Hudson, et al., "JPEG-1 standard 25 years", *Journal of Electronic Imaging* 27.4 (2018)
[83] Sterne, p.5
[84] Hito Steyerl, "In Defence of the Poor Image", *The Wretched of the Screen* (Berlin: Sternberg Press, 2012), pp.31-45; David Harvey, *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* (Oxford: Blackwell, 1989)
[85] Rosa Menkman, *Beyond Resolution* (i.R.D, 2020) https://beyondresolution.nyc3.digitaloceanspaces.com/Rosa%20Menkman_Beyond%20Resolution_2020.pdf [02/09/2024]; Daniel Palmer, "The Rhetoric of the JPEG", *The Photographic Image in Digital Culture* (New York: Routledge, 2013), p.162
[86] David Khan, *The Code-Breakers: The Comprehensive History of Secret Communication from Ancient Times to the Internet* (New York: Scribner, 1996)
[87] Nadim Samman, *Poetics of Encryption: Art and the Technocene* (Berlin: Hatje Cantz, 2023)

Existing literature does not account for the transformation of cryptography in recent decades – of the new techniques and economic vectors which have been developed in this brief period – and so their description in relation to digital commodities is novel to this thesis.

Information, Compression, Encryption

My thesis is structured around three topics: information, compression and encryption. They meet in the figure of Claude Shannon, a mathematician, cryptographer and telecommunications engineer whose work is the basis of networked communication today. On theoretical contributions to communication (i.e. compression) and cryptography, Shannon once wrote: "They were so close together you couldn't separate them."[88] The institutional, technical and theoretical histories of these two technologies are intertwined: in practice, one often entails the other. Shannon coined the term "information" as it is understood by computer science today, and he is generally credited with the invention of information theory, although he called it his "theory of communication".

My first two chapters investigate information and information theory, laying common theoretical ground for the thesis' core chapters. Chapter One describes the joint epistemic and material emergence of information as a concept in signal processing, oriented especially towards the wartime interest in cryptography and the concerns of post-war commercial telecommunications. Chapter Two examines information theory, the framework of Shannon and his colleagues, and seeks to appropriate some of its terminology for the thesis. I am not the first to appropriate the language of information for culture, and I begin this task with a return to Stuart Hall's encoding/decoding theory for televisual discourse. Hall's account offers an insightful interrogation of the language, but it is also a stubborn exercise in a-technical criticism, which benefits from exposure to its epistemic blind spots. This section builds towards a description of codecs – a key category for my thesis – as the embodiments of distinct determinisms, crystalised in technical devices. Compression and encryption are both categories of codec, determined by and determining of economic, social and cultural life.

Taken together information, compression and encryption offer a view into the emergence of digital capitalism, and one cannot separate the media historical or cultural account from this process. You can follow the changing material situation of engineers like Shannon from wartime to commercial communication, for instance, and find a direct corollary in their work: techniques discovered through cryptography are applied to commercial communications in pursuit of quicker, cheaper, faster and (perhaps secondarily) more reliable information transfer.

[88] Shannon quoted in Kahn, p.744

The first product of this transition is data compression, which Part Two of my thesis examines at length. Chapter Three serves as a general introduction to data compression as functioning at a number of levels: technically, economically, culturally and aesthetically. Economic demands for faster circulation motivate technological innovations which cascade into the human sensorium, contributing to, among other things, a generalised sense that life is accelerating. Chapters four and five offer analyses of JPEG-1 (named for the Joint Photographic Experts Group, who developed it), the most widely used compression protocol for photographic images, developed in the 1980s and still ubiquitous (largely unchanged) to this day. Chapter Four investigates the standardisation politics of JPEG's development, supported by archival research and interviews with some surviving JPEG engineers. I highlight the media historical, epistemic and institutional specificity of the work, which is an early example of perceptual coding – compression oriented towards subjective testing of human perception.

Chapter Five addresses the same compression process through a different method, a close reading of the JPEG-1 standard (ISO/IEC 10918) and the JPEG File Interchange Format (JFIF). These documents describe the JPEG compression process and file format as it is used in most cases today (although JFIF is one of several file formats in use for JPEG compression). Treating the standards as consolidations of epistemic work situated, I work to expose their coded logics: modes of representation (including ones which reproduce prejudices), a conception of legibility in circulation, an efficient coding schema which sometimes prioritises spread over speed and a total absence of proprietary coding.

As a non-proprietary compression standard, JPEG-1 has made possible an abundance of information, which entails both a prolific form of an extra-capital, anti-proprietary production and a numbing, exhausting assault on the human sensorium, with corollaries in the ecological impact of its 24/7 computing infrastructure. Chapter Six examines a tradition of slow media, which claim to offer escape from intensive, capitalist modes of production. In the context of data compression, however, I argue that such methods have become ineffective, with fully commodified slow forms pervading digital media. Such a situation, I argue, characterises a complex contestation of 'free time' (time beyond work) in our present, which is often co-opted into one or another productive activity. Chapter Seven turns to the endpoint of acceleration and compression, the question of what happens when production exceeds planetary bounds. I examine the question of 'efficiency' in coding processes, and question if it is possible to reimagine efficiency as an efficient use of resources, not simply an acceleration in circulation.

As I stress throughout the thesis, the interests of 20th century commercial telecommunications are not identical to those of 21st century digital media; compression expanded the communication channel and in doing so made room for circulation beyond the market –

exemplified by filesharing practices. Frustrated with disregard for personal privacy and intellectual property, a coalition of large corporations, grassroots encryption activists and libertarian engineers innovated new applications of cryptography towards the securing of private information and digital property. Chapter Eight offers a genealogy of encryption, examining this historical transformation from a technology of secrecy to one of privacy and ultimately one of property. I discuss the frequent mobilisation of the figure of the cryptographer as a liberator of information and suggest the need to be attentive to its corollary, the enclosure of information through cryptography.

Chapter Nine brings three intertwined histories together: encryption, the occult and the commodity form. Encryption has historically formed part of occult practice, while Marx's description of the commodity reaches for Gothic figurations. I will argue that there are structural similarities between the commodity and encrypted information, which both engender occulted relationships which must be mediated, by exchange value or by a cipher. A hybrid of encryption and the commodity (the encrypted commodity) entails a coming to the fore of such relations. Encrypted commodities facilitate new regimes of control over use (primarily via digital rights management software). Chapter Ten introduces a related concept, cryptoaesthetics: the manipulation of where and when signals are rendered sensible, and of how they can be used. I trace the development of such methods through five applications of cryptography to media forms – DES, JPEG-2000, MPEG, PDF & Spotify. Chapter Eleven, my final core chapter, addresses contemporary cryptography via the milieu in which much of it was innovated: the cypherpunks. I argue that this group held an ambiguous and contradictory politics, at once committed to the dissemination of information and its privation, and trace this through two key technological horizons which originate in the milieu: BitTorrent and Blockchain.

The decision to address compression before encryption was somewhat arbitrary. It comes with affordances: the narrative neatness of a dialectic, unrestrained velocity through compression followed by capture and enclosure through encryption. But there are also trade-offs; this is not, simply conceived, a linear history. The earliest plans for my thesis consisted of three processes – indexing, compression and encryption – but in drafting it became clear that the portions on information theory would be far longer than anticipated, and so I exchanged indexing for information. This third technology had a disquieting and destabilising effect on the apparent unity of compression and encryption, which is somewhat missed.

The continual development of information processing continues with compression and encryption ambiguously intertwined. There is a process to processes, which transform with time. A final coda will look speculatively to a different organisational logic for the circulation of information: to its socialisation.

Part one

Information

Chapter one

The informatics of culture

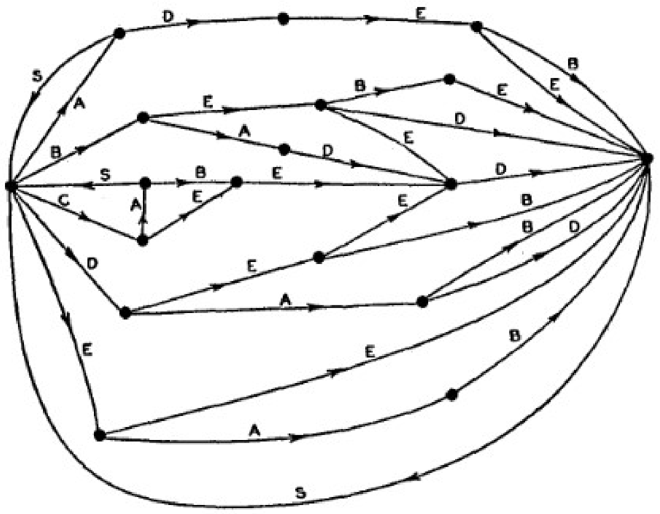

Figure 1.1 Graphical representation of a Markov Chain, from Shannon's *The Mathematical Theory of Communication*

> **Within major historical periods, along with changes to the overall mode of being of the human collective, there are also changes in… its sense perception.**
>
> Walter Benjamin, "The Work of Art in the Age of Its Mechanical Reproduction" (1935)

In her study on the emergence of print culture, Elisabeth Eisenstein named its development in Europe a "revolution".[89] For Eisenstein, the move from scribal to print reproduction cannot be adequately understood as an evolution of methods, but marked a distinct turning point, an epistemic break which engendered transformations of language, law, knowledge and even cognition.[90]

Information has also often been called revolutionary.[91] While such claims can be imprecise and trade in technological progressivism ('things can only get better'), a critical interrogation of

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[89] Eisenstein, p.5

[90] Ibid., p.5-13; Eisenstein's notion of "print culture" has been criticised as encompassing various technologies, cultural forms and economic arrangements; Lisa Gitelman *Paper Knowledge: Towards a Media History of Documents* (London: Duke University Press, 2014)

[91] E.g.: Jessica Matthews, "The Information Revolution" *Foreign Policy* 119 (2000), pp.63-65; or, Peter Drucker "Beyond the Information Revolution" *The Atlantic* (1999)

information as an agent of change can nourish our understanding recent cultural history. This chapter – which establishes a history of information's emergence – will draw on several definitions, but I want to begin with my own: as a historical form which emerged in the 20th century, information is the capacity of a thing to generate meaning as rendered visible via statistics. In this sense – and here a central difficulty – information is not so much a thing as a mode of analysis which nonetheless transforms the things it renders.

We might take from Benjamin's description of media-historical shifts in sense perception that such 'revolutions' are of the senses, sensation and subjectivity. In the 1980s Flusser concluded similarly that "a mutation of our experiences, perceptions, values, and modes of behaviour" was in progress.[92] Eisenstein, Benjamin and Flusser each designate particular significance to major media technologies in the formation of knowledge and subjectivity; these appear as epistemic foundations, integrally part of the aesthetic and political possibilities of their epochs. In Bernard Stiegler's philosophy, recording technologies function as prostheses of human cognition and especially memory.[93] Similarly, Braidotti and Hayles have demonstrated the embodying functions of technology for human subjects, and indeed information.[94] Here (and throughout the thesis) I seek to expand on such approaches to the technics of information and sensation in circuit with subjectivity, on the ways in which the sensible has become subject to computation and been transformed by it. Ontologically, statistical analysis entailed a transformation of its material into things which can be treated as signals and processed as information. The agents of change I'm interested in are information processes: basic operations – copy, delete, substitute – and advanced ones – compress, encrypt.[95] The transformation of things into information is their necessary precondition; in turn predicated on infrastructures, communication networks.

Among technologies of culture, moveable type printing ("the printing press") is one example of what Benjamin called mechanical reproduction.[96] Indeed, print (like the phonograph or the camera) is an "allographic" medium; one in which reproductions are considered legitimate forms of the object.[97] It closely mirrors those characteristics which set mechanical reproduction and

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https://www.theatlantic.com/magazine/archive/1999/10/beyond-the-information-revolution/304658/ [16/08/2024]

[92] Vilém Flusser, *Into the Universe of Technical Images* (Minneapolis: University of Minnesota Press, 2011), p.5

[93] Bernard Stiegler, *Technics and Time* (Stanford: Stanford University Press, 1998)

[94] Hayles, *How We Became Posthuman,* pp.4-5; Braidotti, p.22

[95] Kittler, "Real Time Analysis…", p.6; the original German-language text uses the English "Exchange, Copy and Delete", but as Winthrop-Young notes (p.17), Kittler's use of the word "schaltbar" elsewhere suggests that he is using the word only in the more limited sense "to switch" and not in the sense "to trade".

[96] For an excellent account of print in Benjamin's mechanical reproduction essay, see: Charles Berret, "Walter Benjamin and the Question of Print in Media History" *Journal of Communications Inquiry* 41.1 (2017), pp.349-367

[97] Contrasted with "autographic" forms, in which an original claims unique provenance – though the concept of provenance can to lesser degrees be applied to all these forms; Berret, p.355, p.360

mass media apart from their artisanal forebears (Benjamin even relies on it as analogy): replicability, mobility and (under-stressed) abundance. But Benjamin pointedly did not assign print the same revolutionary potential as photography, film or the phonograph. In "The Storyteller", written shortly later, Benjamin clarifies that he views the press as under the "full control of the middle class", serving only petty bourgeois ideology.[98] Beside the camera or phonograph which seemed to disturb powerful institutions, and were therefore properly revolutionary tools, the press appeared reactionary. It is a point of interest for my study that Benjamin called the form he associated with this capture "information" and that he coined this as information was being theorised in signal processing, a field about which he could have known little.[99] For Benjamin, "information" was a new genre which, in its flatness, was rarely noteworthy, "already shot through with explanation".[100] A product of intense commodification, it was fleeting, trivial, and did "not survive the moment in which it is new."[101]

It would be another decade before information theory would explicitly influence Marxist cultural theory or European post-structuralism (first via Roman Jakobson's linguistics and Claude Levi-Strauss' anthropology).[102] Instead, Benjamin likely alludes to two interrelated fields: military communications (also the imperial management of colonies) and the dissemination of news, both of which drove the construction of global information infrastructures, especially of telegraph cables and interconnected communications channels.[103] These channels brought new genres: "reports", "news", "intelligence".[104] By the 1930s, the global dissemination of news was being undertaken via telegraph by specialised media agencies whose interests, like those of the newspapers, were thoroughly commercial.[105] Meanwhile, militaries in both Europe and the US were investing heavily in electronic communications. Military funded and oriented telegraphy and telephony research was by the end of the 1920s using both the terms intelligence and information to describe the makeup of a telegraph signal, broadly understanding intelligence as

98 Walter Benjamin, "The Storyteller: Reflections on the Works of Nikolai Leskov", *The Novel: An Anthology of Criticism and Theory 1900-2000* (Massachusetts: Blackwell Publishing, 2006), pp.365
99 Ibid., pp.365
100 Ibid., p.365, p.367
101 Ibid., p.366; Cf. Theodor Adorno, "Commodity Music Analysed", *Quasi Una Fantasia* (London: Verso, 1998), pp.37-52
102 Geoghegan, pp.98-100
103 Developments in logistics and printing have also contributed to this increased mobility of news; for expansion of telegraph networks as a form of colonial control, see e.g. Daniel Haedrick, "A Double-Edged Sword: Communications and Imperial Control in British India", *Historical Social Research* 35.1 (2010), pp.51-65
104 Benjamin's claim is not that this new form of communication is the newspaper itself, but that total bourgeois capture of the newspaper has precipitated its emergence; p.365
105 Heidi Tworek, "Magic Connections: German News Agencies and Global News", *Enterprise & Society* 15.4 (2014), pp.672-686; See also: Jean-Michel Johnston, *Networks of Modernity: Germany in the Age of the Telegraph 1830-1880* (Oxford: Oxford University Press, 2021)

the thing being conveyed and information as the content of the signal itself.[106] These uses predate information's formalisation as a technical term by Claude Shannon (although it had already been used on occasion to describe specific mathematical quantities), but it is highly likely that both Benjamin and Shannon extract the word from a common source: the telegraph.[107]

Analytically, however, Benjamin totally overlooks it, misidentifying information with the captured press. For their part, newspapers contemporary to Benjamin were more aware of (and eager to sell) their integration with communication networks. Note, for instance, 19th and 20th century newspapers in English whose titles refer to vectors for information: courier, mail or telegraph.[108] "News" is constructed as a product of information infrastructures, and "the news" isolated from the text (a key allographic function Benjamin overlooks). Early legislation on copyright did not mention newspapers, journals or magazines; one might have an exclusive story, but once news is published there is little to stop it travelling.[109]

This chapter maps the development of an informatics of culture through the 19th and 20th centuries. The term "informatics" emerged quite late (during the 1950s and 60s) to describe a number of practical fields concerned with the processing of information, but here I use it a-historically to group together the mathematical and conceptual foundations of a science of information processing.[110] Primarily, this forms an exegesis of work by three mathematicians, each important contributors to the informatics of culture: Andrey Markov, Alan Turing and Claude Shannon. Conceptually, their work is the origin of my thesis' subjects (compression and encryption) and this chapter aims to establish a common conceptual and historical orientation for later chapters. Culture subject to statistics becomes material to be worked, and this discussion also pertains to the conditions of knowledge-production. Turing and Shannon especially were located within specific institutional, infrastructural and commercial settings from which their work cannot be separated.

Information processing proposes the statistical manipulation of any sign system, including those older than it: today we can treat writing as information, or even, as Flusser does, prehistoric cave

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106 E.g.: Harry Nyquist, "Certain Topics in Telegraph Transmission Theory", *Proceedings of the IEEE* 90.2 (2002), pp.280-305 (first published 1928)
107 First such use is 1925, by the engineer R.A. Fisher; *Oxford English Dictionary*, s.v. "information (*n.*), sense I.2.c," September 2023, https://doi.org/10.1093/OED/1184767006 [01/11/2024]
108 Although this is not true of the major French or German newspapers with which Benjamin was likely more familiar.
109 Though this should not be presented as a simple, inevitable history; see Will Slauter's book *Who Owns the News? A History of Copyright* (Stanford: Stanford University Press, 2019), p.3. The news industry has tried to make its products proprietary, with little success.
110 Likely first used by German computer scientist Karl Steinbuch in his paper "Informatik: Automatische Informationsverarbeitung [Informatics: Automatic Information Processiing]". Several languages use close homophones (the German "informatic" or French "informatique") for computer science.

paintings.[111] But the conditions which allow culture (or indeed anything) to become information, i.e. be subjected to statistical analysis, are historically specific. This chapter is therefore an account of the emergence of informatics (i.e. a science of information), not of symbolic systems which could today be treated as information.

Writing and statistical analysis (Markov)

In 1913, the mathematician Andrei Markov presented a statistical analysis of Alexander Puskin's verse-novel *Eugene Onegin* at the Imperial Academy of Sciences in St. Petersburg, the earliest mathematical description of literature in the tradition of contemporary computing.[112] Via Markov, this section clarifies the conceptual and mathematical operations through which writing was made comprehensible to statistics, and which now comprise the basic materiality of digital culture. Markov's methods (later taken up by Shannon) hijack writing's linear discrete form for the application of forms of computation, interlocution with the numeric language of mathematics, and ultimately the processes of statistics.

Before the early 20th century, statisticians had treated letters in written language as independent events: each letter was given an equal probability following another.[113] Markov was principally concerned with demonstrating that the order in which letters appear is stochastic – that though it is defined by a degree of randomness, this can be statistically predicted. To do so, he transcribed the first 20,000 letters from *Eugene Onegin.* In something like a deconstruction of the text, he also produced a randomised control by reading and printing letters horizontally.[114] Through comparison, Markov demonstrated that the appearance of each vowel and consonant in the original has a statistical relationship to what precedes it, following a normal distribution (an early antecedent to today's large language models): language was for the first time conceivable from the domain of statistics.

This first foray into language only examined the probability of vowel appearance, but forms the methodological basis for graphing the totality of a sign system – e.g. Russian or English – into a chain of possible probabilities: later called a Markov chain (fig-1.1).[115] Via this method complex sign systems – messages, languages, sequences of symbols – are rendered legible as a sequence

[111] Flusser, p.5
[112] Andrey Markov, "An Example of Statistical Investigation of the Text *Eugene Onegin* Concerning the Connection of Samples in Chains", *Science in Context* 19.4 (2006), pp.591-600; David Link, *Archaeology of Algorithmic Artefacts* (Minneapolis: Univocal, 2016)
[113] Ibid., p.30
[114] Pushkin used the same encryption methods to conceal politically contentious portions of his novel; Link, p.53
[115] Shannon, *The Mathematical Theory of Communication*, pp.38-39

of mathematical values.[116] It is a graphing of culture (or of a specific medium for culture, text), which renders the interrelation of signs visible (to analysis, and computation).[117]

The material of Markov's analysis was not incidentally literary: he was attending to statistical repetitions, and Pushkin's verse novel offers a large sample of highly patterned text. But this was also an orchestrated act of ambition, as David Link writes: "Usually, mathematicians wrote texts about numbers, in which the former merely served to elucidate the latter."[118] Markov's rudimentary analysis rearranges the letters of Pushkin's novel, ontologically asserting it as a mathematical object and preparing its text for more complex operations. This was an announcement of the mathematics of culture.

Markov's method owes a lot to the media specificity of written language. As Link argues, it requires linearity (already present in oral language) and a discrete sign system (present in written language).[119] A linear discrete sign system allows Markov's to scan the text, while inscription out of time-series (text on a page) allows for non-linear forms of reading (Markov's vertical control).[120] Language was prepared for mathematics incidentally through the formalisation of writing and the standardisation of print. In the 20th century, written language (and literature) was already arranged into a discrete form, and this is likely why it was the second cultural form after textiles (also discrete, though not necessarily linear) to become informatic. All media oriented towards the human sensorium must also be translated into such a form before they can be informatic, rendering Markov-like processes an enduring prerequisite of their computation.

Already in the 1960s, Derrida claimed that cybernetics could not be rid of writing, to which it was structurally bound.[121] The question of computation's linearity – and its intimacy to writing – has been subject to some debate. Link himself argues that writing is a non-linear medium, in the sense that the recording of symbols makes non-linear readings possible.[122] In the 1980s, Flusser defined technical images (including those on "computer terminals") as non-linear exactly in contrast to the "linear texts" he argued they were supplanting.[123] But his strong identification of image and information rests upon a similar process of abstraction which, like writing, can describe its object (visual information) in a linear sequence of discrete symbols; their representation as something like writing is therefore a requirement of these "new media".[124] Even in film, frames of celluloid

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[116] Ibid., pp.45-46
[117] Though Markoff chains present language as closed and static arrangements of signs, which they are not.
[118] Ibid., pp.32-33
[119] Link, p.36
[120] Speech can be scanned via abstractions other than phonetics – as in the phonograph; Ibid..36
[121] Derrida, *Of Grammatology*., p.9
[122] Link, p.36
[123] Flusser, p.5
[124] Ibid., p.7

comprise a linear form which has been iterated on by video codecs. Indeed, the first working digital computer, constructed by German engineer Konrad Zuse in 1936, used discarded celluloid as punched tape.[125] Only the still photograph escapes the linear construction of older media forms. If computers today seem to erase linearity, they do so only via its automation (analogously to writing), and linear, discrete operations remain a basic condition of their materiality.

Stiegler complains that Derrida collapses all media difference into forms of "arche-writing" – the symbolic-medial basis of communication (in information-theoretical terms, one might say "code").[126] And yet, the material process of computation (which generates "digital culture") is clearly something like writing, and something like inscription. And arche-writing is certainly amenable to the language of information, which is always instantiated, with ambivalence, in some system of representation and some medium.[127] (As Katherine Hayles argues, against the axioms of information theory, all information must be "embodied").[128] But if, as Derrida suggests, this media-technological regime announces the death of speech, it must also contain a general

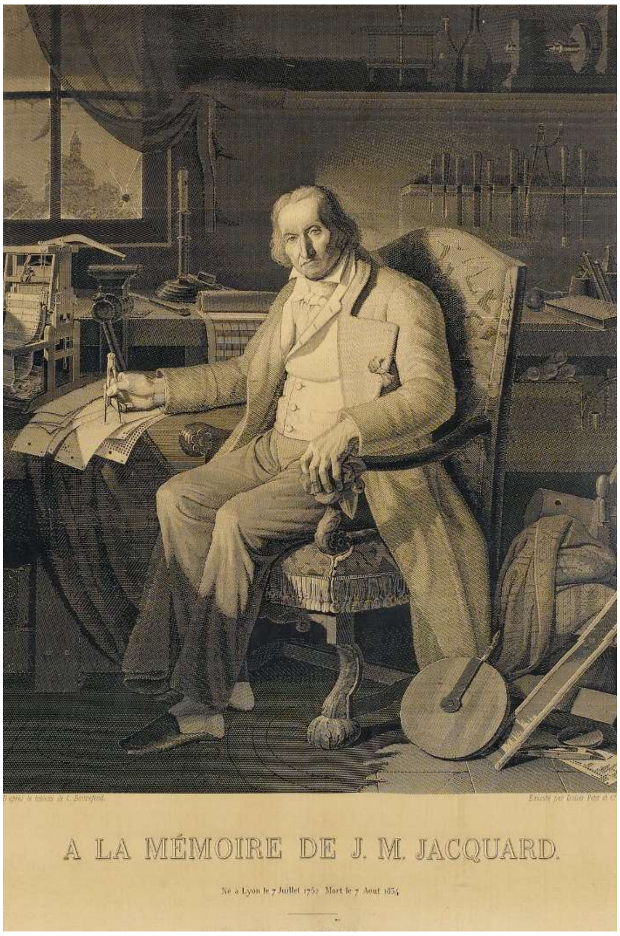

Figure 1.2 Textile portrait of Joseph Marie Jacquard (1839), owned by Charles Babbage who would appropriate Jacquard's punched cards for his Analytical Engine.

This textile image was constructed by a mechanical Jacquard loom, programmed with 24,000 of the punch cards.

Held by the London Science Museum.

[125] Lev Manovich, "New Media: A User's Guide", *Manovich.net* (1999) https://manovich.net/content/04-projects/026-new-media-a-user-s-guide/23_article_1999.pdf [29/10/2024], pp.5-7
[126] Stiegler, "Derrida and technology…", p.239; Derrida, pp.56-57
[127] This intimacy has epistemic roots in structuralist and post-structuralist linguistics, originating with Jakobson's work on information theory; Geoghegan, pp.85-106
[128] Hayles, *How We Became Posthuman,* p.24

transformation of writing as such and a corollary transformation of inscription, which is no longer a product of press, but of the digital computer.[129] Hayles has argued exactly along these lines that, embodied through computation, digital text differs fundamentally to print.[130]

In a roundabout manner this expresses the need for something Stiegler insists on: media specificity. Text was not the first cultural form to be subject to computation; at least one other preceded it, and accounts of the history of textiles demonstrate it as a powerful media-historical antecedent to contemporary computing.[131] Weaving (of fabric and of hair) has functioned as algorithmic practice implicitly based on mathematical knowledge for millennia, and played a significant role in the invention of the digital computer. Textile weaving has traditionally operated on a discrete basis, with the warp and weft of fabric constituting a binary system of representation (fig-1.2); the 20th century transformation of weaving which spurred on the development of digital computation was not from analogue to digital but from human operated to machine operated. This automation anticipates that of the human computer a century later, itself requiring a symbolic intermediary between pattern, machine and fabric (constituting an arche-writing).

The punch card systems used in Jacquard's mechanical looms inherit their binary system of representation (the presence or absence of holes in punched cards) from these forms, anticipating by some time the development of a binary mathematical logic system by George Boole in the 19th century (Boolean logic), which substitutes 0 and 1 for false and true, itself a binary mode inherited from Aristotle.[132] While Boole (and before him Leibniz) is often cited as the inspiration for binary systems of computation, this material inheritance suggests an alternative lineage.[133] This binary formation from textiles is as instrumental to the materiality of computing as the linear, discrete symbolic form of text. Most computers operate as an iteration on woven text: binary discrete linear expression. Before any form can be subject to computation, it must be translated into these terms (what is called a sampling process).

The automation of computing and the materialization of mathematics (Turing)

In the Summer of 1952, the Manchester Mark I computer began to churn out love letters.

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Darling Sweetheart,
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[129] Derrida, *Of Grammatology*, pp.8-9
[130] Katherine Hayles, "Print is Flat, Code is Deep: The Importance of Media Specific Analysis", *Poetics Today* 25.1 (2004), pp.69-70
[131] Plant, pp.37-44
[132] George Boole, *An Investigation of the Laws of Thought* (Project Gutenberg, 2017) https://www.gutenberg.org/files/15114/15114-pdf.pdf [02/09/2024], pp.93-94
[133] Cf: Martin Davis and Virginia Davis, "Mistaken Ancestry: The Jacquard and the Computer" *The Journal of Cloth and Culture* 3.1 (2005), pp.78-79

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You are my avid fellow feeling. My affection curiously clings to
your passionate wish. My liking yearns for your heart. You are my
wistful sympathy: my tender liking.

Yours beautifully,

M.U.C.
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[134]

These playful letters were the products of a friendship between computer scientists Alan Turing and Christopher Strachey. The letters, which Strachey wrote the algorithm in a primitive coding syntax developed by Turing, have been read as works of queer literature, parodying normative expressions of love from which Turing and Strachey, were legally and socially excluded as gay men.[135] While dismissed at the time, Strachey's basic combinatory algorithm represents the first attempt to generate literature with a Turing-style universal digital computer.[136] For a computer to write love letters (even via this simple algorithm) required the conceptualisation of text as a pattern, and its abstract representation via numbers; and is in this sense a literary application of Turing's earlier work.

Strachey's letters were made possible by two of Turing's earlier contributions in particular: 1) a conception of the computable, with which mathematics was inducted into a materialist framework, and 2) the design of an automated computing machine (the digital computer).

Turing first worked on the computation of text under specific historical conditions: as a wartime cryptanalyst. Codebreaking was demanded in response to powerful encryption machines developed early in the 20th century (such as the famous Enigma machine), which could automatically encrypt electronic signals to obscure their contents. (And so, the theorisation of coding messages follows built combinatory machines used for encrypting information). A wartime economy produced unusual conditions for cryptographic labour. War didn't only make cryptography desirable from a military-strategic perspective, it also altered the available workforce.

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134 Andrew Hodges, *Alan Turing: The Enigma* (London: Vintage, 2014), p.601

135 Described by Noah Wardrip-Fruin as "a parody of a process", rendering typical heterosexual expressions of love into a shallow formula: "a small set of vapid statements stored as data"; Noah Wardrip-Fruin, "Digital Media Archaeology: Interpreting Computational Processes", *Media Archaeology: Approaches, Applications and Implications* (London: University of California Press, 2011), p.316; Also see Jacob Gaboury's "A Queer History of Computing: Part Three", *Rhizome* (2013), https://rhizome.org/editorial/2013/apr/09/queer-history-computing-part-three/ [13/12/2024]

136 Wardrip-Fruin claims this is "likely the first experiment with digital literature and digital art of any kind". (Wardrip-Fruin, p.302) Earlier, non-literary examples of computer-generated art (the mechanical loom) and algorithmic writing (as in surrealist automatism, or Dada) do exist; for automatic writing, see: Meredith Malone, eds. *Chance Aesthetics* (St Louis: Mildren Lane Kemper Art Museum, 2009); These were likely dismissed on the basis on homophobia. Turing's biographer Hodges writes that "those doing real men's jobs on the computer, concerned with optics or aerodynamics, thought this silly, but… it greatly amused Alan and Christopher Strachey – whose love lives, as it happened, were rather similar too"; Hodges, p.602

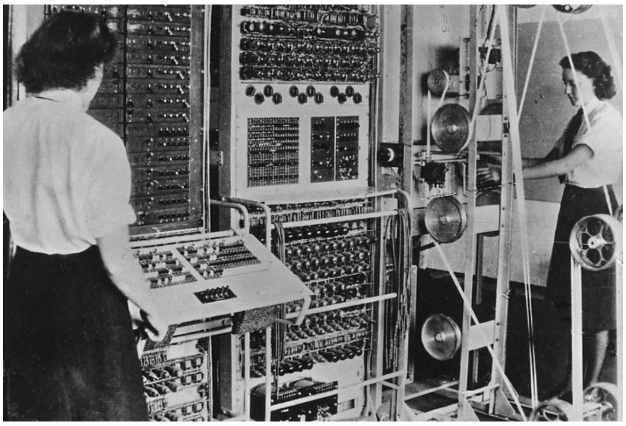

Figure 1.3 Human computers (almost all women) break codes by hand (left) and operate the Colossus computer (right), both at Bletchley Park, 1943. Images from the Bletchley Park Trust.

It is well known that Turing designed and constructed some of the first electronic digital computers (Babbage had developed designs half a century earlier, though never completed).[137] The term computer, though, predates Turing's invention by some time, used in the 17th century to describe "a person who makes calculations."[138] In the 19th century these human computers were professionalised, forming a significant portion of the workforce in maths and science. Universities and military research organisations recruited large numbers of computers to carry out calculations by hand.[139] So, when Turing started to use the term "digital computer" in the 1940s, the adjective "digital" wouldn't have clarified against an "analogue computer" but these professionals (fig-1.3).[140]

Human computers can perform cryptanalysis calculations by hand and codes were broken this way routinely. Across the wartime economy women were drafted into waged work from which they had previously been excluded. Against these extraordinary pressures on labour supply, Turing came to articulate computing machines as automation, as in his 1950 essay, "Computing Machinery and Intelligence":

> The idea behind digital computers may be explained by saying that these machines are intended to carry out any operations which could be done by a human computer. The human computer is supposed to be following fixed rules; he [sic] has no authority to deviate from them in any detail. We may suppose that these rules are supplied in a book, which is altered whenever he is put on to a new job. He has also an unlimited supply of paper on which he does his calculations. He may also do his multiplications and additions on a 'desk machine', but this is not important.[141]

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[137] Martin Davis has a particularly informative account, see: *The Universal Computer: The Road from Leibnitz to Turing* (London: Norton, 2000)
[138] "computer", *Oxford English Dictionary* (June 2008)
[139] William Aspray, et al. *Computing Before Computers* (Ames: Iowa State University Press, 1990), p.237
[140] Alan Turing, "Computing Machinery and Intelligence", *Mind* 59.236 (October 1950), p.437
[141] Turing, "Computing Machinery…" p.436

Turing abstracts the computers' practice into an algorithm: a set of discrete operations for computation by a machine. Digitization begins from an observation of a machinic quality, already present in the labour of human computers, and constructs a (symbolically) analogous process. In a kind of dialectic, Turing abstracted the digital computer from human labour, and came to see humanity in his computing machines (one might point to the M.U.C. love letters, or his work on machine intelligence). It is notable that Turing consistently uses male pronouns in his description of the labour (despite this being mostly female work): automation recategorizes the labour as male.[142] Turing's work is undoubtedly motivated by wartime labour pressures, and here resembles a reaction against the arrival of a primarily female cryptographic workforce.[143]

Anything handed over to digital computation must undergo an analogous digitization, from surveillance data to the signals of an electronic instrument to a digitized artwork. Turing found it necessary to model his machine as operating with discrete states: "everything really moves continuously" he clarifies, "But there are many kinds of machine which can profitably be *thought of* as discrete state machines."[144] Even if the mechanism by which a machine holds information is ultimately continuous (there is an infinite number of ways a current can be arranged in a wire), the machine functions effectively by imagining such states are finite. All digital computers rely on this mode of organisation (it is what makes them "digital"): it forms the basis of their universality, the root of their internal logic and a foundation of their materiality. This discrete system of representation operates as an interface between the mechanisms of the computer (electronic switches or compact circuit boards), mathematical operations (numbers and equations) and external systems of signification to which it can be correlated (such as letters). Such symbolic interrelation makes possible the construction of an executable semiotics (code, written instructions of digital computation). Digitization doesn't render the sign less indexical, therefore, but more so: a great cascade of switches producing effects which are, in this early ideal, determinable in the sense that they are reproducible.

The reduction of these continuous states into binary ones makes possible intense forms of complexity; Kittler identifies, for instance, numeric code as the technical precondition of temporal fluidity, via time axis manipulation.[145] When we drill down far enough, the algorithm to reverse text (Kittler's example is GOD > DOG) is not so different to one which reverses a binary sound file

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142 Cf. accounts which note the intimacy between automatons and labour most often performed by women, such as: Helen Hester and Nick Srnicek, *After Work: A History of the Home and the Fight for Free Time* (London: Verso, 2023), pp.15-47; Also, Plant, pp.12-17

143 Cf. accounts of parallels machine labour and that frequently performed by women: Helen Hester and Nick Srnicek, *After Work: A History of the Home and the Fight for Free Time* (London: Verso, 2023), pp.15-47; Also, Plant, pp.12-17

144 Turing, "Computing Machinery…", p.339

145 Kittler "Real Time Analysis…", p.3

(e.g. 01010100… to …00101010), but to the human sensorium what is produced in the latter case sounds like the actual reversal of sound, even if it is also produced via a reversal of its symbols.

Turing's theoretical model of a digital computer (his "a-machine") is said to be "universal": given an adequate length of tape, it can run any computable algorithm. Such mathematical "universality" correlates to a media universality. Ada Lovelace was the first to note such a possibility in her work on Babbage's Analytical Engine: she notes that a computer "might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations".[146] Lovelace is identifying the possibility of subjecting forms to computation via symbolic representation (information).

But universality does not erase materiality, as has sometimes been popular to suggest.[147] A countervailing perspective to visions of digitization dematerialising culture often comes from computing itself: that informatics entails a "materialisation of mathematics."[148] The popular 1989 computer science textbook *Concrete Mathematics*, for instance, portrays mathematical practice as profoundly altered by the arrival of computing, and promotes a new "concrete" approach against the circular insularity of "abstract mathematics".[149] Indeed, while Turing himself is often cast as a figure of abstraction, his work on computation represents an epistemic break from a Platonic idealist tradition in mathematics.[150] "On Computable Numbers" identifies the limits of mathematics in the working possibilities of computing machines: "a number is computable", he claims, "if its decimal can be written down by a machine."[151] Before he can subject objects (e.g. encrypted messages) to mathematics, he subjects mathematics to the computing machine.[152]

Information is required (in the specific sense it is invoked in computing) to be computable. Turing's philosophy therefore suggests a curious circular conception of information – like the computable – as that which can be treated as information, i.e. subject to computation. These are process-oriented definitions which prepare their material for transformation. Computable numbers are computable because they have been worked upon by a machine, which in-turn

[146] Ada Lovelace, "A Sketch of the Analytical Engine Invented by Charles Babbage", https://www.fourmilab.ch/babbage/sketch.html [28/04/2022]
[147] One might take Mary Anne Doane's essay on indexicality (and its alleged absence) in digital media, as a typical example: "The Indexical and the Concept of Media Specificity", *differences* 18.1 (2007), pp.128-152
[148] Friedrich Kittler quoted in Link, p.77
[149] Ronald Graham, Donald Knuth and Oren Patashnik, *Concrete Mathematics* (New Jersey: Addison-Wesley, 1994)
[150] Paul Cockshott, *Turing and Thought: The Passage to Materialism* (recorded lecture, 2018) https://www.youtube.com/watch?v=wyLDF4j9-8o [02/09/2024]; Also, Paul Cockshott, Lewis Mackenzie and Gregory Michaelson, *Computation and Its Limits* (Oxford: Oxford University Press, 2012), pp. 93-95
[151] Alan Turing, "On Computable Numbers, with an Application to Entscheidungsproblem", *Proceedings of the London Mathematical Society* 42.2, pp.230-265
[152] Turing, "On Computable Numbers", p.230

proves that they were computable; so, too, information only becomes information through its being subject to certain forms of abstraction or processing.

Lovelace (like Markov) indicates that any cultural form which is to be subject to informatics must first be digitized, and so must be represented as something like writing; recorded as information in a linear sequence of discrete symbols. This is reflected at the lowest level in binary code. Hence, alluding to Turing, Kittler declares that in his information-theoretical materialism: "Only what is switchable is at all [Nur was schaltbar ist, ist überhaupt]."[153] Programming languages at higher levels of abstraction, from assembly language through to high-level languages like Python, tend towards the representation of code through natural language (very often as English). This is a second route into text's special significance to informational culture today. As Katherine Hayles argues: "print is flat, code is deep."[154] Things instantiated in digital media (as code or data) almost always rest upon layers of abstraction, of which their users are generally unaware; but the corollary of this abstraction is material complexity and depth.

Information processing (Shannon)

If Turing has become a household name for his contributions to the digital computer, Claude Shannon ought to be at least as well known. Like Turing, he was drafted into cryptographic research during World War II, and began work on what would later be called his "information theory."[155] This was not published publicly until after the war, however, when the dominant drivers of communication research had returned to commercial mass communications technologies somewhat like the news system with which Benjamin identified information.

Shannon published his "Mathematical Theory of Communication" in 1948, including for the first time a mathematical definition for information, a schematic of an information system, and designs for information processes.[156] Shannon's theory of communication ("information theory" was coined later by Warren Weaver, Shannon's collaborator, funder and Rockefeller-affiliated handler), was interested in the major communication systems being developed beyond the military: television, radio and telephone (Shannon worked at Bell Labs).[157] While communications in Europe frequently involved nationalised infrastructures, communication was already big business in the states. And the publication of his communication theory does signal a

[153] Kittler, p.3
[154] Katherine Hayles, "Print is Flat, Code is Deep", p.75
[155] Claude Shannon, *The Mathematical Theory of Cryptography* (1945) https://www.iacr.org/museum/shannon/shannon45.pdf [03/09/2024]
[156] Claude Shannon, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1963), p.56
[157] Geoghegan, pp.32-36

radical departure from the concerns of wartime cryptographic research and a return to commercial communications for the Bell System of telecommunications, a now defunct (broken up via anti-trust intervention) private telecommunications infrastructure led by the Bell Telephone Company and later AT&T, which served as the main telephony system in the US for around 100 years (ending in 1982). Rather than decrypting secret messages, Shannon was by this time concerned with "efficient coding", the coding of information for efficient circulation (today called compression).[158]

Shannon's post-war work presumes a different kind of infrastructure to wartime cryptography. This is clear from the first sentence of his paper, which states: "The recent development of various methods of modulation such as PCM [pulse-code modulation] and PPM [pulse-position modulation]… has intensified the interest in a general theory of communication".[159] His work was oriented towards the technical and infrastructural context of digital telephony. Indeed, as Derrida argues, it is only after the arrival of "practical methods" of circulation as a message that text transformed into something new as information – Shannon's theory is a product of the networks it was designed for, which therefore shape what information is.[160] Just as wartime engineering rendered cryptography into a series of information processes, this work seeks to formalise the efficient transfer of information, which promised massive cost saving across the infrastructure.

Like Turing's digital computers, Shannon's theory – his model of a communication system – is founded on abstractions.[161] His generalised schematic suggests any communication system can be described in terms of six core elements (fig-1.4):

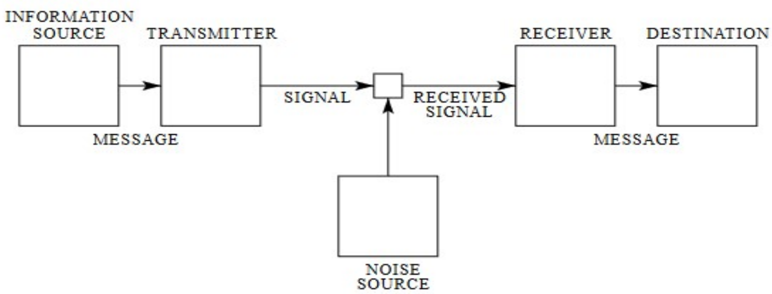

Figure 1.4 Shannon's schematic diagram of a general communication system, included in both versions of his mathematical theory of communication

- An **information source** – which produces a message
- A **transmitter** – which encodes the message as a signal
- A **channel** – which carries the signal to its destination
- A **noise source** – which distorts the signal in some way

[158] Shannon, *The Mathematical Theory of Communication*, p.59
[159] Ibid. p.31
[160] Derrida, *Grammatology*, p.10
[161] Shannon, *The Mathematical Theory of Communication*, p.34

- A **receiver** – which decodes the signal back to the message
- A **destination** – where the message arrives[162]

Such a generalisation has been applied widely to communication systems: from a telephone call to a letter, to a face-to-face conversation.[163] Information sources differ, as does every other part of the system (fig-1.5), but the overall relations of the diagram remain the same. Moreover, the schematic has been applied to systems which are not obviously related to communication at all.

After publication, Shannon's theory was quickly exported across disciplines; some of these have been long-lasting – as in genetics, thermodynamics or linguistics – while others quickly ran their course. In 1956, Shannon published his "Bandwagon" essay, which denounced the lazy application of the theory often by scientists with little knowledge of the domains they claimed to be solving – insisting that the theory was first of all one of communication (even if careful applications could make it useful in other domains).[164] But the manipulation of Shannon's theory also occurred closer to home. When republished as *The Mathematical Theory of Communication* in 1949 (no longer "A", but "The", theory), a long introduction, written by Warren Weaver, was added to the text speculating on the possibility of applying Shannon's theory beyond the technical aspect of communications, to both semantics and 'effectiveness'. In the latter case, he explicitly discusses the potential utility of the theory for designs of propaganda which might "effect conduct".[165] In

Communication system	Information source	Transmitter	Channel	Noise (e.g.)	Receiver	Destination
Telephone	Voice	Receiver	Copper Wire	Electromagnetic interference	Handset	Listener's ear
Letter	Brain/ hand	Pen	Courier, or mail system	Damage during delivery, or wrong delivery	Letterbox	Recipient
Speech	Brain	Larynx	Air	Background noise	Ear	Listener
Propaganda	Propaganda ministry/ hegemonic ideology	Propogandists	Media systems	Alternate messages or interpretations	Audiences	The public, or common sense
Factory	Factory owner/ the market	Instructions to workers/ the foreman	Labour	Striking workers	Output (as commodities)	Consumer/ the market

Figure 1.5 A schematic breakdown several 'information systems' expressed through Shannon's model, bridging technical systems, simple communications and production processes

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162 Ibid., pp.31-35
163 Ibid., pp.31-35
164 "The Bandwagon" *IRE Transactions on Information Theory* 2.1 (1956), p.3
165 Warren Weaver, "Recent Contributions to the Mathematical Theory of Communications", *The Mathematical Theory of Communications* (Urbana: University of Illinois Press, 1964), p.5

such cases the "efficiency" of a system no longer describes the rate of transfer of information, instead it is transformed into a measure of effective control.

Explicit distinctions between Shannon and Weaver's information theory aren't often made, but considering the importance that Weaver's interpretation of Shannon's work has held for mobilisations and critiques of information theory, especially from the humanities, we ought to be more careful in our descriptions of them.[166] Shannon's communications engineer is a specialist operating within tight conceptual and operational confines, while Weaver's is the would-be manager of a much larger system. Weaver's introduction to Shannon's theory – conducted and published without consultation or consent from Shannon – massively expands it, widely reinterpreting and emphasising aspects of the work, but it also elides much of Shannon's contribution.[167] As Weaver introduces the theory, it is primarily "concerned with the accuracy of transference from sender to receiver of a set of symbols".[168] Articulated in this way, the theory becomes primarily one of fidelity; short of eliminating noise (which it concedes is not possible) the theory becomes one of the management of noise.

Weaver's information theory comes closer to cybernetics than Shannon's, proposing the "engineer" as a generalisable controller over anything conceivable as an information process. Spoken in the mode of a cyberneticist, he envisions communication as instruction and expands it to weapons systems and the management of people.[169] Recently translated into English, Michel Foucault's most explicit engagement with information theory, "message or noise?" was evidently influenced by Weaver.[170] In the essay, Foucault describes the construction of a sick body in terms of information (prefiguring, perhaps, Katherine Hayles' argument after the development of an information theory in genetics, the body came to be inverted, contained within, not containing, the gene).[171] Foucault is attentive to the extent information theory works its material: he writes that "illness does not send a 'message,' since a message depends on a 'code' established according to set rules. There is no code in nature… Illness is happy to just 'make noise'… It is medicine that does the rest of it".[172] The doctor, he argues, attends not to a human patient, but to the "non-silence [noise] of the organs".[173] These are domesticated, not just via treatment, but through the construction of analysis itself which renders a complex system intelligible; hearing entails

[166] Geoghegan's historiography of information theory mentions Weaver's "reinterpretation" of Shannon's work, but does not disentangle them; p.12
[167] Described in Hayles, *How We Become Posthuman*, p.300
[168] Weaver, p.4
[169] Ibid., p.3-4
[170] Foucault, "message or noise?", pp.18-24
[171] Katherine Hayles, *How We Became Posthuman*, p.70
[172] Foucault, "message or noise?", p.19
[173] Ibid., p.19

silencing.[174] It is curious, given Foucault's later work on biopolitics, that this account remains fundamentally "diagnostic"; one might expect a more overtly critical account of information-theoretical-medicine as attempting to silence the body, or even as a negation of the living subject, antithetical to the Spinozist mantra that "no one knows what a body can do".[175] Christopher O'Neill's introduction to his translation indicates that this was precisely the concern of Georges Canguilhem, to whom the phrase "non-silence of the organs" alluded.[176] Unlike Foucault, Canguilhem explicitly layers in the question of genetics, the control of the body, and of eugenics.[177] O'Neill argues that for Foucault, information presents an opportunity to escape the "hoary pieties" of the physician, and with it "the authority of medical power."[178] In this interpretation, Foucault and Canguilhem seem to point us towards two different information theories: one through which humans are restricted (this is a Weaverian information theory imposed upon the body as genetics and, implicitly, eugenics), and another that might enable an opening up of the human.

This is Shannon's major contribution which sets him apart from fellow telecommunications engineers. Unlike Weaver, Shannon was a proponent of information theory as a theory of technical systems of communication only – viewing even cybernetics, often considered close to information theory, as an external appropriation.[179] It would be speculative to read his insistence as a reaction against the general interdisciplinary disposition of the milieu (the continuum of the Macey conferences, cybernetics and American philanthropy) that funded his work, but it is certainly marked in its distinction to Weaver. Thirty years after Markov's analysis of *Eugene Onegin*, Shannon invoked *Finnegans Wake* in his mathematical theory not, as Markov does, to domesticate literature, but instead to defer to it. Comparing a statistical analysis of Joyce to that of basic English, he suggests that Joyce "enlarges the vocabulary and is alleged to achieve a compression of semantic content."[180] In utilising this notoriously hard-to-decipher text Shannon makes a claim on the independence of his work from meaning (which is only "alleged here", he offers no analysis of his own); literature is legible only at the level of language or media system. Weaver, of course, is insistent that information has much to say about the construction of meaning. From the late 1940s he would commit information theory towards the machine translation of text,

174 Ibid., p.20
175 Ibid., p.21; Gilles Deleuze, *Nietzsche and Philosophy* (London: Continuum, 1986), pp.39-42
176 Christopher O'Neill, "Foucault and information: on "message or noise?", *parrhesia* 39 (2024), p.11
177 O'Neill, p.11
178 O'Neill, p.11
179 Shannon, "The Bandwagon"
180 Shannon, *The Mathematical Theory of Communication* p.56; There are examples of literary critics describing Joyce as enacting compressions, and Joyce himself encouraged the production of keys and guides for decoding his work, as in Stuart Gilbert, *James Joyce's Ulysses* (New York: Vintage, 1930); For claims of compression, see: Eugene Jolas, "The Revolution of Language and James Joyce", *Our Exagmination Round his Factification for Incamination of a Work in Progress* (Connecticut: New Directions, 1929), pp.129-138

contemporary iterations of which are built into our web browsers; in many ways a culmination of Markov and Shannon's earlier literary insights.[181] But both Weaver and critiques of his information theory frequently fall short of the economic orientation of Shannon's work, which is first of all concerned with "efficiency" not as a euphemism for obedience or quietness, but for rate of transfer.

What are the stakes of Shannon's insistence on communication? One way to think through them is via a distinction between a communication system (Shannon's information system) and a cybernetic system (Weaver's information system). Even while deferring to *Finnegans Wake*, Shannon established the novel as a legitimate "message" for electronic circulation – something that the regime of military communications would never have considered. In insisting that the message itself was not an engineering concern, and that electronic communication might legitimately circulate something as verbose as Joyce's literature, Shannon therefore also reaffirmed the legitimacy of the digital circulation of culture. Weaver, by comparison, inverts Shannon's claim that "the semantic aspects of communication have nothing to say about the engineering aspects", clarifying that "this does not mean that the engineering aspects are necessarily irrelevant to the semantic aspects".[182] This promotion of the engineer comes with a limited military (or managerial) conception of communication systems in which messages comprise commands, or plain intelligence style communications. Such military messages undergo a compression before transmission via strict protocols of expression, interaction and action. In this sense he tried to wrench information theory back into the realm of cybernetics, as a tool of control. Shannon, by contrast proposed a compression of the signal in order to make space for an expansion of expression, for the transmission not just of orders, intelligence and news, but also of something like *Finnegans Wake*. So, Shannon's theory, even as he insists on its separation from culture, is ultimately preparing for the effective circulation of inefficient expression – and in this sense functions as a tool for culture. More specifically, as a tool for propelling culture in circulation.

Even so, Shannon's theory involves a strict disavowal of the idea that an engineer might be informed by expression, as well as of the materiality of information. His essay is a source of a theoretical rift in the substance of communication: between information and meaning.[183] Shannon is aware that messages have meaning, but, unlike Weaver, is insistent: "These semantic aspects of communication are irrelevant to the engineering problem".[184] Information, in his account, is quantifiable; meaning is semantic. Hayles surmises this well with the claim that

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[181] Geoghegan, p.51
[182] Weaver, p.8
[183] Shannon, *The Mathematical Theory of* Communication, p.31
[184] Ibid., p.31

information is "a pattern, not a presence".[185] Such a separation is what allows Shannon to abstract communication into a mathematical quantity: he takes no interest in the effectiveness of the message itself, only in its faithful reproduction at the end of the channel. Meaning is a question for the recipient, not the engineer.

As Hayles highlights, however, this wasn't the only definition of information going: Donald MacKay, a contemporary of Shannon's, attempted to define it in terms of its effect on the receiver.[186] Applying such a definition, Hayles argues, would require that "psychological states be quantifiable and measurable", which she notes "only now appears distantly possible."[187] Shannon's theory has the benefit of being general and generalisable: it only requires that there is some channel capable of transmitting some amount of information. The success of Shannon's particular model, one which isolates information from meaning, is a result of the historical, technical conditions it was produced under: his understanding of information could be quantified, and therefore optimized (whereas tools could not extend into the brain). But both meaning and the medium loom over Shannon's theory: information anticipates the existence of meaning – without meaning there would be no need for his theory of communication – and could not exist at all without some material substrate to pass through.

Weaver writes that in information theory, "The word information… is used in a special sense that must not be confused with its ordinary usage."[188] This is true, but even as (and because) its engineers insist information is neatly defined, information theory maintains two related applications of the term. First as entropy, the mathematical capacity of an information system for variation in its symbols (which correlates to its capacity to generate meaning, even as Shannon disavows the notion) and second as the non-material basis of meaning in the bifurcated system just described. In other words, it is used to describe both a statistical aspect of a system and the symbolic intermediary between meaning and medium in a given message, conceptually washed of these associations. So, Weaver can write that "information is one's freedom of choice when one selects a message", and of communications systems as a means to "convey information".[189] "It is misleading (although often convenient)", he writes, "to say that one or another message conveys unit information."[190] The tension between the misleading and the convenient here betrays the dual definition of the word as it is generally used even in this technical context. While Shannon is usually solely credited with its coining (and his theory of communication is information's first

[185] Hayles, *How We Became Posthuman*, p.18
[186] Ibid., pp.54-56
[187] Ibid., pp.18-19
[188] Weaver, p.8
[189] Ibid., p.9, p.8
[190] Ibid., p.9

usage in this specific mathematical sense), the concept can be understood as emerging from the context of military coding and cryptography over a period of thirty years; a history of the word's emergence in the discipline helps to clarify these meanings. In work from the 1920s on efficiency in electronic communication systems (formative for Shannon), for instance, Harry Nyquist used two words to describe the contents of the telegraph: "intelligence" and "information".[191] In this dual construction "intelligence" is the meaningful content of the message, while "information" is used to describe the thing conveyed (as we might use the words data or code today).[192]

In this construction from the late 1920s, a bifurcation between meaningful content and symbolic base is already present, with information aligned to that symbolic base, but information is not a specific quantity – instead it is used in a general descriptive and non-specialised sense. What Shannon added to this theorisation was a specific, commercially and technically practical, orientation for this bifurcation; between the human and the technical system. The history of information processing demonstrates the historical contingency of this formation: from the 1980s perceptual technics would increasingly include the human sensorium, and Natural Language Processing (NLP) has more recently rendered the semantic a proper object of informatics.[193] Shannon was also not the first to use information to represent a quantity, but the specific sense in which he deploys the word as synonymous with the entropy of a communication system was a novel appropriation from thermodynamics unique to Shannon's work.[194] Here, the information content of a communication system, also called its entropy, describes its unpredictability. For the receiver of a message, meaning exists between entropy and redundancy, since unpredictability is required for a message to be meaningful, but some kind of repetition is necessary for it to be comprehendible – both a totally redundant, and a totally noisy message would be meaningless, likely not received as a "message" at all. But for Shannon's engineer, this trade between redundancy and entropy is the key to the construction of information processes oriented around the efficient construction of a signal. In particular, it is redundancy that creates the possibility of fast transmission and a more effective commercial communications architecture. Out of this, Shannon's paper developed the first designs for a new information process: compression.

As it is described by Shannon, information subject to a comprehensible information theory promotes a conflicted metaphysics. Information (both as mobilised by Nyquist and Shannon) takes for granted the ontological transformation described by Benjamin in his mechanical reproduction essay (the death of the aura of an original), in treating its material not as objects per se, but as signals. It is that part of a message which travels between mediums. First and foremost,

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191 Nyquist, "Certain Topics…", pp.280-305
192 Ibid., p.280, p.282
193 See: Chapter Five.
194 *OED*, "information"

such a formation should be viewed as following on from the construction of large telegraph networks embedded within a larger ecosystem of media reproduction – both 19th century military information networks and news reproduction meet this criterion. But Shannon's information theory is not interested in following the message as it cascades across information networks, or collapses discrete systems, and his diagram of the information system is a closed model.[195] So, while information theory describes information as mobile, it also serves as a container of that mobility. While on the one hand his work requires a set of metaphysical contentions about the transmissibility of meaning, it also seeks to deny the messiness that follows on from this. In fact, in this regard Weaver, who is eager to follow information through semiotics into meaning production networks may have a more complete conception of information than Shannon.

As Tom Watts' science fiction novel *Blindsight* characterises information theory, when met by the incomprehensible "you use information theory to *flatten* it for you"; a hubristic method, destined to collapse.[196] Shannon's theory is ultimately one of flatness: the construction of such a neat channel is destined to collapse, and yet its flatness is exactly what renders it productive, first to telecommunications and later to computing.

In a roundabout way, this returns discussion to Benjamin's notion of information which, as a genre, was also defined by its flatness: anti- or extra-cultural expression, opposed to depth, complexity or ambiguity.[197] Certainly, this was an accurate description of information managed by the major institutions and economic systems of Benjamins moment (including the bourgeois capture of the printing press). Within decades, though, the world would abound in information: some of it flat, some of it deep. While Benjamin was correct to locate the arrival of a new form of communication in his moment, and right to call it information, his limited conception of information as genre, not a medium, falls short of its capacity.

The information revolution

The genealogy presented in this chapter has repeatedly positioned information as formed through attempts at its processing, attempts to reform its contents according to the material interests: most often military communication and commercial media. But there is a flipside to this: following from its essential reductive flatness, information theory has never been in full command of information. An important sense in which it has been revolutionary has been the extent to which it has exceeded and evaded the intentions of the institutions and interests that produced it.

[195] E.g. Michel Serres, *The Parasite* (Baltimore: John Hopkins University Press, 1982); discussed in Chapter Two.
[196] Peter Watts, *Blindsight* (New York: Tor, 2020), p.52
[197] Benjamin, "The Storyteller", p.365

Information is abundant in large scale communications infrastructures; so much so that it often seems inexhaustible.[198] As a radical affront to commodity circulation (which requires scarcity), this is perhaps best showcased by the large and vibrant filesharing networks which were first constructed in the 1980s and exist to this day.[199] These are a backdrop to my compression chapters, and capital's response to them is a major subject of my encryption chapters. Legal distinctions have historically defined information against and apart from the media it is instantiated in; in the 18th century, for instance, debates around copyright established the medium as incidental to legal protection of literary texts.[200] From the end of the 1960s a similar precedent established a distinction between software and hardware. This held a conceptual, legal and (at least for IBM) organisational bifurcation between hardware and software that has been highly influential on our cultural conceptions of what computing is.[201] And yet, files do not float above hardware; they are instantiated in it. Invocations of information as truly non-rivalrous often come hand-in-hand with invocations of its immateriality.[202] Materially, information is iterated (copied), not extended; the ease with information can be copied and relocated is the origin of its mobility and unpredictability, creating the possibility of its abundance.

From the 1980s onwards, this capacity was often invoked under the slogan: "information wants to be free". At their most insightful, the (mostly American) proponents of this slogan present information's freedom not as a moral imperative, but as a stubborn, a priori, trait. "Information does not just want to be free, it longs to be free", writes Eric Hughes in *A Cypherpunk's Manifesto*, it is "Rumour's younger, stronger cousin".[203] One way of reading of the ostensible support for free information among the techno-libertarian movements of the 1990s (in which cypherpunks could be included – though this is by no means monolithic) is as an attempt to innovate forms of accumulation which can survive information's mobility. A warning goes out to other fractions of capital: 'information wants to be free: let's get busy encrypting it.' Indeed, the goal of the cypherpunks was to extend strong encryption to individuals and businesses, for the protection of personal and corporate property. Similarly, in his 1980s account of the MIT Media Lab, Stewart Brand iterates on the slogan to claim that "Information wants to be expensive".[204] Through

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198 Hence its frequent description as a non-rivalrous, non-exhaustible good; Peter Suber, "Knowledge as a Public Good", *SPARC Open Access Newsletter* (2009) https://dash.harvard.edu/bitstream/handle/1/4391171/suber_public%20good.html?sequence=1&isAllowed=y [04/09/2024]
199 See, for instance: Stephen Witt, *How Music Got Free* (New York: Viking, 2015)
200 Hayles, "Print Is Flat, Code Is Deep", p.70
201 Matthew Fuller, Introduction, *Software Studies: A Lexicon* (Cambridge: MIT Press, 2008), pp.2-3
202 Peter Suber talks of a separation between knowledge (which is non-rivalrous and non-excludable) and text, which may or may not be; but this relies on the same a-material distinction between medium and information.
203 Eric Hughes, *A Cypherpunk's Manifesto* (1993) https://www.activism.net/cypherpunk/manifesto.html [04/09/2024]
204 Stewart Brand, *The Media Lab: Inventing the Future at MIT* (London: Penguin Books, 1987), p.204

inversion, Brand reconceives of information's abundance (formerly freedom) as a cost to its would-be sellers and profiteers. Informatics must be seen as a mixed success for capital: far from domesticating culture, information became uncontainable; culture begins to spread via new routes, to mingle in new and unexpected ways, evading accumulation in the process.

At the end of the 20th century, information was structurally disposed to the formation of something beyond commodity circulation or property, of certain kinds of commons. Brand's casual sketches at how to make information profitable (namely, with prescience, subscription), indicate what comes next: the contestation of information as free and abundant.[205]

Information was not destined to be free; it was not born with purpose. Rather, this was historically contingent, it was constructed according to specific strategic and economic demands for the circulation of information – distribution (compression), restriction (encryption) or exposure (decryption). While it is by no means the only way in which compression and encryption act (and neither are singular), both might be read as technological interventions to information's capacity to travel, on its iteration and abundance. My next chapter carries out a far more comprehensive engagement with the language of information theory as an analytical tool for my own project; the remainder of the thesis turns towards the contestation of culture as information from around Shannon's moment onwards (although I will occasionally reach further back).

The informatics of culture acts upon the things we hold in common, upon culture as information. Little beyond this is given; the subtleties of difference between Shannon and Weaver's visions of efficiency are perhaps telling in this regard. Informatics as commodification, or informatics as subjugation, even informatics as socialisation (indeed, any other procedural articulation) are equally imaginable.

[205] Brand, pp.205-207

A Note on Appropriating Information Theory

The following chapter presents a strategic appropriation of information theory. Not entirely without reason, such appropriations can draw suspicion; apologies and excuses have become trope of the genre. Umberto Eco, for instance, adds a postscript to his chapter on information theory in *The Open Work*, clarifying that it is only "to determine to what extent they [concepts] can be applied to it [art]".[206] In his book on the MP3 Jonathan Sterne goes further, warning that embracing information theory is to "elevate the will of the managers and engineers of communication to a kind of divine force."[207]

It is true, as Sterne argues, that Shannon and his colleagues hold a limited set of concerns borne out of specific historical and industrial conditions.[208] One need look no further than the figure of Warren Weaver – whose information theory is so often taken in place of Shannon's – to see danger: Weaver was a director at the Rockefeller Foundation, and an enthusiastic cyberneticist. As I argued in Chapter One, his introduction to Shannon's work quickly promotes the engineer to a general manager of expression and action.[209] "How effectively", he asks, "does the received meaning affect conduct in the desired way?"[210] It is a short step from this, to the thesis put forward by Alexander Galloway in *Protocol* that computational systems are conceptually interlinked with forms of diffuse social control.[211] Galloway is gesturing towards just one strand of cybernetics – corporate management – and the forms of control he describes would be alien to the experiments in democratic feedback and central economic management of Stafford Beer in Allende's Chile, for instance.[212] His appropriation of the word "protocol" to describe such power, therefore, constitutes a synecdoche which incorrectly suggests all protocols are innately aligned with governance by capital. Nonetheless, a routine entanglement of technologies and social logics of control is real – typified today by "productivity software" like Microsoft Teams or more invasive forms of "Bossware".[213]

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206 Umberto Eco, *The Open Work* (Massachusetts: Harvard University Press, 1989), p.68
207 Sterne, p.242
208 Ibid., p.242
209 Weaver, p.24
210 Ibid., p.4
211 Alexander Galloway, *Protocol: how control exists after decentralization* (London: MIT Press, 2004)
212 For cybernetics in Chile, see: Eden Medina *Cybernetic Revolutionaries* (Cambridge: MIT Press, 2014)
213 Luke Munn, "Mapping the "Bossware" Used to Monitor Workers", *Surveillance and Society* 22.2 (2024), pp.104-119

Geoghegan's book on the dissemination of information theory in "French theory" demonstrates capably that the structural linguistics of Roman Jakobson and anthropology of Claude Levi-Stauss drew on information theory, later being inherited into post-structuralist linguistics and philosophy, and outward into a wide range of continental theory and philosophy.[214] He also demonstrates that this initial transfer was supported and encouraged by a network of American philanthropy organised around the Rockefeller Foundation, Macey Conferences, and a wider network of American scientific philanthropy funded by "robber barons" like the Carnegies and Rockefellers.[215] Most substantially, Geoghegan's criticism of information theory rests on an association with game theory, Hayekian cybernetics and eugenics via this Rockefeller milieu.[216] He presents information theory as one of "the colony", "the asylum" and "the camp", not the phone line – and demonstrates well that it has been used as a theory of these things. However, the book doesn't justify its suggestion that talking about "culture as code" is dangerous or substantiate why "encoding and decoding" analyses are "ominous".[217]

Instead, I believe a direct encounter with the language of information is needed for a few reasons: 1) as Christopher O'Neill has recently argued, Geoghegan's study demonstrates a long interrelation of critical theory and information theory, which might be epistemically untangled.[218] 2) The theory is now written into the basic schematics of all our computational and networked devices and so must at least be understood. 3) As I argued in Chapter One, a singular view of information theory as one of management and control is incomplete.

This is not to say that the originating context of information theory is irrelevant. For instance, that Shannon was instructed by Vannevar Bush to do his PhD at the Eugenics Record Office, a major centre for eugenics research in early 20th century America, clearly warrants scrutiny.[219] But when we ignore information we become more, not less likely to reproduce the assumptions of Shannon or Weaver. If we want to overcome amnesia towards the legacy of information theory, epistemic guilt-by-association is a poor substitute for exegesis. Because of the specific interests that funded information theory – not just philanthropy, but also commercial telecommunications and the British and American militaries – I would suggest that appropriations of information theory (including my own) be assessed by two criteria: first, their utility in the terrains to which they are applied but also, vitally, the extent to which they work for, against or beyond this originating context.

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214 Geoghegan, pp.85-132
215 Ibid., pp.24-52
216 Ibid., pp.11-12, 36-40
217 Ibid., p.134
218 O'Neill, p.7
219 Ibid., p.36

Chapter two

Revisiting the encoding/ decoding model

one must tamper with the code.

Jaques Derrida, *Points…* (1992)

If my first chapter was interested in the historical emergence of information as a mode of analysis, processing and production in the 19th and 20th centuries, this second chapter addresses information theory as an analytical tool. Starting from a view that culture is now steeped in (and indeed constructed from) information, I ask how appropriate the language of information theory is for the study of informatic culture today. The intention here is to identify working terms and relations for the analysis in the thesis' core chapters. Most important here is the concept of the 'codec', the embodiment of coding processes (e.g. of a specific compression or encryption protocol), to which I will work; but speaking of codecs entails a wider vocabulary that I also intend to extrapolate upon.

Even if information theory has been subject to at least three "bandwagon" style bubbles – in the 1950s of sciences, the 1960s of structuralist humanities, and the 1990s of cultural theory – it has had a lasting influence (via vocabulary, theory or direct application) on many disciplines, including engineering of all kinds, genetics, linguistics, economics (encompassing the "invisible hand" of the capitalist free market and socialist economic planning), psychology, post-structuralist philosophy, media theory and cultural studies.[220] As discussed in Chapter One, this is something Shannon's funder was more enthusiastic about than he was; Weaver's first

[220] An example from the 1960s is: John Pierce, *An Introduction to Information Theory: Symbols, Signals and Noise* (New York: Dover, 1961) Shannon, "The Bandwagon"; O'Neill, "Foucault and information theory", p.7; A text like Nick Land's *The Thirst for Annihilation*, which tries to make work out of the overlap between information theory and thermodynamics in relation to Bataille's theory of effusion, would be part of this third moment: *The Thirst for Annihilation* (London: Routledge, 1992)

intervention upon Claude Shannon's model for communication, therefore was to insert a claim of generality.[221] In Weaver's hands, information becomes a theory of anything:

> the mathematical theory is exceedingly general in its scope, fundamental in the problems it treats, and of classic simplicity and power in the results it reaches. … This is a theory so general that one does not need to say what kind of symbols are being considered – whether written letters or words, or musical notes, or spoken words, or symphonic music, or pictures. The theory is deep enough so that the relationships it reveals indiscriminately apply to all these and to other forms of communication.[222]

Even limited to "communication", it promises a general theory that can encompass any medium or form of expression; in doing so it falls closer to a general cultural disposition than a form-specific one (i.e. that of film studies, literary studies, art history or even visual cultures), or indeed to media-specific analysis. It's orientation towards processes is one which holds utility for my own project: it is the theoretical origin of the two technologies that my thesis is concerned with – compression and encryption – and brings with it an extensive vocabulary.

Information theory was borne from specific material and historical conditions: a particular network infrastructure and a particular set of research agendas, oriented towards the concerns of 1940s commercial telecommunications (and secondarily to other mass communicative forms). It brings with it many dubious assumptions, not limited to: an insistence on the immateriality of its subject (information); a related division between meaning and information along lines practical to a technical and commercial context which has now passed; and the limitation of communication to a contained, managed and unchanging channel, connecting two individuals. An uncritical appropriation (see my "note on appropriating information theory") would at best reproduce the limited concerns of Claude Shannon, the telecommunications engineer, and at worst those of Warren Weaver, the manager and administrator.

Within cultural studies, the most influential appropriation of Shannon's theory has been Stuart Hall's encoding/ decoding model for culture (though Hall does not acknowledge this origin).[223] Presenting it ostensibly as one of reception, Hall attempted to ground information theory in politics: Hall's model is asymmetrical – there is no guarantee that his encoder or decoder agree with one another, and no predetermined stability in the message. That communication is profoundly asymmetrical is an important contribution which has been influential on my account,

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[221] Cybernetics has often been accused of forming of "a unifying theory" across disciplines; see, for instance Raymond Ruyer, "The Fracture of Cybernetics", *parrhesia* 39 (2024), p.26 https://parrhesiajournal.org/wp-content/uploads/2024/08/3.-Raymond-Ruyer-The-Fracture-of-Cybernetics.pdf [04/09/2024]
[222] Weaver, p.25
[223] Stuart Hall, "Encoding and Decoding in Television Discourse", *Essential Essays Vol.1* (Durham: Duke University Press, 2018)

but Hall's model is also limited. Geoghegan has recently described an "amnesia" from many cultural theorists towards the strength of influence information theory holds on their work; indeed, after Hall, academics have often tried to exorcise information theory from the encoding/decoding model via denial, rather than confrontation.[224] David Morley, for instance, argues dogmatically that to consider the media specificity of an encoding/decoding process "returns us… to a technologically determinist vision of hypodermic media effects… inevitably transforming both the world around us and our very subjectivities".[225] Morley elides any investigation into the technicity of media with blind market hype, and refuses to engage with the

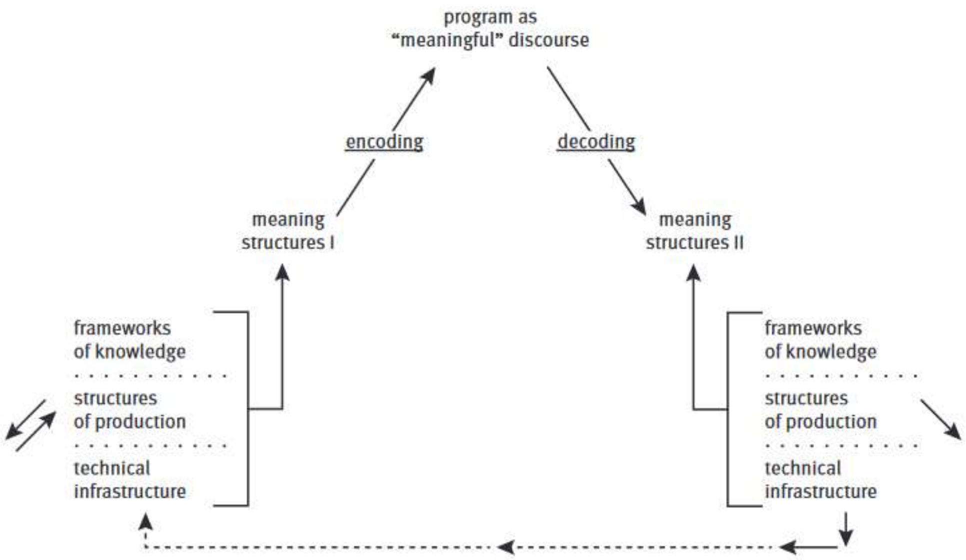

Figure 2.1 From *Essential Essays Vol.1* (2019)

At least three diagrams of Hall's model appear in different editions of the text. This one (from Hall's original 1973 typed paper and reproduced in his posthumous *Essential Essays*) shows a consideration of the dynamism and porousness of the model.

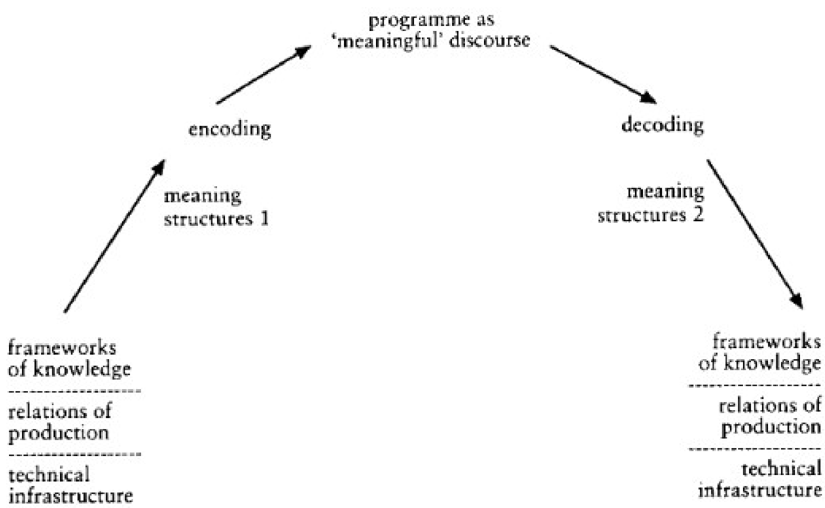

Figure 2.2 From *Culture, Media, Language* (1980)

Likely the most widely distributed version of Hall's model of televisual discourse, published alongside an abridged version of the essay.

Hall's additional arrow, which sketch a circuit between meaning structures and indicate relations to larger systems of meaning and action have been cut, reducing the diagram to a simple binary.

224 Geoghegan, p.173; Most of all in Audience Studies, which takes the essay as an originating document
225 David Morley, "Unanswered Questions in Audience Research" *The Communication Review* 9.2 (2006), p.117

information theoretical origins of his own discipline. Media specific analysis becomes indistinguishable (to Morley) from naive market-driven technological determinism. But ignoring Shannon and Weaver does little to banish them, instead maintaining the relations they penned. Ironically, rejecting the technical content of encoding/decoding has led the same conclusions as Shannon: the engineer and the message have nothing to do with one another (fig-2.2).[226]

And yet, such a claim is not just out of date – engineers routinely encode specific concerns (economic, cultural, aesthetic) into communications technologies – in an era of algorithmically arranged culture, it is also politically naive and analytically unhelpful. I agree enthusiastically with Hall's intervention that "*information*, with its cleansing cybernetic qualities, cannot wash away or obliterate the fundamentally dirty, semiotic, semantic, discursive character of the media in their cultural dimensions", but one must also acknowledge that 'discourse' or 'culture' cannot wash away the problems of technology or of media specificity.[227] In pursuit of a technical language to confront information processes, this chapter attempts a direct engagement with information theory. It tries to unravel some of the contradictions and inadequacies of both Shannon's information theory and Hall's discourse analysis towards a language more conducive to my study. For the most part, this takes the form of a lexicon of information's key terms: signal, code, channel and codec – key words for my thesis. If an information model of culture is to be analytically useful, the epistemic roots buried by Hall's model need to be disinterred, which is where I begin.

The Epistemic Roots of Hall's Encoding/ Decoding Model

Before exploring the lexicon of information in general I want to expand upon my critique of Hall's model and of the 'amnesia' in which it has played a key role; such epistemic blind-spots instruct (via their absence) the lexicon that follows.

Hall's mobilisation of communication theory seeks to represent the formulation of meaning for individual subjects within a system of mass-communication, specifically television.[228] His basic model is as follows (fig-2.1): a television producer encodes (i.e. makes) a television programme which is decoded (i.e. watched) by a viewer according to certain meaning structures (conditions which govern expression and interpretation).[229] The basic structure of Shannon's general model

[226] Stuart Hall, "Encoding/Decoding", *Culture Media, Language* (London: Routledge, 1980), p.54; Hall, "Encoding and Decoding…", p.260
[227] Hall, Stewart. "Ideology and Communication Theory", Rethinking Communication (London: SAGE, 1989), p.48
[228] Hall, "Encoding and Decoding…", p.257; Hall's 1973 typed paper can be found: https://core.ac.uk/download/pdf/81670115.pdf [09/09/2024]
[229] Ibid., p.260

of communication is maintained in this schema, but (influenced strongly by Umberto Eco) Hall also departs from Shannon's theory in useful ways.

While some strands of audience studies have overlooked it, Hall's essay is a clear product of structuralist and post-structuralist linguistics. One can map epistemically a direct route through from Shannon, through Roman Jakobson's linguistics, which sought to treat bits of spoken language – "phenomes" – as data, into Umberto Eco's general semiotic theory, which extends the language of code to culture ("a vast range of phenomena prematurely assumed not to have a semiotic relevance") and into Hall's text, which cites Eco extensively.[230] There is also, noted by David Morley, the direct influences of post-structuralist literary studies (Hall studied English), in particular that of Roland Barthes.[231]

"Classic criticism", Barthes writes, "has never paid any attention to the reader".[232] Hall's model is similarly focused on the question of reception; his viewer, like Barthes' reader, is imbued with the agency of interpretation. Breaking from an older, propogandist model of televisual discourse, Hall suggests that any two viewers are unlikely to receive a message in the same way. Appropriating Eco's conception of the human interpreter as an information decoder, Hall notes that "in the analysis of culture, the interconnection between societal structures and processes [culture] and formal or symbolic structures is absolutely pivotal".[233] What Eco calls codes, he renames "meaning structures", which encompass the full range of determining factors in interpretation (these are "frameworks of knowledge", "structures of production" and "technical infrastructures").[234] Hall's key intervention is to insist that a viewer's meaning structures may not be (almost certainly are not) the same as those of the television producer: different class positions, cultural backgrounds, experiences, political alignments, etc. all contribute to an asymmetry. (Incidentally, also typical in technical systems).[235] There is an interpretive gap, Hall suggests, between encoder and decoder; the meaning generated by a message is never wholly determined by its producer. An energetic reading of Hall can work with the openness of this moment in decoding. Encoding and decoding are both "determine moments", in the creation of meaning, but their relationship – interpretation – is innately unstable.[236]

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[230] Roman Jakobson and Morris Halle, *Fundamentals of Language* (New York: Mouton de Gruyter, 1971); Umberto Eco, *A Theory of Semiotics* (Bloomington: Indiana University Press, 1979), p.6; Geoghegan's historiography of information theory and critical theory shows exactly this route, pp.96-126
[231] Morley, "Unanswered Questions…", p.109
[232] Roland Barthes, "The Death of the Author", *The Norton Anthology of Theory & Criticism* (London: Norton, 2010), p.1326
[233] Hall, "Encoding and Decoding…", p.257
[234] Ibid., pp.259-260; Eco, *A Theory of Semiotics*, p.141
[235] Karnani, p.14
[236] Hall, "Encoding and Decoding…", p260

Hall offers a simple typology of decoders/viewers: hegemonic, oppositional and negotiated.[237] Hegemonic and oppositional viewers operate as might be expected, accepting or rejecting the intended message on the basis of the meaning structures derived from their social positions and experience. The third category, negotiated viewers, are the most interesting: despite asymmetry with the encoder, they accept the overall (hegemonic) message.[238] To the extent these categories are useful, they are not schematics for actual viewers but demonstrations of pivotal points in interpretation. Negotiated decoders are on the cusp of becoming oppositional ones: this is the radical potential in Hall's essay.

The major inheritor of Hall's model has been the field of audience studies – which seeks to study "audiences" as socio-cultural groups via ethnography and other empirical methods.[239] Audience studies has tended to consolidate a limited version of Hall's theory: not a discursive tool but a sedimented method (visible in the erasure of the external arrows Hall sketched in his original diagram, fig-2.1).[240] Morley notes, for instance, that the most commonly published version of the essay completely omits Hall's textual analysis of the 'Western' genre, and that Hall himself was frustrated by the essay's use as an excuse to bypass textual analysis in favour of exclusively empirical audience research.[241] In reception, Hall's decoders have often become concretely situated – determined by class, social, professional and cultural position.[242] Even where cognisance has been taken of these issues, there is more interest in expanding and adding to Hall's categories than in the radical potential of negotiated viewers.[243] Hall may not have followed through on the potential of his negotiated/oppositional decoders, but he explicit about what he considers a misreading of his essay:

> The decision to intervene in order to make the hegemonic codes of dominant elites more effective and transparent for the majority audience is not a technically neutral one but a political one.[244]

In the worst cases this question becomes something like: 'how can we produce messages to appeal to audiences that are not being spoken to?', particularly evident in work oriented towards electoral campaigning. The goal isn't to amplify noisy voices but stifle them: as one study says,

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[237] Ibid., pp.272-273
[238] Ibid., pp.272-274
[239] Morley, "Unanswered Questions in Audience Research", pp.114-117
[240] See caption to fig.1&2
[241] David Morley, Introduction to Part III, "Encoding and Decoding in the Television Discourse", *Stuart Hall: Essential Essays Vol.1* (Durham: Duke University Press, 2019), p.257
[242] Morley, "Unanswered questions…", pp.107
[243] Ibid., pp.101-121
[244] Hall, "Encoding and Decoding…", p.275

"'surround' the people whose vote decision is still dubious so that the only path left to them is the way to the polling booth".[245]

But Hall's essay holds a second buried epistemic root, which Morley is less enthusiastic to dig up. Despite drawing heavily on Umberto Eco's semiotics and Claude Levi-Strauss anthropology, Hall never once mentions Claude Shannon or "information" or alludes in any way to this theoretical origin.[246] In audience studies, such an enthusiastic amnesia is maintained on the basis of avoiding technologically determinism.[247] This aspect of Hall's own essay was rightly criticised by Matthew Fuller almost twenty years ago: "the 'media' elements [transmitter, channel, receiver]", he writes, "have been replaced by the simple term "message".[248] Any technical handling gets elided between just two humans – one on each end of the message. As described in Hall's text, the model holds the possibility of permutation of the decoder (different viewers), but not of any network interaction more complex than a binary producer/viewer pair (though his original diagram, fig-2.1, gestures towards greater complexity).[249] This is exactly how communication is presented by Claude Shannon: a binary transmission over a stable channel, in which the engineering problems have nothing to do with those of meaning. Today, with the expanded significance of digital codecs, the algorithmic delivery of media and large language models producing work near-indistinguishable from that of a human, the anti-technical disposition of some media theorists becomes more untenable.

Hall's encoding/decoding model, as is, remains closed: literally, in the sense it presents communication as a discrete encounter between two individuals (a direct inheritance from Shannon), and also conceptually, contained within an a-technical sociological orthodoxy. Reopening the model demands an act of heresy: we must reimagine Hall as a technological determinist.[250]

Against the best efforts of its major interpreters, Hall's model does enmesh its media-subjects into a wider network of media and culture (even technology). I've already indicated that his original diagram maps outward facing arrows which are conducive to such a reading. While he doesn't

[245] Paul Lazarsfeld, et al. "The People's Choice" *The Audience Studies Reader* (London: Routledge), p.18
[246] Roland Barthes, "The Death of the Author", pp.1322-1326
[247] Morley, "Unanswered questions…", p.107
[248] Fuller, *Media Ecologies*, pp.21-23
[249] In a later reflection Hall writes that "the linearity of communications models as such is now a specific hinderance to further advance", though he is likely commenting on cultural theories of communication, not Shannon's technical theory; the alternative he offers to linearity is a further breaking up of the channel by social, cultural and political mediation; "Ideology and Communication Theory", p.49
[250] To what extent might, for instance, might his account have been enriched by Norbert Weiner's critique of highly individuated conceptions of information? Weiner's critique effectively pre-empts and heads off a Hayekian cybernetics of the individual liberal subject, a bar which Hall's model (even as he discusses Pinochet's coup in Chile as a key case) falls short of.

fully explore the hybrid structure of his encoders and decoders, one of Hall's main contributions – and what makes his model a good entry point to analysis – is beginning the process of breaking them open and considering what they are made of (meaning structures).[251] The interpretive gap he describes between encoder and decoder is not only true in cultural reception, it holds true for information systems. While stuck in Shannon's model of communication between individuals, Hall also hints at the existence of "skewed and structured 'feed-backs'" indicative of a less stable system, though his analysis does not pull at this thread.[252] As Fuller suggests, it is easy for decoding analyses to become a "painful student of consumption trapped in receiver mode."[253] Encoders and decoders are not as neatly distinguished as Hall's text suggests; a basic productive aspect of culture is that viewers also produce, and vice versa.

Hall's meaning structures, while a significant structural intervention, are also underdeveloped: what is their contents? How are they produced? And how are they shared? The text begs all these questions but never lingers on their answers. Hall draws on just enough of the post-structuralist tradition to realise that reading/viewing is a generative act, produced in the reader, but not enough to explicitly cast that reader as unstable, liable to change. The 'technologically determinist' territory Hall and Morley keenly ignore suggests an epistemic route for re-opening an information theoretical model for digital culture, for a lively mobilisation of Hall's encoding/decoding model. I explore these here in the form of a lexicon: a discussion of key terms from information theory which – especially through their critique – offer a structural language for information processing. Most importantly, for my study, the information theoretical model is one in which information processes themselves (as codecs) can be situated in the centre of analysis.

A lexicon from information theory

1) Signal

Though he doesn't explicitly define it, a signal is what travels across Shannon's information system.[254] "Signal" shares an etymological root with "sign", signum in Latin, meaning mark or token; but while a sign suggests stationariness (in material if not meaning), signals are generally in motion.[255] Media-historically the word can be traced through the electric telegraph into pre-electric forms of telegraphy, in which flags or torches were used to communicate simple messages

[251] Hall, "Encoding and Decoding…" p.259
[252] Ibid., p.259
[253] Fuller, *Media Ecologies*, p.22
[254] Signal is at this point basic jargon of his field, with a material history running into the pre-electrical telegraph
[255] "signal", *Chambers Etymological Dictionary* (1988); "sign", *Chambers Etymological Dictionary (1988)*

across distances (as in the example of Telegraph Hill in New Cross, named for a telegraph station with a view of Whitehall).

In Shannon's schema, a message is encoded to become a signal when it enters a communications channel, and decoded when it leaves – language which applies to pre- or post- electrical telegraph systems, or indeed to today's networked communications.[256] As I understand them, signals are the things which moves through channels, be that as electrons, vibration, motion, light, energy, text, etc. They are the material basis of the message, information in motion, an object considered in time. Indeed, signals suggest a different ontological position than that of the classical object: materialist accounts of digital culture have sometimes located materiality only in storage, but being dislodged is the norm for the signal which, though it can be stored, becomes visible only in motion.

Post-structuralist literary studies has attempted to deal with this problem, notably through Roland Barthes' distinction between work and text.[257] The work, as Barthes describes it, is the book ossified; the written word as understood by legal (copyright) and indexical structures (library categorisation); the property of its author, and a commodity for its reader to consume.[258] The text is, by comparison, plural, irreducible, experienced through the act of production, indicative of a mode of reading intimately caught up with writing.[259] This is not a distinction between two kinds of writing, but a tension being played out in the writing itself, and most of all in the act of reading; the work as a discrete object – held, sorted, kept, displayed etc. but also socially pre-determined with meaning, status, etc. – against the text as a point of radical departure: literally more mobile than it had been historically, but also unknowable until the moment of reading. Such texts could easily be retheorized as signals; indeed, Barthes' key concept of "text" ("From Work to Text" was published in 1971) came contemporaneously to the rise of the fax machine.[260] As Dennis Tenen has argued, telegraphic devices set text into space, beyond their expected locations in personal collections or libraries.[261]

Theoretically, in Shannon's model, a signal is comprised of abstract information. But, following Hall and Eco – for whom communication systems are organised around the production of meaning – information might best be understood as unrealised meaning, itself the product of the decoding

[256] Shannon, p.31
[257] Roland Barthes, "From Work to Text", *The Norton Anthology of Theory & Criticism* (London: Norton, 2010), p.1326-1331
[258] Ibid., pp.1327-1330
[259] Ibid., pp.1327-1330
[260] Cf. A historical irony, highlighted by Hayles, in Barthes' claim that text cannot be "computed", though this can also be read as a media specific feature of fax images; "Print Is Flat…", p.68
[261] Dennis Tenen, *Plain Text: The Poetics of Computation* (California: Stanford University Press, 2017), p.136

of information.[262] Indeed, even in 20th century information theory, "information" describes a capacity to generate meaning.[263] Materially, a signal is simply some arrangement of a substrate carrying a message: vibrations in air, marks on paper, electromagnetism, patterns of light, etc. Hall seems to acknowledge this bind when he describes the "object" of television production as a "message: that is, a sign vehicle… organized, like any other form of communication or language, through the operation of codes with the syntagmatic chains of discourse", requiring a "material substratum" (i.e. a medium), but operating in a domain of symbols.[264] In other words, there is already a rift in Hall's account, between the substrate of transmission and the material existence of the signal.

A similar definition might be given to the object, except objects are ontologically fixed within their given mode of organisation, within a single channel. When we scan a book, the book is left behind, but the text (or an image of it) moves forward. Gary Genosko has described "alternate ontological universes" opened up by signals.[265] This is the key characteristic which differentiates a signal from an object: "object" presumes an affinity with the original, "signal" with the copy. Imagine electromagnetic signals reaching the synapse at the end of a nerve. This gap between neurons cannot be crossed by electromagnetic signals. Instead, a chemical process takes place. The electromagnetic signal itself never leaves its medium, and yet it is clear that there is a continuity on either end of the divide (fig-2.3). Signals rely on momentum, not matter, for their material base,

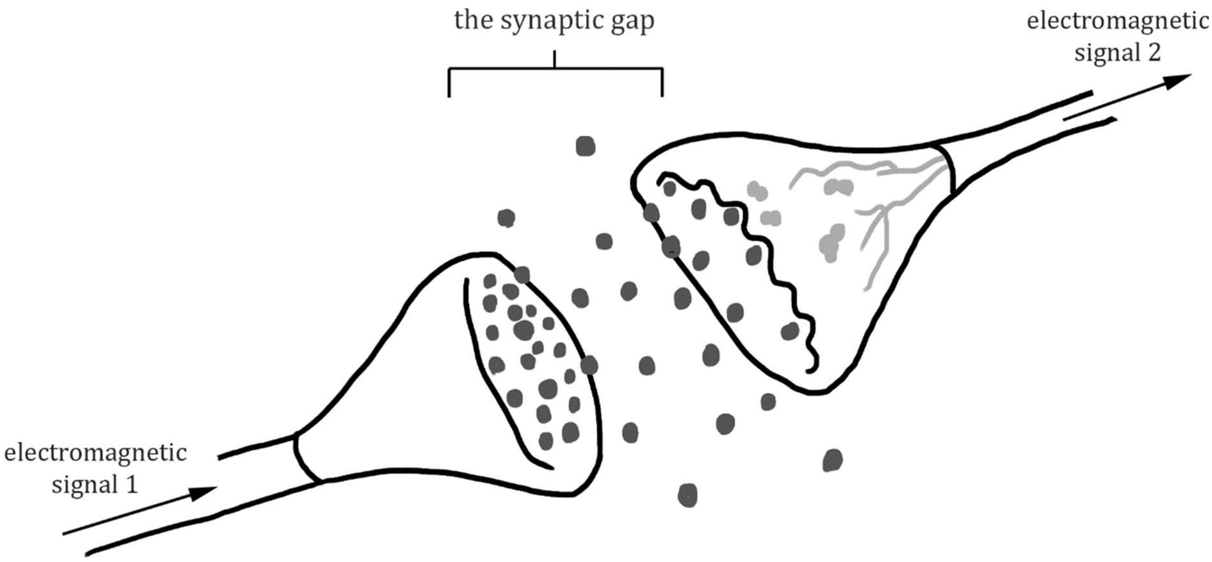

Figure 2.3 A 'synaptic gap' between neurons; literally and analogously, signals can pass between mediums, even as matter (here chemicals or neurons) remains behind. Here, we take for granted that electromagnetic signals one and two are the same, despite their mediation by a third, chemical, medium.

262 See: Hall, "Encoding and Decoding…", p.259
263 In the sense of the variety of meanings which might be produced in a certain channel.
264 Ibid., p.258
265 Gary Genosko, "A-signifying Semiotics", *The Public Journal of Semiotics* 2.1 (2008), p.20

and therefore can cross material boundaries (synaptic gaps), and be forked and duplicated in the process. One signal can become many, and these can diverge from one another (albeit requiring some amount of energy or labour to achieve). The flip side of this is that one signal can be decoded in many ways and might iterate to become many things.

In this sense, signals both adhere to and depart from classical western philosophical assumptions. The bifurcation of signal and substrate (present in Shannon) reproduces an enlightenment mind-body dualism most famously associated with Descartes' axiom, "cogito, ergo sum", which influenced transhumanist visions of uploaded consciousness.[266] But the signal also holds an anti-ontological orientation via its much stronger association with movement and causality than with matter (as such resembling Alfred North Whitehead's conception of a process).[267] And so, the signal troubles Shannon's closed diagram (and Hall's, for that matter); signals are always exiting and entering such narrowly defined channels. Shannon's portrayal of a communication system as discrete is therefore inadequate. A signal is not only constructed by the code system, medium or channel it currently finds itself in, but exactly by its successive propulsion through different code systems with different rules, all of which shape it.

Mediums are therefore significant to the meaning of a message. Indeed, one can find classic information theoretical texts in which the possibility of expression is linked to a specific medium, anticipating the media-technological concept of "affordances."[268] Returning to the example of the scanned book, it is therefore insufficient to say that only the text is carried forward. Certain rules specific to the print – typefaces developed for the press, pages, indentation, metatextual details from chapter titles to page numbers, even the texture of the paper – will be visible in the scan. Each time a signal is encoded it brings detritus – impressions of a previous channel – with it; not just messages, but also meaning structures. The new and the old signal are linked through series; they are the same signal separated by time. Their relationship is mechanical, causal: one generates the other. When, as viewers, we encounter a signal, we view (decode) a product of successive arrangements. Each new system impacts the signal, reshapes its contours in relation to the systems that came before. Often, we encounter multiple signals as though they are one object, but we should be clear that playing a video file, or opening an image file, twice does not materially produce the same signal twice. Digital media always appear through iteration.

Materially, the things of digital culture (files, data, messages, images, sounds, etc.) operate as signals, as things routinely transformed by information processes. They are bound both by the

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[266] Described well by Hayles, *How We Became Posthuman*, pp.283-285
[267] Alfred North Whitehead, *Process and Reality* (New York: The Free Press, 1985)
[268] See, for instance: Harry Nyquist, "Certain Factors Affecting Telegraph Speed", *Bell Systems Technical Journal* 3.2 (1924), pp.324-346; Ian Hutchby "Technologies, Texts and Affordances", *British Sociological Association* 35.2 (2001), pp.441-456

specificity of digital materiality and by the architectures of the information systems through which they travel.

2) Code

One cannot simply substitute the word "signal" for "object" and expect the rest of the system to remain intact. The object and the signal come from epistemic traditions with distinct lexicons. Just as the art object has some assumed bedfellows – medium, artist, viewer, etc. – so, too, does the signal: code, codec, channel, etc. Such terms are not wholly incompatible, but "signal" implies a coding process, the thing according to which it has been produced and organised.

The origin of the word "encode" in English is the information-theoretical labs of Shannon, Turing and their colleagues, as a combination of the prefix "-en" with the root word "code" (so, "to put into a code").[269] Shannon rarely uses "code" as a noun; while "any stochastic process which produces a discrete sequence of symbols" (e.g. written languages or quantized information) is a viable candidates for encoding, it is not clear whether he considers these to be coded before entering a communication channel.[270] To code or to encode, for Shannon, is simply to make something into a signal (implicitly via some technique or device).

"Encode" has the same historical relationship to the digital computer as "inscribe" does to writing or "press" does to the printing press. That is, a partial one. It is clear that encoding is an especially prominent aspect of the mechanics of digital reproduction and that semantically we owe our contemporary understanding of the word to the technology; just as "press" gained meaning after the invention of the printing press and the proto-Indo-European route "skribh-", "to cut", required the invention of script to mutate into "scribere", the Latin "to write".[271] All three forms of sign production contain one another to varying degrees: writing requires im*press*ing an implement against a surface; computational systems *write* information into a storage medium; Elizabeth Eisenstein's account of early print culture clearly demonstrates how the arrival of blocks and plates expanded the repeatability of text and images while often also standardizing them, effectively requiring information to be coded from existing templates.[272] The digital computer does not have a monopoly on encoding, but epistemologically, encoding is unavoidably downstream of the material processes of digital computing; all modern English language uses of

[269] "encode", *Oxford English Dictionary* (1972)
[270] Shannon, *The Mathematical Theory of Communication,* p.40
[271] "scribe", *Chambers Dictionary of Etymology* (1988), p.972
[272] Eisenstein, pp.25-27

"encode" have a genealogy running back through Shannon's information theory. The word "code" is much older, however.[273]

"Code" came into English from Latin and Old French. "Codex" in Latin literally means a block of wood, and later more specifically wood split into leaves and tablets for writing.[274] Towards the end of the Roman empire, amid the legal reforms of Justinian I, "codex" took on legal meaning, referring to such tablets as an inscription-surface for the emperor's statutes. Once it arrived in middle English, the word forked, with "codex" referring to ancient manuscripts bound as books and a new word, "code" retaining the legal meaning, either as a single law or a collection of laws.[275] From this brief etymology we can already surmise two definitions for the word encode, one more-or-less synonymous with inscription, writing into a book or tablet, and the other meaning to put into law. Here "codex" acts as a bridge between a structure of meaning (the law), its written expression (legislation) and the material process of its recording (inscriptions in wood). Even outside of information theory, the word code has continued to take on meaning into modern English. We have moral codes, codes of conduct, social codes, cultural among many others. Foucault talks of such codes in *The Order of Things* as including a culture's "language, its schemas of perception, its exchanges, its techniques, its values, its hierarchy of practices" – that is, any set of rules which might order thought.[276] Roland Barthes *S/Z* proposes "five codes" according to which literary textual analysis might be organised: "hermeneutic", "semantic", "proairetic", "cultural" and "symbolic" for textual analysis.[277] Perhaps most importantly we also have cryptic codes. In this final sense of the word, code refers explicitly to a set of rules which may not be accessible or known (also suggested by post-structuralist codes), that might require a cipher to solve. In this usage code becomes a verb: to code something is to enter it into such a system, and to decode is to remove it or to reveal its true meaning (though encode/decode hold similar meanings, they were not used before the birth of computing).[278]

Friedrich Kittler's history of code focuses almost entirely on this root: he traces codes to Julius Caesar in the 1st century BC, who used a simple shift cipher in his letters, moving each character in the alphabet over (e.g. A → B, HELLO → IFMMP, etc.).[279] There is some evidence that similar encrypted codes had been used before this, but Caesar's cipher is especially well documented,

[273] "encode", *OED*; "code, n.", *Oxford English Dictionary* (September 2020)
[274] "code, n.", *OED*
[275] Ibid.
[276] Foucault, p.xx
[277] Roland Barthes, *S/Z* (Oxford: Blackwell, 1974), p.20
[278] "code, v.", *Oxford English Dictionary* (September 2020)
[279] Friedrich Kittler, "Code", *Software Studies: A Lexicon* (Massachusetts: MIT Press, 2008), pp.40-47

specifically in Suetonius' *De vita Caesarum*.[280] Kittler is typically preoccupied with the military aspect here, and treats coding as synonymous to cryptography. Indeed, Julius Caesar wouldn't have used the word "code", or any etymologically related term; there is no word in Latin to describe such a system. Suetonius settles for describing it as "sic structo litterarum ordine, ut nullum verbum effici posset [such a structured order of letters, that no word could be formed]".[281] It wouldn't be until 400 years later, that Justinian I's legal code would give "codex" the balance of meanings required to represent both abstract symbols and their material expression, both obfuscated script and cipher. So, "code" can refer to any system of rules governing some set of things (the code), but also to individual things in that system (this code), or the act of entering or removing something from that system (to code).

Beyond cybernetics, the key theorist of this generalised "code" is Umberto Eco. Eco's codes are not just technical but also social, moral or linguistic; they define terms of behaviour and expression, govern interpretation and meaning. Semantically, such codes constitute the rules by which signs are generated as "concrete occurrences in communicative intercourse."[282] This does not mean that signs are themselves fixed or organised by code; the reality, in Eco's analysis, is that the sign really constitutes "a highly complex network of changing relationships", not Saussure's classical notion of a sign, formed by a fixed signifier and signified, bound exclusively to one another, but a momentary relation.[283] Hall inherits this definition of code as the basis of his "meaning structures".[284] While broadly synonymous with "codes", these are always expressed in reference to specific encoders or decoders: codes are generic, meaning structures particular. But meaning structures also imply division between the code as an organising principle and its expressions as local occurrences (Hall's central focus in on variety in decoding).

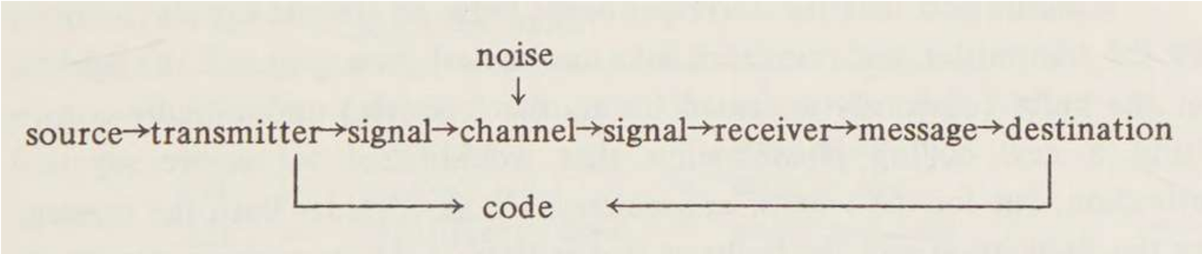

Figure 2.4 Eco's diagram of a communication system, taken from *A Theory of Semiotics* (1976). Eco's schematic elaborates on Shannon's with a "code", an anticipation of the destination in a transmitter according to which a message is constructed.

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[280] Charles Mann, "Unravelling Khipu's Secrets", *Science* 309.5737, pp.1008–1009; Edgar Reinke, "Classical Cryptography", *The Classical Journal* 58.3 (1962), p.11; Suetonius, *De vita Caesarum*, https://penelope.uchicago.edu/Thayer/L/Roman/Texts/Suetonius/12Caesars/Julius*.html [28/04/2022]
[281] Suetonius, p.78
[282] Eco, *The Open Work*, p.49
[283] Eco, *The Open Work*, p.49
[284] Hall, p.230

Eco is more interested than Hall in the overall structure of the communication system. A code, in his analysis, is established between transmitter and destination (not the receiver but some interpreter), colluding from either end of the channel (fig-2.4), a more complex operation than Shannon acknowledges.[285] Together, the encoding and decoding processes form a (social, cultural, technical, linguistic etc.) assemblage that governs meaning, they actualise rules for communication and interpretation. It is the total of this system which constructs the code, and therefore determines the creation of signals.

3) Channel

Channels are grooves or furrows; in information theory they are the routes through which communication is described as occurring: "merely the medium used to transit the signal from transmitter to receiver."[286] Important to my own study, they are the in-between that communication is theorised as occurring through.

Shannon is disinterested in the specificities of medium. The channel, as he invokes it, is a conceptual abstraction through which a signal travels. This could be air, copper wire, a train or cargo ship, time, anything which separates sender from receiver; the in-between of communication, a domain of technical media, not humans, who are positioned beyond the edges of its analysis (fig-2.5).[287] The channel isolates and orients the material before and behind analysis

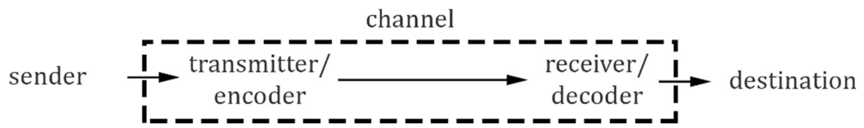

Figure 2.5 Illustration of the isolation of Shannon's channel from its human participants, who are located beyond the edges of analysis.

(and hence re-orientation also changes the analysis); if a communication/ information diagram can be read as a kind of map, the channel is the organisational principle around which all its elements are formed, even and especially as something which is never labelled. It is, literally, a kind of representation of space (in Henri Lefebvre's sense): it is not arbitrary that the line running through its centre closely resembles a wire, the primary channel of telecommunication while Shannon was working for Bell Labs.[288]

But Shannon's abstraction is unstable, and the channel is a key location in his analysis partly because it is where the engineer has least control over the signal. In doing so Shannon constructs

[285] Eco, *A Theory of Semiotics*, p.142
[286] Shannon, p.34
[287] Katherine Hayles, *Writing Machines* (London: MIT Press, 2002), p.130
[288] Henri Lefebvre, *The Production of Space* (Oxford: Blackwell, 1974), p.33

a specific analytical perspective. The statistician Edwin Thompson Jaynes has described the specific perceptual logics embedded in Shannon's theory:

> It seems at first that if information is being 'sent', it must be possessed by the sender. But the sender knows perfectly well what message he [sic] wants to send; what could it possibly mean to speak probability that he will send message M_i?[289]

The message, Jaynes is suggesting, requires statistical description precisely because the engineer (or encoder) does not possess 'their' message; Shannon's construction of the channel (in general, theoretical terms, but also in specific technical ones) is a product of "ignorance" not omniscience.[290] His engineering perspective is one produced by a vulnerability to the possibility of variation in the channel; from a loss of control after the determinate moment of encoding.[291] There are reasons to doubt the isolation of Shannon's bifurcated channel, as examination of the key concept of noise will help to demonstrate.

One strength of Shannon's analysis is his acceptance that messages will be disturbed by the channel – as "noise" – and theorises it as a key characteristic of the channel.[292] Noise, for Shannon, cannot be wholly routed, and is instead treated as a statistical quantity to be anticipated and domesticated via redundancy, the repetition of information in a message.[293] Redundancy can be measured as a statistical quantity in any given communication system; a greater amount of redundancy results in a greater potential for efficient encoding (compression), whereas less redundancy (and hence more entropy) reduces the potential for compression to take place. Assuming noise will distort sections of the message, redundant information also acts as a form of coverage, making it easier to reconstruct the message at the other end of the channel. Weaver notes, for instance, that the English language has a redundancy of "just about 50 percent", meaning that if you were to construct a word letter by letter, half would be dictated by statistical probability, and the other half by choice. [294]

We should be suspicious of Shannon and especially Weaver's invocation of 'noise', a category, long associated with industrial and social control.[295] Karin Bijsterveld has demonstrated the treatment

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[289] Edwin Thompson Jaynes, "Where Do we stand on maximum entropy?" *Maximum Entropy Formalism Conference* (MIT, 1978), p.23
[290] Jaynes, p.24
[291] Cf., Hayles' description of the counterposed perspectives of Shannon and Leon Brillouin, derived from different professional orientations; Katherine Hayles, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* (Ithica: Cornell University Press, 1990), p.59
[292] Shannon, pp.65-66
[293] Ibid., p.56
[294] Ibid., p.13
[295] Karin Bijsterveld, *Mechanical sound: technology, culture and public problems of noise in the twentieth century* (London: MIT Press, 2008)

of noise throughout the 20th century as something to be restricted, reduced and legislated against – not just annoying but dangerous.[296] Bijesterveld reveals complaints about noise frequently act as a proxies for objection to social change: new industrial practices, growing cities and neighbours all produce noise, especially if they are unwanted.[297] Ronald Radano has described, for instance, the categorization of slaves in the American south as "noisy means of production", to be silenced or co-opted.[298] Noise is integrated into Shannon and Weaver's models as a damaging, corrupting force: something always to be guarded against. As Weaver expands information beyond communication, he sits in this tradition of aligning it with political disturbance, in the pursuit of their domestication.

Mobilization towards the domestication of noise miss the value of interference. An alternative, positive case for noise is offered by French biophysicist and philosopher Henri Atlan, in his analysis of random mutation in immune systems.[299] He argues against Shannon:

> For Shannon, who wants to preserve the message, noise is the destroyer and redundancy of the message is the premium we pay to ensure fidelity despite noise. But according to the theory of self-organization, noise (mutation) is the (blind) creator of new information and redundancy is not the cost of fidelity, but an asset, the vehicle for change.[300]

Redundancy remains a form of coverage in Atlan's model, but it is not a sacrifice to keep noise at bay. Rather, it is the space in which noise (and the generation of new information) can occur without jeopardising old information. It is through noise that information generates new meaning. In the biological systems Atlan is concerned with, noise is the necessary and only precursor to novelty. "First noise," says Atlan, "then music."[301]

Atlan departs sharply from Shannon not only in focusing on the generative potential of noise but also in concerning himself with meaning. Meaning in his account is not separable from information, it exists as a function of the interaction of some framework of reception and interpretation with information. Specifically, his account describes the chemical interactions

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[296] Designations of noise are not always problematic, but we should be attentive to the social and political functions they play; Bijsterveld, pp.91-93
[297] E.g.: Bijsterveld, p.33; p.94-95; pp.159-160
[298] Ronald Radano, "Black Music Labour and the Animated Properties of Slave Sound", *Boundary 2* 43.1 (2016), p.183
[299] Henri Atlan, "Immune Information, self-organization and meaning", *International Immunology* 10.6 (1998), pp. 711-717; Jacques Attali ascribes noise with radical liberatory potential in *Noise: The Political Economy of Music* (Manchester: Manchester University Press, 1985)
[300] Atlan, p.712
[301] Ibid., p713

between antigens and antibodies, “the type of immune response the antigen generates.”[302] It is through random mutation (noise) that novel relations of meaning are generated. Far from being irrelevant to the construction of the system, then, it is noise which shapes it. It is therefore not necessary for the information encoder to share this framework with the decoder. Meaning emerges from the relation between message and decoder; without decoding, information is meaningless.

Atlan’s observations have been taken up by the philosopher Michel Serres, most extensively in his book *Parasite*. What Atlan found to be true in genetics – that noise generates novelty – Serres sees as universal. Playing on a pun (“le parasite” refers to noise in a channel, a pest and an abusive guest) Serres describes parasitism, not the subject and object, as the basic mode of relation.[303] “The relation denoted by a single arrow is irreversible” Serres writes; Shannon’s simplification of communication theory into a journey from left to right fails to account for the dynamics of the channel itself, for the generative capacity of noise and the reciprocal qualities of communication (fig-2.6).[304] Noise, to Serres, doesn’t represent a stable distortion but a reorganising principle, a return of the forgotten, the unknown or the suppressed, an interruption from a wider channel which “gives rise to a new system… more complex than a simple chain”.[305] If Shannon contains

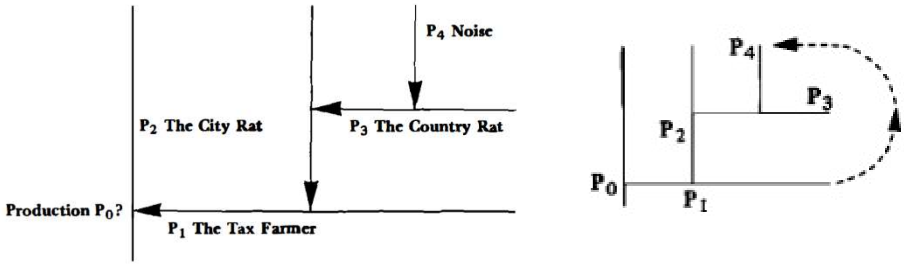

Figure 2.6 A cascade of parasites as graphed by Serres in *Parasite* (1980), finally broken only by noise; the return of an older channel

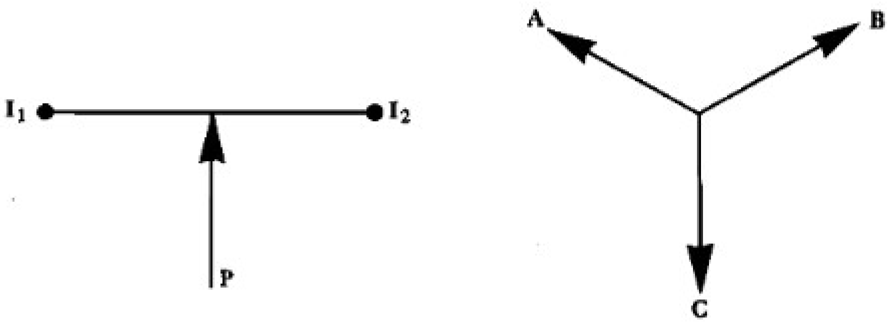

Figure 2.7 Serres offers two graphs of interruption. All signals, he suggests, are another’s noise.

[302] Ibid., p.713
[303] Serres, p.8
[304] Ibid., p.5
[305] Ibid., p.14

communication in a series of discrete and complete systems, situating analysis beyond them, Serres never leaves the channel.[306]

It is precisely noise's designation beyond analysis which makes it noisy; and so, it cannot exist without a decoder to designate it as such. One decoder's noise might be another's message (and vice versa). When something is excluded or unanticipated by the code (or by analysis) it becomes noise.[307] The denial on which Shannon's theory is based – that of the outside, and of its permeation into the channel – can only ever last so long. The interrupter, Serres shows, is also interrupted (rats are scared from the room, but whoever enters is also scared by the rats); Serres refers to this moment as the "oscillation" of the system, and the roles of its various inhabitants are exchanged indeterminately (fig-2.7).[308] What Serres helps demonstrate is that channels are not really stable or singular, as Shannon presents them. Properly understood, they ought to be ecological, not hierarchical. And this threatens the viability an information theory model of communication. Eco responds by acknowledging the limitations of such an analysis: the relations of code are "transitory", only stable for the duration of expression.[309] Serres, meanwhile, abandons Shannon's binary diagram altogether in favour of complexity: chains, cascades and lattices.

The instable expanse of communication leaves Shannon's isolated channel unstable and illusory. Eco's contention that semiotics operate in "transitory" manner is useful in suggesting the stability of a channel can only last a moment.[310] If analysis want to remain attentive to that which Shannon suppresses – to accident and noise – it might shift and place what Shannon defines as the edge of analysis – the codec – into its centre.

4) Codec

Codecs are the technical devices that encode or decode signals, the locations of information processes which are the core focus of my thesis.

Shannon doesn't refer to encoders or decoders, but to transmitters and receivers: devices which put something into or take out of code in a channel (and specifically – for all his insistence on generality – the devices used in telephony). Today computer scientists hold all these things under a single word: codec, software or hardware that processes information.[311] Codec, handily, is a near

[306] Cf. Hayles' critique of Serres; Katherine Hayles, "Two Voices, One Channel: Equivocation in Michel Serres", *SubStance* 17.3 (1988), p.7
[307] Eco, *A Theory of Semiotics*, p.5
[308] Eco, *The Open* Work, p.49; Serres, p.53; Hayles has argued that the introduction of technical devices into Shannon's channel itself anticipates interruption; *Chaos Bound*, p.55
[309] Eco, *A Theory of Semiotics*, p.49
[310] Ibid.
[311] "codec", *Encyclopaedia of Computer Science and Technology* (2017), https://search-credoreference-com.gold.idm.oclc.org/content/entry/fofcomputer/codec/0 [28/04/2022]

homophone, at least in plural, “codecs”, to codex. If a codex was a reference for a code as a system of laws, a codec holds a similar relationship to digital code. "Codec” can refer to any software (or device) that defines and performs data encoding and decoding processes.

But the instability of the channel suggests a need for an expanded conception of codecs. Indeed, there is a long tradition of expanding such language beyond technical systems. Jakobson’s semiotics follows Shannon in omitting the encoder, but he describes encoding as the act of sign production performed by a human.[312] Eco’s *Semiotics*, does use the words encoder and decoder to describe humans on either end of technical and non-technical coded systems: communication devices, language, social codes, cultural conventions, etc.[313] And, of course, Hall appropriates this for his encoding/decoding model. This mode of approach is ubiquitous in cybernetics, perhaps most clearly embodied in Donna Haraway’s cyborg – an assemblage of biological and technical elements socially coded as textualized bodies.[314]

The most useful definition of a codec I’ve encountered, though, appears in the JPEG-1 specification: as “An embodiment of a coding process”.[315] To get the most out of this definition, I want to extend my own tactical distinction between a codec and a protocol. The JPEG standard itself describes a protocol: a set of instructions for carrying out a process. Implementations of this protocol are codecs, embodiments of its process.

Embodiment is a curious and loaded term for a technical document: it suggests the encoder isn’t a device separate from production, but literally the coming together of production; the coming together of disparate things – of separate channels – to produce something else. When Marx talks of "embodiment” of labour in commodities he is referring both to labour as a source of value, and to the reflection between a social division of labour and the commodities it produces, which have dual character.[316] In this sense the value generated by labour is not just a quantity but an effect – alienation – and Marx's phrase gestures towards the embodiment of the commodity in its production. This is a productive way to conceptualise the codec: the embodiment of those things producing the signal (technical, yes, but also social, legal, mechanical, semiotic, aesthetic, etc.).

As cultural phenomena in the most general sense, information processes might be conceived of as protocols. These would take the form of a simple imperative: Copy. Delete. Compress. Encrypt. etc. But at the point that a system (economic or otherwise) can be seen to produce the effect, they become codecs. If, as I’ll go on to argue in my chapters on compression, there are a set of drives

312 Jakobson, p.38
313 Eco, *A Theory of Semiotics*, pp.36-38
314 Donna Haraway, *A Cyborg Manifesto* (Minneapolis: University of Minnesota Press, 2016), pp.11-12
315 “ISO/IEC 10918: 1992” [JPEG-1], Joint Photographic Experts Group (September 1992), p.3; To my knowledge, the earliest use in a technical standard.
316 Marx, *Capital Vol.1*, p.150, pp.132-133

within capital accumulation which require the production of compressions, then these can be analysed as embodied codecs with all the complications and subtleties that entails – including the possibility of acting beyond or against the ostensible intentions of the encoding process.

As an embodiment, a codec has no a priori body: its body emerges through its own act of production. Algorithms, for instance, require code, hardware and operators who can bring these things together – reflected in real archaeological challenges understanding algorithmic objects whose operators and cultures have passed.[317] The idea of body (human or otherwise) as a particular kind of social (re)produced technology has been well discussed in trans studies, for instance in the collection edited by Nikki Sullivan and Samatha Murray, *Somatechnics* (as well as the journal of the same name), which challenges the "naïve materialism in which 'the body' appears as a fleshy substrate that simply *is* prior or in excess of its regulation."[318] Because they embody production processes, codecs tend to produce some sense of themselves. They define themselves after the fact through production. Hence within neoliberal capitalism our own bodies produce an idea of our individuated subjectivity, but within different social and economic conditions they might produce different kinds of subjectivity – different relations to each other and the world.

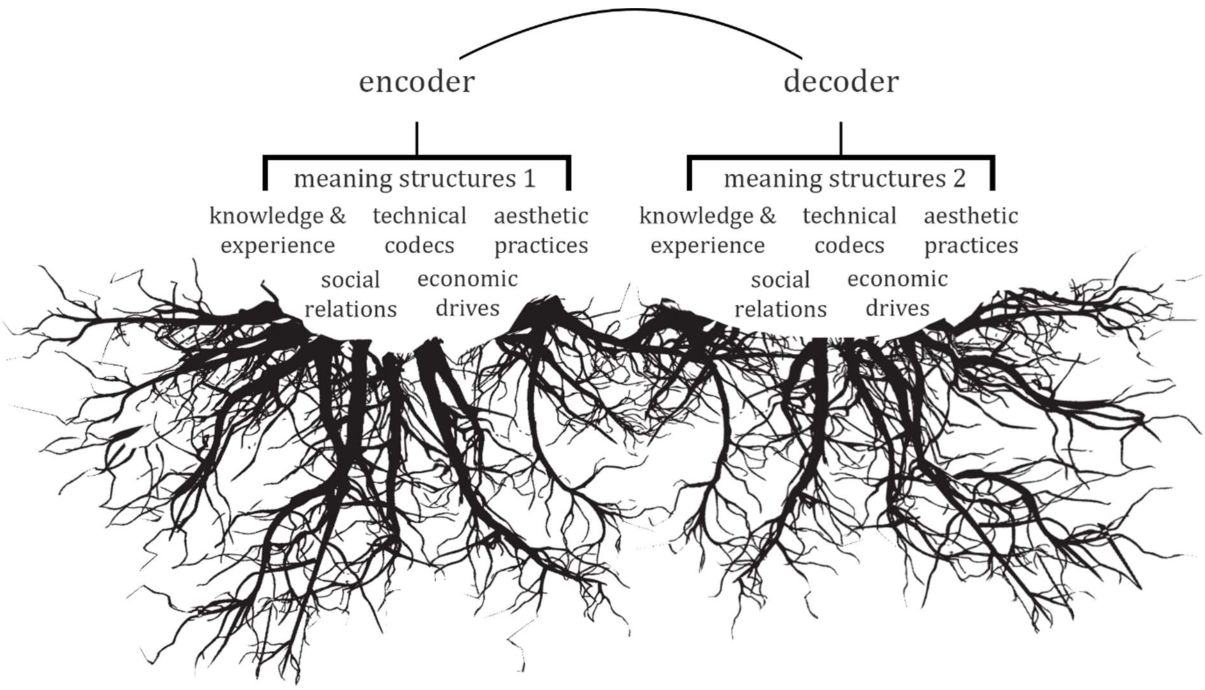

Figure 2.8 Two codecs, constructed in terms of Hall's meaning structures, opened into a larger network of messages and determinisms (an ecology of channels)

[317] As in Link, p.113

[318] Nikki Sullivan and Samantha Murray, *Somatechnics* (Farnham: Ashgate, 2009), p.1

In Hall's account, drawing from Eco, encoders/decoders are made up of meaning structures.[319] We might imagine codecs, then, as a bundle of such meaning structures which determine production. Their coming together is something like the fold in Deleuze's monad: "not merely that which has many parts, but that which is folded in many ways".[320] Meaning structures determine production, not as a vulgar or absolute determinism but, following Henri Lefebvre, a "determination not entailing determinism" – the unpredictable meeting of causal elements, which are themselves the codec.[321] Hall's television producer doesn't construct messages from nothing; as in Noam Chomsky's "filters" there are technical and social factors which determine media production.[322] But to graph these as a mediation (as Chomsky does) is inadequate: the technical and industrial aspects of production do not come after expression, but before and around it. Mediation here implies some pre-mediated state; what Chomsky names the "raw material" of news.[323] Because it must be material, there is no raw material of news (and no unmediated information) – news could not be produced without the arrangements that, Chomsky says, "filter" it.[324] Such meaning structures are not discrete or isolated – they relate to each other through commonly held codes, as part of an ecology of signals and channels (fig-2.8).

The boundaries of a codec are contestable, and their scale variable, but this does not mean they are arbitrary. Embodiment demands some kind of togetherness; codecs must work on a process together. As I'm using the term, a codec is formed of the things that carry out a coding process: physical laws, social and cultural conventions, linguistics, economic arrangements, institutional structures, technical devices, human psychology, etc. The crystallization of these things in the production of a signal, also effectively produces the codec as a discrete technical device.

Hall's meaning structures are liable to change, and with them production. "In a determinate moment", he describes, "the structure employs a code and yields a 'message': at another determinate moment, the 'message,' via its decodings, issues into the structure".[325] There is an important distinction to be made between the average message, whose influence on meaning structures is ephemeral and that of concrete infrastructures or large-scale determining systems like capital. As studies like Shannon Mattern's *Code + Clay… Dirt + Data* reveal, there is often less than we would expect separating media – conventionally understood – from architecture.[326]

[319] Hall, "Encoding and Decoding…", p.259
[320] Gilles Deleuze, "The Fold" *Yale French Studies* 80 (1991), p.228
[321] Henri Lefebvre, *Rhythmanalysis* (London: Continuum, 1998), p.12
[322] Noam Chomsky and Edward Herman, *Manufacturing Consent: The Political Economy of the Mass Media* (London: The Bodley Head, 2008), p.62
[323] Ibid., p.78
[324] Ibid., p.61
[325] Hall, "Encoding and Decoding…", p.260
[326] Shannon Mattern, *Code + Clay… Data + Dirt: Five Thousand Years of Urban Media* (London: MIT Press, 2017)

Buildings and monuments are in the first instance messages, but they are not fleeting; as the breakdown of seemingly timeless messages, the melting of glacial ice is deeply permeated with semantic content.[327] Consider the act of walking across a field: the first few walkers leave footprints, indexical traces of their route chosen somewhat arbitrarily; it doesn't require too many more walkers to wear down the grass and form a path. If the grass grows long in the spring, that worn path will be many people's only option. Such desire lines are messages which have become infrastructures. Via repetition, enforcement or amplification some messages become more concrete than others.

That Hall talks of "determinate moments" is curious.[328] Codecs offer a productive intervention to problems of determination in technical media (discussed previously): beyond vulgar technical or social determinism, they suggest the consolidation of these varied determinisms into specific devices, relations and moments. Like all information theories, Hall's is active upon its objects; in identifying meaning structures it opens the possibility of acting upon them, and in doing so transforming the codec. From Hall's analysis, we might make oppositional viewers of the negotiated; in the case of technical codecs, we might re-orient existing infrastructures to new purposes.

Information Theoretical Analysis

I've argued in this chapter for an expanded information theory centred on codecs as the meeting-points of channels: determinate moments in wider circulations of causality. Information theory offers a remarkably flexible vocabulary (one reason why even its critics – Morley or Hall – are sometimes drawn to its terms). Take this somewhat obscure passage of Marx's *Grundrisse*:

> If it is said that capital is exchange value which produces profit, or at least has the intention of producing profit, then capital is already presupposed in its explanation, for profit is a specific relation of capital to itself. Capital is not a simple relation, but a process, in whose various moments it is always capital.[329]

Capital, here, is not a thing but a *process*, a realisation of profit from exchange value in pursuit of accumulation. Indeed, one way of understanding capitalism is as a self-stabilising cybernetic system, as a circuit oriented around forms of productive process, which can be conceived of as codecs. What Marx calls "capital" would therefore be a consolidation of a number of codecs:

[327] See, e.g. Olafur Elisasson and Minik Rosing's *Ice Watch* installation, in which twenty-four large blocks of ice were left to melt outside the Tate Modern
[328] Hall, "Encoding and Decoding…", p.260
[329] Marx, *Grundrisse*, p.258

embodiments of particular processes of capital accumulation, among which both compression and encryption would be found.

Information theoretical analysis can be disquieting. Foucault praises it as such in his review of Francois Jacob's information theoretical genetics, *La Logique du Vivant*.[330] Its alienated anti-human perspective may "desacralize life", but it also, as Christopher O'Neill has suggested, disempowers those forms of order, power and control which attach themselves to the human.[331] To historical materialism, information theory can offer a route into an anti-humanist materialism invested first of all in understanding the systems of capital accumulation as systems.

Information sustains analysis at a number of scales: I've described, e.g. a production system (television), a specific instance of human communication (a conversation), or minutia within the body (cellular reproduction) and the process of capital accumulation with the same terms. There is an allure to this flexibility: from the highest level to the most minute, any such analysis can and should be chased down a well of causation. Zooming in further on the communicative expanse, encoder/decoders might be dissolved entirely, revealing instead a chain of basic interlinked causalities – essentially what is described by Whitehead's metaphysics. But there can be pitfalls to thinking with Whitehead: Isabelle Stengers has rightly suggested that Whitehead's famous description of the stone obelisk, Cleopatra's Needle, on the London Embankment as engaging in a constant "dance of electrons" tends to obscure that the obelisk had been in modern day Egypt for almost 2000 years, but was extracted and moved to London during Whitehead's lifetime.[332] Whitehead is clearly playing on the idea that something so solid might move, but "the story that insists through" his metaphor is not one of colonial extraction.[333]

This co-existence of micro and macro analysis is bewildering; as an ontological mode it obscures and exposes, clarifies the material basis of analysis while becoming conceptually abstract. Functionally, it can be a noisy framework to operate in and any such analysis must be calibrated: scale, position and resolution are vital concerns. I should be wary of a fractal horizon, beyond which such models are no longer practically meaningful. Zachary Horton attends extensively to the generative, occluding and revealing properties of alterations of scale in his book, *The Cosmic Zoom*.[334] An ecologically oriented media theory, Horton argues, "must work at all scales without

[330] Quoted from O'Neill, p.11
[331] O'Neill, p.12
[332] Isabelle Stengers, *Thinking with Whitehead: A Free and Wild Creation of* Concepts (London: Harvard University Press, 2011), p.41; Alfred North Whitehead, *The Concept of Nature* (London: Cambridge University Press, 1920), p.107
[333] Stengers, p.41
[334] Zachary Horton, *The Cosmic Zoom: Scale, Knowledge and Mediation* (London: University of Chicago Press, 2021)

collapsing their difference… It must go all around the circuit of scalar mediation."[335] That is, it must be able to conceive of both the dance of electrons and the stone obelisk, as well as the forces which move it. Information theory is most usefully conceived as a tool for wrenching a finite number of threads out of the communicative expanse and rendering them legible. But in rendering communication navigable it is also transformative.

Rosa Menkman raises the related question of resolution in optical systems; this is the question of how the competing systems which determine visibility resolve in the production of a particular image (technical, infrastructural, social).[336] Especially important, for Menkman, is the question of how systems of power consolidate themselves within cultural norms, technical standards and devices, and the extent to which these preclude alternative standards which might produce different kinds of resolution.[337] Resolution is attentive to a cycle between infrastructure, perception and culture – it is complimentary to the analytical utility of codecs as I have articulated them exactly in opening the possibility of intervention. Shannon's original essay is oriented towards "efficient encoding", which we now call compression, but it is just as easy to imagine other orientations of systems towards other organisational priorities: the maximisation of fidelity, or the minimization of noise (both of these, in fact, are subsidiary concerns of Shannon's), or perhaps towards a different productive paradigm, not sought after in Shannon's text at all.[338]

Gilles Deleuze once asked for: "A 'cryptography'… which would both enumerate nature and decipher the soul, see into the coils of matter and read in the folds of the soul."[339] The key technologies of my thesis are both embodied in codecs, technical devices and the consolidation of disparate determinisms. Information theoretical analysis suggests something might be learned from their close investigation. This is not an easy task – as Adrian Mackenzie has written, codecs are themselves "monstrously complicated".[340] They can also be duplicitous: even in the case of technologies which are well documented (e.g. JPEG-1), in line with Hall's theorisation, there is no guarantee that what is described in the specification will match its actual use. Moreover, opacity (discussed in Chapter Nine) has become the habit of our technical infrastructures, which are now largely private. The remaining chapters of the thesis, on compression and encryption, comprise an investigation of the digital culture of today through its codecs.

[335] Horton, p.28
[336] Menkman, *Beyond Resolution*
[337] Ibid.
[338] Shannon, *A Mathematical Theory of Communication*, p.59
[339] Deleuze, *The Fold*, p.228
[340] Mackenzie, "codecs", p.48.

Part two

Compression

Chapter three

Aspects of compression

For thirty-five years I've been compacting wastepaper and books, smearing myself with letters until I've come to look like my encyclopaedias… I look upon my brain as a mass of hydraulically compacted thoughts, a bale of ideas.

Too Loud a Solitude (1976), Bohumil Hrabal

So goes the life of Hanta – Hrabal's solitary paper press-operator. Each day, in the push and pull of his basement press, he compacts great works of literature and rags alike into cubes. The English translation says "compacting", but the Czech "lisovat" translates just as well as "to press" (often more specifically "to machine press"). As a compression codec, Hanta's press is itself a bundle of disparate determinisms. First, the compression of paper into cubes. But the basement forms part of the city's metabolism: the jaws of Hanta's press push together to make cubes of the city's surpluses – unread texts, bloody rags and scrap paper – sending them on to be pulped at a paper mill. This second compression is economic: of circulation time, the rate required to deliver the bales to the mill. Hanta is a poor compressor – he agonises over each cube, painstakingly constructing his bales like works of collage. A third compression: poetry.

Uncompressed, books pile up in the street above his basement, weighing down on top of the man until he appears smaller than he once was.[341] A fourth compression: of the press and its operator. Hanta's practice is artisan, literary in its ambitions and not coded to the metabolic demands of the city: he is made redundant by a new, more efficient press, operated by a team of strong milk-drinking socialist subjects, disinterested in the content of their bales and capable of compacting ten times as much as Hanta.[342] As paper and books are cleared, a greater compression takes place: more wastepaper is moved more quickly. Compression accelerates to match growth.

[341] Bohumil Hrabal, trans. Michael Henry Heim, *Too Loud a Solitude* (Houghton Mifflin Harcourt Publishing Company: New York, 1990), p.18
[342] Ibid., p.47

Newly antiquated, Hanta has an apocalyptic vision: all of Prague – himself included – swept up into the press and compacted between its massive jaws, producing yet another cube (and a fifth compression). Dreading this, he returns to his press and climbs in with the paper: a final compression. Hanta's vision holds a realisation: even in obscurity, the press makes the city. It is ecologically arranged, produced by and producing its surroundings; it is a fold, a codec. To introduce a new press is to introduce new codes for circulation and production. What will the armies of rats who swarm his basement for blood-soaked rags eat?[343] What will the new surplus of recycled paper give birth to? What will happen to Hanta under its new regime? The new press entails a paradigm change; none of Prague will escape it, and Hanta prefers to die in the channel he knows.

Hanta and his press form a typical compression codec: an embodiment of economic, mechanical, aesthetic and social concerns. They operate in the form of a cascade across the economy of Prague; so too, data compression cascades into our senses. All digital signals – films, television, music, texts, images and everything else rendered from code – are subject to compression. All these things are altered; their processing is also a production. But signals do not stop at the end of the channel, and the repercussions of compression resonate beyond the aesthetics of these media forms. Most simply, this manifests as an intensity, of production, and ultimately consumption; a kaleidoscope of aesthetic encounters with radical consequences for us as media subjects and producers of signals.

This chapter introduces compression generally and data compression specifically. Compression codecs embody vying determinisms, not neatly aligned to a single set of interests. I begin with a sense, pervading much art and writing, that modernity and postmodernity have been defined by a bewildering acceleration; such perspectives endure into the present, where data compression often enacts a literal decay of signals travelling at speed. A body of critical literature has sought to address this subjectivity in terms of aesthetics, culture and ultimately economics; perhaps most helpful is David Harvey's concept of time-space compression – an account of the economic and geographic compression of space within an inflationary capitalist economy – which is integral to my understanding of data compression. But data compression does not only circulate information-commodities, indeed it has often facilitated forms of non-capital accumulation and undermined the circulation of conventional commodities. It therefore raises questions about how this abundance might differ from capital accumulation, and whether it remains viable at planetary limits to growth.

[343] Ibid., pp.19-20

Data compression

> *Data compression* is, in the context of computer science, the science (or art) of representing information in a compact form. It has been one of the critical enabling technologies for the ongoing digital multimedia revolution for decades.[344]
>
> *Fundamental Data Compression*, Ida Mengyi Pu

Data compression is the process of dividing a signal up into discrete units – bits – and rearranging them for efficient travel, or to occupy minimal capacity in storage.

The theoretical origin of all our data compression technologies is Shannon's *A Mathematical Theory of Communication*, though he uses the term "efficient coding" – and his definition of this remains implicit.[345] Efficient coding is not straightforwardly the greatest reduction in size; too much coding can be inefficient, when the work/ time required to generate it becomes too great.[346] For this reason, his conception of efficient coding is best understood in terms of circulation speed, not smallness. The goal of such a formation is faster transmission, a greater flow of information; a definition that is derived (as I argued in Chapter One) from the economic concerns of his employers.

Data compressions are not isolated processes. The flow of digital multimedia culture enabled by compression is central to Ida Mengyi Pu's textbook definition, as much as the making of things smaller. "Without compression techniques" Pu claims, "none of the ever-growing Internet, digital TV, mobile communication or increasing video communications would have been practical developments."[347] Compression techniques are a function of, and a precursor to, the circulation of the so-called "information economy" both in the application of computational systems for traditional logistics and the actual circulation of information-commodities: software, digital music and video, online services, etc. Within such an economy, compression reduces the size of signals, speeding up their transmission and allowing more to be circulated, more quickly. The end result is a compression of circulation-time, and an expansion of economic activity.

The first wave of data compression techniques (those of Shannon and his colleagues) were lossless: they attempted to completely reconstruct the source data at the end of the channel. Early attempts at circulating audio-visual data digitally followed the same principle. Image scans may

[344] Ida Mengyi Pu, *Fundamental Data Compression* (Oxford: Butterworth-Heinemann, 2005), p.1
[345] Shannon, *The Mathematical Theory of Communication*, p.62
[346] Ibid., p.17
[347] Pu, p.1

have been low resolution and imprecise (and in this sense lossy) but the encoding and decoding of that signal on either end of a telegraph wire followed the same lossless methods as other transmissions.[348] Today, JPEG is the most prevalent compression schema for still images, ubiquitous on the web and on smart phones. More JPEG photographs are taken each year than film photographs that have ever been taken, but JPEG holds historical significance besides such ubiquity, as the first application of perceptual coding: a mode of lossy compression which deletes information deemed unimportant for human perception.[349] The most widespread sound and moving image compression schemas in use today are all downstream of JPEG, most clearly MPEG and its successors. Without the development behind JPEG (and in particular a statistical function called the Discrete Cosine Transform), the abundant audio-visual culture of the past thirty years simply would not have materialised. Given JPEG's position at the vanguard of this change, it is perhaps not surprising that it remains so prominent thirty years after publication.

A view from the press

> We are in a rush. We are making haste. A compression of time characterizes the life of the century now closing.
>
> James Gleick, *Faster*

James Gleick's book *Faster: the acceleration of just about everything* belongs to a well-defined genre of cultural thesis that state modernity (and the contemporary) can be defined by speed.[350] Through technology, Gleick argues, life is accelerating to the point that our bodies' biological limits have been surpassed.[351] In doing so, he aligns himself with a modernist sentiment: a vision of society lost to speed, a blur in which things begin to vanish entirely (fig-3.1).[352]. A key invocation (with a different tone – jubilation not despair) comes from the Italian Futurists: "We declare that the splendour of the world has been enriched by a new beauty: the beauty of speed".[353] Filippo Tommaso Marinetti's provocation which would become an artistic and intellectual companion to Italian Fascism. These tendencies merge in strands of accelerationist thought: "Nothing is more

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[348] Maynard McFarlane, "Digital Pictures Fifty Years Ago", *Proceedings of the IEEE* 60.7 (1972), p.768
[349] Hudson et al, p.7
[350] James Gleick, *Faster: the acceleration of just about everything* (London: Little, Brown & Company, 1999), p.9
[351] Ibid., pp.15-21
[352] See, e.g. Alberto Toscano's on the "promethean gap", a view that humans have been exceeded by their production; "The Promethean Gap: Modernism, Machines, and the Obsolescence if Man", *Modernism/modernity* 23.3 (2016), p.604
[353] Filippo Tommaso Marinetti, "The Founding Manifesto of Futurism", *Futurist Manifestos* (Boston: MFA Publications, 1970), p.21

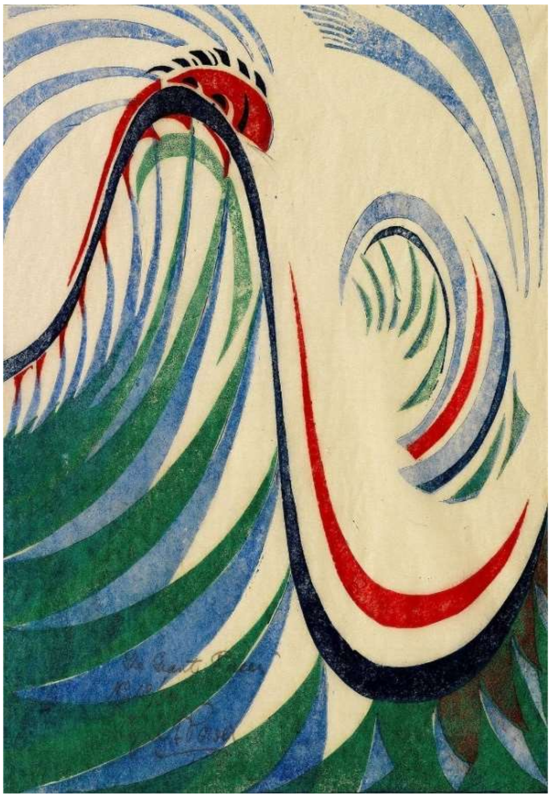

Figure 3.1 Cyril Power, *The Giant Dipper* (linocut print, 1930s)

In portrayal of speed breaking complex forms down into simple, abstract and distorted ones, Power’s print is a somewhat typical modernist portrayal of acceleration via technology.

infectious than the passion for collapse”, writes Nick Land, whose work slides from condemnation to the valorisation of speed, finally landing on a banal conservatism.[354]

Paul Virilio is the foremost philosopher of a technologically-blurred subjectivity. He has traced dromology (the science of speed, literally of “the racecourse”) through Nietzsche (and much earlier – “the world as we see it is passing”, he quotes Paul of Tarsus at the beginning of *Aesthetics of Disappearance*).[355] Indeed, soon after the industrial revolution, Nietzsche decried that thinking itself had sped up and spread out: “it is as if we carried in our heads an unstoppable machine that keeps working even under the most unfavourable circumstances.”[356]

Compressions and accelerations come together: an expansion in space produces a compression in time, and vice versa. In physics, if an object can drop mass it can travel faster. In logistics, if a commodity can travel faster its circulation requires less time. And so, Virilio’s account of accelerating culture describes a counterposed temporal compression, in which society changes faster than its inhabitants can comprehend.[357] “Beyond 60 frames a second”, he claims, “you can

[354] Nick Land, *Fanged Noumena* (New York: Sequence, 2011), p.247; Robin McKay and Ray Brassier’s introduction to this collection concedes a “degeneration” of Land’s work from “scalpel-sharp dissection of the body of capitalism” to “a superlative cosmic version of the familiar neo-liberal narrative”; Editor’s Introduction, *Fanged Noumena* (New York: Sequence, 2011), p.51

[355] Paul Virilio, *Politics and Speed* (Los Angeles: Semiotext(e), 2006), p.84; Paul Virilio, trans. Philip Beitchman, *The Aesthetics of Disappearance* (NYC: Semiotext(e), 2009), p.17

[356] Friedrich Nietzsche, *The Gay Science* (New York: Vintage Books, 1974), p.81

[357] Virilio, *The Aesthetics of Disappearance*, p.48

no longer perceive anything."[358] You cannot perceive anything beyond 60 frames, or above 60 frames you cannot perceive anything at all? His accelerated prose is ambiguous. Speed, for Virilio, destabilises the mind's sense of duration, resulting in the "disappearance of consciousness as the direct perception of phenomena that inform us of our own existence."[359] His analysis situates speed not as a temporary effect of change, or an operation of re-organisation, but as a sustained environment, "not a means but a milieu."[360] Virilio offers a view from the press: a determined examination of speed from the inside.

A defining feature of this milieu is its instability. Speaking to Friedrich Kittler at the end of the 1990s, Virilio (for whom society had been on the brink of collapse for the previous 20 years) asks: "What happens to the society that stands at the limit point of acceleration?" and gives his own answer: "when the railway was invented, derailment was invented too."[361] Speed has exceeded the capacity for human comprehension, ushering in a phantasmagoric world of illusion. Kittler disagrees, insisting on the speed of light as an as of yet unreached limit.[362] Indeed, derailment – the crisis of uncontrolled speed – ought to bring with it a massive deceleration, but "the violence of movement" is seen as a continuity of acceleration in Virilio's writing, rather than the end of it.[363] It's easy to portray Virilio as myopic, a victim to his own valorisation of speed. This is the reading David Harvey makes of Virilio: trying "to ride the trigger of time-space compression… and hopefully command it".[364] Harvey's historical analysis concedes that "the world sometimes *seems* to collapse inwards upon us", but that does not mean it actually does in his view, in any concrete sense, collapse. And just because the subject feels as though they are in the jaws of a press, doesn't mean they will be crushed in it.

But both Kittler and Harvey overlook that the experience of acceleration-as-compression that Virilio describes is widespread enough to constitute a cliché across visual and textual representation; it is a real perception. More helpfully, an information theoretic perspective can tell us that derailment is a generalised stochastic phenomenon – some portion of trains crash over a period of time – and this is exactly what Virilio is suggesting: the thoroughly technologized society of Virilio's 1970s requires an encounter with speed, whether or not one voluntarily boards the train or race car.

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358 Virilio, *Virilio Live*, p.71; Also, Paul Virilio, "Speed-Space", *Impulse* 12.4 (1986)
359 Virilio, *The Aesthetics of Disappearance*, p.114
360 Virilio, *Virilio Live*, p.71
361 Ibid., p.98
362 Virilio, *Virilio Live*, p.98
363 Virilio, *The Aesthetics of Disappearance*, p.109
364 Harvey, *Postmodernity*, p.351

Culture under compression

It is fitting, given Hanta's vision of Prague's inhabitants falling into his press, that "presse" first appears in English in the 13th century referring to a crowd, or throng.[365] Etymologically, the packing in of people is integral to the word. In the 14th century "press" starts to be used to describe the act of pressing; "compresse", literally press together, comes into Middle English from the Anglo-French "compresser" at roughly the same time. In the 16th century the word becomes associated with the printing press, and the massive explosion of literary culture that followed. By this point the English "press" contains the meaning of "lis" in Czech, the mechanical squeeze of Hanta's press: rapid production, circulation and destruction of texts. In the present, we can see several ideas bound up in the word: the pressing together of objects or of crowds, groups of people, the distillation of ideas or "condensation of language" as the OED puts it, making things smaller, the creation of print text or images, and also coercion.[366] These meanings and associations are not discrete but interlinked, compressed into the word "press" itself.

This etymology suggests that when pushed together, people might form a mass. Yet, after a century of continual development in compressive technology, we don't find solidarity but an increasingly individuated mass culture. The cinema gave way to the television, the personal computer and finally the phone, among many examples. Indeed, Virilio's account, while it purports a general disposition, sometimes struggles to articulate the violence of speed in terms which are not individual.

Marxist and post-Marxist cultural analyses make claim to a collective origin of Virilio's acceleration. Jonathan Crary has drawn heavily from Virilio in his description of 24/7 capitalism, comprising the ongoing erosion of non-productive time by capital, and the sleepless subjectivity that erosion generates.[367] But Crary suggests Virilio's subjectivity has its origins not in a libidinal urge, nor the specific psychological facets of fascism or war, but in economics. "24/7 markets and a global infrastructure for continuous work have been in place for some time" Crary argues, "but now a human subject is in the making to coincide with these more intensively."[368] As much as there has been a drive to minimise circulation time, there has also been a trend towards maximising labour-time. These two things are connected – a reduction in circulation-time facilitates an increase in labour-time – but circulation time is not the only barrier to productivity:

[365] "press", *Merriam Webster Dictionary* https://www.merriam-webster.com/dictionary/press [19/01/2022]
[366] "compression", in *The Oxford English Dictionary*, https://0-www-oed-com.catalogue.libraries.london.ac.uk/view/Entry/37880 [23/04/2021]
[367] Jonathan Crary, *24/7: Late Capitalism and the Ends of Sleep* (New York, Verso: 2013)
[368] Ibid., pp.3-4

> In its profound uselessness and intrinsic passivity, with the incalculable losses it causes in production time, circulation, and consumption, sleep will always collide with the demands of a 24/7 universe.[369]

For Crary, sleep is the last barrier to productive time and has therefore come under relentless assault from the 24/7 – both a mantra and an organisational principle. If sleep cannot be wholly eliminated, “it can be wrecked.”[370] Crary finds, for instance, that since the early 20th century the average American’s sleep has reduced from around ten hours, to eight, to six and a half hours.[371] Productivity requires wakefulness. This erosion is yet another compression, one caused by a nexus of other compressions: the mobile phone, overstimulation, economic compression. Out of screens and floodlights, he sees an “illuminated 24/7 world without shadows.”[372] This illumination is, paradoxically, not an aid to seeing. In fact, it “disables vision through processes of homogenisation, redundancy and acceleration.”[373] This is the insomniac subjectivity at the heart of Crary’s polemic: without sleep there is not really waking, and without dreaming there is not really cognition. Eternal daylight is blinding.

Others have been attentive to the pulverising effect of capital accumulation on aesthetic forms. Already in the 1930s Theodor Adorno was commenting on the role that media technology was playing in altering the quality and appearance of the sounds and images delivered to him: “the records”, he writes, “now fabricated out of a different mixture of materials, wear out faster than the old ones. The incidental noises, which have disappeared, nevertheless survive in the more shrill tone of the instruments and the singing.”[374] Cheap records correspond to cheap apparatuses. He describes both the camera and phonograph as embodying “not only the technology of distribution but also that which is distributed.”[375] In other words, as commodities not only the art object (i.e. the record or print) but also devices of circulation (the phonograph, the camera, etc.) deteriorate in pursuit of exchange value.

But accounts like Adorno’s embody specific aesthetic concerns and commitments. His valorisation of fidelity puts him in alignment with today’s recording professionals, for instance, who Jonathan Sterne describes as having “long complained that MP3s have less definition than the CD recordings from which they are made.”[376] However, as Sterne highlights, low-fidelity

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[369] Ibid., p.10
[370] Ibid., p.17
[371] Ibid., p.11
[372] Ibid., p.9
[373] Ibid., p.33
[374] Theodor Adorno, “The Curves of the Needle”, *October* 55 (1990), p.48
[375] Ibid., p.48
[376] Sterne, p.3

formats have remained popular even now that bandwidth is more plentiful.[377] There can be joy in compression; contra Adorno, there is a response that derives pleasure from the crunchy, corrupted sensations generated in lossy compression, or even that valorises this noise for the opportunities it presents. Moreover, high fidelity images are large, slow to load and expensive to store. So many images and sounds circulating online today (especially those circulating for free – i.e. not as commodities) do not meet the demands of professionals and audiophiles. There is more than one reason for the abiding popularity of lossy compression formats. As Sterne argues, marks of past technological contexts "may persist… long after they are needed"; the sound of lossy compression is familiar, even appealing, to MP3 listeners. Even if compression is less technically necessary, this may not be a reason to move on from it. Hito Steyerl has called for an alternate model for value defined not by resolution or exchange value, but "velocity, intensity and spread."[378] Lossy compression, here, is generative, a physical exchange of mass for energy.[379] The aesthetic decay of repeated lossy compression is key to their acceleration. Still, this observation applies just as compellingly to the objects of lossless compression (even if they travel more slowly).[380]

From JPEG and other perceptually oriented lossy codecs, e.g. MP3, there comes an explicit style of compression embodied in the uncanny distorted JPEGs washed up on Steyerl's cyber-shores, and

Figure 3.2 Rosa Menkman, "A Databent Joint Photographhic JPEG Image" in *The Glitch Moment(um)* (2011)

Formed by introducing random errors into the compression process.

[377] Ibid., p.3
[378]Adorno, pp.48-55; Steyerl, p.41
[379] Steyerl, p.41
[380] Ibid., p.41

worked through in glitch practices like Rosa Menkman's (fig-3.2), which seek to examine the process of visual decay.[381] In sound, projects like William Basinski's *The Disintegration Loops*, or Burial's *Untrue* similarly mobilise compression to create haunted, ethereal textures. Yet, for much of the human sensorium, discrete image-aesthetics may not be as impactful as image economy: beyond the qualities of a given sound or image, is the fact of their abundance.

There is precedent for such sensory abundance, which was noticed during the emergence of consumer capitalism. Observing a similar overabundance of light as Crary in the arcades of 19th century Paris, Walter Benjamin theorized this sensory phenomenon as "phantasmagoria":

> people entered in order to be distracted. The entertainment industry made that easier for them by lifting them to the level of the commodity. They yielded to its manipulations while savouring their alienation from themselves and from others.[382]

The phantasmagoria is stultifying in its overabundance: it marshals its audience to retreat into its shallow surface. Susan Buck-Morss' work on the synaesthetic system helpfully draws together some of the threads in economics, aesthetics and human physiology already raised.[383] Buck-Morss views the human nervous system as in circuit with the world it perceives and acts within. "As the source of stimuli and the arena for motor response", she writes, "the external world must be included in the complete sensory circuit".[384] In opposition to a classical model of isolated human biology, she names this the "synaesthetic system", where external stimuli and aesthetics are bound through the biological operations of the human body.[385] But there is only so much the human sensorium can take. Building on Benjamin's analysis of phantasmagoria, she describes how the synaesthetic system can instead become one of "anaesthetics", protecting the subject from the "the trauma of perpetual shock" through numbing. [386] Within a phantasmagoria, its goal, as Buck-Morss describes, "is to numb the organism, to deaden its senses, to repress memory".[387] Overstimulation triggers a retreat of the human psyche – the condition described by Virilio.

A volume of aesthetic practice plays off this condition today: hyperpop records like 100 gecs' *1000 Gecs* or Sophie's *Oil of Every Pearl's Un-Insides*, as well as experimental hip-hop like Death Grips' *Exmilitary*, take the vulgar, aggressive and poorly compressed as material to work with. Billie

[381] Rosa Menkman, *The Glitch Moment(um)* (Amsterdam: Colophon, 2011), p.22
[382] Walter Benjamin, "Paris: Capital of the Nineteenth Century", *Perspecta* 12 (1969), p.168
[383] Susan Buck-Morss, "Aesthetics and Anaesthetics: Walter Benjamin's Artwork Essay Revisited", *October* Vol.62 (1992), pp.3-41
[384] Ibid., p.12
[385] Ibid., p.13
[386] Ibid., p.18
[387] Ibid., p.18

Callio's immersive sim game *Cruelty Squad* echoes such accounts of a compressed culture via a hybrid of sensory overload and body horror.[388] It offers a critique of the effects of overstimulation and frictionless operations on the body, both through its grotesque biopunk phantasmagoria and the commodified bodies of its inhabitants. The game's interface (fig-3.3) is an intrusive throbbing border that constantly lights up with health and status indicators. Level and character design constitute a mesh of saturated textures, shifting uncannily over their models. Low polygon graphics are deployed here as a signifier for accelerationism; *Cruelty Squad* is, overtly, a dystopian satire of techno-libertarianism. The game's protagonist is transhuman, run though with proprietary body modifications – more property than person – and subject to constant, painstaking quantification: you can press "tab" to bring up a stock-market overlay and trade harvested organs and corporate shares alike. *Cruelty Squad* requires the player to set the game to the lowest possible resolution before completing the game (fig-3.3); it depicts an acceleration in which capital has gutted out all quality, depth, fidelity.

When we think of compression in relation to the audio-visual, or to art, it is tempting to foreground such lossy examples. The perceptual coding of such images – explored in Chapters Four and Five – makes their compression especially visible, ripe for analysis. Alexander Galloway and Jason LaRivière, for instance, describe lossless compression as "essentially a misnomer, and in fact not a mode of compression at all."[389] For Galloway and LaRivière lossy and lossless modes

Figure 3.3 *Cruelty Squad* (2021) opening credit sequence (above); The sensory overload of cruelty squad's UI (top left); the game in 640x480p (left)

[388] *Cruelty Squad*, Consumer Softproducts (2021)
[389] Alexander Galloway and Jason LaRivière, "Compression in Philosophy", *boundary 2* (2017), p.142

are ontologically distinct, but such a hard division ignores the technical situation in which they are often deployed together, the media-historical one in which lossy compression is a complication of Shannon's theorem and most of all the similarity of economic and social functions played by both categories. Treatises for or against lossy media can find themselves addressing a media situation which is now past: while lossy methods remain ubiquitous, the visual decay associated with it has receded in the past decade (and has become nostalgia). The lossy is only one part of the issue; already in Adorno's account, while he is singularly focused on decay (of apparatus and sound), we can read through the lines to see a parallel process occurring. As much as the quality of playback is transforming, the reach and location of playback is also in flux: cheap phonographs are also accessible phonographs, and new markets mean new listeners – whatever the fidelity.

The economics of compression

> After three thousand years of explosion by means of fragmentary mechanical technologies, the western world is imploding.[390]
>
> Marshall McLuhan, *Understanding Media*

As in *Too Loud a Solitude*, the technological escalation of compression follows a higher-level compression, in economics. Expansion and collapse, as McLuhan alludes to in *Understanding Media*, have a complex relationship to one another: the push and pull of a mechanical press, crushing objects, accelerating them out of Hanta's basement and making his world smaller in the process.[391] Losing mass and gaining speed – acceleration and compression are two sides of the same coin. The economic compressions I'm interested in are not contractions to an economy as a whole; rather, routine functions within the apparatus for delivering growth in an inflationary capitalist economy. Specifically, I am mobilizing an idea David Harvey reads from Marx, of "time space compression."[392] Compression in this sense describes the reduction of circulation time (an acceleration in the movement of commodities) which is necessary to realise production. Such compression prevent circulation from becoming a bottleneck in the cycle of consumption and production that comprises capital accumulation. The "incessant, frictionless operations" of 24/7 life, as Jonathan Crary labels them – that is, of constant consumption and production – are required to deliver more consumers (and more of each consumer) to an inflationary economy.[393]

[390] Marshall McLuhan, *Understanding Media* (London: Routledge, 2001), p.3
[391] Ibid., p.3
[392] Harvey, *Postmodernity*, p.147
[393] Crary, p.24

But this is not a closed circuit, and the question is not one (as mainstream economics would have it) of distributing scarcity. Georges Bataille offers an appealing alternative: surplus defines human economies. [394] At the limits of growth (at any scale, an organism, a society or a planet), Bataille argues, we find pressure which must be released, be it through squander, luxury, eating, death, reproduction.[395] In the case of a capitalist society, he argues, excess is reinvested more excess (the basic Marxist concept of MCM', capital accumulation for its own sake).[396] But for extension, and growth, to be possible, new space must be opened up.[397] The reconfiguration of the economy is productive of new arrangements of space (circulation generates, not simply distributes). And this has a material effect on space as we experience it.

As such, the acceleration of accumulation correlates to a compressive effect on space. In a much-discussed section of notebook V of *Grundrisse*, Marx discusses this effect:

> while capital must on the one side strive to tear down every spatial barrier, i.e. to exchange, and conquer the whole of the earth for its market, it strives on the other side to *annihilate this space with time*, i.e. to reduce to a minimum the time spent in motion from one place to another. The more developed the capital, therefore, the more extensive the market over which it circulates, which forms the spatial orbit of its circulation, the more does it strive simultaneously for an even greater extension of the market and for greater annihilation of space by time ["die Vernichtung des Raums durch die Zeit"].[398]

That Marx phrases this as an "annihilation" shouldn't go unnoticed – the German "Vernichtung" translates variously to destruction, extermination or annihilation, as in Martin Nicolaus' 1973 translation of *Grundrisse*, and most English language scholarship.[399] Marx clarifies that even if it is labour that creates value, circulation realises it; "Circulation time in itself is a barrier to realisation."[400] If circulation is to effectively realise value, the space it covers must be collapsed, and as further reductions in circulation time are introduced, space continues to collapse in on itself. Circulating a commodity – along road, rail, copper wires or optical cables – takes time, and that time impedes the rate of accumulation. In digital circulation, the limit of optical speed establishes capacity as a barrier to circulation; efficient coding and the reduction of noise both offer further reductions to circulation time, especially when scaled-up to the mass flow of signals.

394 Georges Bataille, *The Accursed Share* (New York: Zone, 1991), p.29
395 Bataille, pp.33-35
396 Marx, *Grundrisse*, pp.247-257
397 Bataille, p.36
398 Marx, *Grundrisse*, p. 539
399 Ibid., p.539
400 Ibid., p.543

So, data compression of an image also entails its acceleration. It can cover more space, more quickly.

Vernichtung/annihilation is a totalising concept, with which Marx suggests cascading effects into subjectivity. Contemporary to Marx, the radical homogenisation effect that the railway enacted upon local constructions of space and time is well documented.[401] This is an unambiguously lossy compression (fig-3.4) – discrete understandings of time and place becoming permanently homogenised, and with them cultural localities lost.[402] The material stakes are made clear in Harvey's description of time-space compression's destructive processes:

> the homogeneity of space can be achieved through its total 'pulverization' and fragmentation into freely alienable parcels of private property to be bought and traded at will upon the market.[403]

If this fragmentation is also productive, it only comes with the irreparable loss of the space/ place ("Raum" in Marx's German) it destroys – the freeing up of space relies on the decomposition of what came before.

The steam train is often taken as the key compressive technology of the long 19th century, but it is not the first with significance for the period. Before it, in the pre-history of capitalism, was the printing press. Eisenstein's account of print culture situates it not merely as an intensification of

Figure 3.4 The train's surroundings dissolve in William Turner's *Rain, Steam and Speed, The Great Western Railway* (1844).

As Michel Serres has argued, "the perception of the stochastic" replaces form in Turner's later paintings. Here the steam of the locomotive's boiler generates the dissolution of Turner's landscape.

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401 Cf. Wolfgang Schivelbusch, *Railway Journey: The Industrialization and Perception of Time and Space* (Oakland: University of California Press, 2014)
402 Michel Serres, "Turner Translates Carnot", *Hermes : Literature, Science and Philosophy* (London: Johns Hopkins University Press, 1982), p.58
403 Harvey, *Postmodernity*, p.254

the literary culture, but as a qualitative phase-shift in the status of the copy.[404] Mark Turner has described the compressive function of the steam engine, driving 19th century "railways, steamships and printing presses"; that is, a massive expansion not just in the production of text, but crucially of its circulation.[405] And it is not incidental that, in his account, "growth" and "containment" come together; expansion and contraction churning out new terrain.[406] The 19th century saw the emergence of new technologies of mass reproduction: the personal typewriter for text, the phonograph for sound, and photochemical film for image; perhaps most importantly was the arrival of the telegraph which built new electric routes for communication. By 1861, Jeffrey Sconce notes in his book *Haunted Media*, the telegraph network had outstretched the transcontinental railroad across America; two years later a cable was laid across the Atlantic.[407] With this expansion, Sconce demonstrates, messages were newly mobile, uncanny entities no longer easily held or controlled by their originators.[408]

Facsimile reproduction of images over telegraph was first achieved in the mid-19th century, before being popularised for use by newspapers in the early 20th century.[409] Already in 1920 the idea of a facsimile newspaper in the home was being developed – it is not a big jump from these proposed systems to the videotex terminals that emerged in the 1970s and 80s, or by extension to the modern personal computer.[410] Such developments would bring McLuhan into agreement with Marx and Harvey: "Today, after more than a century of electric technology, we have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned."[411] The history of capitalism, then, could be read as a dialectic of expansion and collapse, with successive compressions drawing disparate localities towards each other. In such a mode Barney Warf describes that "the world became 60 times smaller between 1500 and 1970 when we compare the speed of airplanes with that of medieval ships."[412] A continual expansion of communicative and logistics networks, met with a continual collapse of space onto itself.

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[404] Eisenstein, p.16
[405] Mark Turner, "Seriality, Miscellaneity and Compression in Nineteenth-Century Print", *Victorian Studies* 62.2 (2020), p.292
[406] Ibid., p.288
[407] Jeffrey Sconce, *Haunted Media: Electronic Presence from Telegraphy to Television* (London: Duke, 2000), p.21
[408] Ibid., p.21
[409] Maynard McFarlane, "A Historical Look at Facsimile", *IEEE Transactions on Education* 23.3 (1980), p.151
[410] Ibid., pp.154-155
[411] McLuhan, p.153
[412] Barney Warf, "Teaching Time–space Compression", *Journal of Geography in Higher Education* 35.2 (2011) p.145

In logistics, Concorde (first flown 1976) represents an apogee in this trend: the rupture of natural limits (sound) in blind pursuit of acceleration. While Concorde was a commercial failure, discontinued in 2003, compressions in communication have continued apace. From the 1970s onwards a series of "format wars" penetrated communication networks into the home, starting with VHS and audio-cassette, followed by various videogame cartridges, then CD, DVD and BluRay, steadily shrinking in size and expanding in capacity until growing networked bandwidth allowed file transfer to displace physical digital distribution. As Yves Citton notes in *Attention Ecology*, the fact of being able to choose between media-cultural objects is a contemporary phenomenon.[413] "Our cultural frustrations arise less and less frequently from a lack of resources", he argues, "and increasingly from a lack of available time to read, listen or watch all the treasures hastily downloaded onto our hard drives or recklessly accumulated on our shelves."[414] The switchover between these two dynamics could be identified with the arrival of overnight television, or with the widespread adoption of the internet; either would place it broadly contemporary to those final Concorde flights. Citton's claim underscores a similar contention from Jonathan Crary, that the "incessant operations" of 24/7 culture conceal "its cancellation of the periodicity that shaped the life of most cultures for several millennia".[415] Crary's account is most interested in the periodicity marked by sleep (although his argument goes further, looking at the erosion of cyclicity in general), but his observation is readily transposed to media, where we can see the blurring of increasingly frequent serial forms into round the clock coverage and, ultimately, on demand services. Hence, data compression has been integral to media compression. It suggests we now face a historically unique form of engagement with media and mediation, brought about by several centuries of successive compressions.

Harvey's own analysis runs into the 1990s, transitioning from logistics technologies (trains, freight, planes, etc.) to communications (telegraph, telephone, etc.). He describes, for instance, satellite communication systems between the 1970s and his present as having "rendered the unit cost and time of communication invariant with respect to distance", an analysis mirrored in Lisa Parks' *Cultures in Orbit.*[416] Parks describes satellite television as "part of an ongoing dialectic between distance and proximity" – collapsing space for their viewers in a manner which is both intimate and alienating.[417] That her analysis focuses primarily on television and surveillance, though, casts some doubt on Harvey's claim: even if satellites can achieve such a levelling for a limited bandwidth for those with access to them (governments and large corporations; GPS

[413] Yves Citton, *The Ecology of Attention* (New York: Polity, 2016), p.16
[414] Ibid., p.17
[415] Crary, pp.29-30
[416] Harvey, *Postmodernity*, p.293; Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham: Duke University Press, 2005), p.174
[417] Ibid., p.174

systems), satellite coverage has never offered such a time-space compression for communications in general. (Though, as Harvey himself argues: "time-space compression always exacts its toll on our capacity to grapple with the realities unfolding around us" – perhaps he can be forgiven for being taken in by the magnitude of this particular compression).[418]

Time-space compression and information processing

Effective data compression has prefigured the radical expansion of large-scale communication infrastructures, itself generating massive reductions in circulation time. I should note that other technological compressions have occurred contemporaneously to data compression, notably reductions to the size of computer components. In the case of SSDs, integrated circuits have replaced the larger spinning disks of hard drives, folding compressions into their layered circuitry. Such compressions compound each other: smaller and smaller chips in more compact devices, circulating larger amounts of information with increasingly little latency. More images on screen and more time spent watching them: soundtracked lives. Media and economics in 'real-time' (which Kittler has shown is not real but technical).[419] Understood in this way, data compression is not distinct from time-space compression (or Crary's 24/7 or Virilio's speed) but a constitutive part of it: one of the core infrastructural interventions in the contemporary circulation of capital, and a driving force of time-space compression since at least the 1990s.

The process of data compression reads well as a time-space compression: when divided into bits, data is pulverized into alienable fragments for efficient transit. Lossy compressions make clear expressions of this drive: fidelity and integrity fall beside the need first of all for circulation (and render them noticeable). Such a formation is neat, but it is not stable. The vast majority of what Steyerl calls "poor images", for instance, are not commodities. The internet has not always been, and even today is not unproblematically, a 'market' – even if it is often treated as such. It is therefore worth briefly considering the economic function of data compression over time.

As I argued in Chapter One, Shannon's work on compression represents a clear reorientation towards the concerns of commercial telecommunications in the middle of the 20th century. Time-space compression explains well why the Bell System would be interested in developing "efficient" forms of digital coding for telephone signals: compressed signals occupy less of the channel and allow more phone calls to be made over the same network, creating more space for

418 Harvey, *Postmodernity*, p.306
419 Kittler, "Real Time Analysis…", p.14

profit. But follow data compression beyond the commercial telecommunications networks of the 1940s or 50s and its relationship to capital accumulation becomes ambiguous. The early internet was a military resource sharing system; when scientists and academics began to use it for communication, they were doing so in the margins often beyond the remit of their employment. So much of the information circulated on the internet has not been in the commodity form. Only in the 1990s – after much of the technical innovation required for a multimedia web had been completed – did internet service providers (ISPs) ascend in the image of telecommunications as a means to commodify data transfer in general.[420] Techniques for the production of discrete digital commodities came much later – discussed in Part Three – and entail the restraint, not the propulsion, of commodities. While it may not have taken long for capital to tear up state infrastructures, even the private internet is home to what Richard Barbrook has called "cybercommunism" and Dymtri Kliener has called "peer production" (within a "telekommunist" framework) – grassroots sharing economies which constitute a socialisation of information.[421]

Compression in such a case in not neatly aligned to capital accumulation but to a form of non- or extra-capital accumulation, to abundance. Abundance can take on a socialist utopian character (as in titles like Aaron Bastani's *Fully Automated Luxury Communism*, or ecomodernist visions of building through climate catastrophe), or a disastrous ecological one (as in Kohai Saito's degrowth communism).[422] As a feature of information systems, though abundance has historically been encountered as a problem: shortly after the end of World War II, the engineer and science administrator Vannevar Bush complained that "The investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember, as they appear."[423] His proposed solution – the Memex – is often taken as a key precursor to hypertext. Sergey Brin and Larry Page's PageRank (which would become the early algorithm of Google) developed a normative citation indexing method (which ranked web pages by the number of links pointing to them) was similarly expressed as a solution to the proliferation of "Junk results" in early search.[424] Nonetheless, data compression in the earliest periods of the web (up to 1995) does seem to break from Marx and Harvey's thesis of

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420 See, e.g., the decline of community freenets in: Thomas Keenan and David Trotter "The changing role of community networks in providing citizen access to the Internet" *Internet Research* 9.2 (1999), pp.100-108
421 Richard Barbrook, "Cyber-communism: How the Americans are superseding capitalism in cyberspace" *Science as Culture* 9.1 (2000), pp.5-35; Dymtri Kleiner, *The Telekommunist Manifesto* (Amsterdam: Institute of Network Cultures, 2010), p.22
422 Aaron Bastani, *Fully Automated Luxury Communism* (London: Verso, 2019); Kohei Saito, *Marx in the Anthropocene: Towards the Idea of Degrowth Communism* (Cambridge: Cambridge University Press, 2022), p.162
423 Vannevar Bush, "As We May Think", *The Atlantic* (July 1945) https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/ [18/09/2023]
424 Sergey Brin and Larry Page, "The Anatomy of a Large-Scale Hypertextual Web Search Engine", *Computer Networks and ISDN Systems* 30 (1998), p.108

pulverising space and instead having made space for kinds of common information and infrastructure – at least this is how it is presented in the utopian literature of the period.[425] In reality the early internet entails a complex set of modulations of geographic spaces which are more frequently structured and organised via computation, alongside the generation of new kinds of virtual space.[426]

Where does this leave the historical claims of time-space compression? Close investigation of the development of compression techniques during the early period of web-like technology will reveal active contestation over the nature and purpose of standards and of the network. My next two chapters focus on JPEG, a key technology of this ambiguous moment and of compression in general. My investigation will reveal that the multimedia web was not neatly a product of market dynamics, state support or grassroots enthusiasm – but some amount of all three. Historically, one thing that can always be said of large-scale compressions is that they produce new formal arrangements: of space, social life, aesthetics, and culture. This isn't only a question of intensity, but quality. Compressions are generative, both in the sense that they make space for things, but also because, like all encoding processes they involve production (even in a lossless channel – of time/position).

Of course, there *are* limits to compression. And as *Too Loud a Solitude* clearly demonstrates, compression is not only a feature of capitalist economies. Rather, it is a general feature of economies pursuing growth (and we cannot lazily associate the end of compression with the end of capitalism – although this would doubtless change its tenor). However boundless compression's milieu might appear from within, the transformation of space in the pursuit of growth cannot go on forever. Bataille's ecological view of the general economy sets this ultimate limit as the biosphere, the boundaries of life on Earth.[427] Up against the limits of growth, Bataille argues, life enters into "ebullition" – it boils over.[428] We now know unfettered growth is incompatible with a sustainable ecology; ecological crisis is the unspoken endpoint and antithesis of compression – the threat of a contraction to follow its expansion.[429]

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[425] E.g. John Perry Barlow's utopian libertarianism; from Thomas Moore's *Utopia* onwards, utopian projects have conceptually rested on new land, as in the colonial undertones of Barlowe's writing; John Perry Barlow, "A Declaration of Independence of Cyberspace", *EFF* (1996) https://www.eff.org/cyberspace-independence [25/09/2024]
[426] Rob Kitchin and Martin Dodge discuss the complex modulation of space through code in, *Code/Space: Software and Everyday Life* (London: MIT Press, 2011), pp.65-80
[427] Bataille, p.29
[428] Ibid., p.30
[429] Timothee Parrique, et al. *Decoupling Debunked: Evidence and arguments against green growth as a sole strategy for sustainability* (EEB, 2019) https://eeb.org/wp-content/uploads/2019/07/Decoupling-Debunked.pdf [28/02/2023]

Chapter four

JPEG, making a protocol

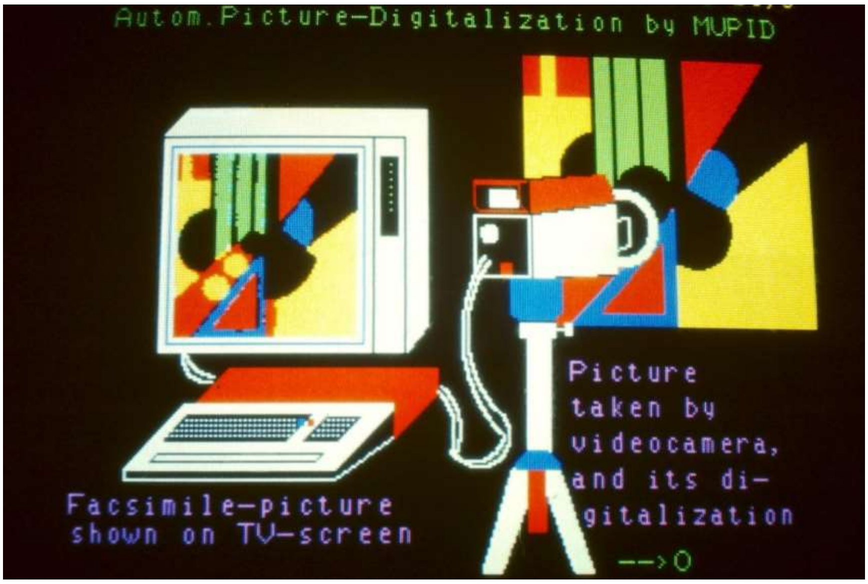

Figure 4.1 Videotex graphic representation of a facsimile-picture on TV, via an Austrian MUPID terminal (1982)

The history of compression can be inflected as one of social, cultural or economic forces but, unavoidably, it is run through by devices. I'm interested in technical codecs as embodiments, in the particular, of general histories and logics; artifacts which reflect and expose the determinisms they bring together, and which constitute their processes. The next two chapters will therefore focus on JPEG (named after the Joint Photographic Experts Group, that developed it), an integral protocol in the histories of both image processing and compression.

Jonathan Sterne's book *MP3: The Meaning of a Format*, which explores the MP3 as part of "a general history of compression", is an important precedent.[430] JPEG also belongs to a general history of compression: of photographic images and of perceptual data in general. While some aspects of my approach do differ from Sterne's, I view these chapters as a contribution to this same history. MP3 and JPEG are closely related technologies, with similar roles in the cultural-

[430] Sterne, p.5

economies and aesthetics of digital sound and vision respectively; they were released within a year of each other, and both became integral to the development of the so-called 'new media' era; both achieved their remarkable compression rates using Fourier-related transforms. These transforms express the discrete values of their audio-visual data (e.g. pixel intensities) in terms of sinusoid frequencies, which can themselves be subject to additional compression methods. Indeed, MPEG, of which MP3 is part, was strongly influenced by JPEG – its chair Leonardo Chiariglione had worked on JPEG in the first half of the 1980s before founding MPEG with the intention of extending these methods into the domains of video and sound.[431]

Sterne is interested in formats: standards for the arrangement of information in storage or transmission that consolidate cultural and economic concerns in the material. As an analytical mode he calls this "format theory".[432] Strictly speaking, JPEG is not a format, but a protocol: a method or process for image compression which, when instantiated (embodied) in software, becomes a codec. The differences between our approaches can thus be surmised from the different statuses of MP3 and JPEG: MP3 really is a file format, but JPEG is a protocol (corresponding formats, most often JFIF or Exif, are not defined in its standard). So, while Sterne's *MP3* is first of all concerned with the structure of MP3s, I'm more immediately interested in the process instantiated by JPEG. This process was designed by a committee of engineers and published as a standard (for implementation in systems that did not yet exist). Sterne rightly argues that standardisation entails a politics, the coming together of commercial, institutional and political concerns, as well as the invocation of cultural norms among key groups of experts and professionals[433].

I read codecs as embodiments of determinate moments (encoding/decoding), but as also determined by more than the technical: by the economics of development, by intuitions, by aesthetic values, by the desires of users and by accidents of design. These are (as described in Chapter Two) the coming together of distinct orders, logics and determinisms. As such this chapter and the next approach JPEG from two distinct analytical modes. First, in direct dialogue with Sterne's account of the MP3, I describe of the development of JPEG as a contested and contradictory product of interests. Remarkably there are no direct, extended accounts of JPEG's history or cultural impact, and so what I offer is a novel historical analysis of its development, drawing on articles published by those who worked on JPEG, or in the fields from which they

[431] Istvan Sebestyen, interview March 2023
[432] Sterne, p.6
[433] Ibid. pp.131-137

drew, and my own interviews with engineers.[434] Drawing on the methods of Science and Technology Studies, I have sought to fill in this gap via what has been written in technical journals by the engineers themselves, epistemic research into the fields they drew upon and my own interviews with six engineers and standardisation professionals who worked on JPEG in different capacities, carried out between September 2022 and June 2024.[435] The next chapter, by contrast, will attempt a close reading of JPEG documentation as textual embodiments of its process. I aim to clarify the operational priorities and functions of JPEG, working outwards from its originating text. These two quite different methods are intended to offer different reliefs to JPEG as an infrastructural technology within wider circuits of information processing and networked communication

A brief history of digital photograph transmission

In the 1920s, it was a great achievement to transmit a newspaper image across the Atlantic in less than a week by telegraph; today, if an image takes a second to load we consider it a frustration.[436] What caused this incredible reduction in circulation time? In terms of network engineering, the answer might appear straightforward: compression, the expansion of capacity and software optimizations like web caching.[437] The earliest attempts at large scale image compression and

Figure 4.2
An early image sent over Telegraph printer (1921).

Image tone values were scanned at fixed intervals in a helical pattern and perforated into tape for transmission as telegraph signals, then – across the Atlantic – reproduced as half-tone images by an experimental teleprinter apparatus.

The system initially allowed for five tone values, before being expanded to eight, ten and fifteen by 1929.

[434] Daniel Palmer's short chapter on "The Rhetoric of JPEG" is a rare exception – and offers a compelling parallel case to my own, that JPEG's processes are of aesthetic, ideological and political interest; Palmer, pp.149-163
[435] Paul Rabinow's *Making PCR* is a key methodological touchstone; see discussion in introduction.
[436] McFarlane, "Digital Pictures Fifty Years Ago", p.768
[437] See chapters 4–6 of Jane Abbate's *Inventing the Internet* (London: MIT Press, 2000)

transmission were not – as much media history is presented – a product of military research, but instead of the newsroom.[438]

News images were valuable commodities to newspapers on both sides of the Atlantic, but they had limited shelf lives. In 1920, two communications engineers working for the Daily Mirror, Harry G. Bartholomew and Maynard D. McFarlane, transmitted photographic images across the Atlantic for the first time using digital signals on deep-sea telegraph cables – this became known as the Bartlane system.[439] Bartlane encoded film negatives as a telegraph signal, exposing five levels of light onto photographic paper (fig-4.2).[440] While the first images took weeks to transmit, refinement of equipment and technique meant that an experienced operator could transmit an image in around two hours, including coding and transmission.[441] Today this pace would be considered glacial, but the short term consequences for British print culture were radical: for the first time, news from America could be reported with comparable visual clarity to domestic news.

The economic impetus for Daily Mirror engineers to work on such a system is clear: news is worth more when it is new, and visual information from across the Atlantic offered new objects of visual fascination to information-consumers. But there are also political and cultural questions to consider: the Bartlane system was built upon existing infrastructures that linked Britain to the USA, specifically. The routing of these cables therefore governed the flow of culture, allowing America to seem closer, perhaps, than much of the world beyond Europe (fig-4.3). Bartlane prefigured later decades of networked communication: the basic process of facsimile image sampling – the translation of image data into a series of discrete values in sequence – were transferred into a developing telephone network, first in news and finally in the 1960s to consumer models, notably the Xerox Magnafax Telecopier in 1966, the first fax machine.[442] Bartlane made possible the mass distribution of photographic images, while fax rendered this a consumer, not strictly professional, activity.

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438 Cf. the conclusion of Kitter's *Gramophone*, *Film, Typewriter*, pp.253-263; Carolyn Marvin's study of 19th c. electrical communication offers an alternate rubric, revealing early work on electrical networks to often be amateur and deeply invested in the generation of public spectacle; *When Old Technologies Were New: Thinking about Electrical Communication in the Late Nineteenth Century* (Oxford: Oxford University Press, 1988)
439 McFarlane, "Digital Pictures…", p.768
440 Ibid., p.769; J.W.Milnor, "Picture transmission by submarine cable", *Electrical engineering* 60.3 (1941), pp.105-108
441 McFarlane, "Digital Pictures…", p.770
442 McFarlane, "A Historical Look at Facsimile", pp.153-155

For a similar phase-shift, we must wait until the 1980s: the expansion of internet infrastructure, the World Wide Web, the widespread adoption of the personal computer and the portable digital camera. From the perspective of image processing, the key development of this moment was a technique: perceptual coding, lossy compression oriented towards a model of human perception.

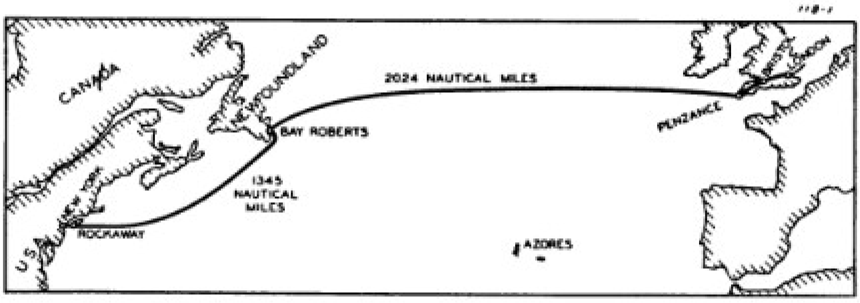

Figure 4.3 A map of the deep-sea cable route, from Penzance to Bay Roberts (1926)

A repeater in Bristol allowed connections to the submarine cable from London, and a further submarine cable could take messages to New York

JPEG was the first standardisation of such a technique and applied a human visual system model to its process, casting visual data as a perceptual category destined for decoding in the human sensorium. The Bartlane system was used to transmit around 500 images over the 19 years it was in use, while by 2010 Google had indexed over 10 billion images from the web, the vast majority of which would have been JPEGs (representing a minority of the total number of JPEG images, most of which are never uploaded).[443] This massive compression corresponds to an acceleration: the end of film photography as a mainstream consumer activity, the beginning of digital visual culture as we know it today, the formation and success of a multimedia Web. More JPEGs are now made each year than film photographs in the history of photography, and it has therefore become the predominant form of the medium.[444]

The Joint Photographic Experts Group

The name of JPEG is a source of some confusion. Colloquially, "JPEG" (jay-peg) normally describes a kind of image, generally photographic, stored on digital devices and transmitted over the internet with the file extension ".jpg" or ".jpeg"; more accurately, these should be called JPEG images. But "JPEG" is also used to refer to the compression processes often used on these files; this should be clarified as "JPEG compression". The name JPEG is derived from an acronym, standing for the "Joint Photographic Experts Group", the committee that developed the JPEG-1 standard for image compression, often simply called "the JPEG specification". Linguistically, therefore, "JPEG" joins together a category of objects (JPEG images) with the means of their

[443] McFarlane, "Digital Pictures…", p.768; MG Siegler, "Google Image Search: Over 10 Billion Images, 1 Billion Pageviews A Day", *TechCrunch* (2010) https://techcrunch.com/2010/07/20/google-image-search/ [05/10/2022]
[444] Hudson, et al., pp.6-7

generation and circulation. JPEG images/ files are JPEGs because they are produced by JPEG compression, and embody the processes that govern JPEG, both those that are explicitly expressed in the JPEG-1 specification and those that are not. In this way JPEG typifies my description of a codec in the introduction of this thesis, embodying the relation between the organisation of a coded system (what might be called the cultural economy of digital images) its signals (JPEG images/files) and their meaning structures (the JPEG-1 specification and other documentation that governs them). For ease, I've clarified these in a definition list, overleaf.

JPEG Definitions

JPEG File Interchange Format (JFIF): the most popular file format for JPEG files; utilising the baseline version of JPEG and including necessary clarifications for use on the web including colour space, pixel density and thumbnail coding.

Joint Photographic Experts Group (JPEG): a committee of expert image coders who develop and publish JPEG standards; a "joint" venture of the International Organisation for Standardization (ISO) and the International Telecommunication Union (ITU).

JPEG-1: the original JPEG standard, published in 1992 and still widely used to this day.

JPEG 2000: a later standard released by JPEG; intended to be JPEG-1's successor although never widely adopted.

JPEG codec: an embodiment of the total JPEG coding process (encoder, interchange file format and decoder)

JPEG compression: an encoding process defined by the JPEG specification, designed to reduce the number of bits required to represent image data via a suite of processes, most notably the Discrete Cosine Transform (DCT).

JPEG decoder: an embodiment of JPEG's decoding process as defined in the JPEG-1 specification; takes compressed image data and decodes it into reconstructed image data.

JPEG encoder: an embodiment of JPEG's encoding process as defined in the JPEG-1 specification; takes raw image data and encodes it as compressed image data

JPEG image: reconstructed JPEG image data, which has been subject to JPEG compression and reconstructed by a JPEG decoder.

.jpg: the file extension reserved for JPEG image data in the JPEG-1 specification.

JPEG wasn't developed for the web (which it predates by around three years), or for home computers as we now understand them, but first of all (in the European context at least) for a set of defunct mass-media services collectively known as videotex – text based interactive information systems including Teletext in the UK and Minitel in France (fig-4.4).[445]

The early development of digital image coding can be separated into two broad categories: graphic or photographic coding (closely related to another distinction – between vector and bitmap graphics).[446] While graphics are graphed by computer programmes (fig-4.4), either as arrays of pixels or vectors, photographic type images are facsimile reproductions in a digital environment of complex, 'real-life' imagery via a sampling process (as in Bartlane, fax or indeed JPEG).

In 1983 when Graham Hudson, a BT Labs engineer who would go on to chair the JPEG committee, started attending videotex standardization meetings with the standardization bodies CCITT (which became ITU – the International Telecommunication Union) and ISO (the International Organization for Standardization), existing work was almost entirely focused on coding graphics and text, and in particular of the difficulties of coding different alphabets; where work was being done on "facsimilie", this was primarily concerned with documents, not photographic images[447] Internal competition had ossified these spaces, with participating organisations heavily invested in specific technologies (such as the UK Post-Office's Prestel videotex system Prestel with Mosaic

Figure 4.4 the travel page of BBC's CEEFAX Teletext service with graphics (left), and a Minitel terminal (right). At the beginning of the 1980s graphics remained the prevailing type in computer science research labs, particularly in the US and Japan but also across Europe.

[445] Ibid., p.10
[446] Debated in reference to videotex: K.E. Clarke "What Kind of Pictures for Videotex", *Viewdata Conference* (London, 1980)
[447] Graham Hudson, interview September 2022

graphics).[448] Photographic coding was at this point a marginal area of enquiry, but appears to have benefitted internally from this lack of attention and prior investments, allowing for a culture of sharing and open collaboration between organizations.

While more work had been done on graphics, interest in what was then called "photovideotex" in Europe was growing. In 1982 when Austrian engineers transmitted a (black and white, very high contrast) Volker von Bonin image using a MUPID terminal (fig-4.5), it took around four minutes to download, and so bespoke compression techniques were needed if the technology was to become practically applicable. One year later, at the Telecom 83 conference, Hudson (with others at BT Labs) demonstrated real-time photovideotex over the ISDN (Internet Services Digital Network; routed through a telephone connection), a 64kb/s connection. Other similar demonstrations had been shown since at least 1980, when the Centre national d'études des télécommunications (CCETT) showed the first Minitel photovideotex prototype to conferences in North America and Europe.

The Joint Photographic Experts Group (fig-4.6) was founded in 1986 as a joint venture between two international standardization organisations: the International Organization for Standardization (ISO) and the International Telecommunication Union (ITU), a specialised agency of the United Nations, with a committee composed of picture coding experts from North America, Europe and Japan and chaired by Graham Hudson. Attendees of the committee varied, but a core

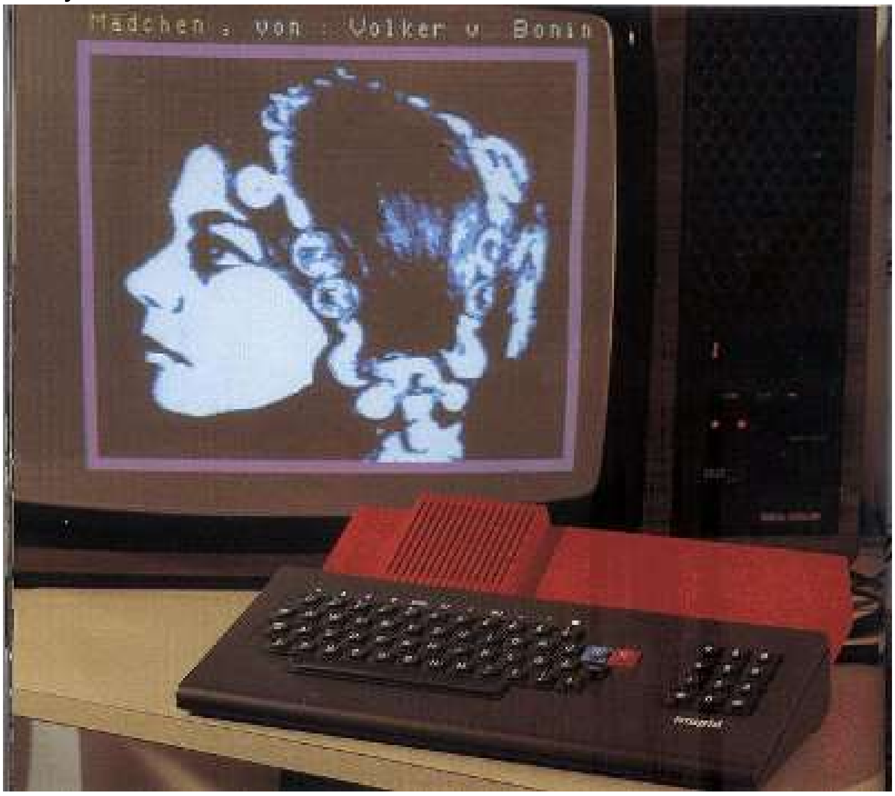

Figure 4.5 Mädchen by Volker von Bonin, from a MUPID terminal brochure (1982). This early image – rendered without colour – contains only a small number of tone values, likely less even than Bartlane, likely coded according to a standard for the facsimile reproduction of documents.

[448] Ibid.

group of around a dozen members oversaw the process from conception to publication. These members came from European public (or publicly funded) research organizations (BT labs in the UK, CCETT in France, ANT and Siemens in Germany, and Kjøbenhavns Telefon Aktieselskab (KTAS) in Denmark), four private companies from the US (IBM, Storm Technology, DEC and C-Cube Microsystems), the Israeli Zoron Corporation and the Japanese NEC Corporation. It was the European organisations who were explicitly interested in videotex, generally conceived as publicly maintained communications services, while their American, Israeli and Japanese colleagues were working in the context of corporate communications, microchip production and consumer electronics.

Meanwhile, the European Union formed PICA (the Photovideotex Image Compression Algorithms project), an initiative started a year earlier as part of the European Strategic Programme on Research in Information Technology (ESPRIT), also chaired by Graham Hudson and sharing key members. Explicitly, PICA was established to develop video compression techniques for commercial videotex services.[449] Functionally, PICA fed into JPEG: compression techniques developed and refined through PICA were handed over to JPEG for standardization. Services like Minitel in France and Prestel in the UK, and the more basic Teletext supported simple graphics constructed from 2x3 blocks of a single colour and background; the aspiration of PICA was to find a compression method capable of displaying visually complex imagery within such services. The bandwidth available was often tiny: Teletext, for instance, (perhaps the most limited of such services) was coded into the tiny gap between television frames (the vertical blanking interval),

Figure 4.6 The Joint Photographic Experts Group committee (Copenhagen, 1988)

[449] Alain Leger, "Jpeg at 25: Still Going Strong", *IEEE Multimedia* (June 2017), p.3; István Sebestyén, SOME LITTLE-KNOWN ASPECTS OF THE HISTORY OF THE JPEG STILL PICTURE-CODING STANDARD, ITU-T T.81 | ISO/IEC 10918-1 (1986-1993), *ICT Discoveries* 3.1 (2020), pp.2-36

enough bandwidth for just a few words per second. JPEG and PICA had slightly more space to work with, a 64kbit/s ISDN telephone line connection, but the aspiration was to encode images in real-time over such connections (already being used by fax machines, albeit less efficiently).[450] As would later become convenient, this is the same standard required by the web, which backpacked on the telephone network until the end of dial-up, more formally sharing the space with the introduction of broadband. Today, dedicated landline telephone connections are being phased out, and telephone connections instead run over the internet.[451] Videotex services, especially Minitel, represent an important moment in the transition from older technologies of image distribution, especially fax, and contemporary internet technologies and infrastructures.

Psychovisual testing (Copenhagen 1988)

By 1987 PICA had proposed ten image compression methods and presented these to JPEG. In meetings at KTAS (the Danish telecommunications company) in Copenhagen, the committee refined this down to just three – one of IBM, one of NEC and a third from KTAS itself – which went forward to a final selection meeting in January 1988, also at KTAS.[452] Though positioned as a ‘competition’, the process was collaborative – effective coding methods were combined when possible. Down the hall from JPEG at KTAS, were engineers who would go on to work on MPEG sound and video compression (core MPEG member Leonardo Chiariglione had also attended

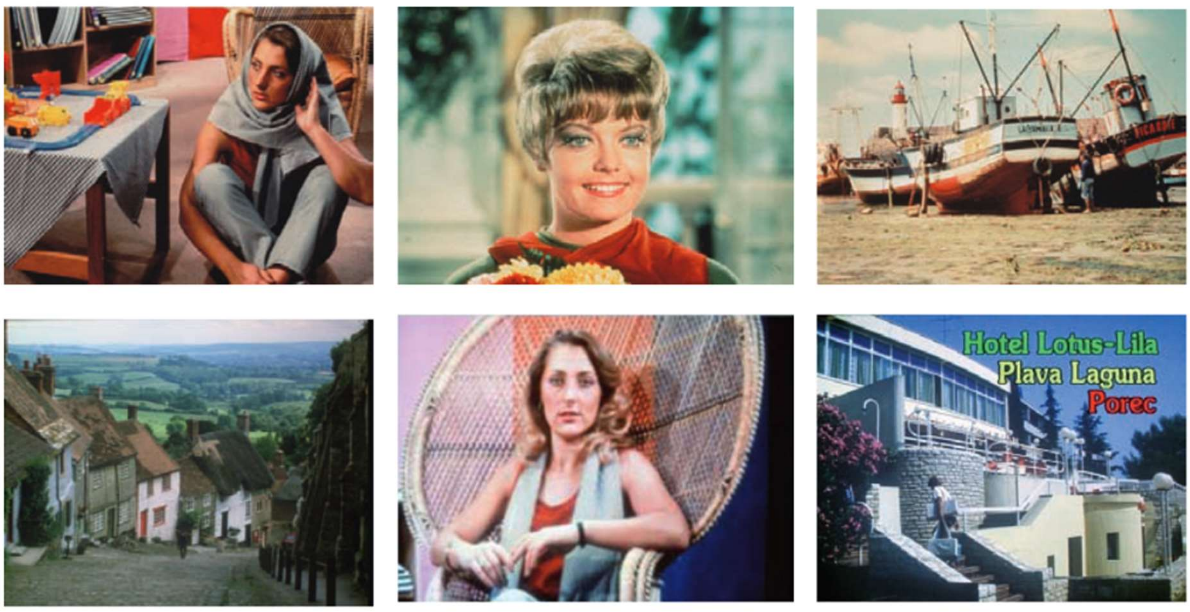

Figure 4.7 Test images used in PICA & JPEG subjective testing. Images anticipated expected use-cases, such as holiday advertisements and headshots, some with small portions of text.

[450] Hudson et al., p.3
[451] Ofcom, “The future of fixed telephone services: policy positioning statement” (February 2019) https://www.ofcom.org.uk/__data/assets/pdf_file/0032/137966/future-fixed-telephone-services.pdf [05/10/2022]
[452] Leger, p.3; Birgir Niss, email correspondence 2023

some early JPEG meetings); they would take direct inspiration from the developments in still image compression being showcased.

The JPEG committee ascertained the efficacy of potential methods via a process called “subjective testing”. Test images (fig-4.7) were compressed under test conditions (using custom hardware and software) and compared by a panel of engineers (fig-4.8).[453] Images would be compressed to set levels (in the final round of testing: 0.75, 0.25 and 0.08 bits per pixel) and ranked in quality from “bad” to “excellent”.[454] These test images (several of which have gone on to become standard compression test images), as well as a description of appropriate display equipment were

Figure 4.8
JPEG’s final round of subjective testing, Copenhagen (1988).

JPEG engineers rated the visual fidelity of three coding methods at different levels of compression on 720x576 CRT monitors

[453] Leger, p.5
[454] Hudson et al., p.11

supplied by a representative from IBA (the Independent Broadcasting Authority, now ITV). In the final round of tests at KTAS around twenty engineers gathered to compare the quality of images. A "double stimulus technique" was used, in which users compared the original uncompressed image to the compressed one. These tests were carried out using 720x576 pixel CRT monitors (4:3 aspect ratio) in a "TV studio environment" as specified by Vivian, the contemporary industrial standard in television.[455] To prevent manipulation tests were "blind". However, only engineers who had attended JPEG meetings regularly were allowed to input and it is clear that these results reflect the perceptions of a small group of professional insiders.

In 1988, KTAS conditions couldn't be controlled as tightly as the labs in which these techniques had been developed, something noted by engineers but accepted on the basis it might be closer to normal viewership conditions. Test results are inseparable from this apparatus, but it would be easy to criticise them excessively: that apparatus effects the quality of image is also true in use – and the test apparatus exceeded the resolution of commercially available videotex systems. The tests thus represented a controlled (and slightly higher resolution) version of the viewing conditions that could be expected at the time. As well as demonstrating the quality of image compression, these tests were also designed to prove the viability of the method for real-time decoding of the image-data; a necessary pre-request of its commercial roll-out.

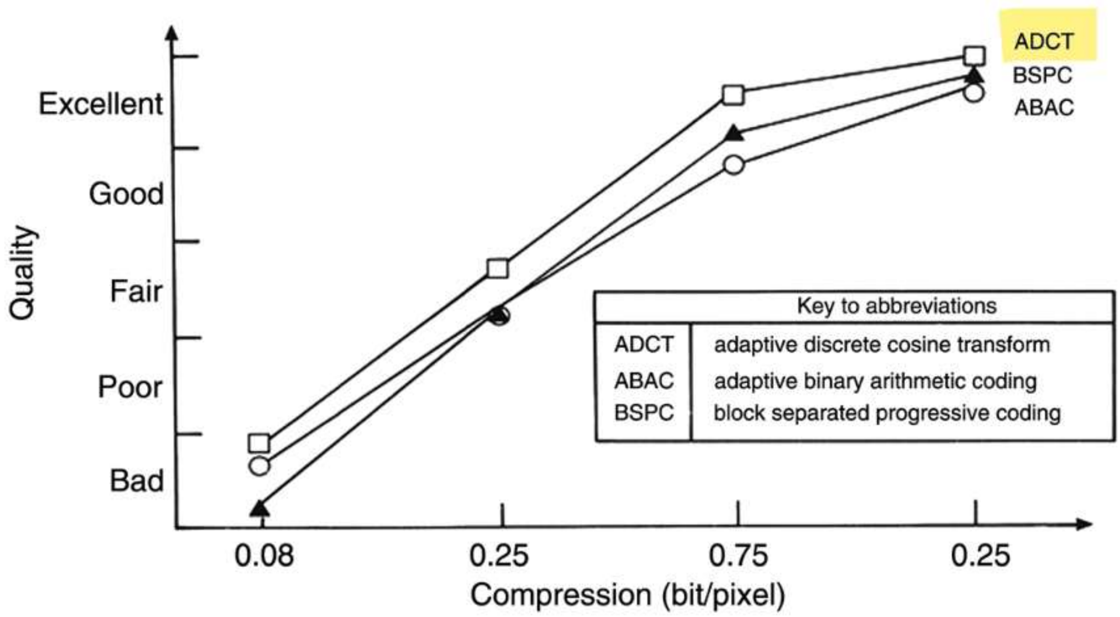

Figure 4.9 The results of JPEG's final round of subjective testing (January 1988). The ADCT combines a DCT based method and a quantization method developed by two separate teams within PICA

[455] Ibid., p.2

KTAS's method, an adjusted version of the DCT (Discrete Cosine Transform), itself a kind of Fourier Transform, won these tests decisively. As well as providing the best subjective results, it was the only method capable of demonstrating real-time compression over an ISDN telephone connection (64 kb/s) to a contemporary IBM computer. I discuss the ADCT process in Chapter Five, but it remains the most significant aspect of JPEG's compression schema. The ADCT calibrates its compression schema with psychovisual data (itself founded on a model of the human visual system as a decoder) in order to offer an image that appears recognisible to the human eye even at these compression factors. In subjective tests the DCT consitently produced less perceptual degradation in test-images than other methods at all compression ratios.

Engineers tested image quality at a range of compression levels: in subjective testing ranging from "excellent" to "bad", corresponding to a compression rate of around 0.25 bits/pixel to just 0.08 bits/pixel (fig-4.9). Even if the subjective results suggest a negative outcome for this lower end ("bad"), engineers were impressed that the image could remain somewhat legible at such compression rates when contemporary videotex was only capable of 16 bits/pixel.[456] Herein lies the intrinsic link between JPEG's status as a technology of economics and aesthetics, of distribution and meaning: JPEG's capacity to generate meaningful signals for the eye and brain is limited by its compression process, without which there would be no circulation at all, and the image simply wouldn't reach the brain for decoding. The demand for circulation means "poor" or even "bad" images are preferable to no images, or to fewer "good" or "excellent" images. Such a demand is of course cultural, but it is also economic: the organisations for whom these engineers worked, in different ways, all had vested interests in the creation of economies of images.

These perceptual tests were the primary method by which the DCT was identified as being more appropriate for JPEG's compression than the other methods being considered. Beyond the DCT's effectiveness, there are two important observations to draw from the tests themselves: 1) the DCT was primarily tested in reference to television images displayed on cathode ray tube monitors in the late 1980s, with low resolutions even compared to a few years later; and 2) the engineers at JPEG describe near-imperceptible distortion ("excellent" images) at good compression rates, but in practice the level of distortion produced by JPEG compression often exceeds what would have been categorised as "poor" in such tests. This display context casts some doubt on some engineers' claims that the ADCT can produce results "indistinguishable from the original" – "excellent" on a CRT moniotor (which produces smooth, diffuse pixels) is qualitatively different from "excellent" on an LCD monitor (which doesn't), let alone at the much higher resolutions available today. The ubiquity of heavily artifacted JPEGs online also suggests the importance of such fidelity-based

[456] Ibid., p.7

criteria may be overstated.[457] In JPEG-1, this is what is described as the "appropriate accuracy" of the encoder: the acceptible level of visual loss identified within specific display conditions.[458] All claims about JPEG's visual fidelity – of impressive legibillity or of decay – are produced through such contexts. JPEG-1's authors cannot have conceived of its actual display conditions.

Test images contained up to 16 bits of information per pixel (8 for luminance, 8 shared between two chrominance channels); while the hope had been to compress images to 2 or maybe even 1 bit per pixel, engineers were surprised to find with the ADCT they could compression images as low 0.8 bits per pixel and still discern their contents. This category of image – legible but distorted – would become a ubiquitous kind of JPEG image. Nonetheless, even higher resolution images were achieving a remarkable compression ratio, well exceeding prior imaginations. With this, engineers began to speculate on new applications: the cinema, for instance was suggested as a potential route, as was medical imaging. In the years following the development of JPEG-1 (from 1988) many engineers would go on to work in such industry environments (medical, press, advertising agencies), adapting the process to the needs of specific fields. Aspects of JPEG do find themselves in video standards, such as MPEG, and today digital cinema is the norm.

The politics of standardisation

The Joint Photographic Experts Group was a colaboration, embodying different kinds of interests, and therefore entailed internal negotiation – what Sterne calls the poltics of standardisation.[459] In one such example, the committee hosted an unlikely and little known battleground between free and private conceptions of the internet, years before the development of the Web.

During the drafting period (1988-1991), such negotiation became more explicit through a debate around the status of intellectual propety in the standard. Alain Leger, an engineer from CCETT and an original member of the committee, led a drive to keep IPR (intellectual property rights) out, while IBM, which had invested heavily in a proprietary compresion technique that failed to meet the compression ratio of the ADCT (a non-proprietary method) resisted the adoption of this into standard, and wanted other aspects of its propritary research included.[460] Out of this struggle, the "baseline JPEG" was born: this split the JPEG specification into a free and public domain basic schema, and a more complicated (and – given computing power and knowhow to implement it – a somewhat greater compression) proprietary alternative. But it was the straightforward and

[457] Ibid., p.11
[458] JPEG-1, p.23
[459] Sterne, pp.131-137
[460] Alain Leger, email correspondence 2023

accessible baseline version which then chair Greg Wallace promoted in technical journals after publication, and which is still used today.[461]

One factor in the different positions put forward by engineers is doubtless their instituitonal context – a nationalised telecommunciations company producing public technologies up against a private computing giant looking to monetize the process – but there is also an infrastructural context here. It is not incidental that opposition was led by French engineers. While IBM had recently released its personal computer (which would become the basic unit of the Web), by the early 1980s Minitel was well established as a publicly operated mass communications network, partly on terminals distributed for free by the state.[462] Minitel remains a powerful imaginary, alongside the likes of Cybersyn and the Cleveland Freenet, as alternative models for networked communicaiton to the largely private internet of our present.[463]

Within such networks, engineers imagined the expansion of existing videotex from text to image, including internet shopping, estate agent and holiday listings, train timetables, dating profiles and pornography. Some of these, primarily though not entirely commercial, use-cases were made into mock-ups for testing and demonstration (fig-4.10). Alongside test images, they offer a curious view into the imaginaries of the engineers: simulating visual representations and modes of looking, and thus indicating a particular politics of looking. The human face is clearly of central importance in them, and yet it appears that the engineers who worked on JPEG (all but one of whom were male) were more interested in testing female faces than male ones. While not one of the final test images used at JPEG, "Lenna" – the cropped playboy centrefold of model Lena Forsén

Figure 4.10
Example of a dating profile mock-up created for Minitel.

A note on material history: before the advent of home printing, all such records exist as film photographs of monitors, not files or printouts.

461 Greg Wallace, "The JPEG Still Picture Compression Standard", *IEEE Transactions on Consumer Electronics* 38.1 (1992)
462 See, e.g. Julien Mailland and Kevin Driscoll, "Minitel: The Online World France Built Before the Web", *IEEE Spectrum* (2017) https://spectrum.ieee.org/minitel-the-online-world-france-built-before-the-web [19/10/2024]; Simon Nora and Alain Minc, *The Computerisation of Society* (London: MIT Press, 1980)
463 Cf. Liam Mullally, "Steps to a Collective Internet", *Autonomy* (2024) https://autonomy.work/portfolio/we-do-not-yet-know-what-a-network-can-do-steps-to-a-collective-internet/ [19/10/2024]

that was infamously ubiquitous in digital image testing from 1972 until the recent past – certainly appears in some of the literature cited in JPEG-1's bibliography.[464] Alexander Monea has argued it is "the assumption of banality, the presumption that such an image was by default uncontroversial, that belies its heteronormativity."[465] Such images are made invisible by the hegemonic codes that produce them, and only as that hegemony weakens do they become obvious. From the Volker von Bonin "girl" image, through Lenna and many of JPEG's test images, a heteronormative male visual pleasure is one code tangled into design.

Beyond this, it stands out that all the models used in its final test images are white – long documented (only recently confronted) inadequacies in the technology and cinematographic practice of the film industry when it comes to filming actors with dark skin should raise questions about JPEG's capacity to render black and brown faces with the same degree of clarity as white ones.[466] While the gender of these images' subjects point towards a gender politics of representation, as images used in the calibration of an image codec, skin colour will more profoundly have affected the ability of the codec to affectively render the full range of human skin tones. The framing of contemporary "inclusive" products like Google Pixel "Real Tone" photography as able to "represent the nuances of different skin tones for all people, beautifully and authentically" and marketed explicitly towards people of colour, points to a continued legacy of colour bias in photographic development beyond film of which JPEG is evidently part.[467] More work needs to be done to expand our understanding of such inadequacies, which are less well documented in digital than film photography.

Death of videotex and the birth of the web

In 1988, following Graham Hudson's departure from the JPEG committee, Greg Wallace took over as chair (as he was seen as neutral in the IPR debate), overseeing the writing up on the standard. The bulk of this work was undertaken by Greg Wallace and Joan Mitchell (of IBM), including painstaiking implementation of IBM's proprietary arithmetic coding – though this has rarely been used in practice. The standard was published in September 1992.

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[464] E.g.: Wen-Hsiung Chen, "Scene Adaptive Coder" *IEEE Transactions on Communication* 32.3 (1984), p.231

[465] Alexander Monea, *The Digital Closet: How the Internet became Straight* (Cambridge: MIT Press, 2022), p.63

[466] Lorna Roth, "Looking at Shirley, the Ultimate Norm: Colour Balance, Image Technologies and Cognitive Identity", Canadian Journal of Communication 34.1 (2009); see also: Liam Mullally, "Technopolitics and political Technologies (Afrofuturism & Broadband Communism), *Autonomy* (2023) https://autonomy.work/portfolio/digital-horizons-3-technopolitics-and-political-technologies-afrofuturism-broadband-communism/ [19/09/2024]

[467] "Real Tone", *Google* https://store.google.com/intl/en/ideas/real-tone/ [18/10/2024]

Videotex still appeared to be an important (if not the only) application upon the standard's publication in 1992. But such services were not long lived, falling out of use by the early 2000s and discontinued in the following decade (Prestel was discontinued in 1994; both the BBC's Ceefax service and Minitel in 2012). JPEG's primary application we know now, has been the web.

In 1993, JPEG was integrated into Mosaic, the first web browser to include multimedia functionality and briefly the most popular, itself developed in a public institution (the National Centre for Supercomputing Applications). Public development was quickly displaced by private: Netscape (founded by Marc Andreesen, who co-developed Mosaic), Microsoft's Internet Explorer, then finally Google Chrome and Mozilla Firefox, all of which have continued to support JPEG.[468] At the W3C (The World Wide Web Consortium) conference in 1994, it was adopted as a standard for all web-browsers. As some of JPEG's original engineers are keen to highlight, this adoption would have been unlikely without the IP-free baseline version of JPEG. Alongside HTML, which governs the overall format and text of a webpage, JPEG now forms one half of the division between text and image that has ruled the web for much of its history: text crawlable, comprehensible to algorithmic systems, and image, an array of data which can be transmitted and acted upon by computational systems, but until recently only meaningfully deciphered by human viewers. Of course, Mosaic and its successors didn't only support the JPEG image compression format, they also supported GIF and PNG (among others), so JPEG's total ubiquity cannot be arbitrarily explained by its inclusion; some aspect of JPEG's design must have contributed to its prominence in the web.

In this sense JPEG was always a kind of legacy technology: designed for a different media era than the one it operates in.[469] This may not actually be that unusual of a position for something so hegemonic and, really, it is a way of saying that JPEG has helped to produce the media era it now operates within; as one of the technologies that generated the current era, it appears strangely antiquated in the world of its own making. In the history of image compression, JPEG represents a break: older methods were either operated as a circulation technology for niche commodities (e.g. news images at the Daily Mirror) or monetized as a consumer or business device and service (e.g. fax). The early web, by contrast, was an academic, public endeavour: emanating first out of CERN, and then distributed between public, commercial and hobbyist stakeholders.[470] 2000s forums (Tumblr, 4chan, etc.) which so clearly embody an aspect of JPEG culture are run for profit

[468] Marc Andreessen, *NCSA Mosaic Technical Summary* (1993), p.3
[469] Istvan Sebestyen calls JPEG a "human heritage standard". Sebestyen argues that such a volume of JPEG images exist that codecs will always be needed to decode them; "ITU Interview: Istvan Sevestyen, ITU Special Rapporteur for JPEG and Former Ecma Secretary-General" *YouTube* (2018) https://www.youtube.com/watch?v=XGa_3NYwRQg [19/10/2024]
[470] See: Tim Berners Lee, *Weaving the Web* (New York: HarperCollins, 2000), pp.25-34

but cannot directly monetize content. The relationship between JPEG and capital is clearly a complex one; Harvey's account of time-space compression adequately explains its development, but it does not seem to explain much of its use. JPEG presents a peculiar crisis for capital: one of over-circulation.

Chapter five

JPEG-1, a close reading

Figure 5.1
News image of Concorde taking its final flight, reconstructed JPEG data (2003).

Square artifacts in high contrast areas indicate the materiality of its coding process.

in what one calls the real life of these existences "of flesh and bone"… there has never been anything but writing.

Jaques Derrida[471]

In Chapter Two I appropriated a JPEG-1 definition of an encoder as "An embodiment of an encoding process".[472] A JPEG codec is an embodiment of the JPEG encoding and decoding processes; one which adheres to the JPEG-1 standard. But "embody" is a curiously loaded term for a technical document, it suggests that a JPEG codec draws the compression process together into a body. It is also an apt formulation: even before bundling in an account of the aesthetic, social or economic, JPEG's technical construction is actually quite diffuse – it contains a number of protocols, several but not all of which will be in any implementation. "Embody" brings to mind

[471] Derrida, *Of Grammatology*, p.159
[472] JPEG-1

questions of representation, of human values or rules and their expression through institutions; it suggests JPEG codecs might take up and enact the values of JPEG in their everyday function.

This formation – the codec as an embodiment of a text, itself an embodiment of social, political, economic and cultural norms and demands – also lends a particular significance to texts. It positions specifications as a narrow funnel between the exorbitant realms of determinism and use, as a kind of fold. This is one way of reading Derrida's provocation that "there is nothing outside the text": texts (taken expansively) function as legible planes through which such things are articulated.[473] Like most digital technological-cultural forms, JPEG operates from text: a bundle of code, codec, specification and image data. This is the case for all the programs we call algorithms; in the complex of digital culture/ technology, text goes all the way down, or almost all the way down until you hit a binary bedrock, its material base.

Codecs are engaged in inscription – coding requires marking a substrate, even if that is only electromagnetic patterns on a hard-disk – but they are also inscribed upon: there are documents and practices that instruct their design and function. This chapter takes this rich textual base and seeks to appropriate it as a route into analysis, via a 'close reading' of JPEG-1 (ISO/IEC 10918) and other specifications required for implementation, notably the JPEG File Interchange Format (JFIF). In practice, such a close reading entails first encountering the standards (narrowly) as a description of a process, as technical exposition, a means of "coming to grips with [codecs] as technical processes", which Adrian Mackenzie has described as a key problem of analysing codecs.[474] Second, reading can go further to encounter these documents as texts, which frequently express more than they were intended to. Technical standards are situated in a particular cultural, institutional, professional and in a textual world, that renders them meaningful and that they also tacitly reproduce. As in any deconstructive method, such a close reading seeks to reach and collapse the assumed discursive limits of the text – which would include their positioning as politically and epistemically neutral, banal, non-aesthetic literature.

This chapter asks what is embodied in these standards, and how they work with their material. This is at once a procedural and an epistemic question (standards point to literature through a bibliography – links which are routinely followed), of how JPEG-1 proposes to work with its images and with the knowledge on which it is founded. I look especially to its work with information theory: the novel ways it figures the channel as open and intervenes upon Shannon's conception of "efficiency".

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[473] Derrida, *Of Grammatology*, p.159
[474] Mackenzie, "codecs", *Software Studies: A Lexicon*, p.48

The JPEG and JFIF Standards

"Digital compression and coding of continuous-tone still images – requirements and guidelines" (ISO/ IEC 10918, ITU T.81), normally called JPEG-1, is the core text of JPEG. It describes in mathematical terms a set of image compression techniques, developed largely in the 1980s by members of PICA.[475] Note that "JPEG" appears nowhere in this title and "JPEG-1" nowhere in the text: the specification predates notions of the JPEG file or image, which as forms are downstream of its schema. The scope of JPEG-1 is more modest – guidelines for adaptation in situ – and upon first reading strikingly generalist in outlook: summative rather than prescriptive. This is what JPEG engineers refer to as its "toolbox approach"; the specification was designed to cover a significant range of applications identified at the point of its development, including security, medicine, teleconferencing, and videotex.[476]

It includes both "lossy" and a "lossless" process (though the lossless mode is underdeveloped), two entropy coding options (Huffman or arithmetic), and designs for "sequential" or "hierarchical" modes in which images are either processed in full or as a series of progressively high-resolution renders (allowing for faster renders during slow loading processes). The result is a sprawling document, over 180 pages long and packed with a laundry list of methods, processes and definitions. Across these, though, JPEG-1 describes three main entities: 1) an encoder, which performs compression on image data, 2) a decoder, which reconstructs that image and 3) the interchange format. The interchange format, "a coded representation of compressed image data for exchange between application environments", is the JPEG image in motion.[477] It establishes requirements for compressed image data to be sent between applications (e.g. from camera to computer, from photoshop to web, or simply between devices) before decoding. It concerns circulation over compression (i.e. establishes the conditions of JPEG images' mobility); it mandates hospitability from applications using JPEG, allowing files to cross "the boundary between application environments."[478]

Not only does the standard include mutually exclusive coding processes, it also omits much of what is needed to practically implement its recommendations. Programmers implementing JPEG, therefore, first have to reduce it to one set of processes and second, draw upon additional documentation to define those things that are missing: the container format, colour space, file format and thumbnail coding. All these things occupy space and contribute to the character of

[475] JPEG-1, p.1
[476] Hudson et al., p.6, p.10
[477] JPEG-1, p.23
[478] Ibid., p.21

JPEG's compression. Even before JPEG-1 had officially been published, such a clarification was offered by the JFIF (JPEG File Interchange Format) an open-source file format specification, first published by Eric Hamilton in 1991.[479] While JFIF's modifications to JPEG-1 shouldn't be considered absolute, they offer a clarification on the iteration of its process that has become ubiquitous – and it was officially integrated as part 5 of JPEG-1 in 2011. Methodologically, JPEG-1 can be read through JFIF to produce an approximation of JPEG in use (and excluding those aspects of its toolbox which have become, or always were, redundant).

The JFIF specification describes its file format in clear terms:

> `JPEG File Interchange Format is a minimal file format which enables JPEG bitstreams to be exchanged between a wide variety of platforms and applications.`

JFIF is not interested in complicating JPEG; "Nor should it", states the specification, "the only purpose of this simplified format is to allow the exchange of JPEG compressed images."[480] JFIF is an attempt to make JPEG workable as software, to set its compression in motion and facilitate the spread of images as a component in the early web.[481] The first and most important stipulation of JFIF, therefore, is that it "strongly recommends" (though does not strictly require) use of the "baseline" version of JPEG-1.[482]

Baseline JPEG is the intellectual property free version of the protocol integrated through the internal campaigning of JPEG engineers and operates in the sequential lossy mode with Huffman coding.[483] Huffman coding and arithmetic coding are both forms of lossless entropy coding, which seek to reduce redundancy (i.e. repeated, patterned information – e.g. 10010010001100, which contains several repetitions of "100") in binary code. Arithmetic coding was an active, developing area of research at the time of JPEG's development, into which IBM were heavily invested, and so receives a series of citations from the 1980s. Huffman coding is an older (and simpler, although marginally less efficient) method for achieving the same effect, described in a single 1952 paper: "A Method for the Construction of Minimum Redundancy codes."[484] It has the significant benefit of not being subject to patent rights or proprietary restrictions as part of the baseline standard.[485] This means a coding process as follows:

479 Eric Hamilton, "JPEG File Interchange Format" (September 1992)
480 Ibid., p.2
481 Ibid., p.2
482 Ibid., p.2
483 JPEG-1, p.22
484 David Huffman, "A Method for the Construction of Minimum Redundancy Codes" *Proceedings of the IRE* 40 (1952), pp.1098-1101
485 Sebestyen, pp.19-22

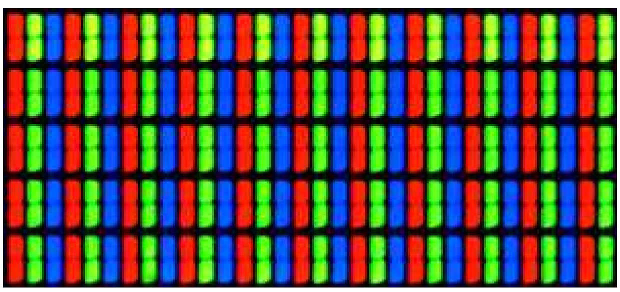
1. Raw image data is subject to a Discrete Cosine Transform (DCT)
2. The resulting data is quantized (rounded to a smaller set of values in a lossy process)
3. Data is subject to a entropy coding (Huffman)

JPEG on the web almost always embodies this baseline version, and my analysis focuses on those sections of JPEG-1 which describe it (the DCT, quantization and Huffman coding) while avoiding others (Arithmetic coding, the lossless mode and the hierarchical mode). These sections do demonstrate the institutional priorities of JPEG-1's development and work as points of comparison to the baseline version, but they do not describe JPEG as it is generally used.

Colour-space transformation

But JFIF doesn't just refine JPEG-1, it also adds to it. First, it defines a container format: the basic shape and organisation of a JPEG file. In JFIF this consists of an SOI (start of image) marker, a JFIF APP0 marker identifying the file format as JFIF and containing optional additional information, followed by an SOS (start of scan) marker, the image data, including table specifications and finally an EOI (end of image) marker. Despite remaining minimal, the JFIF APP0 marker does include space for thumbnail coding, which has become a key item in the visual syntax of the web (although perhaps thumbnails are less used than they once were). In addition to this, JFIF defines the orientation of a JPEG image "from left to right and top to bottom" – essentially restating the process of JPEG-1's sequential mode.[486] It is less visible today, but anyone who suffered through a dial-up internet connection will recognise this pattern, where the image loads in line by line, as a visual refrain of the early internet.

The most conspicuous gap JFIF seeks to fill, though, is colour space – the model by which colour is encoded and physically represented. JPEG-1 includes the process for compressing one or



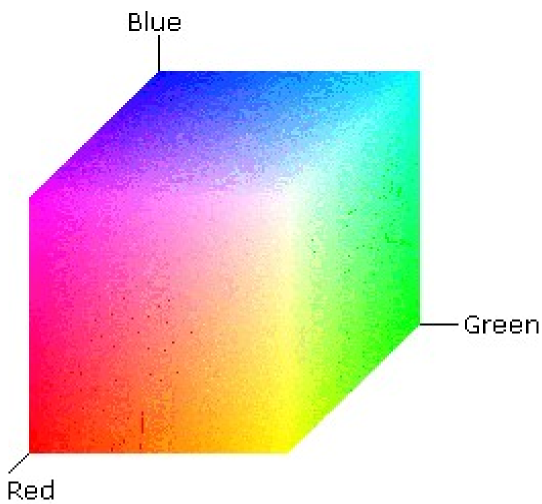


Figure 5.2 Magnified RGB components of a CRT monitor (left) and the RGB colour space (right)

[486] Hamilton, p.4

multiple components but does not specify a colour space: this could be a greyscale images with only one component – intensity – or colour images with multiple components. Colour space is seen as something external to the core specification to be developed for individual application environments; and it is true that colour spaces tend to correspond to specific representational environments (mediums).

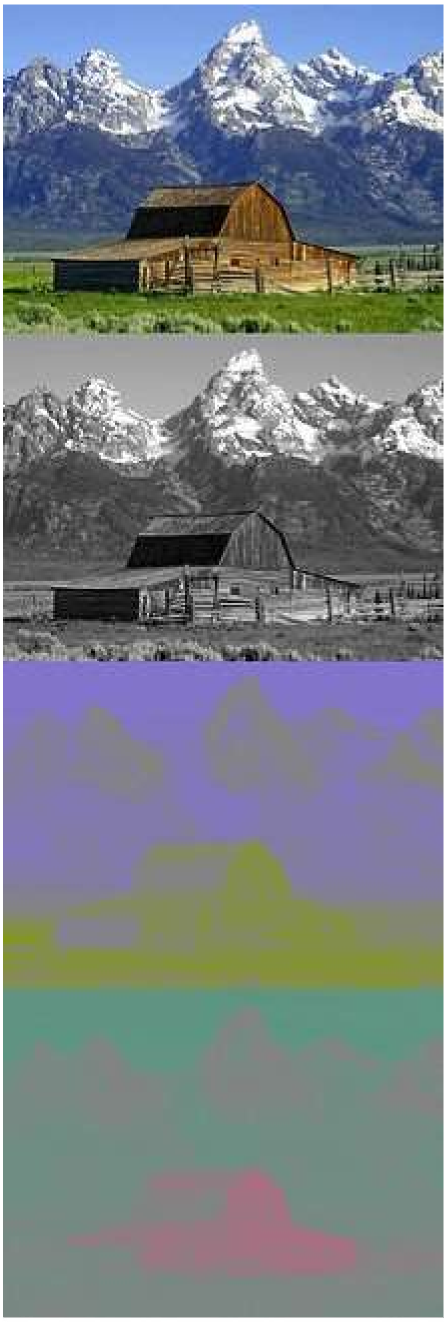


Figure 5.3 Still Image in the YCbCr colour space, broken into its components: Y, CB and then Cr.

JFIF allows up to four components (colour elements) and recommends YCbCr (luminance, blue-difference, red-difference) colour coding.[487] The digital representation of colour is made possible by a colour model, an abstract mathematical description of colour representation. RGB coding, for instance, which is frequently used by computer and television monitors, separates colour into three components, with values between 0 and 255: Red, Blue and Green. Older monitors, such as CRTs, really do have red, blue and green light emitters in close proximity to each other (fig-5.2), which, when their intensities are adjusted, appear to the human eye as different colours and shades: from no colour (0,0,0) to white light (255,255,255). This abstract colour model corresponds directly to a colour space, a 3D representation of the distribution of its colours. In the case of RGB colour, this is simply a cube, with red, blue and green each represented by one axis (fig-5.2), but this includes a high degree of redundancy and so isn't appropriate for a compression schema like JPEG. YCbCr coding is instead divided into luminance (Y; a description of the intensity of each pixel), blue-difference chrominance (Cb) and red-difference chrominance (Cr) (fig-5.3). The two chroma components are colour-difference components, meaning their values are defined by difference from the Y, luminance, value. They can be represented by the equations **Cb = B – Y** and **Cr = R – Y**, where B and R represent red and blue on a 2D plane. These colour-difference components alone generate some compression, but by separating luminance and the two chroma components, the YCbCr colour space allows different rates of compression to be applied to each.

[487] Ibid., p.3

YCbCr necessitates a transformation in the image (what is called a colour space transformation), encoding it into a new framework of visual representation before JPEG compression has even been applied. Colour spaces tend to be organised around material regimes of representation – the arrangement of LEDs, or the interaction of dyes. Here colour space is oriented towards a compressive regime: not only the maximum reduction of redundancy in the signal, but also its preparation into a form that can most effectively be compressed by JPEG. Yet this is still a material schema; JFIF's colour coding process points towards the existence of forms of compressed materiality which are not immediately comprehensible to the human sensorium.

'Image data' and form

As part of its toolbox architecture JPEG-1 expresses itself in general terms, referring to "image characteristics, display devices and viewing characteristics" generally, not to specific industries or implementations.[488] Such openness is a recurrent feature of JPEG-1, but it also obscures a more prescriptive attitude towards image conception: as is clear from its development, JPEG is concerned first of all with "natural image or realistic scenes", photograph-like images.[489]

Within JPEG-1, the encoder is said to act upon "source image data", and to produce "compressed" or "reconstructed image data". "Image data" is defined as "either source image data or reconstructed image data".[490] Compressed image data is itself defined, as "A coded representation

Figure 5.4.
DCT based compression at 0.08 bpp (bits per pixel), 0.25 bpp, 0.75bpp, and the original test image. Even at 0.08 bpp (a reduction of 12.5x), both balloon and clouds are clearly legible to the human eye. In practice, JPEG images have routinely been compressed way beyond this.

[488] JPEG-1, p.15
[489] Hudson et al., p.19
[490] JPEG-1, p.4

of an image, as specified in this Specification".[491] Such circular definitions – in which parts of the machine are defined only through their procedural relations to one another, not in absolute terms – is quite typical of a coding standard. Actually, "a coded representation of an image" is a good definition for image data – even as it maintains the central ambiguity around what constitutes an "image". This question is left to a common-sense, which is worthy of investigation. There are, concretely, forms of the image which JPEG considers legitimate, and mechanisms by which it can recognise them – but this is only implicit in its process.

In fact, the standard states explicitly that "The amount of compression provided by any of the various processes is dependent on the characteristics of the particular image being compressed…"; only images with certain characteristics are effective objects for its method.[492] DCT-based compression produces more visible blocking in areas of very high contrast and is therefore not appropriate for representing graphics or text (at least when fidelity is considered desirable). This is exactly its orientation towards what its engineers call "natural image or realistic scenes."[493] This effect can be seen clearly when comparing JPEG test images at high compression rates: transitions between solid blocks of colour are more clearly artifacted (as in the balloon against a clear sky), than between areas of visual complexity (the balloon against a cloudy sky; fig-5.4). Clearly, JPEG actively promotes some forms of visual representation over others, in the process defining the limits of what can and can't be expressed in its production, with significance to both aesthetics (the visual appearance of the image) and for economics (the reach and distribution of that image).

One mode to think the construction of an image is form – that of the image itself: which material arrangements of the image align with JPEG engineers' idea of an image. In particular, this is a question of JPEG's specific relation to photography. Even if JPEG-1 doesn't define what an image

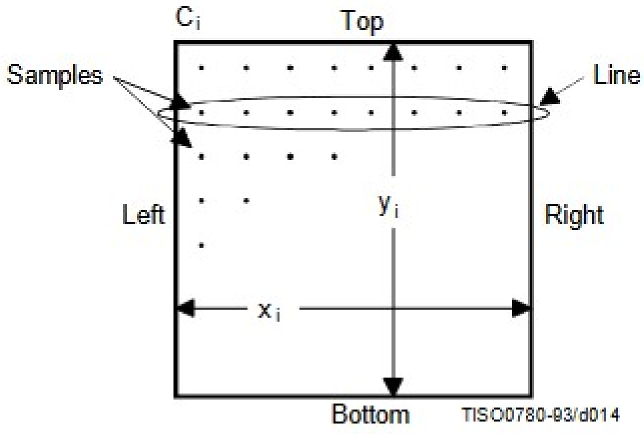


Figure 5.5
Schematic of an image, taken from the JPEG-1 standard.

The axes describe the array if samples making up a 2D image.

[491] Ibid., p2
[492] Ibid., p.14
[493] Hudson et al., p.13

is, it does describe the form it expects to encode: “continuous-tone still images”, which are greyscale or colour images composed of a continuous range of values (as opposed to a binary image, formed of just black and white pixels).[494] At the smallest scale, it describes these as being made up of “samples”, “one element in the two dimensional array” of an image.[495] Above this, JPEG images (at least those acted on by the DCT) consist of blocks, “an 8x8 array of samples, or… DCT coefficient values.”[496] Finally, all the samples of an image form scans or components, “one of the two dimensional arrays that comprise an image” (fig-5.5).[497] Each component represents one axis of a colour space, like YCbCr in JFIF, and when overlayed, they constitute the image. So, a JPEG image must be comprised of some number of 8x8 blocks of information arranged on a two-dimensional plane into a rectangle. In terms of expression, this generates rules which do not apply

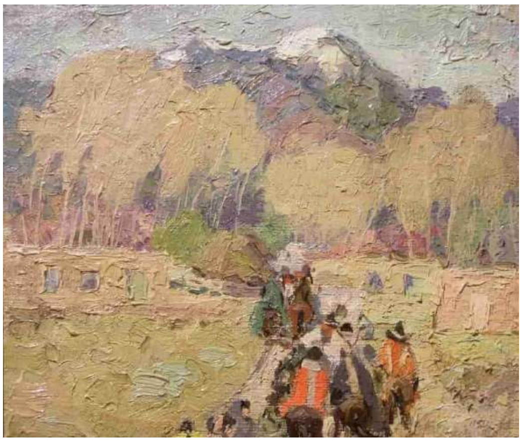


Figure 5.6 *Untitled* (top), *Taos Mountain, Trail Home* (bottom) and the opening cut-scene of *Half-Life 2* (right)

Impasto painting, décollage techniques and three-dimensional videogame environments are just three examples of visual work which build depth upon a plane

[494] JPEG-1, p.1
[495] Ibid., p.2
[496] Ibid., p.6
[497] Ibid., p.6

as strictly in other regimes of visual reproduction, from painting to virtual environments (fig-5.6).[498]

Notably, JPEG-1 describes its images as made up of samples, not pixels. Pixels are the graphical representation of an image through a monitor (in print these are called dots), whereas samples are measurements (e.g. of some colour component, or of luminance) taken from an image: samples produce pixels.[499] Scans have the same relationship to components, a two-dimensional array of samples, measurements or pixels, values. In this sense, JPEG-1 proposes to convert continuous tone images into discrete tone images, composed of a finite number of samples with discrete values. Such a framing obscures that the images JPEG processes normally have already been digitised (i.e. they are already discrete), either as the outputs of a digital sensor array, or as image data. In practice, JPEG treats samples from discrete images as though they are continuous, further reducing their fidelity. The frequency with which JPEG samples each component can range from one to four (horizontally and vertically), with one creating just one sample for every four pixels in the source image and four creating one every pixel. Here, JPEG ekes out another opportunity for compression: different components can include different sampling frequencies with a maximum compression factor of 16 for each component. This process, called down sampling, is only used in JPEG-1 as part of its hierarchical mode (which contains multiple resolution scans of one image within the same file), but JFIF applies different sampling frequencies to each colour component.[500]

It may not be immediately clear to what extent this is a necessary function for generating digital images, as opposed to a unique effect of JPEG's compression-oriented design. To this end it is productive to compare JPEG's construction of images to other digital image formats, especially PNG. Both are bitmap images, meaning they represent images as an array of pixel values (as opposed to vector images, which give the computer instructions for "drawing" an image itself). Both imagine the bitmap image, and especially the image file, as the fundamental unit of digital visual culture. Both process their images without reading or interpreting them – as a vector format would. But, whereas JPEG clearly imagines itself as extending out of a specific material culture of the image (photography) PNG design is oriented towards a different kind of image: namely, graphics and text. Unlike JPEG, PNG excels at compressing images with high areas of contrast, compressing such images effectively without reducing the clarity of lines.

[498] Wolf Vostell, *Untitled* (décollage on paper, 1958); Cordelia Wilson, *Taos Mountain, Trail Home* (oil on canvas, 1920s); *Half-Life 2* (Valve, 2004)
[499] JPEG-1, p.21
[500] Ibid., p.17; Hamilton, p.4

The pre-digital form which most closely mirrors such constraints is the photograph. Camera manufacturers, viewed digital photography as a decades-off development, played no role in JPEG's development, though the first consumer compact digital camera (Canon's PowerShot 600), released four years after JPEG-1, relied on the standard to compress photographs into its small casing.[501] JPEG images are and are not like film photographs in key ways – they visually resemble photographs, but the technical mechanisms they use for reproduction are different and there is no strict requirement for the data represented in a JPEG image to have been sampled via digital photography.[502] Compressed image data, unlike its equivalent (the film negative), does not appeal to the human sensorium any direct way.

It might be tempting to frame this as remediation: the photograph, conceived conventionally as an image captured on a rectangle of photosensitive paper, has been pulled through the logic of binary data, and reshaped in order to appear on our monitors. Such an argument is put forward in Jay Bolter and Richard Grusin's *Remediation*.[503] Media, they argue, "present[…] themselves as refashioned and improved versions of previous media".[504] The joint drives of immediacy (wanting closer and quicker access) and hypermediacy (wanting more of the thing) have motivated new media forms to take up and reproduce older forms, refashioning what came before.[505] Their core claim that "no medium… seems to do its cultural work in isolation from other media, any more than it works in isolation from other social and economic forces" is certainly true, but mediation falls short at describing JPEG's facsimile-position for a number of reasons: 1) it underplays the deep penetration of digital technology into the act of taking a photograph – some images may still use photographic paper or film as their substrate before being converted into a binary form, but most are now taken on digital cameras and never organised as anything other than a JPEG; 2) it idealises pre-digital photography as somehow less mediated, despite the comparable significance of its technologies of capture and reproduction; 3) it has a tendency to assign media fairly fixed characteristics, rather than ascribing agency to instances of their construction.[506] It can be easy to misunderstand the role that facsimile plays in such a case: JPEG doesn't, simply put, reproduce or mediate the photograph, it encodes the photograph, and in doing so it doesn't only make photos into digital images, it also encodes certain *rules of photography* into the production and circulation

[501] Cf. Hudson et al.'s description of Kodak's attempts, p.3; "1992-1996: Refinement & Innovation" (Canon Camera Museum) https://global.canon/en/c-museum/history/story08.html [05/10/2022]; Canon is cited as a copyright reference but was largely not present during JPEG meetings, though Kodak did send representatives
[502] The history of photography is itself very open, informed by a number of traditions and origins, see: Geoffrey Batchen, *Burning with desire: the conception of photography* (London: MIT Press, 1997)
[503] Jay Bolter and Richard Grusin, *Remediation: Understanding New Media* (Cambridge: MIT Press, 1999)
[504] Ibid., p.15
[505] Ibid., pp.1-15
[506] Ibid., p.15

of those images. These remain as a framework of production, materially integral to the generation of meaning but equally pliable to the influence of other meaning structures.[507]

Psychovisual coding

Besides form, JPEG-1's process might be thought through the question of what it anticipates. One such thing is the human sensorium. While this might appear obvious or mundane in film photography (which resembles its print for much of the process), the human sensorium (or a model of it) also instructs the JPEG process in profound ways, and is what makes its huge compressions possible. In a radical departure from Shannon's conception of information theory, JPEG-1 is calibrated towards humans as decoders of visual information, drawing them into the channel.

JPEG-1 anticipates a specific viewer: a construction that engineers call a "human visual system model." Human visual system models give systems analysis descriptions of human vision as computation. The earliest papers cited by JPEG-1 to this effect date to the 1980s but work on human vision as an information process dates to the late 1950s.[508] During this period, a dialectic emerged between work on so-called "computer vision" – attempts to facilitate human-like comprehension of visual data in computers, typified in the work of MIT's David Marr – and cybernetically-enthused anatomical research on human vision, through which human sensation and computational signal processing were blurred.[509] A naive presumption that a computer might be made to "see" within just a few years co-existed with a belief human vision might be totally described in discrete, computational terms; these were productive naiveties among which JPEG was formed.[510]

In the late 1960s the electrical engineer William Schreiber explicitly proposed applying findings from the anatomy of vision to image compression, and less than a year later, two scientists of vision, Fergus Campbell and John Robson experimented using Fourier analysis to model the thresholds at which contrast is visible to the human eye.[511] That 7-million cone cells and 100-million rod cells correspond to just 1-million fibres in the optic nerve led to a conclusion that the

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[507] Cf. Lev Manovich's account of "simulation" in digital software; "Inside Photoshop", *Computational Culture* 1 (2011) http://computationalculture.net/inside-photoshop/ [05/01/2025]
[508] JPEG-1, p.182; the key text in this regard is James Gibson, *The Senses Considered as Perceptual Systems* (London: George Allen & Unwin Ltd., 1966); first published 1959
[509] David Marr, *Vision* (San Francisco: W.H.Freeman and Company, 1980)
[510] Marr, p.16
[511] William Schreiber "Picture Coding" *Proceedings of the IEEE* 55.3 (1967), pp. 320-330; Fergus Campbell and John Robson, "Application of Fourier Analysis to the Visibility of Gratings", *Journal of Physiology* 197 (1968), pp.551-566

retina must itself carry out some bandwidth compression before the signal leaves the eye.[512] On the same basis, a conclusion was reached that image processing does not only occur in the brain, but across the optic nerve and in the eye itself, in the retina, photoreceptor cells and the optical construction of the eye.[513] It is this portion of a human visual system, cut "across the optic nerve" to exclude the higher functions of the brain, that JPEG-1 is oriented towards.[514] As in Shannon's information theory, which totally excluded the human, this is a distinction drawn along the descriptive capacity of then-existing anatomical knowledge.[515]

The schema can be summarised by a flow diagram (fig-5.7), in which the eye's optics and the retina process image data to produce a neural image for the brain, and the retina functions as an image processor, "weighting certain features over others".[516] From experimental results, it was determined that rather than scanning visual information like a flat image, human eyes extract "certain spatial, temporal and chromatic features for neural coding."[517] In computer vision this is called the "primal sketch" and concerns edges (as well as bars, blobs and terminations).[518] Fourier analysis allowed the system to be broken up into a discrete number of channels: a lowpass channel (i.e. one that filters out high frequencies) to identify overall contrast and a bandpass channel (i.e. one that carries frequencies within a certain range) which carries line and edge information within the eye.[519] In 1974, a mathematician called Nasir Ahmed proposed a Fourier-like transform for use in digital image processing, which he called the Discrete Cosine Transform (DCT), which was itself picked up by PICA and used in JPEG-1 to prepare data for a lossy process: quantization.[520]

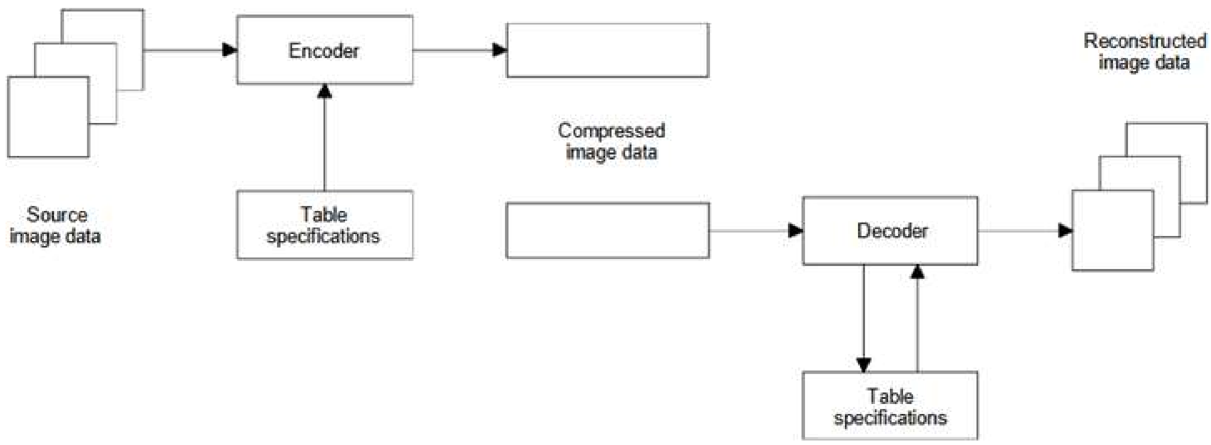
The human visual system model posits that the retina is lossy: "the idea is to code just that image information that is important for viewing the image."[521] With a human decoder at the end of the channel, in other words, data deleted by the eye in a lossy process anyway becomes redundant and can be deleted before transmission or storage. Two transformations occur here: 1) the human

Figure 5.7 Communication diagram of the human visual system (Granrath, 1981)

512 Ibid., p.553; p.558
513 Douglas Granrath, "The role of human visual models in image processing", *Proceedings of the IEEE* 69.5 (1981), p.558
514 Ibid., p.552
515 Cf. Hayles, *How We Became Posthuman*, pp.18-19
516 Granrath., p.555
517 Ibid., p.558
518 Marr, pp.68-74
519 Ibid., p.555
520 Nasir Ahmed, et al. "Discrete Cosine Transform", *IEEE Transactions on Computers* (1974), pp.90-93
521 Ibid., p.558

visual system becomes another codec, instantiated in the channel while 2) the codec itself comes to resemble the eye it is anticipating.

Experimental results cited by PICA suggest that colour is coded relatively between two channels, a primary red-green one and a secondary yellow-blue, with a third achromatic channel.[522] Via these channels, the model posits, the retina "extract[s] just the information necessary for discriminations to be made about objects in the outside world without actually making those discrimiantions."[523] This model of the retina is remarkably similar in appearance to the thing that image engineers were seeking to develop, a codec which could code image information for fast transmission at a significant transmission rate, without losing data which might be important for the extraction of meaning further down the line. In the case of its division between chromatic and achromatic colour information, it forms the theoretical origin of compression-oriented colour models which perform a similar division, like YCbCr.[524] A model for digital image coding, here, is



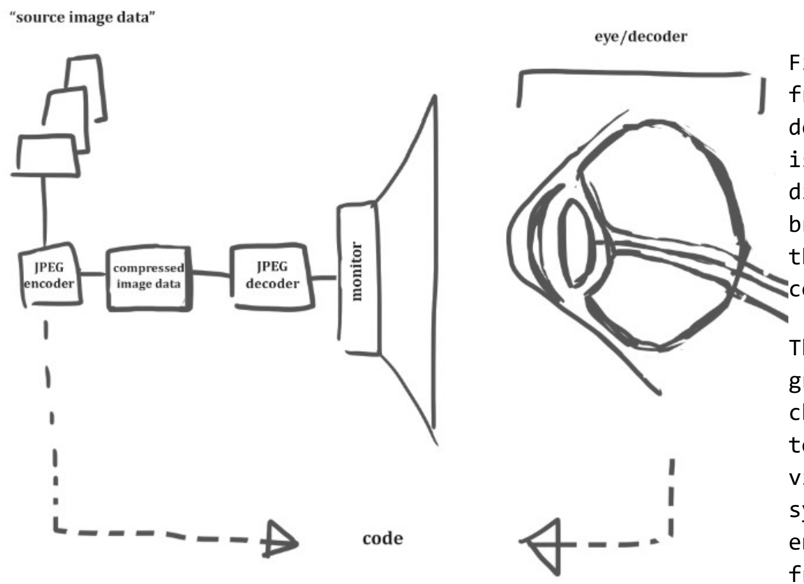


Figure 5.8 Schematic diagram from the JPEG-1 standard describing its process (above) is much like Shannon's own diagram of communication, but broken in two, anticipating the possibility of storing compressed data.

The actual process, however, greatly expands Shannon's channel (drafted by me, left) to anticipate the human as a viewing apparatus. There is a symmetry between the JPEG encoder and the human eye, from which its process was derived.

522 Granrath., p.555
523 Ibid., p.553
524 Ibid.., p.555

derived from a model of a biological system of perception, which in-turn is made to resemble Shannon's communications channel. Within the realm of psychovisual image processing, the language of perception and encoding become mutually descriptive: JPEG's codec, like the eye, prepares visual data for interpretation – for the extraction of meaning. Both JPEG and the human visual system act as image processors, with relatively fixed structures for encoding data that are themselves agnostic to meaning (at least on an individual scale: the eye can also develop through evolution, and table values can be altered between codecs). This is why, until recently, images have not been crawlable or deciferable by digital systems without the presence of metadata. Only through diffusion models and complex systems of artifical cognition have they now become deciferable to digital systems in and of themselves, without metadata or contextual cues.

In a departure from Shannon's isolated, technical conception of the channel, the viewer is drawn in (fig-5.8). Recalling Umberto Eco's conception of code, the decoder is always already determining the structure of the encoding process, and the rules that govern meaning is a collaboration from both ends of the channel.[525] As JPEG's compression ramps up the image does not degrade uniformly, those aspects of the image which are most prioritised in the eye are spared. JPEG, we now know, has often been ineffective at preserving visual fidelity. What it has been consistently good at (across different levels of fidelity) is preserving a version of the the image that the human eye can decode and generate meaning from. JPEG's most effective compression occurs in this zone: when the image is visibly altered, yet remains legible to the brain's decoding apparatus. Conditions of display are important – loss is more noticeable to the eye on a higher resolution monitor – but JPEG has always been lossy, even when it was first presented on 720x576 pixel displays. Whether or not loss is perceivable to human eyes, baseline JPEG-1 is always perceptually oriented.

Legibility (DCT and quantization)

In JPEG-1, this work on psychovisual image coding is realised in two interconnected processes: the DCT and quantization. Together, these are responsible for JPEG's remarkable compression ratio, as well as its most visually recognisable characteristics. Mechanically, they enact a preference for highly legible images – that is images which can be understood by viewers even at low fidelity, to which the process is oriented. Legibility, in this sense, is a near cousin of fidelity, but one with a radically different technical-aesthetic arrangement; rather than the maintenance of a signal in strict terms, it describes the maintenance of meaning within a specific techno-aesthetic assemblage, or set of meaning structures. A signal can be radically altered – and in JPEG

[525] Eco, *A Theory of Semiotics*, p.33

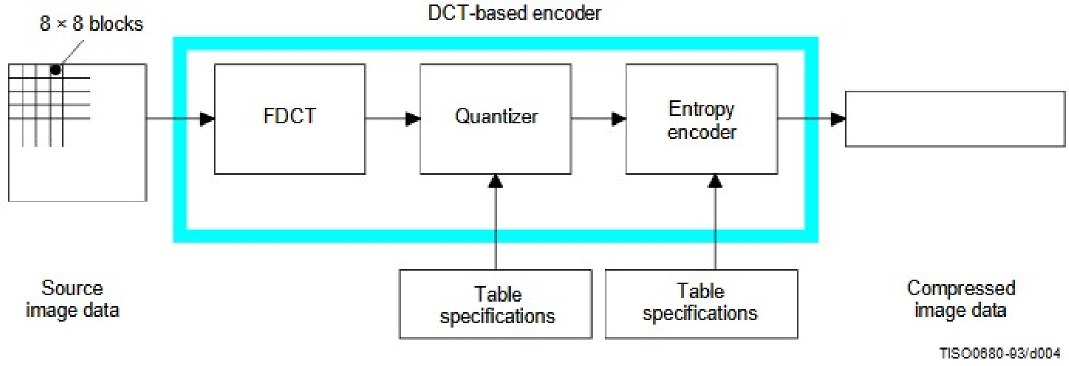


Figure 5.9 The DCT-based encoding process, comprised of sampling > Forward DCT > Quantization > Entropy coding, taken from JPEG-1

often is – yet remain legible. Legibility presupposed a prioritisation of certain kinds of information which are necessary for a reading process; (contra Shannon) they entail engineers getting involved with the messy work of meaning. In order to understand why and how JPEG produces the kinds of images it does – and the terms on which it concerns itself with meaning – one must digest these processes. In aid of this: a brief detour through the mathematics.

The DCT is a near relative of the Fourier transform. Like the Fourier transform, it can express a datapoint as a sum of sinusoid wave functions; in the case of the DCT this is a sum of cosine waves. JPEG uses a DCT-based encoder, summarised in a flow diagram (fig-5.9). The first step in this flow diagram is the forward DCT or FDCT (also called DCT II, or often just "the DCT"), which is applied individually to every 8x8 block of the image, defined by the formula:[526]

$$S_{vu} = \frac{1}{4} C_u C_v \sum_{x=0}^{7} \sum_{y=0}^{7} s_{yx} \cos\frac{(2x+1)u\pi}{16} \cos\frac{(2y+1)v\pi}{16}$$

The DCT can take an 8x8 block of 64 samples (say, of luminance) and translate them instead into a value which describes this array instead as the relative intensities of 64 example cosine waves.

It helps to think through this process visually: on a graph a standard cosine wave oscillates between 1 and -1 on the y axis, repeating with a frequency of 2π (fig-5.10); higher frequency

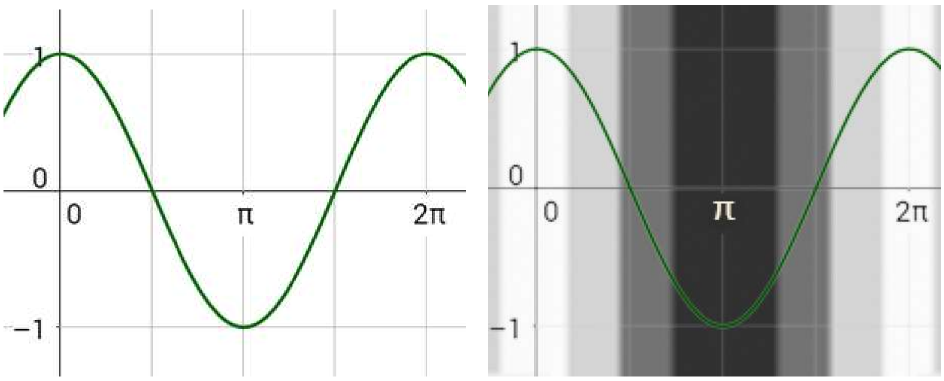


Figure 5.10 graphs of y=cosine(x) (left), and with y-axis values translated to pixel intensity values (right)

[526] JPEG-1, p.27; p.2

cosine waves repeat more often and lower frequency ones less often. If y is taken to represent relative intensity of each pixel, and x the width of the image, this cosine wave can be represented as a series of pixels. By using cosine waves with different frequencies, one can create eight different arrays of pixels along the x axis (fig-5.11). If this is repeated for the y axis, these can be

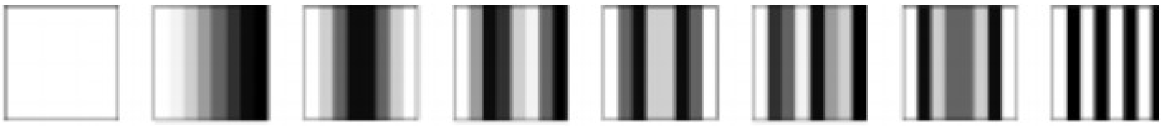


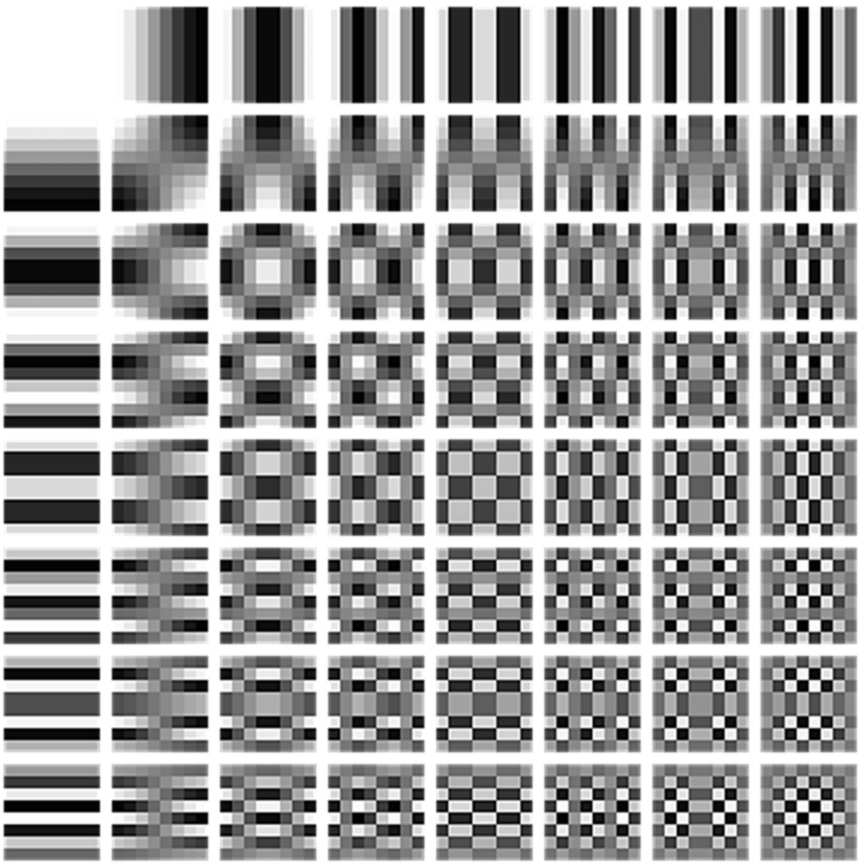
Figure 5.11 The eight basic sample blocks used in JPEG's DCT, x-axis only

combined to create 64 different 8x8 blocks (fig-5.12). JPEG works on the assumption that any 8x8 array of pixels can be represented with a high degree of accuracy as some sum of these 64 example blocks. The role of the DCT is to translate an 8x8 array of pixels into DCT coefficients, which express the weighting given to each one of these blocks.

Because luminance values in JFIF are on a scale from 0 to 255 but cosine waves oscillate around 0, each of these values has 128 taken away from it to produce a shifted block centred around 0. The FDCT equation is then applied to this shifted block, producing an array of 64 coefficients between -1024 and 1024. Rather than each of the 64 values representing the intensity of a particular pixel, they represent the degree to which each of the example 8x8 arrays contributes to

Figure 5.12
All 64 sample blocks used in JPEG's DCT process.

Each 8x8 bloc of input image data is translated into a combination of these sample blocs, which correspond to cosine functions



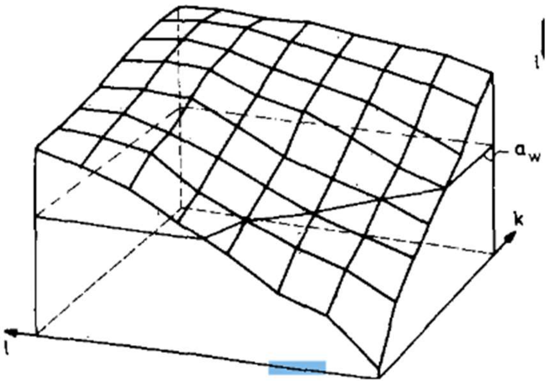


Figure 5.13 3D mapping of DCT coefficients by the thresholds at which they trigger stimulus in the human eye, from Herbert Lohscheller's experimental results (1984).

Coefficients above line aw approach no impact on human perception of complex images. Only the eleven coefficient squares in the front right corner (which correspond – confusingly – to the top-left of fig-5.12) Lohscheller argues are needed for the perception of visually complex imagery.

the block. As the top-left 8x8 block has a frequency of 0 (it is essentially a clear square), it represents the relative intensity of the block compared to the rest of the image. Here blocks with the largest coefficient values hold a significant impact on the image, while those with low values contribute little or nothing. In a standard DCT process these values can be simplified (rounded up or down, or even deleted) in what is called quantization, preparing the data to compress well via simple entropy coding methods.[527]

But JPEG-1 applies a modified version of the DCT process (the adjusted discrete cosine transform), adjusted towards a human visual system. As a rule, the lower frequency blocks (i.e. those towards the top-left of fig-5.12) tend to have much higher coefficients than the low frequency ones. According to JPEG's psychovisual model they are also generally less likely to

Luminance

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

chrominance

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

Figure 5.14 Luminance and Chrominance Quantization tables from JPEG-1; squares correspond to the sample blocks in fig-5.12

[527] When JPEG engineers began using the DCT, they found images legible at less than 1/10 bits per pixel.

matter in human perception. (fig-5.13)[528] As such, JPEG assumes, very small coefficients can be zeroed with little to no perceivable effect on fidelity. So, in the ADCT, coefficient values are weighted during quantization according to experiment tests of human vision ("psychovisual thresholding"), carried out with standard test images – the same images described in Chapter Four. [529] Early results demonstrated that such methods could reduce a transmission time of around two minutes via standard DCT to just 17.5 seconds.[530]

JPEG-1 includes sample quantization tables (fig-5.14), by which each coefficient value is supposed to be divided, and then rounds values to the nearest integer. Along the lines suggested by Lohscheller, many quantized values will become zero. You can see in JPEG-1's example table that a comparatively large quantization effect is placed on the bottom-right high-frequency values, especially in chrominance. This is an implementation of a low-pass filter, modelled on the eye as a signal processor – of course these observations are also mediated by particular technical conditions and displays, as well as the presumption in testing that images are photographic. Not only that, as I argued in Chapter Four, most such test images were either landscapes or the faces of light-skinned white women, and as such are oriented towards ways and locations of looking. The tables also demonstrate the comparatively high degree of compression that chrominance is subject too; this is another observation of the human visual system model, that the eye is much better at detecting intensity than colour. While JPEG-1's sample tables are broadly representative of those used in practice, quantization tables can and are altered, allowing for compression and fidelity to be exchanged at one another's expense. In applications like Photoshop, this is often presented as a slider bar from high quality/ low compression rate to low quality/ high compression rate. What such a slider often obscures, is that quantisation tables effect the quality as well as quantity of compression.

Quantization is an active site within an active site: the calibration levers of the DCT and hence JPEG's compressive schema. We should be cautious equating fidelity with meaning; psychovisual science demonstrates here that fidelity is less important to the creation of meaning than we might imagine.[531] JPEG's ability to distribute meaning is not independent from, but contingent on, the (meaning) structures that govern its distribution: aggressively compressing areas of high visual frequency has little effect on the photographs and visually complex images that JPEG-1 was written for, but other kinds of images, which rely on high frequency information to portray

[528] Herbet Lohscheller,"A Subjectively Adapted Image Communication System", *IEEE Tramsactions on Communications* 32.12 (1984), p.1318
[529] JPEG-1, p.143
[530] Ibid., p.1321
[531] Instead, a "primal sketch" of lines and edges is built up from intensity changes and spatial organisations; see Marr, pp.54-74

meaning, are rendered illegible. The clearest example of this is text, for which changing just a few pixels can radically alter the shape of a character (each character of 12 point text is roughly the size of two of JPEG's blocks, depending on the letter concerned). Even in large text, harsh contrast produces visible distortion and "blocking" along edges, where quantization has altered the values of individual pixels within large areas of a single colour. (Hence text is so often coded as data and "written" in situ, by a web browser, e-reader etc. – far more compression is gained from storing text in unicode than compressing it as an image). This is also true for vector graphics and other simple forms with sharp contrast between areas or shapes.

To complete JPEG's encoding process, the values produced by quantization are arranged in a string starting from the top-left DC value and zig-zagging across the AC values (fig-5.15).[532] This is optimised for the situation where most of the non-zero values are clustered in the top left corner (low contrast areas), leaving a long chain of zeros which can be more efficiently coded. The whole of this process is carried out for each block of the image, working in horizontal rows from top left to bottom right (fig-5.15)– hence distortions often appear in bands (fig-5.16).[533] Finally, each block's chain of values is arranged into a single continuous string, and these are Huffman encoded to produce compressed image data. Decoding is achieved via a reversal of the process, "essentially the opposite of corresponding main procedure within the encoder", though the data recovered will not be what was input.[534] Such an asymmetry means that the JPEG process cannot be exactly reversed; opening (decoding) a JPEG is always productive of something new, as is saving

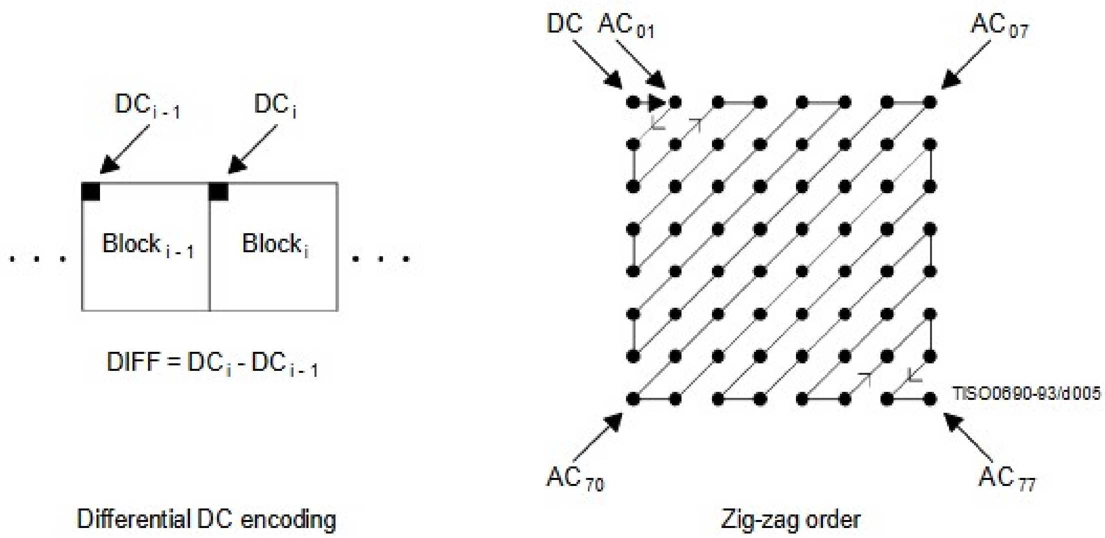


Figure 5.15 Encoding by line between blocks (left), and the zig-zag encoding pattern used within blocks (right); from the JPEG-1 standard

532 JPEG-1, p.17
533 Rosa Menkman, *A Vernacular of File Formats* (August 2010) https://creative.colorado.edu/~keho2869/glitch/Vernacular-of-File-Formats.pdf [05/10/2022], p.15
534 Ibid., p.15

Figure 5.16

Data moshed JPEG by Rosa Menkman from *A Vernacular of File Formats* (2010)

Here, distortions follow key points in linear horizontal lines, a product of JPEG's protocol (itself derived from horizontal linear norms of reading English text)

(encoding) it (hence editing software normally exports images as JPEG files, rather than 'saving' them). Each time a JPEG is exported it degrades, shifting as data but uncannily more-or-less the same as an image.

Jonathan Sterne's account of MP3 as a format unpicks the difficult question of fidelity, which at once is valorised by technical professionals (in audio) and certain audiophiles but has often been rejected by more casual listeners or popular cultures.[535] Legibility perhaps offers another way forward when thinking about perceptually adjusted codecs like MP3 and JPEG; in both MP3 and JPEG we see an orientation towards (imperfect, perhaps more so in sound) models of meaning formation; rather than crediting the widespread popularity of these formats to either the innate joy of decay or to base desires for cheap volume over quality (without totally discounting these things), we might instead consider the specific ways in which they appeal to the human senses as legible artefacts.

Constructing efficiency

A surprising feature of JPEG design is that, even while straightforward compression (i.e. reduction in bitrate) is eked out of every corner, the *most* compressive iteration of a process is often not used. Reducing bitrate as much as possible, it turns out, is often simply not the fastest option.

A straightforward example of this is the Karhunen-Loéve transform (KLT) which, despite being capable of greater compression than the DCT and other related transforms, was abandoned by JPEG engineers in the mid-1980s because it also demanded far more computational power (more

[535] Sterne, p.5

than was practically feasible at the time).[536] Such a conflict between time saved in compression and lost to computation goes back at least as far as Claude Shannon's *A Mathematical Theory of Communication*, as Warren Weaver summarises: "it happens that as one makes the coding more and more nearly ideal, one is forced longer and longer delays in the process of coding."[537] That no KLT based image compression schema has been adopted since suggests that this isn't simply a case of computers having insufficient processing power, but an ongoing trade-off between the distribution of computational resources, time required for coding/decoding and compression rate. A similar observation can be made about the non-adoption of JPEG 2000, despite its greater bitrate reduction. Even comparing the features of JPEG-in-use to the unused aspects of JPEG-1 this dynamic remains clear. Arithmetic coding is almost never used, despite outperforming Huffman coding. This case is more complicated only because there are *more* factors in competition with bitrate reduction: arithmetic coding is more computationally intensive, harder to implement and requires access to several patents, which represent a direct legal barrier to implementation, especially in open-source projects.[538]

Another factor, for instance, might be called openness. JPEG's interchange format insists that table data be stored at the front of the compressed data stream (at the cost of some, although admittedly not a huge amount of, compression). This includes, for instance, all the quantization values which have been applied. Any JPEG decoder – such a design mandates – must be given the resources to decode any JPEG image, even if this indicates a proprietary calibration design (e.g. Photoshop's implementation).[539] This simple mechanism is what ensures JPEG's hospitability to a range of formats across multiple application environments; rather than simply effecting compression ratio, it ensures JPEG files remain mobile, and is a key aspect of their tendency to spread. Yet it is also inherently anti-proprietary: it makes it impossible to ringfence or restrict the spread of a JPEG file (while also opening them up to processes like data moshing). It shapes the JPEH into a strange kind of anti-commodity which might act as a signifier for a commodity – as in a printed label or an NFT image hosted on a domain linked in a blockchain – but it cannot become a commodity itself. This simple design choice has had a significant historical effect on the visual economy of the internet, which has emerged as a free phantasmagoria of endless images – exhausting and plentiful. Here, as in the balance between legibility and compression rate, there is a conflict between multiple ways of understanding the 'efficient' flow of information – to return to Shannon's word.

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[536] Hudson et al., p.9
[537] Weaver, p.18
[538] Sebestyen, pp.22-23
[539] Ibid., p.23

JPEG-1 then, and really any compressive schema, can be read as a *balance of compressive factors* – which are both drives motivating development and sedimented meaning structures. I've pointed to at least five: 1) reduction in data size/ bitrate 2) legibility 3) processing time and effort 4) openness/reach. Reduction of bitrate for a finite channel was, economically and institutionally, the core motivator behind JPEG's development. Legibility, as opposed to fidelity, was a basic metric by which the viability of JPEG compression methods was measured in development, and – in relation to the human visual system model – forms an organising principle within quantization and the DCT. Processing time and effort dictated hardware and software possibilities in the 1980s but continue to be important factors for JPEG-in-use, where overly taxing processes have been repeatedly abandoned. Openness is both a design ethic and technical orientation. The tension between these five drives is what produces the specific character of JPEG compression, and it is only through their resolution that JPEG has become hegemonic. As soon as JPEG is broken down into such factors, though, it becomes clear that a) there is nothing inherently 'right' or 'natural' in the balance they achieve and b) that these same five factors do not affect every instance of compression. A different balance of factors may well produce a different character of compression, and it is possible to think of alternative ethics of compression; instead of the reduction of circulation time (which is almost always linked to an increase in production), for instance, we might look towards energy-efficiency or towards something resembling socialisation.

Such subtlety in one's understanding of "efficiency" can have radical effects on the production of a codec, and – under scrutiny – it becomes clear how central "efficiency" is as an input to Shannon's theory: both the location in which the social, political and economic enter the fray, and the point at which they are rendered as neutral, technocratic concerns. Weaver (in alignment with Shannon) defines an efficient transmitter as one that can "maximize the signal (or one may say, the channel) entropy and make it equal to the capacity C of the channel."[540] That is, efficient coding corresponds to an effective expansion of the possibility of information transfer in a channel. These are concerns borne from specific infrastructural and economic situations – the limited capacity of American telephone lines and the desire of telecommunications to transfer more information across these channels, in pursuit of the maximation of profit. But in fact, Shannon's schema is not so single-minded, and, as mentioned, considers computation time as another factor of efficiency in tension with the channel's effective capacity.[541] The rate of transfer of information is therefore

[540] Weaver, p.18
[541] Shannon, *The Mathematical Theory of Communication*, p.62; Weaver, p.18

the key criterion which straddles these concerns, corresponding exactly with the circulation of information as a commodity, and aligning to Harvey's description of time-space compression.

In JPEG, too, efficiency demands a maximum transfer of information. Though IBM likely had different motivations for the work than the CCETT, Minitel was conceived as a commercial system in thoroughly social democratic terms: distinctions can be drawn on the question of public or private planning, but these do not fundamentally undermine Harvey's argument.[542] But the intentions of JPEG-1's design do not wholly govern its use. One aspect of JPEG-1's conception of efficiency – its openness – creates problems for the circulation of information as a commodity in practice. Compressed JPEG image data, when released onto an international infrastructure of networked information, can travel widely and quickly. The mistake, here, was not also installing walls or locks into the codec.

JPEG-1 compression is hegemonic, in the sense that it was produced by hegemonic forces, but also that it forms an invisible, ubiquitous and unchallenged meaning structure for everyday expression. Because it is uncommodifiable, the jpeg image acts as a barrier to the economic drives that invented it. In this sense it is both liberatory and restrictive; the effect of JPEG's schema is not fully that intended by its developers, and certainly not that intended by its funders (Prestel was discontinued three years after the standard's publication), but its escape is limited. If JPEG is in some way counterposed to capital accumulation, it is certainly not counterposed to accumulation in general. It is intimately linked to an ecological crisis, whether or not people are paying for it; more photographs were taken between 2015 and 2017 than in the whole of photography's existence prior to that, the vast majority of those JPEGs.[543] This trend has shown no sign of slowing.

[542] Nora, p.113
[543] Hudson et al., p.6

A note on “JPEG culture”

The last chapter invoked an idea of “JPEG culture” – this note offers a short reflection on the elusiveness of this concept. That JPEG-1 has played an important role in the distribution of digital images is easy to demonstrate: in both of its major applications (storing compressed images on digital cameras and sharing them over the internet) JPEG-1 remains ubiquitous. The number of photographs taken since the advent of the compact digital camera far exceeds those taken on film, and so JPEG images have a strong claim on being the most prolific material format for photographic imagery not just in the history of digital photography, but the total history of the photograph.[544] Closely comparable technologies like MP3 seem to stand in idiomatically to forms of circulation, cultures of sounds, with which they’re associated. Despite JPEG’s ubiquity, I’ve found it hard to distil a notion of JPEG culture.

Thinking to the 2000s and early 2010s, I easily recall MP3s that embody the era: tinny pop music shared between mobile phones and MP3 players; in ringtones, CD rips and LimeWire downloads; Grime, 00s R&B and landfill indie; *Boy in da Corner*, “Do You Know”, and *Silent Alarm* leaking out of cheap headphones.[545] These are specific examples of MP3 culture, but they come to mind easily; JPEG is less evocative. Perhaps this is simply a product of JPEG having endured longer than MP3, which has largely been displaced by higher fidelity formats, themselves subsumed within encrypted digital rights management software. MP3, in this sense, is easier to periodise. But, intuitively, the absence of clear contenders for a JPEG culture suggests differences their economies: JPEG remains more hegemonic, and so it is also more invisible. Its logics are distributed and diffuse, personal and varied, more grassroots in their articulation, in and outside of industry circulation and capital accumulation.

Short of identifying specific images, there are certain kinds of images that might embody a JPEG culture: those shared on image boards, blogs and forums, or email; the memes, adverts, spam and other errant images strewn across the internet. Hito Steyerl’s “In Defence of the Poor Image” is an account of such ephemera.[546] A poor image, she argues, is:

> a copy in motion. Its quality is bad, its resolution substandard. As it accelerates, it deteriorates… distributed for free, squeezed through slow digital connections, compressed, reproduced, ripped, remixed, as well as

[544] Hudson, et al., pp.6-7
[545] Dizzee Rascal, *Boy in da Corner* (XL Recordings, 2003); Enrique Iglesias, “Do You Know”, *Insomniac* (Interscope, 2007); Bloc Party, *Silent Alarm* (V2 Records, 2005)
[546] Steyerl, pp.31-44

> copied and pasted into other channels of distribution… the trash that washes up on digital economies' shores.[547]

Poor images are freed by decay, washing up on unexpectedly (though implicit also is that such an "abundance" of digital waste has ecological corollaries). Steyerl offers Thomas Ruff's *jpegs* series as an embodiment of their visual character.

Ruff takes images from the internet and blows them up to massive proportions. At this scale the 8x8 pixel blocs that construct a JPEG image are exposed, rupturing the perceptual tricks on which it rests (fig-5.17).[548] Indeed, Ruff's work stands as a well-known attempt to tame JPEG's errant circulation and aesthetics of decay: if you're so inclined, you can buy his hardback collection from around £100.[549] Few of Ruff's JPEGs are freely accessible as JPEGs, and his publisher has done a good job of keeping the collection out of the internet's grey spaces. They are therefore oddly uncharacteristic of the thing they aim to portray, exploiting the material construction of JPEG images while also ripping them from that base for display in galleries and as fine art prints. Through domestication Ruff has robbed his JPEGs of their kinetic energy, of their reach. What remains is a dead specimen, showcasing anatomy but devoid of movement, real-time behaviour or life. Ruff's work distils a style, but falls short of the cultural life of JPEGs.

JPEG images extend beyond such self-conscious identification. It would be inaccurate to limit JPEG culture to the era of visual decay and relative anarchy Ruff's images recall. Alongside its early integration into the internet, the other factor underscoring JPEG's success was its adoption as the compression of choice for handheld digital cameras, and later, smart phones. Most JPEGs never

Figure 5.17 Thomas Ruff's jpeg *ny02* (left); blown up to reveal blocs (right)

547 Steyerl, p.32
548 Thomas Ruff, *jpeg ny02* (chromogenic print, 2004)
549 Thomas Ruff, *jpegs* (New York: Aperture Press, 2009)

made it to the internet, but remained on SD cards, USB sticks and hard drives, or were printed. This aspect of JPEG culture is not visible in aggregate but is no less significant. JPEG culture should be understood as encompassing such a variety of cultural-aesthetic modes; it survives today (remarkable, considering it is 30 years old) even after its blocky, low-resolution artifacts have faded. JPEG has outlived the moment of Steyerl's poor image.

There are no great artists of JPEG as a form. One can find practitioners working with it in meaningful ways (Ruff, Menkman, etc.), but its visual economy – unlike that of film, photographs, painting, even the MP3 – is not centred on 'artists'. Structurally JPEG belies provenance, and its visual economy is not one that produces singular or complete works. JPEG images are always in a transitory position, the domain of signals, and have often been shunned by the art and publishing worlds for their lack of fidelity. The structure of JPEG itself negates the modes of authorship on which the professionalised art world relies.[550] You cannot sell a JPEG copy, since ownership cannot be inscribed in the image (though you might sell a right to it). Enclosing them in a gallery halts the kinetic energy which defines such images. Artists like Ruff, interested in JPEG's visual economy, in the materiality of decay, routinely extract JPEG images from their formats.

A JPEG image can be had but not owned; there is no material recourse to its enclosure. All of this means JPEG does not tend to produce traditional objects for art historical or aesthetic discourse: personal photographs, ironic ephemera (i.e. memes), news images and amateur production. Such things dominate our visual sensorium – make up much of our aesthetic lives – but because (excepting news photography) they are not easily attributable to an artist, they are often overlooked as art.

The unique visual economy of the JPEG image also marks its total incompatibility with the commodity form. JPEG-1 stands as perhaps the clearest expression of the over-circulation crises with which digital capitalism has had to grapple across information forms. But it also typifies the total overstimulating abundance that has characterised digital culture. It is curious, and a conceptual difficulty, that such an (anaesthetic, 24/7) overabundance of information comes exactly at a moment in which accumulation appears to be breaking down via acceleration.[551]

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[550] See, e.g. Chicago Press guidelines, which suggest that "Each time a JPEG is opened and re-saved in the JPEG file format, the image deteriorates" and therefore indicate specific handling processes to avoid degradation; "Art Preparation Guidelines", *The University of Chicago Press* https://press.uchicago.edu/resource/artdigest.html [28/12/2024]

[551] Cf. Buck-Morss; Crary, p.17

Chapter six

Real-time crisis: temporal strategies in compressed media

Idleness, which destroys wealth and corrupts men.

Willam Beveridge (1942)

The train doesn’t make voyagers of us but packages to be expedited

Leo Tolstoy, quoted by Virilio[552]

Time management has been integral to the coordination of labour since at least the industrial revolution; so much so that one of the basic senses in which the word free is invoked – “free time” – is as time spent not working.

Indeed, at the foundation of the British welfare state, William Beveridge characterised idleness as a moral failure that endangers the individual and society, and positioned time spent idle as a malign counterpart to time spent working. Idleness, he claimed, “destroys wealth and corrupts men”.[553] His conditional welfare provision was designed to coerce idle workers back into work, rendering them productive. Against figures like Beveridge, Andre Gorz has situated free time, principally via the shortening of the work week, strategically as both a liberation from and within work.[554] Similarly, the French politician Jean-Luc Mélenchon has characterised free time as time “to live, to love, to do nothing if we like, to attend to loved ones; to read poetry, to do painting, to sing, or do nothing.[555] Art of all kinds here occupies a utopian post-capitalist space – both a means of survival and the thing that is being fought for. Its implication in such ideation has also sometimes led to its conception as a revolutionary means. This is implied, for instance, in Walter

[552] Perhaps apocryphal; Virilio, *Aesthetics of Disappearance*, p.113
[553] Beveridge, p.170
[554] Andre Gorz, *Critique of Economic Reason* (London: Verso, 1989), pp.92-93
[555]Jean-Luc Mélenchon, “on free time” https://x.com/broderly/status/1641910171914891264?lang=en-GB [25/09/2024]

Benjamin's famous invocation of the politicisation of art as a rejoinder to fascism's "aestheticization of politics".[556] It is also present in Felix Guattari's "new ethico-aesthetic paradigm", which he argued was heralded in hypertext and early digital media.[557] In the spirit of such aspirations for art, this chapter intends to shift from technics to poetics through close examination of a number of temporal strategies which have emerged in response to the perceived temporal intensity of modernity.

The basis by which time spent not working might be characterised as unproductive is perhaps less clear today: more and more, our leisure activities find ways of rendering us productive. Much of our 'free time' is today occupied by the consumption of cultural products, which render granular engagements and idle cognition into units of consumption within a complex apparatus of interface, advertisement and micro-transaction; our days are not simply composed of labour time and of free time, which is our own. Compression in general – perceptual coding techniques (e.g. JPEG) especially – have ushered in new temporal regimes and forms: a continuous, 'real-time', media present. Livestreams and on-demand streaming both present novel temporalities to scheduled terrestrial television, for instance. Such forms have significance to free time and are, in interesting ways, aimed towards it. Adorno and Horkheimer were already fleshing out a critique of the "culture industries" appropriation of free time in the mid-20th century; their argument, that non-productive time is incessantly coopted towards the consumption of commodities, strongly anticipates that of Crary's *24/7*.[558] I want to suggest that compressed digital media have produced new temporal rules which art, if it is to hold a political character, must militate against.

One category of media is particularly active in this sense: that which is not just subject to compression, but aimed towards compressed subjectivity. I examine idle games as such an example – mobile games which run even when closed, and which enact endless inflationary accumulations for their player. Once monetized, such games render idle time once again productive. One such game, however, *The Longing*, demonstrates a successful appropriation of these mechanics towards something other than productive free time – the valorisation of idleness – and therefore warrants attention.

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[556] Benjamin, "The Work of Art…", p.259

[557] Felix Guattari, *chaosmosis: an ethico-aesthetic paradigm* (Sydney: Powerhouse Publications, 1995), pp.98-99

[558] Cf. Theodor Adorno and Max Horkheimer, "The Culture Industry: Enlightenment and Mass Deception", *Dialectic of Enlightenment* (Standford: Standford University Press, 2002), pp.94-136

Compression as Poetry

"*exchange*, *copy*, and *delete*. From crossword puzzles to palindromes, all our letter-based games rely on these operations. Poetry was probably no more and no less than their maximization."[559] Kittler's invocation of compression as poetry is a typically playful provocation. It might appear that literary culture, more directly linked to "press" than "compress", is unimportant to a contemporary understanding of compression, but Kittler's invocation (via Shannon) of shared operations between games and poetry points to a more direct continuity. As discussed in Chapter One, both Andrey Markov and Claude Shannon used literary texts to demonstrate their theories. The arbitrary arrangement of letters within writing is the basic criterion of both poetry and Shannon's compression, which both value brevity – although their codecs are somewhat different. From Shannon's efficient coding schema to JPEG, compression has impressed upon aesthetics, affecting the quality and distribution of sensation.

Shannon is more interested in crosswords than literary examples: here the recurrence of letters, regardless of meaning, allows words to be arranged into rows and columns. Poetry, on the other hand, stakes an interest in the ecology of its arrangement: the interaction of limited elements to produce a maximum of meaning. "The semantic aspects of communication", Shannon claimed, "are irrelevant to the engineering aspect."[560] This equivocation is what made his theory practically applicable (the pursuit of meaning is, after all, what made Hrabal's Hanta lose so many productive hours), but the claim is only viable in a closed communication system: real-life, ecologically arranged communication systems don't reflect it. All codecs affect their signals and all compressions entail poetics. Dennis Tenen has described how, with the advent of telegraphy, "language compressed and pushed through... wires underwent a number of transformations."[561] Unlike the printed word which remains in place, he says, "the electrical signal is nearly instantaneous… The digital inscription gains a new dimension which extends away and beyond the reader's field of vision."[562] This is a straightforward McLuhan-esque claim: inscription exchanges longevity for geographic reach and what it means to read it is fundamentally altered in the process. All compressive media technologies represent, qualitatively and quantitively, an escalation on its premise.

One thing my close reading of JPEG-1 has brought out, is that compression codecs are implicated in the generation of meaning. By thinking of compression as a poetic, not simply technical, device, I intend to foreground its capacity to produce and transform meaning. An obvious question which

[559] Kittler, "Real Time Analysis, Time Axis Manipulation", p.6
[560] Shannon, *The Mathematical Theory of Communication*, p.31
[561] Tenen, p.135
[562] Ibid., p.136

comes out of such a claim is: what do the poetics of compression look like? Compression and acceleration tend to entail one another, but as sensations they can be distinct. Contemporary to Paul Virilio, for instance, Nancy Holt and Richard Serra's television broadcast, *Boomerang* (1974) – in which Holt hears her own voice repeated back to her with a second's delay – demonstrates exactly this: slowness not speed – as delay, being out of sync – integral to the experience of signal processing.[563] As Sybille Krämer argues in her analysis of Kittler's time axis manipulation: "In media technology, time itself becomes one of several variables that can be manipulated."[564] While I've already described an aesthetics of lossy compression, compression in general (lossy or lossless) entails a form of poetics – enacted especially through temporal transformations (accelerations in space). Compression troubles many of our assumptions about time and media, and radically alters the meaning of temporal strategies in art.

Slow media

> They had to think in words. That was their problem. The action moved too slowly to accommodate their vocabulary of film.[565]
>
> *Point Omega*, Don DeLillo

Whether positioned against Marinetti, capital accumulation or modernity in general, the 20th and 21st centuries have seen the emergence of a number of "slow" aesthetic practices and movements: slow food, slow cinema, slow television, slow fashion, slow journalism, etc.[566] These movements share some common characteristics. They claim an anti-capitalist, anti-globalisation, pro-local orientation, and are often also expensive or characterised as elitist practices which cater to small sub-cultures. In cinema, such work goes back to (and before) the structural films of the 1960s.

Filmmakers like Hollis Frampton and Tony Conrad developed art films as a location of resistance to mainstream narrative cinema, instead foregrounding the material process of playback. Flicker films, such as Conrad's *The Flicker* (1966), consisted of strobing sequential black and white frames; in *The Flicker* synthesiser sounds reminiscent of a spinning film spool mimic this imagery and evoke its process.[567] As frames repeat, dirt and scratches on the film's frames become noticeable; the film is ostensibly a repetition of two frames (black and white), but with nothing

563 Nancy Holt and Richard Serra, *Boomerang* (1974), https://www.youtube.com/watch?v=8z32JTnRrHc [01/03/2023]; hosted on non-commercial public-access television.
564 Sybille Krämer, "The Cultural Techniques of Time Axis Manipulation: On Friedrich Kittler's Conception of Media," *Theory, Culture and Society* 23.7 (2003), p.106
565 Don DeLillo, *Point Omega* (London: Picador, 2010), p.13
566 Carlo Petrini, "Slow Food Manifesto", *Slow Food* (2003) https://www.slowfood.com/wp-content/uploads/2023/10/slow-food-manifesto.pdf [21/09/2024]
567 *The Flicker*, dir. Tony Conrad (1966)

else to focus on, the material difference between each copy becomes evident. Frampton's *Lemon* (1969) depicts a lemon against a black background under changing lighting conditions.[568] As in *The Flicker*, with little else to watch but the intricacies of the lemon's form, the materiality of the film itself rises to our attention (fig-6.1).

Lemon has a runtime of 7 minutes and *The Flicker* 30 minutes: these films are playful provocations, but they also generate a meditative space counter to our expectations of a sensory stimulation from the cinema. Even if some of them (like *Lemon*) made money, their wholesale rejection of the narrative function (and to a certain extent, entertaining function) of mainstream film stands in the face of its formulation as a commodity. Though not explicitly associated with the movement, several of Andy Warhol's films from this era take this durational practice further: *Sleep* (1964) plays a loop of John Giorno (Warhol's then lover) sleeping over a period of five-and-a-half hours; *Empire* (1965) is even longer, depicting a stationary shot of the Empire State Building over a period of eight and a half hours.[569] "Slow film" or "slow cinema" emerged in the 2010s as a critical term to capture these experimental uses of slowness, alongside more mainstream articulations; a style of cinema which rejects "the accelerated tempo of late capitalism", instead foregrounding long takes, quotidian subject matter, minimal narrative as a kind of anti-accelerationist project.[570]

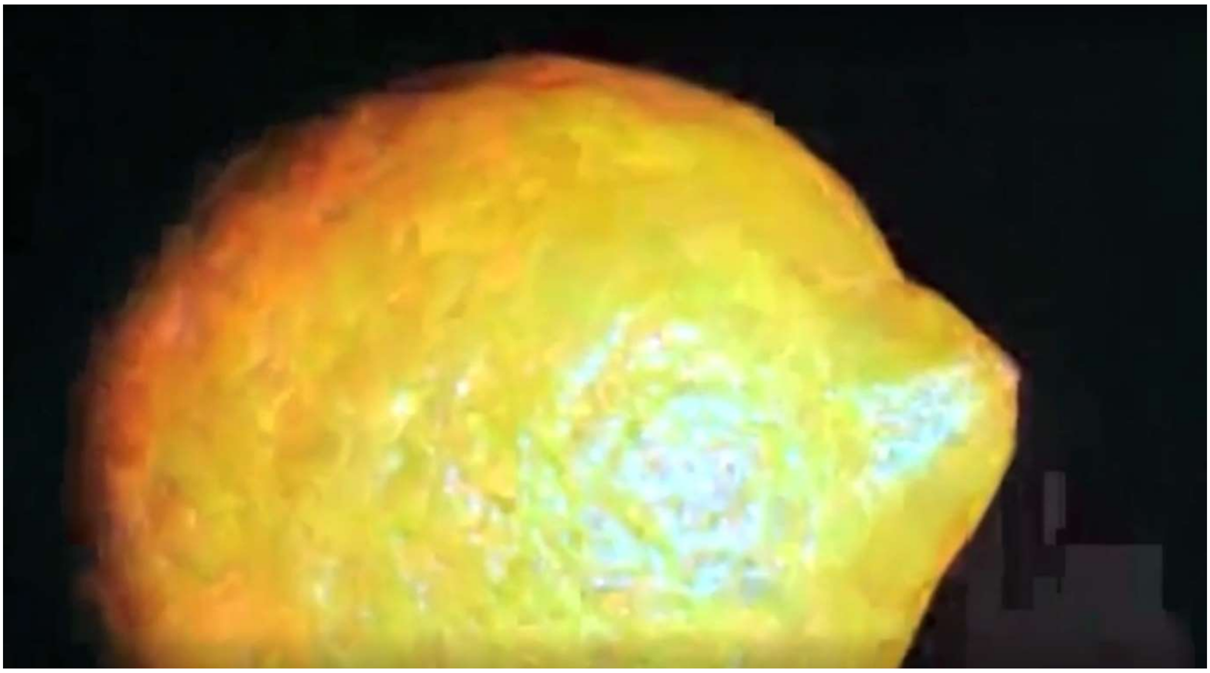

Figure 6.1 *Lemon* (1966), streamed on YouTube (2022). As the original aimed to with celluloid film, 2atching the film online today does a similarly good job of exposing the material construction of lossy data compression.

[568] *Lemon*, dir. Hollis Frampton (1969)
[569] *Sleep*, dir. Andy Warhol (1964); *Empire*, dir. Andy Warhol (1965)
[570] Tiago de Luca and Nuno Barradas Jorge, "From Slow Cinema to Slow Cinemas", *Slow Cinema* (Edinburgh: Edinburg University Press, 2016), pp.1-20

The proponents of the term don't present the diverse set of films and practices under its banner to be totally coherent – but they do identify a throughline of activity, very often interpreted as politically resistive. Ira Jaffe, for instance, contrasts the style to Benjamin's phantasmagoria, arguing that such films depict "an emotional and geographic sphere relatively free of the distractions Walter Benjamin… found characteristic of modernity."[571] Such critics stress the "space" such films generate for contemplation (of the film or reflexively, for the viewer) against the "haste" that characterises contemporary capitalism.[572]

All of this has led to a general critical perception that the slowness of slow media is itself resistive: to the sensibilities of mainstream (narrative cinema) production and even to film's status as commodity. In this tradition, one might frame slow audio-visual forms as resistive to compressed culture, a bulwark against the incessant operations of digital capitalism and a meditative space for recovery. However, I do not think this bears out media-historical interrogation. The extreme durations of slow cinema are made possible of technical manipulability of film: *Empire* relies on slowing down footage, while *Sleep* and *Flicker* utilise repetitions of copied frames. But at the point of these films' creations, there was no commercial form of cinema which could reconcile such length.

Erik Satie's *Vexations*, a piano piece which instructs the player to repeat the same short phrase 840 times, unearthed and published by John Cage in 1949, is part of the same tradition.[573] The earliest performances of the piece were exercises of extreme endurance for performer and listener: at the first live performance, organised by Cage, ten pianists played in relay, the performance ran from 6pm one day to 1pm the next and at least one journalist fell asleep.[574]

The conditions of extreme repetition and boredom engendered in such a performance are themselves interesting, but a history of the piece's distribution helps illustrate the overall trajectory of slow anti-commodity art. When Cage first published and performed *Vexations*, its extreme duration made it impossible to record a full performance on the recently introduced long-play record. When it was released in the Netherlands in 1983, *Vexations* was performed just thirty-five times, and the listener instructed to flip the record repeatedly (fifty times) to reach the piece's full duration.[575] On CD, there are examples with as many as fourty repetitions of the piece, but it was not until 2017 that a version became available with all 840 repetitions, streamable

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571 Ira Jaffe, *Slow Movies* (New York: Columbia, 2014), pp.4-5
572 Ibid., p.8
573 The original composition was likely a joke, never intended to be played Erik Satie, "Vexations", *Contrepoints* 6 (1949)
574 "Vexations Review", *New York Times* (11/9/1963), pp.45-48
575 "Erik Satie, Robert De Leeuw – Vexations", *Discogs* https://www.discogs.com/Erik-Satie-Reinbert-De-Leeuw-Vexations/release/1752753 [23/02/2023]

through Spotify (with each repetition categorised as one track on an album).[576] The technical requirements of reconciling this extreme performance with the commodity form had finally been met through compression and Spotify's media delivery architecture.

When you're looking for them, examples of radical speed are everywhere: the 140bpm tempo of Grime and the 180bpm tempo of Gabba, valorisation of the overstimulating, abrasive and garish in hyperpop (an audible articulation of the contradictions of capital), videogame speedrunning, Twitter's compressed character limit and TikTok's usual sub-one minute video length. But alongside faster, shorter media a survey of mainstream digital cultural forms also reveals a novel abundance of slow forms; for every TikTok there exists a Twitch. Livestreaming is the standout example, but examples of slowness permeate forms, genres and mediums: slowed-down Vaporwave records, the lethargy of UK Drill or SoundCloud rap, the lofi sound-production of Nujabes and the lofi livestreams that emulate him, endless playlists and barely edited podcasts, to name just a few.[577]

Slow media has been spoken of almost exclusively as a resistive domain: "a socio-cultural movement whose aim is to rescue extended temporal structures from the accelerated tempo of capitalism."[578] But the livestream especially troubles this basic formula. Take, for instance, the

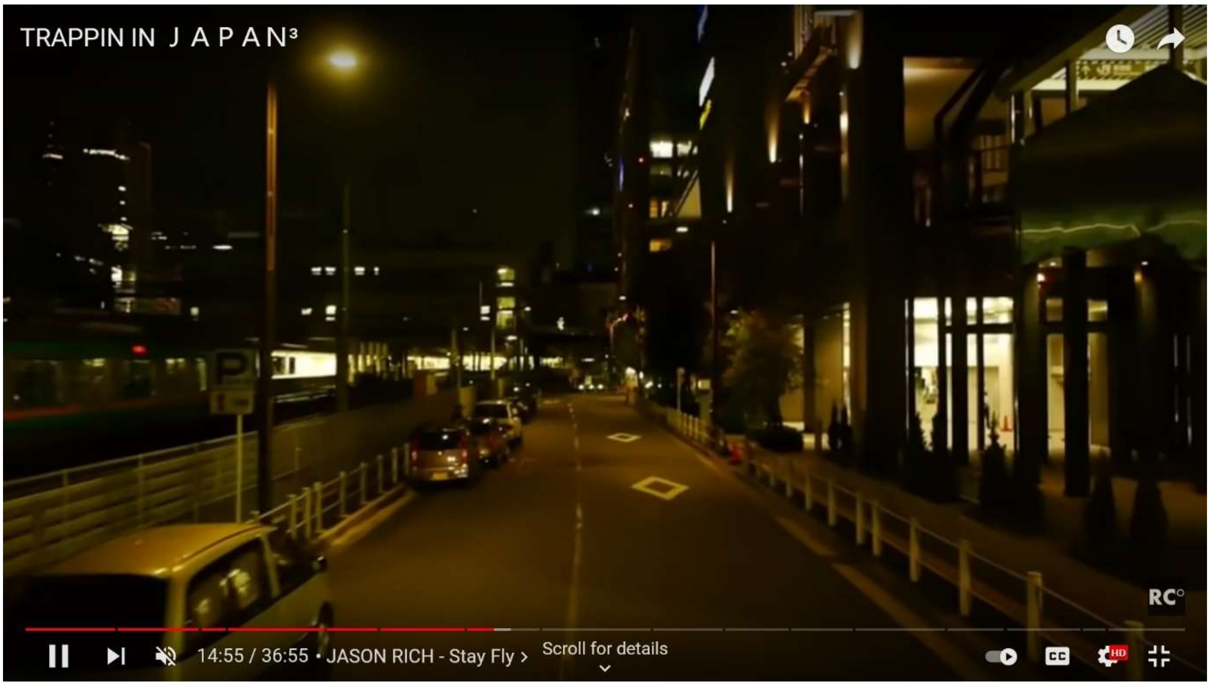

Figure 6.2. *Trappin in Japan*, a popular YouTube livestream, features 'slow' dash-camera footage alongside minimal trap beats

576 Ibid.; Alessandro Deljavan, *Satie: Vexations (840 times)* (Verso, 2017)
577 See, e.g., for Vapourwave, Macintosh Plus, *Floral Shoppe* (PrismCorp Studios, 2011); For Drill, Harlem Spartans, "Kennington Where It Started", *YouTube* (2017) https://www.youtube.com/watch?v=ed-oXKDmca0 [21/12/2024]; for SoundCloud rap XXXTentacion, "Look at me!" (Empire, 2015); Nujabes, *Metaphorical Music* (Dimid Recordings, 2013)
578 de Luca and Jorge, p. 3

livestream series *Trappin in Japan*, which features dashcam footage of Japanese cities and motorways (fig-6.2). The clips are long, without cuts or heavy editing – all features of slow film.[579] But as visual additions to music (also quite slow), they become more complex: one layer of sound and image among many, part of a maximation of sensation, an accompaniment to work, and a means of generating advertising revenue. They become something like the background music Adorno criticised in the 1930s.[580]

The mobilisation of music for productivity is not itself new. Shane and Graham White note, for instance how slave owners co-opted their slaves' singing to boost productivity.[581] From sea shanties to industrial working songs, the rhythms of song have long been integrated with labour.[582] Such music was also a reservoir for resistance ("which side are you on?" sings Florence Reece, in a well-known industrial folk song).[583] When Siegfried Krakauer surveyed the newly emergent salaried classes of Germany, he found typists trained to a phonograph: "The rotation speed of the record is gradually increased, and without the girls really noticing it they tap faster and faster."[584] This human, machine assemblage clearly yielded results, as it saw older typists without such training made redundant.[585]

Through algorithmically generated playlists, sensory stimulation can be near-continuous (even sleep might be accompanied by white noise). Self-generating playlists represent an intensification of radio: 1) they almost totally eliminate curation time i.e. time spent not listening or watching and 2) they make listening as frictionless as possible. Additional consumption time isn't just found in the commute but works its way into labour-time, overlapping forms of production and consumption, maximising extraction of value from both. There is a further effect: the homogenization of labour and leisure time. That work follows people home in the form of emails is well documented, but here leisure also follows people into work.[586] All of this time can be subject to granular financial operations.

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[579] Ryan Celsius, "TRAPPIN IN J A P A N3", *YouTube* (2017) https://www.youtube.com/watch?v=DqPgURTYygQ&t=899s [19/01/2022]
[580] Theodor Adorno, "Music in the Background", *Essays on Music* (Los Angeles, University of California Press, 2002), pp.506-512
[581] Shane White and Graham White, *The Sounds of Slavery* (Boston: Beacon Press, 1992), p.55
[582] Stan Hugill, *Shanties from the Seven Seas: Shipboard work-songs and songs used as work-songs from the great days of sail* (London, 1984), p.1; Rob Young, "'Jowel, Jowel and Listen Lad': Vernacular Song and the Industrial Archeology of Coal Mining in Northern England", *Historical Archeology* 48.1 (2014) p.1
[583] Florence Reece, "Which Side Are You On?" (1931)
[584] Siegfried Krakauer, *The Salaried Masses* (London: Verso, 1998), p.43
[585] Krakauer, p.43
[586] See: Liuba Bellkin, et al. "The Invisible Leash: The Impact of Organizational Expectations for Email Monitoring After-Hours on Employee Resources, Wellbeing and Turnover Intensions", *Group & Organizational Management* 45.5 (2020), pp. 709-740

Today there is reason to be suspicious of a critical position that aligns slowness with resistance, on either aesthetic or political terms. A major legacy of compression is exactly the movement of long, slow audio-visual forms into the mainstream. It reveals shortness to be integral to one form of discrete commodity mass reproduction, not a prerequisite for the commodification of art in general. Real-time media has dissolved the distinction (in political character, at least) between fast and slow; the drive for accumulation is generally ambivilant as to whether we consume one sixty-minute video or sixty one-minute videos. Instead, both fast and slow today comprise, via compression, a single temporal media regime: what Virilio called "real time" and Kittler called "simulated time", a continuous simulated present constructed from an array of time manipulations.[587] This is a technological simulation of real-time immediacy constructed from computational operations to the time axis: copy, delete, substitute, reverse, and compress.[588]

Idle games and idle time

The idle game – a relatively young genre of (primarily mobile) videogames also referred to as incremental games – was born in of a real-time milieu and operates with its material. Notable examples of the genre are *Cookie Clicker* (which established its basic mechanics) and *AdVenture Capitalist* (which monetized them).[589] Such games' engagement with compression is twofold: 1) they operate in and through a continuous present and 2) they enact time-compressions through their central accumulative mechanic. The basic mechanical features of idle games are as follows: players have a quantity of something (currency, cookies, numbers) and can click to get more of them; they also have the option to invest this currency in automation, which produce this quantity without their input or even presence (such games run in the background, or use machine clocks to simulate this); as the game progresses, huge quantities of currency can be invested to produce larger and larger accelerations in accumulation.

As the name suggests, idle games operate on idle time. Nominally, this is time not spent playing the game (when the application itself is idle). Idle time cuts across conventional distinctions of labour time and free time in curious ways. Unlike free time, the counterpart to labour time and "shackled to its opposite", idle time as invoked by Beverage is wasted: neither dedicated to nor anticipating work, and not necessarily realising value in consumption.[590] But in the context of a real-time media system, idleness also suggests the remaining time which has not been rendered

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[587] Paul Virilio, "Speed and Information: Cyberspace Alarm!", *ctheory.net* (1995) https://journals.uvic.ca/index.php/ctheory/article/view/14657/5523 [03/01/2025]; Krämer, p.106
[588] As Tim Lenoir has suggested in his work on the military-entertainment complex, the invocation of "real" in real-time (always accessible) media not only corresponds to growing intensities of engagement with digital media, but also a reconstruction of cultural perspectives of "the real"; "All but War Is Simulation: The Military-Entertainment Complex", *Configurations*, 8.3 (2000), pp.289-335
[589] Cookie Clicker, DashNet (2013); *AdVenture Capitalist*, Kongregate (2014)
[590] Adorno, "Free Time", p.195

as either labour time or free time – and might include sleep as conceived of by Crary, for instance. And so idle time is not neatly aligned or synonymous with free time, but is instead located in any durations which embody a radial unproductiveness: time spent not working during the work day, or not consuming during free time, time spent commuting, reflecting or doing nothing at all.

Despite their superficial simplicity, the primary mechanics of idle games, as I will argue, are temporal – experienced in a play of duration, in Henri Bergson's sense of the experience of time as it passes.[591] This play of duration, then, extends beyond the game application to encompass the player's own idle time. There is a clear case – as Paolo Ruffino has identified – for the idle game (especially in its most effectively monetized iterations) as a kind of capitalist realist fiction, turning inflationary acceleration towards endless inertia.[592]

A popular theoretical tool for interpreting idle games has been "interpassivity", which Sonia Fizek appropriates from Robert Pfaller and Slavoj Zizek, to position gameplay as a delegation of play from player to their device.[593] Fizek suggests such games undermine idealised conceptions of "interactivity", with players instead automating their enjoyment. But interpassivity is only part of such games, which I would suggest reach towards a tension between time (as measured by a clock) and duration (as experienced by those traversing it), in the trade-off between passive and interpassive modes, in the tensions and mobilizations of waiting, counting, timing, of passing time and having the same events gradually slow before being rapidly compressed, of seeing achievements pile up to absurd and incomprehensible volumes.[594] Idle games require player engagement for the spectacle of accumulation to be generated; waiting is a mechanical barrier to achieving this, but the player return is what drives it forward. As an engine producing faster and faster accumulation, a game like *Cookie Clicker* is incomplete without the player, who is required to realise its potential for accumulation via their return. In this sense they are implicated in its inflationary mechanics, not simply observers of it.

The question of when to invest is at the centre of all these games – especially those with more complex "prestige" mechanics, which allow players to trade progress for a modifier on future growth; waiting too long or too briefly can cost player time. Such a play operates outside of the user-interface, in the question of when to return. Player time is the currency here, and temporality

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591 Henri Bergson, *Time and Free Will* (London: George Allen & Unwin, 1950), pp.75-139
592 Paolo Ruffino, "The End of Capitalism: Disengaging from the Economic Imaginary of Incremental Games", *Games and Culture* (2019) https://journals-sagepub-com.gold.idm.oclc.org/doi/full/10.1177/1555412019886242 [14/12/2021], pp. 218-219; Mark Fisher, *Capitalist Realism: Is There No Alternative?* (London: Zero Books, 2009)
593 Sonia Fizek, "Interpassivity and the joy of delegated play in idle games", *Transactions of the Digital Games Research Association* 3 (2018), pp. 137-163
594 As in Einstein and Bergson's debates on time

is the location of play: the question is not what should I do in the game (which contains few meaningful choices) but how long should wait I before returning? Or, how much more slowness can I endure before I get to experience another acceleration? The player invests their time into a future compression, which will be experienced as a release from the slowness they are currently enduring. This drive towards compression in duration is the primary (perhaps only) source of pleasure after the game's initial cycles.

Cookie Clicker therefore entails two distinct durations: first of the game window itself, clicking to accumulate cookies, and spending these to improve the rate of accumulation, and second of the intervals between play sessions, in which the game continues to accumulate without the player present. Counterintuitively, it is the first duration which most clearly exhibits interpassivity, with player choices so minimal as to practically be pre-determined. The second duration, and the question of when to return, becomes the more active of the two, with strategies for waiting entailing different outcomes in the game's growth curve. Gameplay becomes a play of/with compressions, of time and on-screen accumulation.

Such mechanics complicate Fizek's account of interpassivity in two significant ways: (1) they suggest that deferred or outsourced gameplay might relocate sites of interactivity, not only eliminate them, and (2) that passivity/ automated gameplay might be interwoven with forms of interactivity, with pleasure not neatly derived from either. This doesn't mean the inversion asserted by this framework of interpassivity isn't useful, though. Fizek notes that in such games, "gameplay is reversed, as if the 'load' screen was the actual game and the gameplay a moment to 'wind up' or 'load' the game".[595] Player agency is clearly profoundly troubled if the player has no choice in their intervention other than to 'invest' routinely and keep the productive engine going – one might ask who/what is being played here.

This an inversion becomes more significant in the case of monetized mobile games (in which idle mechanics are increasingly a feature). User retention has repeatedly been identified by mobile game developers as vital for successful monetization: how is it possible to get players to continue giving over time or money for a cheaply built and maintained, ostensibly empty game?[596] While *Cookie Clicker*'s mechanisation of durational compelled players to return; *AdVenture Capitalist* renders this return productive by conceptualising it as a tool of user retention. "Time loses value without interaction", writes the games' developer, Anthony Pecorella, compelling users to return

[595] Fizek, p.152
[596] E.g., an infamous industry presentation: Torulf Jernström, "Let's go whaling: tips and tricks for monetizing mobile game players with free-to-play", *YouTube* (2016) https://www.youtube.com/watch?v=xNjI03CGkb4 [18/01/2022]

within a specific window.[597] When they return, players get to experience a “celebratory moment” as they shift the growth curve upwards.[598] As in *Cookie Clicker*, the play of waiting is integral to the game’s accumulative engine: by encouraging the player to game waiting the return becomes a lever at the players disposal, and one they activate willingly. The game spills into the intermediate durations between openign the app, occupying idle brain cycles as players anticpate their return. But such idle time is no longer unproductive, as in *Cookie Clicker*.

AdVenture Capitalist is an idle game not only because it runs idly, in the phone's background, but also because it seeks to act upon the idle, non-productive time of the player. It persues monetization as one route to rendering idleness productive: via advertisements and microtransactions, which expand upon the genre’s core mechanics. In both cases these do not offer players straightforward progress, but time accelerations. And the monetisation of time has curious effects on the status of idle time, now organised around the activiation of processes which are economiocally productive. Time spent playing or anticipating *AdVenture Capitalist* is therefore not wasted for the developers of exploitative mobile games or for capital accumulation. This is particularly interesting in the case of adverts, which can be understood as a means of transforming player attention into a commodity for advertising, and therefore becomem a strange form of labour: idle time rendered as labour time.

The dangerous anti-productiveness idlesness once held for Beveridge is gone, as is any threat to accumulation. Instead it takes on a new politics: one in which even idle cognition might be a form of consumption, even labour. All this is sold via an imaginary of endless frictionless accumulation in which there is no resistance to progress, no countermeasures or balancing; *AdVenture Capitalist* is mechanically impossible to fail, but equally impossible to win. Either end-state would be equally threatening to this illusion of continuity, as well as to the game’s consequent ability to generate revenue for its developers.

A defence of idleness

What response is there to such a regime? *AdVenture Capitalist* mobilises idle mechanics cynically for extraction and accumulation. A very different appropriation of the genre, *The Longing,* works against the instrumentalization of free time and towards an affirmative conception (and generation) of idle time.

[597] Anthony Pecorella, “Idle Games: The Mechanics and Monetization of Self Playing Games”, *GDCVault* (2015), https://www.gdcvault.com/play/1022065/Idle-Games-The-Mechanics-and [14/12/2021]
[598] Ibid.

Figure 6.3

A Shade, *The Longing*'s Protagonist, remarks on the fact that they (and its player) are waiting.

On-screen text reads: "sometimes I want to stop walking and just sit down to think"

Most idle games appeal to their players with speed; *The Longing* (fig-6.3) instead confronts them with slowness – and so initially resembles slow media.[599] The game depicts the 400 day wait of its subterranean imp-like character, "a shade", which elapses in real-time if the game is running or not. There is no running, and a shade takes minutes to cross a single screen. Such a glacial place is an affront to mainstream game design which tends towards fast walking speeds, endless running, flying, vehicles and fast-travel mechanics). Mechanically, the game inverts idle acceleration: early in the game the player will come across a closed door, which takes five minutes to open; such waits get longer, incrementing towards extreme degrees of slowness. If the player seeks to rush the shade they will respond plainly: "luckily I have plenty of time, so I'll gladly wait."[600] Rather than getting faster, the game begins by incrementing towards more extreme degrees of slowness; waits grow from minutes to hours to days. You cannot really play the game compulsively – since sooner or later it will tell you to go away for a week. And so, quite early on, *The Longing* confronts both the shade and the player with the task of enduring these waits, and it poses a question: what to do with this time?

This question is central to the *The Longing*. Waiting is neither innately joyous nor necessarily fun, "the longing" of the game's title is most obviously that of the shade: for company (of the king or others), for escape, for affection, for purpose – all things they lack in their empty underground ruins. It is also of the player, for the time-crush of conventional gameplay. One could simply close the game and reopen it in 400 days, but there is also a lot to be found in the shade's underground caverns if the player is patient: secret rooms, trinkets, coloured rocks and sheets of paper for drawing. There are books which can be read; *The Longing* hands its player a copy of *Moby Dick*

[599] *The Longing*, Anselm Pyta (2020)
[600] *The Longing*

and gives them more than enough time to actually read it. Many games deploy reading materials as one among many textual layers: narrative depth, exploration or visual fascination. In *The Longing* they are instead deployed as one among many ways of being idle, of passing time, of doing nothing at all. These things are not generally productive – in-game or outside it.

Unlike *AdVenture Capitalist*, waiting in *The Longing* is not a moment before gameplay, but (as in conventional slow media) a space for departure, to read, to get distracted, to explore, to think or to do nothing. This situation is complicated, however, by a second mechanic, which players must discover on their own: time moves faster when the shade is fulfilled, busy enjoying himself. Here the game enacts a more conventional temporal compression and departs from the general temporality of slow media. If this slightly undermines *The Longing*'s slowness, it offers something altogether more interesting and novel. It enables a more complex play with duration: acceleration is conditional, and the player isn't only given the power to accelerate (as in *AdVenture Capitalist*) but also to put the brakes on. The relationship between system and user is again inverted: interpassivity and interactivity are traded knowingly. Under a newly compressed temporal regime, *The Longing*'s default slowness stops being an imposition and becomes a break: waiting is reconciliatory and purposeful, a necessary reprieve from a clock accelerating towards zero.

The Longing is therefore not, simply understood, a "slow" game, and entails a more complex durational play than other examples.[601] It offers a rejoinder to the idle mechanics of cheap-to-develop extraction-machines like *AdVenture Capitalist*, but unlike slow media, it does so via a generalised defence against monetization on the one hand, and through a play of duration on the other. It reconstructs the mechanical engine of idle incrementation towards the production of a different milieu: duration as space, waiting as departure. *The Longing*'s achievement is modest but real: a re-orientation of the compressive engine of idle games towards something other than accumulation, an anti-productive ethic of idleness.

Poetics and infrastructures

Much controversy has been attached to the first sentence of Kittler's preface to *Gramophone Film Typewriter*: "media determine our situation".[602] I'm more interested in the opening of his introduction, which attaches itself to the imminent expansion of the fibre optic.[603] Optical media sit at the centre of Kittler's thought as a limit point to acceleration; they announce a digital age in

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[601] See: Sonia Fizek "Introduction: Slow Play", *New Directions in Game Research II* (New York: Columbia University Press, 2022), pp. 129-146; J Vanderhoef and M.T Payne, "Press X to Wait: The Cultural Politics of Slow Game Time in Red Dead Redemption 2", *Game Studies* 22.3 (2022) https://gamestudies.org/2203/articles/vanderhoef_payne [11/01/2025]
[602] Kittler, *Gramophone, Film, Typewriter*, p.xxxix
[603] Ibid., p.1

an almost millenarian manner. Time-axis manipulation, the temporal manipulation of signals by computational means, is an important concept in Kittler's work, but here its possibility is strictly infrastructural.[604] One might distinguish between technique and regime: signal processing makes possible time axis manipulation, but it is the computer network that makes possible its mobilisation in a generalised cultural regime.

Real-time digital accumulation is a product of media infrastructures, including both networked computing and softer infrastructures, like ubiquitous compression protocols. Reorienting mass communication and computation to something other than capital accumulation demands infrastructural thinking. Cultural practice – including interesting and compelling examples such as *The Longing* – is not enough to overcome this exorbitant question, and it would of course be unreasonable to expect it to do so. But what it can offer is a location of survival, and a horizon to work towards. Art might at least anticipate the space ""to live, to love, to do nothing if we like, to attend to loved ones; to read poetry, to do painting, to sing, or do nothing".[605]

[604] Kittler, "Real Time Analysis, Time Axis Manipulation", p. 5; see also Winthrop-Young's introduction or Krämer
[605] Mélenchon

Chapter seven

Crash! Compression at the limits of growth

eptitranxisticemestionscers desending, Ivan Seal (2017)[606]

it is the permanence of the war of Time that creates total peace, the peace of exhaustion.

Paul Virilio, *Speed and Politics* (1977)[607]

The exhausted world is not only sick from speed, it's *on* speed (and a lot more) just to get by.

Ajay Singh Chaudhary, *The Exhausted of the Earth* (2024)[608]

eptitranxisticemestionscers desending, the cover-art for stage 5 of James Leyland Kirby's ambient record series, *Everywhere at the End of Time*, eludes comprehension.[609] Its form is sculptural;

606 Ivan Seal, *eptitranxisticemestionscers desending*, Oil on Canvas, 2017, https://www.frac-auvergne.fr/oeuvre/eptitranxisticemestionscers-desending/ [27/02/2023]
607 Virilio, *Speed and Poltiics*, p.69
608 Ajay Singh Chaudhary, *The Exhausted of the Earth* (London: Repeater, 2024), p.177
609 The Caretaker, *Everywhere at the End of Time*, V/Vm Test Records, 2016–2019, https://www.youtube.com/watch?v=wJWksPWDKOc [27/02/2023]

certain features could be part of a figure, others resemble raw materials – stone or coral perhaps – but they do not coalesce. It is a painting of nothing, composed of parts that seem to belong to elsewhere, beyond the borders of the image: it signifies a kind of semantic exhaustion. Visually, it is a strong companion to Kirby's attempts to simulate the subjectivity of memory-loss and cognitive decay in *Everywhere at the End of Time* (*EatEoT*). *EatEot* enacts a steady decline from lucidity to total forgetfulness and isolation, into the bliss and terror beyond knowing. Its attempt to replicate the memory states of Alzheimer's rest on a series of escalating compressions: once familiar sound-samples broken down into smaller parts and dislocated. By taking this logic to its extreme, "beyond awareness", *EatEoT* offers one theoretical endpoint to compression. Like the plateauing rate of acceleration of idle games, *EatEoT* reaches homogeneity: sound is ground into dust, forming an exhausted desert-expanse without demarcation or meaning. This is what Kirby calls the "viewpoint of post-awareness", when the Alzheimer's patient becomes "unaware there is a problem", once they can no longer remember that they are forgetting.

Much of *EatEoT* comprises a dislocated, even menacing, nostalgia. Samples from big band and ballroom records, complete with sonic traces of their material history and age – the cracks and pops of old vinyl and mechanical playback – initially play out in full. Periodically these reappear, only truncated, rearranged and rendered unrecognisable, "pulverized", broken up into freely alienable parcels.[610] Memory appears only as decay; the nostalgia of Mark Fisher's hauntology, where the optimism of the past becomes cruel beside the reality of the present. Indeed, Kirby's earlier work *Sadly, The Future Is No Longer What It Was* was cited by Fisher as a key example of hauntology, "not so much a longing for the past as an inability to make new memories."[611] *EatEoT* is exhausting, and its sound-scape exhausted.

The state of exhaustion offers an affective counterpart to that of life on speed (a mirror of Virilio's derailment). Exhaustion as Ajay Singh Chaudhary theorises it not only a product of the depleting of resources, but also of a particular form of "overabundance": the accelerating exploitation of resources that leaves exhaustion in its wake.[612] This last chapter on compression proposes a short reflection from the point of view of exhaustion; it asks what happens to compression at the limit point of growth, and what compression might offer to an exhausted world.

EatEoT's soundscape is a compelling figure for such exhaustion. John Cage has described silence (or the "ambient noise" of that silence) unlike composed sound, as having no "frequency,

[610] Landon Bates, "The Process: The Caretaker", *The Believer*, September 18, 2018, https://believermag.com/logger/the-process-the-caretaker/ [17/02/2023]; Marx, *Grundrisse*, p.543
[611] Mark Fisher, "What Is Hauntology?", *Film Quarterly* Vol.66.1 (2012), pp.16-17; Mark Fisher, "Memory Disorder: Interview with The Caretaker", *Ghosts of My Life* (Alresford: Zero Books, 2014), p.113
[612] Chaudhary, p.171

amplitude, [or] timbre", only a "duration".[613] Cage was writing, though, from the perspective of the composer; for the listener time is less marked. Each track or stage might have a run-time, but it is generally difficult as a listener to determine where you are in these stages, or how close you are to their end. An inflationary expanse emerges from the dust of what came before (literally constructed from the fragments of its once coherent composition). Stage six, "Confusion So Thick You Forget Forgetting" begins with little to no demarcation in sound; a quiet hum fades slowly, by chance quiet indistinct loops of sound enter, some lasting for minutes, others for seconds. There is no sense of repetition, no orientation, no way of placing sounds in sequence or defining a destination. The sound is not building or fading or materialising into anything but ambient entropy. This is the "End of Time" from the work's title: after the recognisable features of sound fade, duration is the last thing to go. What remains is a landscape of boundless compression: an expanse, rather than a point; the logical endpoint of unrestrained inflationary expanse; total exhaustion via compression.

EatEoT offers a demonstration of the technical and procedural relationship between compressions and memory-loss, bound up with – through a model of neurological decay – loss of the ability to access the material origins of that condition. But such an expanse as an allegory for compression is haunted by the same spectre that haunts the endless accumulation of idle games. Long before the drive for compression breaks down all meaning, before it makes rubble of our minds, it will run up against the ecological limits to growth. Interruption is inevitable.[614] Bataille theorizes this as "ebullition", boiling over, "a moment bordering on explosion".[615] At the limits of growth energy must go somewhere: war, revolution, system collapse, self-destruction, reproduction. The intersection of limit-points and desolation recalls Fredric Jameson's much quoted phrase (popularised in Fisher's *Capitalist Realism*), that:

> It seems to be easier for us today to imagine the thoroughgoing deterioration of the earth and of nature than the breakdown of late capitalism; perhaps that is due to some weakness in our imaginations.[616]

Indeed the "end of the world", as Fisher paraphrases it, is eminently imaginable today. *EatEoT* as an exhaustion narrative might be contrasted to the more conventional ecological imaginary of the doomsday clock counting down to midnight (fig-7.1). One can think of films like *Don't Look Up* or *Melancholia* which depict the apocalypse as a sudden, discrete moment, or even activist

[613] John Cage, "Erik Satie", *Silence* (London: Calder & Boyars, 1968), p.80
[614] "noise gives rise to a new system", Serres, p.14
[615] Bataille, p.30
[616] Fisher, *Capitalist Realism*, p.8; Fredric Jameson, *The Seeds of Time* (New York: Colombia University Press, 1994), p.xii

messaging that we have x number of years to reach net-zero.[617] But doomsday clocks have a tendency to run slow. The Bulletin of the Atomic Scientists' Doomsday Clock, for instance, founded in reaction to the then present threat of nuclear destruction, started at seven minutes to midnight in 1947. The sixty years since have seen the emergence of several parallel, new threats for the clock's editors: US foreign policy and climate change.[618] Since 1995, these have moved the clock almost ceaselessly towards midnight, and so the clock must perform compressions to enable its countdown to continue: in 2020 it ticked over from 2 minutes to 100 seconds, in 2023 to 90 seconds, tending towards midnight but never reaching it. (If catastrophe takes long enough to arrive maybe it will begin counting down in fractions of a second).

Figure 7.1 Clocks count to midnight' Bulletin of Atomic Scientists 1947 (top); 2020 (bottom); and an allusion in *Watchmen* (1987) to the clock reaching midnight (right)

617 *Don't Look Up*, dir. Adam McKay (Netflix, 2021); *Melancholia,* dir. Lars Von Trier (Nordisk Film, 2011)
618 See, "timeline": https://thebulletin.org/doomsday-clock/timeline/ [19/01/2022]

Reaching midnight for such a clock is impossible; will the Bulletin of Atomic Scientists put out a press release during the apocalypse? Any crisis large enough to justify reaching midnight ought to break the clock, undermining the infrastructure that keeps it ticking. As *EatEoT* demonstrates long uncertain durations imply infinite length (especially true in the homogenous time of compression) but that does not stop an end from coming – in Kirby's record this is a choral break from the silence, and the needle reaching its centre. Such an endpoint is hard to predict from within compression's milieu as its factors are external to the central tenants of continual accumulation and inflationary economics. But accumulation does rely on the continual extraction of finite resources and the transformation of the planet's ecosystem, most significantly via carbon emissions. Such emissions represent a material barrier to growth, our so-called "carbon budget."[619]

This material barrier functions powerfully to undermine the idea that liberal economies, or even capitalism generally, can be permanent. Surplus, Bataille correctly identifies, is dangerous: it is not concretely possible to identify when or how ebullition will occur, only that it will. It is worth remembering the always present but often overlooked ecological framing of Jameson's original statement. We might find it easier to *imagine* the end of the world than the end of capitalism, but that doesn't mean that the "thoroughgoing deterioration of the earth and of nature" is itself *imaginary*. Instead, Jameson's formulation offers itself as a choice: either pursue the end of capitalism or get the destruction of the earth (Rosa Luxemburg's rallying cry, "socialism or barbarism", expressed as resignation to the latter). That is, in our present the end of capitalism *through* the thoroughgoing deterioration of the earth and of nature is now the default position.[620] What does that mean for us, inhabits of the surplus-generating machine that is capitalism? What happens when its limit is met, when the Anthropocene collides with the biosphere? The disastrous collapse of our cultures and the planet that sustains them might be one such ebullition. One aspect of the acknowledgement of this danger has been the emergence of a new determinism, that capitalism (and with-it time-space compression) will not end in reform or revolution but ecological crisis – and that this ecological crisis is unavoidable. As a tendency this most apparent in the emergence of a climate fatalism – in which ecological catastrophe is an inevitability that must be come to terms with, rather than fought, overcome or even survived – as well as related expressions of climate grief, ecological mourning etc.

But the world will not end in 2050 if we are not at net zero emissions; life will go on, only harsher, crueller and more exhausting. It is important to remember that this steady and thoroughgoing

[619] Pierre Friedlingstein et al., "Global Climate Budget 2020", *Earth System Science Data* 12 (2020)
[620] Saito, *Marx in the Anthropocene*, p.172

exhaustion is what we are up against; there is no bomb to save us from it. The exhausted, as Chaudhary conceives it, is a political bloc – a coalition of those exhaustion by boundless accumulation and exploitation.[621] Kirby and Fisher's hauntological concerns were also embedded in a specific milieu, to which one can map a direct continuity of contemporary exhaustion: neoliberal Britain after the 1990s, the beginning of the austerity-era. Blair's election, perhaps more than Thatcher's successive governments marks the beginning of capitalist realism proper for Fisher: the self-elected political arm of the labour movement pursuing a neoliberal agenda, the end of alternatives. Such a milieu, the period in which Francis Fukuyama's infamous "end of history" remained a kind of dominant ethos, continued from the mid-1990s at least until *Capitalist Realism* was published in 2008 – the same year as the financial crisis and bank bailouts, which Fisher saw as a state re-assertion of the neoliberal hegemony, and just before the introduction of austerity in the UK: an extreme compression on the state and government spending.[622]

How should the exhausted confront compression – "efficient coding" – as an economic logic, communications infrastructure and information processing technique? I do not wish to be drawn far into debates of degrowth vs. modernism, which have become stratified into unhelpful orthodoxies.[623] There is no question that we need to build – to employ a certain kind of 'modernist' thinking via planning, cybernetics, design, etc. But it is also clear that endless accumulation, capital or otherwise, serves only to exhaust ourselves and the earth; 'ecomodernism' as generally articulated has not been able to answer this problem, aside via a vulgar prometheanism that suggests technology, not social or economic change, will resolve the crisis (a conventional technological solutionism).[624] In doing so, such thinking falls into a pattern described by James Snead over forty years ago: "precisely the belief that there is no repetition in culture but only a difference, defined as progress and growth."[625] The technologization of "efficiency" via compression on the one hand creates the possibility of abundance without exhaustion, but has in practice only contributed to a general acceleration of accumulation, and in fact escalated the exhaustion of the earth. Compression exposes a general bind: we should desire on the one hand to construct a future from tools produced by capitalism, but we should not aspire to do so in its

[621] Chaudhary, p.166
[622] Fisher, *Capitalist Realism*, p.78
[623] See Saito, *Marx in the Anthropocene* for a degrowth perspective on ecomodernism, and for a response: Matt Huber and Lee Phillips, "Kohei Saito's 'Start from Scratch' Degrowth Communism' *Jacobin* (2024) https://jacobin.com/2024/03/kohei-saito-degrowth-communism-environment-marxism/ [24/09/2024]
[624] For a promethean 'ecomodernist' account see: Lee Phillips and Michal Rozworski, "Planning for the Good Anthropocene", *People's Republic of Walmart*, (London: Verso, 2019) pp.233-241; Also Saito's critique: Kohai Saito, *Capital, Nature and the Unfinished Critique of Political Economy* (New York: Monthly Review Press, 2017) pp.9-11; and Saito, *Marx in Anthropocene*, pp.136-137
[625] James Snead, 'Repetition as a Figure of Black Culture', *Black Literature and Literary Theory* (London: Methuen, 1984), p.60

image. Instead, we might look for 'efficiency' beyond growth, in iteration, reconciliation or cyclicity.

But compression also presents problems that 'slow' politics cannot answer: on the one hand, exhaustion is clearly a product of a general situation of overaccumulation, not just of capital accumulation, and on the other slowness is at best ambiguous, and clearly appropriable into the mechanisms of capital accumulation. Saito's own critique rests too strongly on an idealised, independent, non-human Nature, and a methodological and philosophical over-committal to dualism.[626] Indeed, a large part of his project to find an ecological Marx is invested in removing ecology from environmentalism.[627] What is needed instead is a recoded compression, a confrontation with and reformation of "efficiency", and a fundamental overhaul of digital infrastructure. In this sense I agree wholeheartedly with Saito's claim that Marxist theory "needs to redefine 'abundance' because its traditional usage is incompatible with objective ecological limits."[628]

Part Three will begin with a surprising problem faced by capital around the outset of the 21st century: the need to restrain certain forms of commodity circulation. In the production and circulation of digital commodities, the overabundance of information (through compression) undermined the scarcity on which capital relies and made the circulation of such products as commodities impossible – even undermining their analogue equivalents. We might draft a formula for this non-capital accumulation along the lines of C' or I' (as in a compression of Marx's CMC'): information begetting more information, free production producing more free production. As such, protocols like JPEG-1 offer one rubric for imagining post-capitalist abundance: the drive for accumulation unmoored from capital, a machinic drive towards the plentiful production of commodities. However, the biosphere is not concerned if it is filled with carbon for the sake of a human collective or a powerful few at the expense of the rest of us.

One could cite this abundance alongside Saito's claim that we cannot transcend capitalism's central dynamics by mobilising its extractive tools, "as if the maximal acceleration of the existing tendencies of capitalism could ultimately realize a final leap to communism"[629] Actually existing compression, one could argue, is all about growth. But this doesn't mean that certain factors in compression could not be put to other ends; indeed, one incidental effect of compression is already a reduction in the energy required to circulate information. Without circulation technologies and certain forms of consolidated, at-scale, technologized production, we simply

[626] Both exemplified in "Monism and the Non-identity of Nature" *Marx in the Anthropocene*, pp.103-135
[627] E.g., Saito, *Marx in the Anthropocene*, pp.107-119
[628] Ibid., p.162
[629] Ibid., p.171

could not sustain a growing human population, but this doesn't mean these systems ought to remain as they are or that comfort ought to be defined in the terms of consumer capitalism. At its worst, Saito's version of degrowth implies "real natural limits" as absolute, rather than a product of metabolic processes, including those of non-human nature and of human economies.[630] There is a risk here of opening a backdoor to Malthusianism, to population control and to ecofascist rhetorics – though these are of course not Saito's positions.[631]

Malthusianism suggests that growing populations of a particular organism inevitably entail the overconsumption of resources and population collapse due to starvation. It has been a dominant current in conservative environmentalism, including, for instance, the book co-published by King Charles – though we might be suspicious of a King suggesting that famine, poverty, ecological destruction and extinctions are products of over-population, rather than of accumulation, exploitation and inequality.[632] Contra Saito's claim, anti-Malthusianism does not require the perception that natural limits are mere "social construction", rather it requires the historical observation that social and technological intervention have already altered "natural limits" to human population – and that such interventions can be rendered in political terms.[633]

Considering compression through its codecs is helpful in working through some of these tensions. As I demonstrated in my reading of JPEG-1's conception of "efficiency" (i.e. compression), its coding process is not simply that of Shannon. Instead, it presents a contesting number of factors oriented around fidelity, compatibility, ease of computation, reduction in file size (and consequent mobility). One can readily imagine a compression codec oriented towards ecological efficiency – towards the minimisation of energy use, and efficiency of distribution. The mass distribution of discreet commodities is, among other things, a very inefficient way of dealing with the circulation of information. Thinking in such a way requires an infrastructural mode: what role, for instance, might information infrastructures or digital libraries play in the reduction of redundancy across the system?

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[630] Saito, *Marx in the Anthropocene*, pp.103-104
[631] See: Thomas Malthus, "An Essay on the Principle of Population" (Gutenberg, 2020) https://www.gutenberg.org/cache/epub/4239/pg4239-images.html [24/09/2024]; also see David Harvey's on the politics of Malthusianism: David Harvey, "Population, Resources, and the Ideology of Science" *Economic Geography* 50.3 (1974), pp.258-262
[632] He argues "one reason why we are losing natural diversity so quickly is the rapid increase in our numbers… the ability of our planet to meet our needs has significantly decreased. We are using up its natural resources as if they were inexhaustible and without long-term value"; Prince Charles, Tony Juniper and Ian Skelly, *Harmony: A New Way of Looking at our World* (London: Blue Door, 2010), pp.53-54
[633] Saito, *Marx in the Anthropocene*, p.104

Part three
Encryption

Chapter eight

A genealogy of encryption

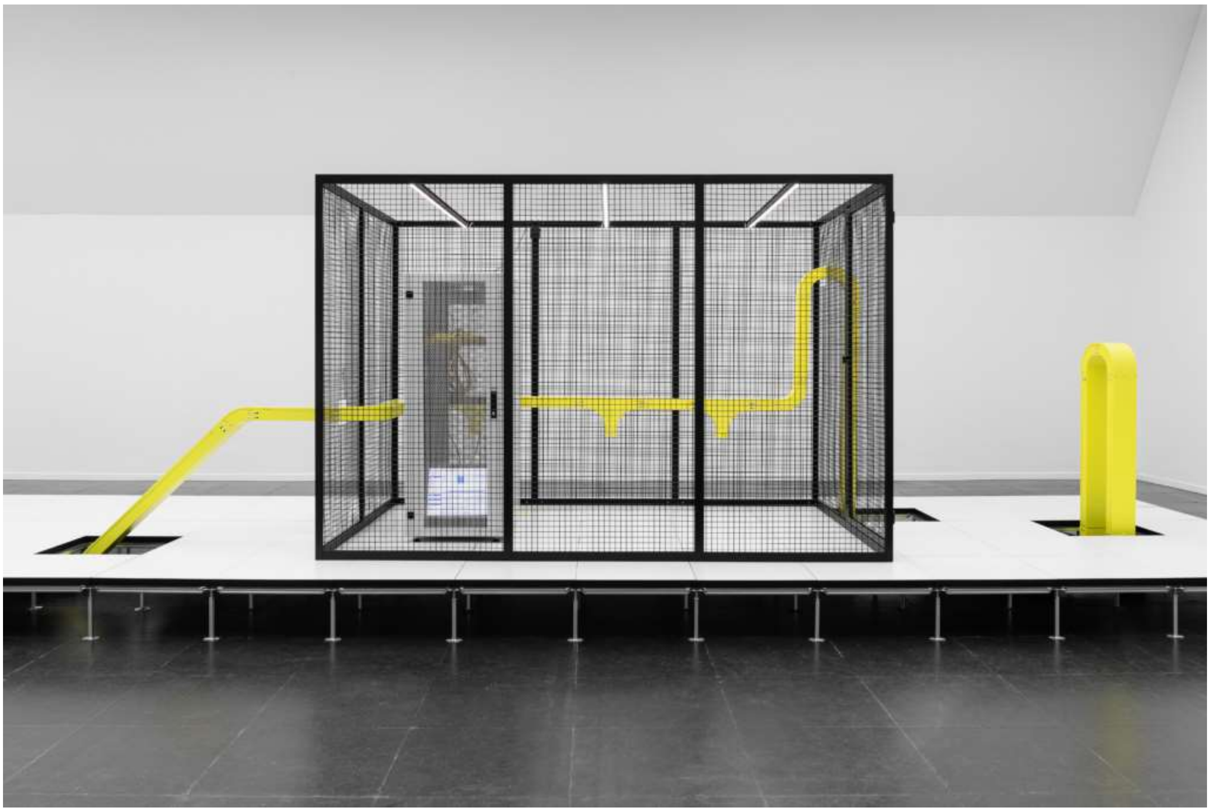

Figure 8.0 Eva and Franco Mattes, P2P, Server cage, cabinet, racker server, torrent software, 2022 (FMAV, Modena), https://0100101110101101.org/p2p/

Cryptography… is the "material" from which the walls, boundaries – and bottles – of cyberspace will be fashioned

John Perry Barlow, "The Economy of Ideas" (1994)

Information wants to be free but is everywhere in chains

McKenzie Wark, *A Hacker Manifesto* (2001)

A server in a cage. Eva and Franco Mattes' 2022 installation (fig-8.0), *P2P*, feels like an appropriate figure for digital culture today, which as we encounter it is so often defined by proprietary exclusion. The Mattes' server is almost totally encased, with only a small channel in the cage for a bright yellow cable housing. This housing, also a kind of cage, is conspicuous: It encircles the room and connects the server, via the gallery's infrastructure, to the wider internet. So, the cage is porous: information is flowing through it, and gallery attendees can see inside, although they can neither enter nor access its information. Inside the machine are other forms of enclosure, technical arrangements designed to limit access to information – images stored on the server are only accessible via the peer-to-peer BitTorrent protocol and are otherwise encrypted, the practice of coding information is such a way as to control access.

What are we to make of these layered and interrelated forms of enclosure? Against the ostensible openness of the gallery, though which we access art, *P2P* enacts an inversion, and reimagines it as a privileged location of non-access.[634] Artworks – files stored on the server – are withheld from their would-be viewers, who are left to view the enclosure itself (but accessible to anyone beyond the gallery with a torrent client). *P2P* is an appropriate figure for digital culture today not just because servers are often housed in cage-like locations, but more so because a historically novel form of encryption has made enclosure (and exclusion, outside the enclosure) a basic component in the experience of everyday digital capitalism.

Part three of this thesis will suggest that, after the accelerated circulation of compression, encryption has been mobilised as a technology of enclosure, rendering the digital circulation of files viable for capital accumulation and technologizing against the extra-commodity mobility of information. This first chapter on encryption offers a genealogy of encryption as an information technology, and as a tool of privation. Towards the end of the 20th century, I will suggest, cryptography – the study and practice of encryption, a function at least as old as writing itself – collided with then fledgling forms of digital capitalism and, for the first time in this 3000-plus year history, became something radically new. Despite massive diversity of technique and mechanism, all historical and ancient examples of encryption up to this brief period are iterations on secret or concealed writing, messages encoded so as to only be legible to their intended recipients. This is until, decades after their development, a set of World War II secrecy functions were appropriated to new purposes: privacy and privation. Encryption today is still secret writing, but it is also a mechanism for disciplining errant circulation, enclosing virtual space and allowing accumulation within a supposedly open, distributed network.

This was on the one hand a response to a crisis within capital itself, under assault from the sharing economies of the early web and from the issue of digital over-circulation discussed in my chapters on compression.[635] On the other, it was a direct demand of many supposed tech

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[634] For the ambiguous public-private logics of art galleries, see: Laura Harris, "Private View? The Organisational Performance of 'Privateness' and 'Publicness' at an Art Gallery", *Cultural Sociology* (2023), https://journals.sagepub.com/doi/epub/10.1177/17499755221147610; another example is Joanna Moll's *16/2017*, in which a gallery was closed to reduce its carbon impact.
[635] Barbrook, pp.5-40; Kleiner

visionaries in the techno-cultural milieu from which much of today's digital infrastructure emerged. From the 1960s through the 1990s organisations like the Electronic Frontier Foundation (EFF) saw the marketisation of networks as part of their capacity for generating freedom. John Perry Barlow, a founder of the EFF, writes for instance that "Cyberspace consists of transactions, relationships, and thought itself" – as though each of these things are naturally co-constitutive.[636] These visions appear remarkably naïve in the present, and reminiscent of a Hayek-infused cybernetics: blind faith in the market as an invisible guiding hand.[637] This chapter picks at the problems entailed by such an encounter, between cryptography and capital, drawing together some of the core technical, economic, and conceptual forces that constitute the juncture. I view encryption through its codecs: the meeting point of apparently distinct determinisms in technical devices, which produce and transform information in the terms of their cumulative logics.

Capitalism has been itself changed: today's information systems do not operate under the same logics as pre-digital capitalism – a phenomenon which has caused some to theorise that capitalism as such is over, ushering in something like neo- or techno-feudalism, or vectoralism.[638] Whether or not we have come to the end of capitalism, we have certainly arrived at a juncture, in which encryption offers a salve to accumulation. I follow encryption practices from their longstanding application as tools of secrecy through to their reinvention as tools of privation, with a corresponding reorganisation of cultural logic.

It is an irony given its mobilisation in utopian visions of digital distribution (most clearly articulated in Bitcoin), that encryption can be seen to generate such intense forms of unfreedom. This unfreedom is articulated especially clearly in McKenzie Wark's work on information.[639] Freedom of one kind or another is integral to the accounts of both encryption's proponents and its detractors, and as a technology which determines access it is closely implicated in the generation and delimitation of freedoms – a final reflection will examine the function of "freedom" in encryption debates.

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[636] Barlow, "A Declaration of Independence…"
[637] For Hayek's cybernetics, see: Yuk Hui, "Why Cybernetics Now?", *Cybernetics in the 21st Century Vol.1: Epistemological Reconstruction* (Hong Kong: Hanart Press, 2024), pp.11-22
[638] McKenzie Wark, *Capital is Dead* (London: Verso, 2019), p.5; Yanis Varoufakis, *Technofeudalism: What Killed Capitalism* (London: Vintage, 2023), p.8; Jodi Dean, "Same as It Ever Was?", *New Left Review* (May 2022), https://newleftreview.org/sidecar/posts/same-as-it-ever-was [20/12/2024]
[639] McKenzie Wark, *Hacker Manifesto*

Encryption-as-secrecy

In both the popular imagination and the technical literature there is a tendency to think of encryption as a kind of lock.[640] Simon Singh's *The Code Book*, perhaps the most accessible and widely read book about cryptography in English, uses exactly these terms: "The art of secret communication, otherwise known as cryptography, will provide the locks and keys of the Information Age."[641] Of course there are limits to this heuristic – the mechanics of a physical lock and an encryption codec are different – but the spatial metaphor at play is also (perhaps unintentionally) revealing. The lock, within this assemblage, is both the thing which excludes and the thing which allows entry; it is a device for controlling permeability within a wider infrastructure of enclosure.

The lock, the gate, the fence; these all foreground an interrelation between encryption and privation, the enclosing of things to render them as property, to generate monopolies of extraction and transform commons into commodities. Following this thread will reveal a great deal about encryption today, about the arrangement and control of new kinds of digital production and reproduction. But Singh's mobilisation of the lock and key metaphor is curious, since his history of encryption is totally disinterested in encryption as a technology of enclosure. Instead, he focuses exclusively on "secret communication." In this sense *The Code Book* is both totally conventional (no existing text on the history of cryptography departs from this framing, at least in the English language literature) and not entirely wrong; encryption-as-secrecy does effectively capture one key function of cryptography from ancient writing systems to new computational methods developed in the early 20th century.[642]

In English, the word "encryption" only emerged at the end of this period, in early 20th century information theory. But "cryptography", from which it is derived, is much older. Cryptography first appears in English in 1658, a loan word from the French "cryptographie."[643] Cryptanalysts writing in English tend to focus no earlier than the 15th and 16th centuries, primarily looking to Europe and East Asia.[644] Following cryptography into the ancient Islamic world reveals some much older examples. A number of Arabic philosophers and mathematicians worked on cryptography in the 8th and 9th centuries. The *Book of Cryptographic Messages* written by al-Khalil in the 8th century is perhaps the earliest example of this work. The book is lost but demonstrates the existence of both

[640] In the technical literature as something which can be unlocked with a key, e.g. Joan Daemen and Vincent Rijmen, *The Design of Rijndael* (London: Springer-Verlag, 2001), p.vii
[641] Simon Singh, *The Code Book: The Secrete History of Codes and Code-breaking* (London: Fourth Estate, 1999), p.xi
[642] Singh; Khan
[643] "Cryptography", *Chambers Dictionary of Etymology* (1988), p.240
[644] See e.g. Satoshi Tomokiyo's work: http://cryptiana.web.fc2.com/code/crypto.htm

a code-breaking and making practice based on the permutation of words. Al-Khalil's work was influential on al-Kindi's work in the 9th century, which offers the earliest known example of what we today call relative frequency analysis.[645] His *A Manuscript on Deciphering Cryptographic Messages* describes a process of counting the frequency of each letter's appearance in normal written text and using that to decode text encrypted by substitution.[646]

Laura Marks has written about practices of secrecy developed by Shi'a Muslims in the same period in order to avoid religious persecution.[647] Via Etan Kholberg, she describes "taqiyya", a strategy of concealment in which omissions and misleading expressions are used to protect both the speaker from persecution and any potential reader or listener from dangerous or unbearable knowledge.[648] The word cipher also originates in this context as "sifr", the Arabic word for zero; both this word (via the French, "cifre") and knowledge of Arabic encryption practices travelled into Europe in the Middle Ages notably in the form of "books of secrets" (although rudimentary encryption methods are found in writing in Europe as early as the 9th century and appear to have been widespread).[649]

Something like cryptography appears in a number of other ancient writing systems.[650] There is some speculation, for instance, that hieroglyphs in the tomb of Khnumhotep II (an Egyptian nobleman who died around 1900 BC) utilise a large number of unusual symbols for this reason.[651] Homer's *Iliad*, composed sometime in the 8th or 7th century BC, includes a description of "tablets sealed" which only have their "secret… revealed" (an order for their courier, Bellerophon, to be put to death) when read by their intended recipient.[652] Whether this is a description of cryptography as such or simply a sealed tablet is not clear – but the intention to obscure meaning through "secret" writing is explicit. If this is a description of cryptographic practice, its existence within an oral tradition suggests encryption may be an innate function of writing. A mechanical

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645 Lyle Broemeling, "The Account of Early Statistical Inference in Arab Cryptology", *The American Statistician* 65.4 (2011), p.255

646 Ibid., p.256

647 Laura Marks, "Talisman-images: from the cosmos to your body", *Deleuze, Guattari and the Art of Multiplicity* (Edinburgh: Edinburgh University Press, 2020), p.237

648 Ibid., p.237, Etan Kohlberg, "Taqiyya in Shi'i Theology and Religion", *Secrecy and Concealment* (Leiden: Brill, 1995), pp.345-380

649 William Eamon, "Books of Secrets in Medieval and Early Modern Science", *Sudhoffs Archiv* 69.1 (1985), pp.26-49; Benjamin Saltzman, "Vt hkskdkxt: Early Medieval Cryprography, Textual Errors and Scribal Agency", *Speculum* (2019), pp.975-1009

650 Albert Leighton overviews known cryptographic practice in Ancient Greece and Rome in "Secret Communication Among the Greeks and Romans", *Technology and Culture* 10.2 (1969), pp.139-154

651 Although cryptographic accounts are sparse, e.g.: M Rathidevi, R Yaminipriya and S.V. Sudha, "Trends in Cryptography Stepping from Ancient to Modern", *IEEE International Conference on Innovations in Green Healthcare Technologies* (2017), p.2; other literature describes enigmatic or cryptographic symbols from the Old Kingdom onwards, e.g. John Coleman Darnell, "Ancient Egyptian Cryptography: Graphic Hermeneutics", *Enigmatic Writing in the Egyptian New Kingdom* (Berlin: De Gruyter, 2020), pp.7-48

652 Homer, *The Iliad* (Project Gutenberg, 2006), https://www.gutenberg.org/files/6130/old/6130-pdf.pdf, pp.189-190

cryptographic device called a scytale – a wooden rod around which a long narrow piece of parchment could be wrapped in order rearrange its characters – was used by Spartan generals from the 5th century BC.[653] Much more widely written about is the Caesar cipher, a simple substitution code described in Suetonius' *De vita Caesarum* and used by Julius Caesar in the 1st century BC to encrypt (although there is no equivalent word in Latin) his messages.[654] In each of these cases, secrecy remains the rubric under which cryptographic practice is pursued.

Returning to the beginning of the 20th century, information theory became interested in cryptography under much the same rubric. Research into telecommunications and electrical engineering was ongoing in the first decades of the 20th century, driven by a number of fields including military research, early public radio and, prominently, news media.[655] Without being overly deterministic, it is safe to say WW2 triggered a massive expansion of interest in cryptography.[656]

At the outbreak of World War II, specialists from across communications, mathematics and engineering were drafted into military research. This was the case for Alan Turing, who arrived at the Government Code and Cypher School on 3rd September 1939, two days after the start of the war. It was also the case for Claude Shannon, although he entered military research slightly later (1941) at Bell Labs after completing his PhD at MIT in 1940.[657] Such specialists were enlisted to work on cryptography, the practice of encrypting and decrypting messages (terms which were coined during the period).[658]

Much of the progress made in cryptography during this period was embodied in specific devices: first the Hebern Rotor Machine, developed by Edward Hebern in the US at the beginning of the 20th century from typewriter machine parts.[659] This was followed by a number of encrypting devices, most notably the ENIGMA machine built by German engineer Arthur Scherbius in 1923 and used extensively in World War II.[660] The 'bomba' decryption machine was invented by Polish cryptanalysts in 1938 and would become the basis of both British and American machines,

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[653] Leighton, p.149
[654] Singh, p.13
[655] Newspapers proliferated teleprinters, and were used by The Daily Mail as early as 1912 (Link, p.189); Also, the Bartlane transatlantic picture transmission system, described in Chapter Five.
[656] A stronger claim is made by Kittler, who characterises war as the "historical a priori" of modern media; Geoffrey Winthrop-Young, Introduction, *Operation Valhalla: Writings on War, Weapons, and Media* (Croydon: Duke, 2021)
[657] Everett Rogers, "Claude Shannon's Cryptography Research During World War II and the Mathematical Theory of Communication", *Proceedings of the IRRR International Carnahan Conference on Security Technology* (1994), pp.1-5
[658] Link, p.193
[659] F.L. Bauer, "Rotor machines and bombes" *The History of Information Security: A Comprehensive Handbook* (London: Elsevier, 2007), p.385
[660] Ibid., p.392

including the bombe built by Alan Turing in 1939.[661] Ultimately, this work would culminate in the invention of early universal computers, like the Colossus computer at Bletchley Park in 1943.

In a small number of British and American research labs especially, a mathematical description of coding systems was developed – later called information theory. Through information theory, compression and encryption became inextricably bound; Claude Shannon and his colleagues worked on both, sometimes interchangeably.[662] Shannon published his "Mathematical Theory of Cryptography" internally in 1945, but this was not the same kind of paradigm-defining text as his *Mathematical Theory of Communication* published three years later, after the war.[663] One significant reason for this is that his theory of cryptography was not published until 1949; curiously, several concepts generally credited to Shannon's later work – notably "entropy" and "redundancy" – also appear in this earlier work on cryptography. His pivot from cryptography to compression is therefore not a break as such, but a reorientation – and really, a reflection of the changing institutional context in which Shannon found himself (from military cryptography to commercial telecommunications). If data compression is the encoding of data for faster transmission, encryption is the encoding of data to prevent unwanted decoding; in practice, one often contains the other. It is not generally emphasised, for instance, that to decode a compressed file requires information about the decoding process. This is why, to take a contemporary example, JPEG stores table data in the header of its file. There is not, functionally, much difference between this and a decryption cipher other than the fact that one is intended to be obscure and the other accessible.

Shannon characterised his "Mathematical Theory of Cryptography" as a theory of "secrecy systems"; it is highly likely that Simon Singh inherits this framing from him, directly or indirectly.[664] He differentiates between systems of concealment, such as invisible ink, and those of "'true' secrecy", which use codes or ciphers to render text incomprehensible.[665] Today, this distinction is upheld as one between obfuscation and encryption – the first of which seeks to render information undetectable and the second illegible (one might note the specificity of such a distinction, which essentially originates with Shannon). Shannon's analysis itself is similar to that of al-Kindi in the 9th century, drawing upon the statistical likelihood of letters to appear in language – though unlike al-Kindi, Shannon also accounts for their likelihood to appear in sequence.[666] While methods were quickly evolving, the cultural and political logic underscoring

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661 Ibid., pp.426-428
662 Hence they are easily muddled or muddied; see, e.g.: Galloway and LaRivière, p.143
663 Shannon, *A Mathematical Theory of Cryptography*
664 Ibid., p.2
665 Ibid., p.1
666 Ibid., p.3

the application of cryptography during WWII had remained similar at least as far back as Homer's description of Bellerophon's sealed tablet: namely, secrecy, hidden communications with the intention of intrigue, espionage or military logistics. This is the common basis of both al-Kindi's and Shannon's work on the subject.

Data encryption, which originates in these devices and theories, describes a process, and a specific set of techniques for encoding information in such a way that it cannot be decoded (deciphered or decrypted) without the right cipher, or code. For instance, when you connect to a website via HTTPS (the Hypertext Transfer Protocol Secure), your browser uses TLS (Transport Layer Security) encryption to communicate with the web server to which you are connected. This renders all information other than that needed for the signal to reach its destination illegible to anyone other than the intended recipient. If anyone were to intercept your connection (your internet service provider, for instance, or a cybercriminal on public Wi-Fi), they couldn't inject anything into the signal, or record any of its contents, other than the top-level domain name (e.g. "www.wikipedia.org") – which of course does entail some forms of visibility .

There are many such digital systems which rely on encryption for security: banking, email, communication via apps like WhatsApp, Signal or Telegram and local network connection, to name just a few. In addition to these, perhaps less intuitively, is a range of encryption practices which come under the title of DRM (Digital Rights Management). Information is not innately proprietary; it must be rendered as such. Achieving this is not trivial, it requires intervention on the production and reproduction of information, on the codec. DRM guards files accessed through streaming services and media platforms like Spotify, Netflix, Steam, etc. from being shared or accessed by users without legal permission via a subscription or discrete purchases. By forcing users to use proprietary applications, DRM also dictates which modes of interaction are possible for the user (since files can only be decoded with proprietary interfaces or applications). This is a joint technical-legal construct which seeks to enforce property rights against the near-unlimited replicability of digital files; it is an attempt to discipline the circulation enabled by compression. Current standards of data encryption cannot be broken by brute force – no computers exist with the power to identify their keys by trial and error.[667] To decrypt the encrypted therefore requires circuitous methods, a cipher must be acquired by other means: targeting the wider system or the humans that interface with it.

Mathematically, relatively little was required beyond Shannon's contributions (and those of his colleagues) up to the publication of his *Mathematical Theory of Communication* to achieve this

[667] Information Technology Laboratory, *Advanced Encryption Standard (AES)* (November 2001), https://nvlpubs.nist.gov/nistpubs/FIPS/NIST.FIPS.197-upd1.pdf

expansive infrastructure. But Shannon's mobilisation of encryption was decidedly within a paradigm of secrecy. The application of cryptography today, especially after the expansion of personal computing and the internet, appears to hold a new orientation. From the late 1960s, with the introduction of the Data Encryption Standard (DES) a new paradigm for encryption rose to prominence: privacy.

From privacy to encryption-as-property

Neither the development of electronic communication, nor of the electronic computer, not even Claude Shannon's contributions to a theory of encryption, offer any substantive departure from the cultural logics of cryptography established in antiquity. However, a more substantial departure is prefigured in the writing of Shannon's sponsor and key interpreter, Warren Weaver.

For instance, remarking on the importance of Shannon's work on communication to the mathematics of encryption, Weaver writes that:

> the theory contributes importantly to, and in fact is really the basic theory of cryptography which is, of course, a form of coding. In a similar way, the theory contributes to the problem of translation from one language to another, although the complete story here clearly requires consideration of meaning, as well as of information.[668]

Even in this apparently straightforward commendation, Weaver subtly intervenes upon and expands the theory. He begins by observing a similarity between decryption and translation – not uncontroversial among cryptographers, who often distinguish between themselves from deciphers of lost ancient scripts, who they call "epigraphers".[669] By definition encrypted messages are obscure, and cryptanalysis does reveal parallels between the lost and the hidden. There is also an evident methodological cross-pollination in their deciphering – some World War II cryptanalysts even went on to make major discoveries in the decoding of ancient texts after the war.[670] One can position the Rosetta stone, for instance, as a cipher which enabled the decryption of Ancient Egyptian Hieroglyphs.[671] The justifications via which cryptanalysts distinguish themselves are revealing difference is found not in method but in intentionality.[672] For many cryptanalysts, the presence of an adversary, the code-maker, is what defines their practice. And, of course, many cryptanalysts are also cryptographers. So, while the translator or epigrapher only

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668 Weaver, p.25; Weaver worked extensively on machine translation – part of a wider interest in meaning
669 Andrew Robinson, *Lost Languages: The Enigma of the World's Undeciphered Scripts* (London: Thames & Hudson, 2009), p.20
670 Ibid., p.325
671 Ibid., pp.56-59
672 Ibid., p.20

reveals (and transforms) meaning, the cryptanalyst is also ambiguously implicated in the muddy work of destroying meaning. A translation can be wrong (from the perspective of its original author), but it will remain meaningful; if the cryptographer does their job well, unwanted meaning becomes impossible.

Importantly, such debates hinge on distinctions between translation and decryption. Weaver's intervention lies in the second half of his comment: characteristically, he contradicts Shannon by declaring his theory one of meaning. In doing so – this is the key intervention – he also reimagines it as one of control: decryption and translation are in the same way responsible for the revelation (or not) of meaning. At the lowest order of abstraction, Weaver's "technical problem", this relates to legibility.[673] At a higher order of abstraction, "the semantic problem", Weaver discusses comprehension (and, recalling Hall, different kinds of interpretation).[674] Finally, at the level of "effectiveness", Weaver relates information theory to behaviour: how effectively can desired conduct be determined by a message (which might be a communication or in a more general cybernetic sense some kind of signal)?[675]

But such a mode of cryptographic practice would not be achieved for several decades. In the early 1960s, engineers working at IBM looked into the encryption of digital files as a means of preventing the unlicensed copying of software, but this was abandoned on the basis it would be

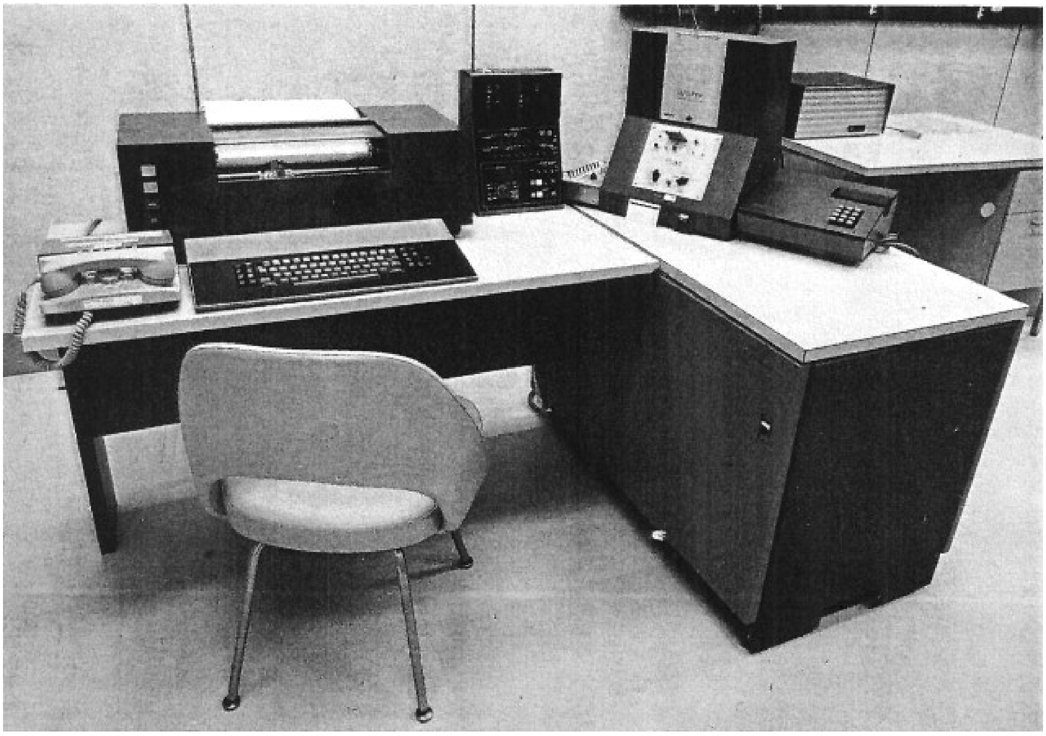

Figure 8.1 Photograph of Lucifer attached to an input keyboard.

Taken from J.L Smith's internal memo "The Design of Lucifer" (1971)

[673] Weaver, p.4
[674] Ibid., p.4
[675] Ibid., pp.5-6

too onerous on users and degrade the quality of the product.[676] Later in the decade, following a series of anti-trust lawsuits, IBM "unbundled" hardware and software, laying the ground for software conceived of as a commodity distinct from hardware.[677] By the end of the 1960s, IBM had formed a cryptography research group, largely following demand from the banking sector for digital financial systems and nascent forms of what today we call e-commerce – notably developing a commercial encryption algorithm for Lloyds Banking Group ATM machines.[678] This group produced a series of encryption protocols in hardware and software called "Lucifer" (fig-8.1), based on Shannon's prescriptions for ideal secrecy.[679] While the protection of money was an early commercial application for Lucifer, the public rationale was instead oriented towards notions of "privacy". In 1973, Horst Feistel, who led the group, claimed that "There is growing concern that computers now constitute… a dangerous threat to individual privacy."[680]

The paradigm of privacy itself isn't novel here, in the 1960s and 70s it was already a major concern, especially in photography. In 1890, American lawyers Samuel Warren and Louis Brandeis responded to the first commercially successful Kodak camera (fig-8.2) by writing a passioned defence of "the right to privacy… in person and property."[681] In it, they propose a "right to be let alone" from unauthorised representation through photography, especially in "private and domestic life".[682] A century later, in the 1980s, the perceived importance of privacy at home would be a key factor in a supreme court decision to maintain the "domestic threshold" – beyond which copyright cannot pass – and effectively exempt the home from piracy legislation.[683] There is some irony in privacy discourse underscoring both legal protection for piracy in the home and the development of DES, given the kinds of digital rights management it would become integral to. Feistel's mobilisation of this language in relation to encryption certainly is novel, though, and

[676] Mikko Välimäki, *The Rise of Open Source Licensing: A Challenge to the Use of Intellectual Property in the Software Industry* (Helsinki: Turre Publishing, 2005), pp.21-23; Watts Humphrey, "Software Unbundling: A Personal Perspective", *IEEE annals of the history of computing* 20.1 (2001), p.60
[677] Fuller, ed. *Software Studies*, pp.2-3
[678] David Leech and Michael Chinworth, "The Economic Impact of NIST's Data Encryption Standard (DES) Program" *The National Institute of Standards and Technology Program Office Strategic Planning and Economic Analysis Group* (October 2001), https://web.archive.org/web/20170830020822/https://www.nist.gov/sites/default/files/documents/2017/05/09/report01-2.pdf [02/10/2024]; Alan Konheim, "Horst Feistel: the inventor of LUCIFER, the cryptographic algorithm that changed cryptology", *Jounral of Cryptographic Engineering* 9 (2019), p.86
[679] J.L. Smith, "The Design of Lucifer, a Cryptographic Device for Data Communications", *IBM Research* (1971), https://dominoweb.draco.res.ibm.com/reports/RC3326.pdf ; Konheim, p.96
[680] Horst Feistel, "Cryptography and Computer Privacy", *Scientific American* 228.5 (1973)
[681] Warren Miller and Louis Brandeis, "The Right to Privacy", *Harvard Law Review* 4.5 (1980), pp.119-220
[682] Ibid., p.195
[683] Adrian Johns, *Piracy: The Intellectual Property Wars from Gutenberg to Gates* (Chicago: University of Chicago Press, 2009), pp.450-453

signals a clear move away from secrecy. Advocates of encryption standards – like Feistel – routinely conceived of them in terms of personal and corporate privacy interchangeably.[684]

After some collaboration with the NSA, Lucifer would go on to be adopted by the US government and be published as a standard (DES) in 1975. DES is a block cipher, which means its encryption algorithm is applied one block of data at a time. A major utility of this method is an ambivalence to form or application: it can be applied to any existing kind of binary information – a core requirement of the original call for the standard. Even if IBM wasn't yet interested in digital rights management, others were newly empowered to do so; anything deemed "private" might be enclosed: personal photographs, sensitive messages (perhaps these are the kinds of applications Feistel was invoking with the "private"), but also transactions of digital currency and the property of large media organisations, including exactly the kinds of music and video that were by this point routinely being copied on cassette-tape and shared behind the "domestic threshold".[685] DES represents the earliest generalisable technical barrier to the digital copy, and as such was integral in the formation of something which now seems mundane: digital property.

From secrecy to privacy, to property, this is a slight but important re-orientation: two decades later when the digital commodity began to provoke crises across information-oriented industries – prominently journalism, music, and software development, but including many others – this paradigm change paved the way for the encryption of digital commodities themselves, a new mode of encryption-as-property. In 1991, rapper Biz Markie was sued for copyright infringement for a sample on his song "Alone Again (Naturally)" by Grad Upright Music Ltd.; the successful case, in which sampling practices were characterised as "rampant" stealing, established a legal

Figure 8.2

Advert for The Kodak Camera (1888), which places emphasis on consumer, non-professional markets – from *The Photographic Herald and Amateur Sportsman* (November 1889)

[684] See, e.g. EFF, *Cracking DES: Secrets of Encryption Research, Wiretap Politics & Chip Design* (1998), examined at length in Chapter Ten.
[685] Johns, p.449

precedent in which sampling required permission, and an industry precedent for complex financial arrangements, under which creative sampling logics also become market logics.[686]

In the 1990s, much of the debate around encryption moved out of technical journals like those of the IEEE or Bell Laboratories, and into the pages of technology magazines like *Wired*, where the potential applications of encryption in culture were being discussed. This is where John Perry Barlow proposed cryptography become the "walls, boundaries – and bottles" of cyberspace.[687] After DES was cracked, a successor standard (the Advanced Encryption Standard – AES), was released which would allow individuals and industry to encrypt data to a standard that even the US government could not crack.[688] The Secure Digital Music Initiative was started in 1999 as a collaboration between the computing, recording, internet service and banking industries, including Microsoft and NatWest, and chaired by a key figure in the development of MP3, Leonardo Chiariglione.[689] The initiative sought to implement an industry standard for encryption to prevent online music piracy – although it was ultimately unsuccessful. In 2009 one major motivation for moving away from CDs towards digital files for Steve Jobs was precisely the failure to introduce proprietary encryption into the physical format.[690] For him, digital downloads heralded an opportunity to domesticate illegitimate use, from commercial piracy to informal sharing.

Unlike DES, AES has never broken by brute force, but both protocols formulate their encryption standards as a component within software or hardware, meaning they are generalisable, and can be implemented in a variety of technical systems with different objects and purposes; this can and does include "secret" applications, such as end-to-end encryption of messages, but it also includes creative application within digital rights management (DRM) software.[691] These are closed, encrypted environments (such as digital platforms or marketplaces: Spotify, Steam, Amazon Prime, Netflix, Shutterstock, etc.) through which the circulation of digital files and assets is controlled. The most sophisticated integrate media-circulation with playback, restricting the flow of information to proprietary clients and prohibiting a basic digital operation: the copy.

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686 Claire McLeish, "Hip-hop sampling aesthetics and the legacy of Grand Upright v. Warner", *Popular Music* 42.1 (2023), pp.79-103

687 John Perry Barlow, "The Economy of Ideas", *Wired* (1994) https://www.wired.com/1994/03/economy-ideas/ [02/10/2024]

688 "'EFF DES Cracker' machine brings honesty to crypto debate", *EFF* (1998), https://w2.eff.org/Privacy/Crypto/Crypto_misc/DESCracker/HTML/19980716_eff_descracker_pressrel.html; Daemen & Rijmen, p.v

689 Christopher Jones, "SDMI: Divide or Conquer?", *Wired* (1999), https://www.wired.com/1999/11/sdmi-divide-or-conquer/

690 Steve Jobs, "Thoughts on Music", *Apple* (2007), https://web.archive.org/web/20070207234839/http://www.apple.com/hotnews/thoughtsonmusic/

691 *AES, p.*26

Encryption as liberation

So, encryption has entered the 21st century as a powerful and ubiquitous tool of control; all this might obscure the fact that codes have often acted as tools of counter-hegemony. The principle of *taqiyya* among Shi'a is evidently an example of this. Similarly, Sadie Plant has offered a compelling description of women as "whispering in their own strange codes, ciphers beyond [Baudrillard's] linguistic powers."[692] This is the anti-hegemonic language of a group heavily policed by patriarchal society, but there are many more examples which might be drawn upon: the handkerchief codes used by cruisers in 1980s San Francisco to signal preferences (fig-8.3), or Polari in Britain, coded creoles such as Gypsy in Panama or contemporary activists organising through Signal are just a few examples.[693]

One hope for the early internet was that it might democratise the expression of those who have been silenced. Indeed, in Plant's account the pseudonymity of cyberspace acts as exactly such an anti-hegemonic tool. She describes that "men who presumably wouldn't have dreamt of trying to pass as female in any other context or medium were eagerly cross-dressing their Net messages."[694] Networked communication here functions as a form of obfuscation, protecting the poster from

Figure 8.3 Hal Fisher, "Handkerchiefs" from *Gay Semiotics* (1977)

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692 Plant, p.107
693 Hal Fisher and Julia Bryan-Wilson "Gay Semiotics Revisited" *Aperture* 218 (2015), pp.32-41; "Hal Fisher", *Project Narrative Informant* (2017), https://www.projectnativeinformant.com/artists/hal-fischer; Michael Aceto, "Variation in a secret creole language of Panama", *Language in Society* 24.4 (1995), pp.537-560
694 Plant, p.112-113

the prying eyes and cultural policing she would encounter in real life, and allowing her to code her own gender. The human body is also a kind of enclosure, and networked communication can offer virtual agency; encryption forms a functional part of a digital embodiment that is personal but not necessarily propertied.[695] In this sense, at least, it can paradoxically return as a tool of liberation.

In *The Fold*, when Deleuze is reaching (via Leibniz) for a figure to navigate between matter and subjectivity he chooses a cryptographer: "someone who can at once account for nature and decipher the soul, who can peer into the crannies of matter and read into the folds of the soul".[696] This is someone to whom "the secret of liberty" might be comprehensible.[697] It is curious that both histories and media representations of cryptography – particularly those focused on the military technology of 20th century Europe – are often more interested in code-breaking than code-making (including both Singh and Khan's accounts). Across diverse forms and modes of representation, the cryptographer repeatedly appears as the liberator of information, rarely as its container; Bletchley Park, where codebreakers including Alan Turing worked during WWII, in particular acts as a conduit for such narratives. Some of the many film/TV/literary depictions include *The Imitation Game* (2014), and the novel of the same name; *Enigma* (2001), a spy thriller which substitutes Turing for the fictional (straight) Tom Jericho as its primary protagonist; *The Bletchley Circle* (2012-2014), which follows four female codebreakers turned amateur detectives working at the site.[698]

Both *Enigma* and *The Bletchley Circle* rely on a perceived intimacy between the role of the codebreaker and that of the investigator; unsatisfied or unfamiliar with the work of mathematicians and engineers, they sidestep into the more established narrative conventions of the spy thriller (*Enigma*) and detective drama (*The Bletchley Circle*). In both cases the purpose of the cryptographer as codebreaker becomes the revelation of mysterious truth, often by means other than cryptography. *The Imitation Game* does not abandon cryptography to the same degree – Turing's work is cryptographic problem-solving, and this is the only means by which he can uncover obscured truth – but the narrative role remains similar. No attention is given to the design

695 For transgender telepresence in cyberpunk fiction, see: Thomas Foster, "'Trapped by the Body'? Telepresence technologies and transgendered performance in the feminist and lesbian rewritings of cyberpunk fiction", *Modern Fiction Studies* 43.3 (1997), pp.708-742
696 Deleuze, *The Fold*, p.3
697 A thread can be drawn through Renaissance efforts to decode nature and Leibniz' search for a universal symbolism to unite mathematics, science and philosophy, into cybernetics and information theory as 'theories of everything'; Deleuze, *The Fold*, p.3
698 *The Imitation Game* (The Weinstein Company, 2014); *Enigma* (Miramax Films, 2001); *The Bletchley Circle* (ITV, 2012-2014)

or use of Enigma itself, or to the Typex.[699] This is complicated somewhat by the film's portrayal of Turing's life, in which we see him forced to hide his homosexuality, as the resonance between this "imitation game" and that of codebreaking is clearly a primary interest of the film. As far as mathematical codes are concerned, though, the encoder of encrypted information remains, at all times, an invisible adversary.

A similar set of conventions can be found in journalistic portrayals of cryptography. Two distinct recent examples are the decoding of some of Mary Queen of Scots' letters 445 years after they were written, and the potential cracking of an encrypted USB-stick containing $235 million in lost Bitcoin.[700] The latter article in *Wired*, complete with cross section scans of the USB-stick, photographs of forensic displays and group photos of the hacking team, is keen to evoke the idiom of a heist movie (fig-8.4). But this reporting is also under constraints (perhaps the reason it relies on such imagery), since the team, who have not yet received approval from the USB's owner for the hack, are unwilling to reveal their methods.

Imogen Savage's coverage of the Mary Queen of Scots' codebreakers in *The Financial Times* is more at liberty to discuss methods. Mary's codes are complex operations, which don't only rely on substitution, but also on repetition and deletion. Savage writes the piece as a dual narrative, swapping back and forth between an account of Mary and her codebreakers; she draws not only

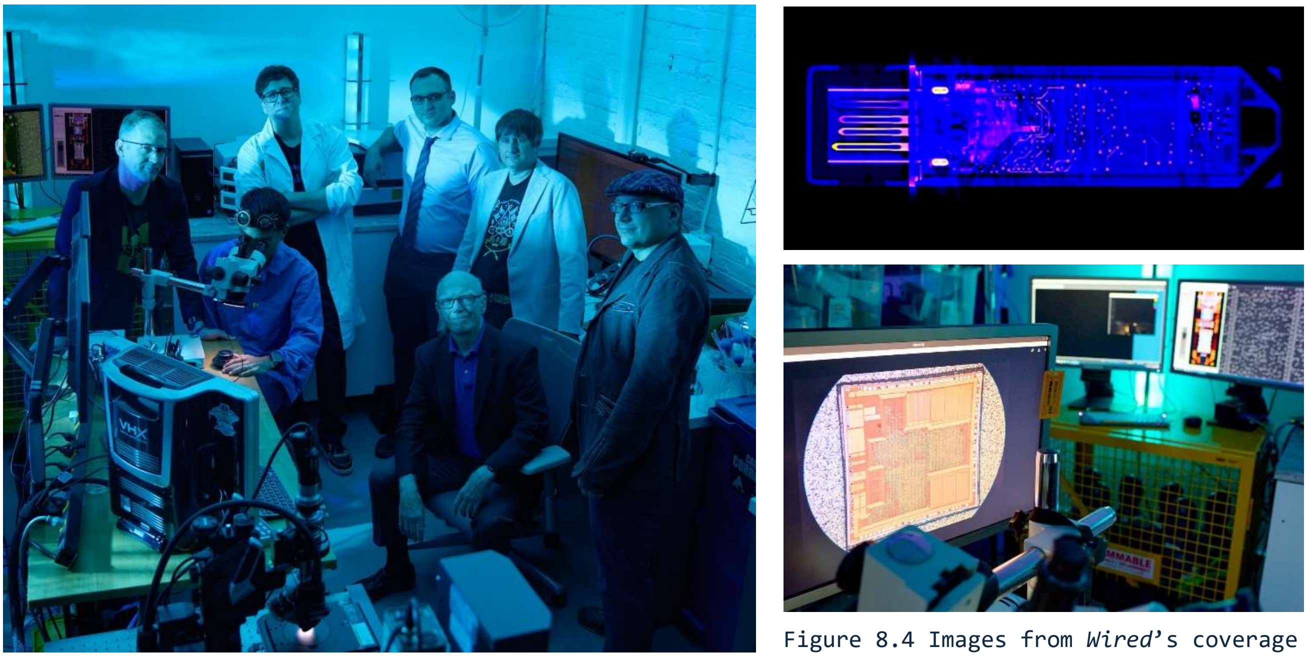

Figure 8.4 Images from *Wired*'s coverage of the USB cracking

[699] David Easter, "Protecting secrets: British diplomatic cipher machines in the early Cold War, 1945-1970", *Intelligence and National Security* 34.2 (2019), p.157

[700] Imogen Savage, "How three amateurs cracked a 445-year-old code to reveal Mary Queen of Scots' secrets", *The Financial Times* (6 July 2023), https://www.ft.com/content/bb1fe5d4-6059-4a98-8a6d-19a0009e6693; Andy Greenberg, "They Cracked the Code to a Locked USB Drive Worth $235 Million in Bitcoin. Then It Got Weird", *Wired* (24 October 2023), https://www.wired.com/story/unciphered-ironkey-password-cracking-bitcoin/

on existing biography, but also new findings and direct quotations from the letters themselves. Here, codebreaking opens up the possibility of an encounter with the code maker, whose testimony was formerly encrypted. As a cryptographer, Mary remains an especially interesting figure, since many of her coded letters were penned during (and because of) physical imprisonment.

In cyberpunk fiction the hacker is the figure who can overcome such exclusion (more likely enforced by a corporation than a state) and "jack-in" to cyberspace without authorization. Like the cryptographer, the hacker is typically a liberator of information. And, because cyberspace is information rendered as virtual space, in *Neuromancer* (1984) a hacker is not just someone who can overcome the corporate machinations or machinic privation behind cyberspace, but someone who can physically traverse it, who is free to traverse it. At the end of *The Matrix* (1999), Neo flies into the sky, a bodily manifestation of the freedom afforded to him by his mastery of this virtual space.[701]

All this liberation begs a question: if all the cryptographers and hackers are busy freeing information from occlusion and privation, who has been doing all the encrypting? Cybernetics, the science of governance or control is derived from kubernḗtēs, the one who steers and, idiomatically, the captain or leader. "Cyber-", as in cyberspace or cyberpunk, retains this root and transforms it into a (sometimes ambiguous) image of freedom, embodied in Gibson's hackers, or Neo flying above a cityscape. Control and liberation coexist uneasily, and there is a tension here: what kind of freedom does Neo embody? That of the individual (here of the "chosen one") or of the collective (of masses released from the simulation)?

It requires a naïve reading of *Neuromancer* to imagine private property or laissez-faire capitalism are being set up as desirable. Such readings abound, as suggested by the fact that the primary cultural mobilisation of the "crypto-" suffix today is in cryptocurrency and its techno-cultural milieu.[702] Such technologies aspire towards the inscription of property into digital objects, and the making of contracts absolute, inescapable. Freedom is for the property owner (who has hacked themselves to the top of a hierarchy), and the world being fought for is less that of *Neuromancer* than that of Tom O'Donnell's satirical short story, "L.P.D.: LIBERTARIAN POLICE DEPARTMENT", wherein every granular operation of life is subject to the logics of the market: "I pulled my own gun, put a quarter in it, and fired back".[703]

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701 The Matrix (Warner Bros, 1999); William Gibson, *Neuromancer* (London: Gollancz,1984)
702 The cypherpunks were influenced by Gibson (see Chapter Eleven), hence the archaic "cypher", which recalls "cyberpunk"; or for a parallel example, the appropriation of "metaverse" from Neal Stephenson's *Snow Crash* (New York: Bantam, 1992)
703 Tom O'Donnell, "L.P.D.: Libertarian Police Department" *The New Yorker* (2014), https://www.newyorker.com/humor/daily-shouts/l-p-d-libertarian-police-department

Encryption as neginformation

Perhaps it is unsurprising that code breakers are more willing to make their efforts visible than code makers (who have an interest in secrecy). Perhaps code breaking is simply more amenable to narrative forms than code making. Nonetheless, we should be sceptical of the cryptographer as hacker or liberator. One can try instead to trace the cryptographer as a jailor. "Information wants to be free but is everywhere in chains."[704] McKenzie Wark's intervention in *A Hacker Manifesto* holds a clear political and ethical character; this is an elision of two already-existing slogans: first "Information wants be free", first used by Stuart Brand at the 1984 Hackers Conference, and second to Jean-Jacques Rousseau's *The Social Contract,* "Man is born free, and everywhere he is in

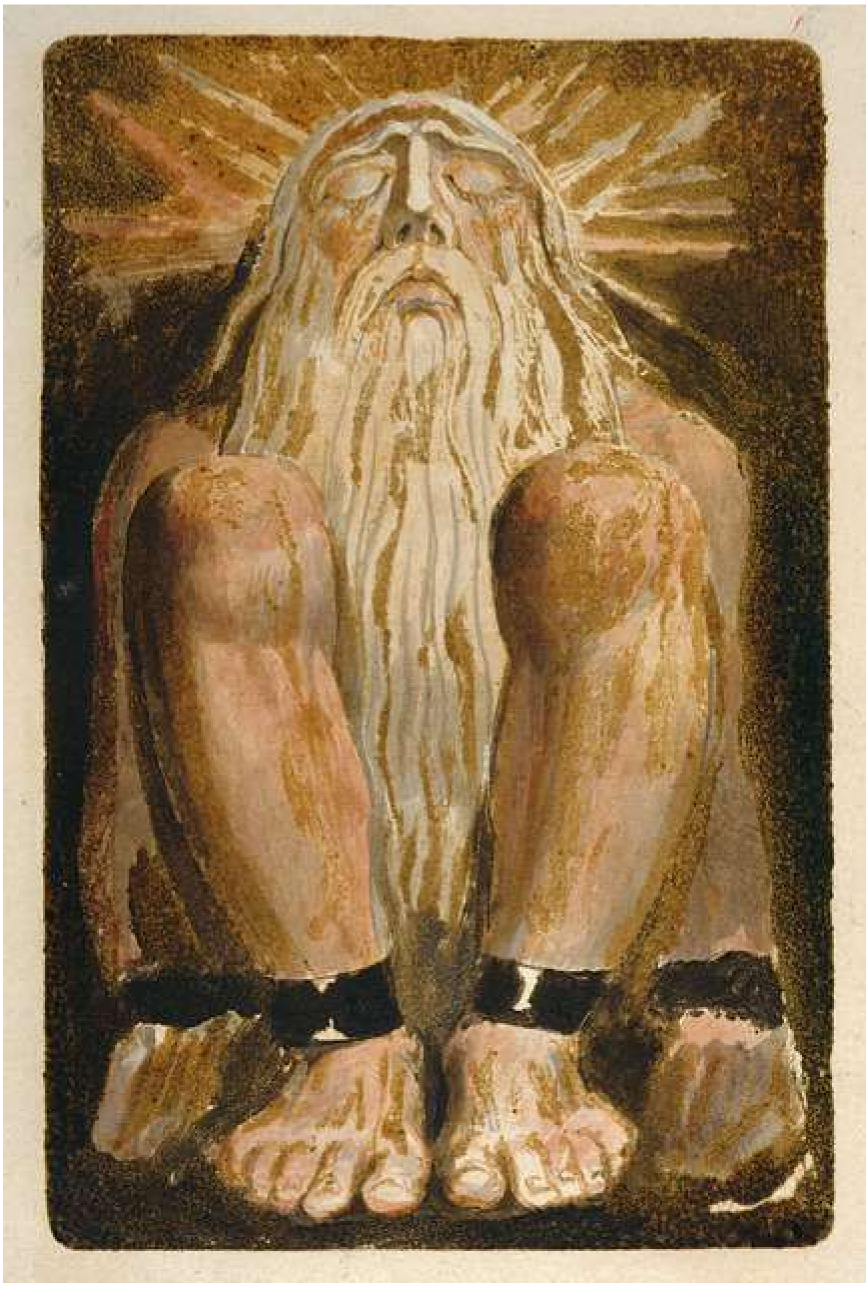

Figure 8.5

William Blake, *The Book of Urizen* (1794), p.11.

Blake's Urizen – the embodiment of law, abstraction and reason – appears in chains; a stark contrast to the figure of Los, who embodies creativity.

[704] Wark, *Hacker Manifesto*, 126

chains".[705] Information's chains, in her analysis, are a result of conflict between the creators of abstraction ("hackers") and its aspiring owners ("vectoralists").[706] The forces of creation are pitted against those who would own and therefore limit it.

Wark's hacker sits clearly within a tradition I've already outlined, of the hacker as a figure of mastery, and of liberation (we might also think of a book like Steven Levy's *Hackers: Heroes of the Computer Revolution* as a direct antecedent, which has a much narrower conception of the hacker).[707] But her invocation of the hacker as any who "create the possibility of new things entering the world" (in other words, not just as someone who works with computers, but anyone involved in the novel), sets her in another tradition alongside, for instance, William Blake for whom chains are also a figure for both un-freedom and un-creativity (fig-8.5) and for whom creation and freedom are close to synonymous. But the question of encryption raises problems for the figure of the hacker, who is also a cryptographer, and so is implicated in the possibility of precluding this freedom through creation.

Invocations of information's free-ness abound, with little consistency in their relation. As a legal structure, "freedom of information" describes a mechanism by which information held by public authorities can be rendered free, as in rendered transparent or public. In the UK, the *Freedom of Information Act 2000* defines the terms of this mechanism. That it includes a lengthy list of exemptions and a heavy bureaucratisation of the process of accessing information suggests it may be as interested in restraining the movement of information as in making it freely accessible.[708]

A different conception of free (or 'open') information is built into the design of many audiovisual compression standards, such as JPEG. As discussed in Chapter Five, key values needed for decoding a compressed JPEG image are included in front of the compressed file. Practically, this means any implementation of JPEG should be able to read any JPEG image; it is designed to ensure no special permissions are required to open the image. This organisation of information entails freedom for users, who are free to access, view, share, save, copy, edit.

Free software, a programming movement and software licensing structure from the 1980s onwards, formalised an adjacent model: it defines software as free when anyone is allowed to run it, inspect its source code, distribute it or modify it.[709] While these requirements might seem to

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705 Aideen Doran, "Free Libraries for Every Soul: Dreaming of the Online Library", *Memory of the World* (March 2014), https://www.memoryoftheworld.org/blog/2019/10/25/free-libraries-for-every-soul/#fnref-2; Jean-Jaques Rousseau, *The Social Contract* (New York: Carlton House, 1947), p.1

706 Wark, *Hacker Manifesto*, 221

707 Steven Levy, *Hackers: Heroes of the Computer Revolution* (London: Anchor Press, 1984)

708 United Kingdom Parliament, *Freedom of Information Act 2000*, Adopted November 2000, https://www.legislation.gov.uk/ukpga/2000/36/

709 Christopher M. Kelty, pp.97-116

run counter to the commodification of information, Richard Stallman, founder of the Free Software Foundation, is resolute that such a formation is not anti-commercial; he has often characterised this as "free as in free speech, not free as in free beer."[710] But why shouldn't information be free as in free beer? A free beer is certainly easier to drink than one which costs money. Stallman's answer – that this "is a matter of liberty, not price" – is inadequate when price itself stands as a clear barrier to access.[711] One might contrast Stallman's slogan with that of Salvador Allende, who famously called for a democratic socialist "revolution flavoured with red wine and empanadas."[712]

In *The Communist Manifesto*, Marx and Engels accuse the bourgeoise of having "in place of the numberless indefeasible charactered freedoms… set up that single, unconscionable freedom - free trade."[713] One can make a similar accusation of Stallman: defending access to the market as a core freedom. Free as in free market. Rather, as Wark writes, "The commodification of information means the enslavement of the world to the interests of those whose margins depend on information's scarcity".[714] Markets entail freedom for capital via the coercion and exploitation of other classes.[715] Techno-libertarianism has often produced contradictory notions of freedom; Ted Nelson, for instance, who coined the word "hypertext" in the 1960s, was an early proponent of microtransactions, which he called "micropayments".[716] He imagined a horizontal, emergent plane of textually interlinked information that could also serve as an immediate, automatic vector for the transfer of money. From this period onwards the hypertextual information network was also being characterised as a market network, with little attention to how marketisation might come to undermine its free character.[717] Distribution, in such a context, is more closely related to Friedrich Hayek's invocation of the decentralised, 'efficient' use of knowledge in free-market economies, than it is with any notion of redistribution, fair or equal dissemination.[718] In the mid-1990s John Perry Barlow described encryption as "integral to the protection of intellectual property", itself conceived of as a freedom.[719] Such a crypto-libertarian crypto-politics came to a head in the "cypherpunk" movement of the 1990s and early 2000s, for whom "privacy" was

710 Stallman, *Free Software*, p.41
711 Ibid., p.41
712 See, for instance, Evgeny Morozov, *The Santiago Boys* (Chora Media, 2023)
713 Karl Marx and Friedrich Engels, *The Communist Manifesto* (London: Verso, 2016), p,8
714 Wark, *Hacker Manifesto,* 132
715 Against which could be placed Marx and Engels society "in which the free development of each is the condition for the free development of all", p.50
716 Ted Nelson, "A Thought for Your Pennies: Micropayment and the Liberation of Content", https://archive.ph/hPH6a
717 Ted Nelson, *Literary Machines Edition 87.1* (California: Computer books, 1987), p.2
718 Friedrich Hayek, "The Use of Knowledge in Society", *The American Economic Review* 35.4 (1945), pp.520-521
719 Barlow, "The Economy of Ideas"

integrally linked to the possibility of an open internet.[720] They positioned encryption as a liberator of information "from the public realm", which might infringe on that privacy.[721] I discuss this milieu in Chapter Eleven, but for now it will suffice to point to the strange circularity, in which calls for an open internet, free from corporate or state restriction serve to justify the creation of complex mechanisms of digital property, via encryption.

But designs for the digital commoning of information were, at least initially, more successful than those for marketisation, and when filesharing began to emerge in the 1990s, they embodied a more literal free-ness. Gillian Welch's song, "Everything is Free", written and recorded in 2000, a year after the founding of Napster, responds to such practices with scorn, she sings:

> Everything is free now, that's what they say
> Everything I ever done, gonna give it away
> Someone hit the big score, they figured it out
> That we're gonna do it anyway, even if it doesn't pay[722]

There is an allure to Welch's country idiom, which places the song somewhat out of its time; clean guitar tone and bare vocals cast the digital medium as an imposition upon her decidedly analogue practice. The ironic refrain of Welch's song suggests that free information might come at the cost of other freedoms; allegedly, the freedom to make music. But this is also a revealing framing, since it makes clear that Welch's ownership over her own work requires exclusion and exclusivity. Again, we might accuse Welch's song of reaction: siding with the music industry over its listeners and the explosion of creative practice born from filesharing. Against "cybercommunism" we got Spotify.

If these invocations of "free" information dramatize some of the tensions circling Wark's text, they certainly don't cohere into a single notion.[723] In fact, they are run through with contradictions. Christopher M. Kelty has described the "ambiguity" and "obfuscation" built into terms like "free" and "open", which evidently act as signifiers for diverse, even opposed, politics. Mobilisations of information as free are profoundly political; they concern what becomes legible to who, and what new material arrangements, accumulations or distributions abstraction can be turned towards.

Lossy compressions hold some freedoms of their own, as Hito Steyerl's poor-image essay examines in detail; most of all freedom from the "permanence of the 'original.'"[724] Poor images are

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[720] Eric Hughes, *A Cypherpunk's Manifesto* (1993) https://www.activism.net/cypherpunk/manifesto.html [22/07/2024]
[721] Ibid.
[722] Gillian Welch, "Everything is Free", *Time (The Revelator)* (Acony, 2000)
[723] Chrsitopher Kelty, *Two Bits: The Cultural Significance of Free Software* (Durham: Duke University Press, 2008), p.143
[724] Steyerl, p.42

part of an errant, continual (re)production and hold no guarantee of authenticity or fidelity, but in doing so they also become a site of invention, departure and surprise. Poor images are not what they were made to be, but what they have become at speed, and in becoming new, they embody the kind of freedom-as-creation Wark is mobilising.

This particular mode of understanding "free" information is as much a function of information (and its core property, abstraction) as of politics. When Wark suggests that "information never exists without material support," she is indicating that, at the highest level, information's "chains" are a result of its confounding materiality.[725] Information is abstraction – as in Markov's work transforming *Eugene Onegin* into a statistical pattern.[726] It cannot exist without a substrate – copper cables, light, air, etc. – yet it also always seeks to escape the material, both through its capacity to cross material barriers (what I called the synaptic gap in Chapter Two) and in the disregard it pays to its substrates, to which it often appears to bear little relation. We might see the vast network of cables and wires which circulate information around the globe and into our homes as a metaphorical prison for information, which aspires towards a purer abstraction.

But where else is there to go? Without such confinement information could not exist, and in the final analysis it is always resolutely material. Radio waves and satellite communications might not be so obviously enclosed as information that travels down wires, but they remain confined to substrates, and subject to the limitations and affordances these offer. So, too, are our voices and the electric and chemical signals in our brains; we have yet to discover any form of abstraction which can escape the chains of its own material existence. But this confinement is also, paradoxically, the thing which propels information. Harry Nyquist was one of the first to theorise the complex interrelation between information's confinement and its propulsion in his 1924 essay "Certain Factors Affecting Telegraph Speed".[727] In it, he argues that the material of a communications channel has an affect not just on the feasible speed of transmission but also on what kinds of waveform can achieve the greatest speed. He considers radio, land lines and submarine cables in turn, concluding that optimal wave functions vary between each "type of circuit" (medium) information travels through. Far from exorcising information from materiality, this requires the engineer to take specific interest in the medium whenever constructing a codec. Only in adapting to the properties of its medium, can information speed up its escape from that medium.

Most important is what this ongoing escape makes possible: the realisation of meaning. This is the "determinate moment" of decoding, in Stuart Hall's analysis of communication, which itself

725 Wark, *Hacker Manifesto*, 127
726 Markov, p.591
727 Nyquist, "Certain Factors Affecting Telegraph Speed", pp.324-356

"issues into a structure".[728] Here information is decoded into meaning, which itself structures the decoding of information. Umberto Eco takes this a step further by arguing that the coherence of a communication system is only a momentary product of its reception.[729] Information is rendered as information through its apprehension as meaning by a third party, the interpretant, which retroactively generates a chain of signification, even if that meaning is simply the recognition of a substrate as containing the capacity for information.[730] In other words, information (which contains the potential of meaning) only becomes information retroactively once meaning is realised. If there is no moment of decoding, no creation of meaning, there is no information. (Although, as Eco notes, to realise meaning is also to destroy the potential of information, whose potential is "reduced" at the point of interpretation.[731])

If information is conceived as a meaning potential, then encryption must entail a kind of negative information function, neginformation, which realises an absence of meaning.[732] Indeed, the act of copying has often been bound up in attempts to control proliferation. Cornelia Vissman has described how legal filing systems often systematically follow duplication with deletion from old copies: "The act of copying is followed by the act of cancelling."[733] By contrast, what Wark calls free information would be information in its ideal form, as the unrestrained raw material of meaning. Information is free when it realises meaning, is free to become meaningful, to travel and transform. But while Wark is making a primarily political claim (to which I am sympathetic), I am more interested in a structural one. Encryption is structurally opposed to the creation of meaning in the broadest of terms; its function is not to create misunderstanding (which is meaningful) but the negation of meaning itself.

Mobilising encryption as a communications technology entails discrete limitations to meaning and knowledge (secret messages); mobilizing it as an economic technology entails structural barriers to creativity on the one hand, and reproduction of profound forms of inequality on the other. Under these definitions, information subject to market logic can by definition never be free – "free as in free beer". But embedded within a conception of information as potential is the germ of a more emancipatory politics than that of Americanised "liberty". Encryption-as-property is a consequence of capital accumulation adapting to the conditions of networked digital communication. How might this more radical capacity of information – its meaning potential –

[728] Hall, *Encoding and Decoding*, p.260
[729] Eco, *The Open Work*, p.49
[730] Eco, *A Theory of Semiotics,* pp.70-71
[731] Ibid., pp.140-141
[732] Cf. Katherine Hayles' discussion of Léon Brillouin and Claude Shannon's conceptions of entropy and information, and Brillouin's "negentropy" in *Chaos Bound*, pp.48-60
[733] Vissman, p.27

adapt to the same conditions? What interventions are required to expand this form of freedom? We could do worse than start with the shadow library.

Shadow libraries are large online databases of digital texts, often but not exclusively academic; prominent examples include Anna's Archive, Aaaaarg.org, Monoskop, Library Genesis, SciHub and Z-Library.[734] These libraries function as an alternate form of circulation to the DRM-infused direct output of academic publishers and journals, with all files available to download for free, generally in the form of .pdf or .epub, and without any attached DRM. In practice these are widely used resources which have become integral to the infrastructure behind academic work.[735] They also entail a purposeful disregard for the property rights embedded in digital commodities and have therefore been articulated as a form of "civil disobedience" by librarian-activists Marcell Mars, Manar Zarroug and Tomislav Medak.[736] For Mars, Zarroug and Medak such shadow libraries are an extension of the radical impulse behind the public library as first articulated by Melvil Dewey: "free libraries for every soul".[737] A different inflection of 'free': universal provision, access and care (for archive and public).

The public library is not the only genealogy in which shadow libraries can be placed. Library Genesis, one of the largest and oldest shadow libraries, has been placed in a continuity with underground pirate libraries in post-Soviet Russia.[738] Balázs Bodó describes the coming together of communist ideology promoting a reading public, a practice of censorship during Soviet administration and the collapse of publishing afterwards as key contexts for textual scarcity, the habitual hoarding of books and consequently informal pirate libraries as integral to Russia's media circulation.[739] Such practices were directly translated into digital archives after the popularization of the internet.

In a response to 2004 legal action from the copyright holder of Theodor Adorno's work, Sebastien Lüetgart (who ran shadow library textz.com) argues for the resilience of the public domain, he writes:

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[734] See: Joe Karaganis, ed. *Shadow Libraries: Access to Knowledge in Global Higher Education* (Cambridge: MIT Press, 2018)

[735] There is no systematic review of shadow-library use, but existing work (and my own, subjective, experience) indicates it is widespread. One study of students at an Indonesian university found 86% of students were using shadow libraries; Stanislaus Axel Paskalis and Alfredo Putrawidjoyo "Undergraduate students' use of shadow libraries as counter-enclosure of knowledge", *Bekala Ilmu Perpustakaan Dan Informasi* 18(2), pp.189-203

[736] Mars, Zarroug and Medak

[737] Ibid.

[738] Balázs Bodó, "The Genesis of Library Genesis: The Birth of a Global Scholarly Shadow Library", *Shadow Libraries: Access to Knowledge in Global Higher Education* (Cambridge: MIT Press, 2018), pp.25-52

[739] Ibid., p.33

> your ‘intellectual property’ has become part of the very public domain that had granted you these copyrights in the first place. Of course they will not be available instantly, and of course we will not publish them ourselves – but you can take our word that they will be out, in countless locations and formats, and that not even a legion of lawyers will be able to get them back. [740]

Lüetgart isn’t articulating the public domain as a legal category here, but as a functional relation. Adorno’s work is in the public domain because it is accessible to the public for free (Adorno’s work is widely available through shadow libraries), not because it has been legally designated as such (it hasn’t). Such infrastructures of access offer a basic affront to encryption-as-privation. They reveal the comparative strength of a project which aligns itself with free information: the encryption of information demands an economy, far less is needed to render it once again free.

[740] Quoted in Aideen Doran, “Free Libraries for Every Soul: Dreaming of the Online Library”

Chapter nine

Occult objects: encryption and the commodity form

Artist's Shit no.31, Piero Manzoni (1961)

> **The commodity appears at first sight an extremely obvious, trivial thing. But its analysis brings out that it is a very strange thing, abounding in metaphysical subtleties and theological niceties.**
>
> Karl Marx, *Capital Vol.1*

What's in the can? We aren't supposed to look. We aren't supposed to want to look. This is even though its contents are the only reason we were ever interested. In 1961, Piero Manzoni canned 90 tins of his faeces, which have since fetched prices of over £200,000.[741] The aura of Manzoni's

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[741] Piero Manzoni *Artist's Shit, no. 031* (1961); for instance, a tin sold for €275,000 in 2016. "Record per 'Merda d'Artista' di Manzoni: 275mila euro per la scanoletta n.69", *La Stampa* (08/12/2016) https://www.lastampa.it/cultura/2016/12/08/news/record-per-merda-d-artista-di-manzoni-275mila-euro-per-la-scatoletta-n-69-1.34752641/

Artist's Shit, an indexical link back to its creator via excretion, is the supposed root of this absurd exchange value, in Manzoni's own account: "if collectors want something intimate, really personal to the artist, there's the artist's own shit, that is really his."[742]

Artist's Shit holds this exchange value and so it is sacred. We must treat it with veneration: we aren't allowed to open the can to prove its provenance; use (as paint) is forbidden. Whatever is inside, opening the can would cause the value to plummet. We do not really want to open it, anyway, because we know once opened it will be mundane, underwhelming. The taboo of faeces certainly helps, but the fact that *Artist's Shit* is not just a banal sort of disgusting – something odd but uninteresting – is owed first of all to the form Manzoni chose for his work: the commodity.

What Marx called "commodity fetishism" animates *Artist's Shit*: imbues it with a mysterious, occult character.[743] The sealed container is both a literal and metaphorical invocation of this; on the one hand steel encloses its contents, obscuring our view even via technological means, and on the other it stands in for the opacity of exchange relations. Are there really faeces inside? Are they Manzoni's? What happens to faeces sealed in a container for 60 years? These are things about which I am suddenly, uncharacteristically, curious.

This aspect of the commodity – which, for reasons I will elaborate, I characterise as an 'occult' relationship – is central to its entanglement with encryption today. Recent years have seen debates around the relevance of the commodity form, especially under conditions of digital circulation (namely its displacement by "the asset").[744] In a bid to offer new relief to this juncture, this chapter explores the reconfiguration of the commodity form and of encryption towards novels kinds of occult arrangement. Out of the collision, I argue, has emerged a new value form neither exactly like a traditional commodity or asset: the encrypted commodity.

Even before their collision in the late 20th century, the encrypted and the commodified shared a common structure with other occult objects. Such objects include the crypt or the coffin, the server, so called "books of secrets", number stations, Lovecraftian horror. Each of these objects embodies an occult symbolic relationship with its subject: one characterised by a specific structure of mediation (fig-9.0).[745] Occult objects are obscured, inaccessible behind a veil (this

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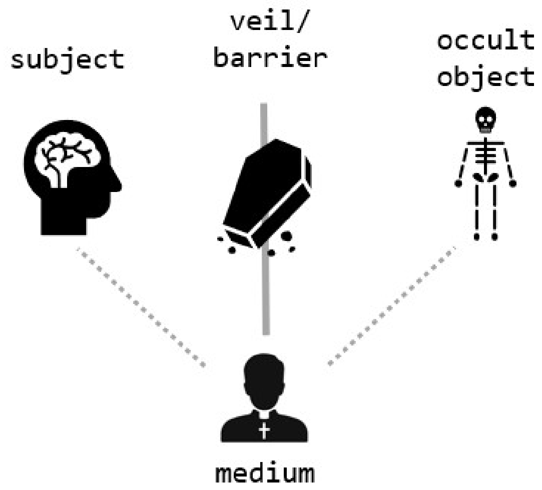
742 Freddy Battino and Luca Palazzoli, *Piero Manzoni: Catalogue Raisonne* (Zurich: Skira, 2004), p.144
743 Marx, *Capital Vol.1*, pp.163-177
744 Adkins, Lisa, Melinda Cooper and Martijn Konings, *The Asset Economy: Property Ownership and the New Logic of Inequality* (Cambridge: Polity Press, 2020); Birch, Kean, and Fabian Muniesa, *Assetization: Turning Things into Assets in Technoscientific Capitalism* (Cambridge: MIT Press, 2020)
745 Such a schematic comes with important caveats: 1) Marx describes exchange as a symbolic process, but the consumption of goods in often not merely communicative (e.g. eating food), and this therefore applies mostly to the information commodities addressed throughout this thesis; 2) These are cases in which a third party mediation is especially important to the process of meaning creation, or of use, and should not imply a normal situation in which communication or consumption is unmediated. Any system of production, indeed any act of communication, entails some amount of mediation.



Occult object	Veil	Possible mediums
Dead body	Coffin, death	Priest, medium, shrine, tombstone, scientific description
Encrypted message	Encryption/ mathematical transformation	Cipher, cryptanalyst
Encrypted commodity	Alienation, social division of labour	Exchange value
Encrypted commodity	Encryption	Proprietary interface

Figure 9.0 Schematic diagram of the symbolic structure of an occult relation (left); table of occult relation examples (right)

could be a container, a code, or alienated social relations) which can only be overcome via mediation, be this via a priest, a medium, a talisman, text, a cipher, a cryptanalyst or an exchange value. Occult characteristics contribute to the construction of complex logics of access and restriction, such as social taboos, religious rituals and ceremonies, or complex mathematical formulations. Manzoni's *Artist's Shit* is a good example: rather than opening the can, I might participate in its exchange. A crypt or coffin is another pervasive one: once sealed it begs the question of what is inside, but reopening is (generally) forbidden and repulsive. If I want to access the grave without being confronted by the grim reality of death within, I might instead seek mediation with a priest, through rituals (returning to the grave), or with abstract scientific description.

Marx clarifies that exchange values are symbolic: they are socially derived, standing-in for use-values, themselves obscured by the social division of labour.[746] Notoriously, the section of *Capital Vol.1* which describes this fetish characteristic of commodities reaches for the language of gothic fiction.[747] This Gothic inflection has led Marxist and post-Marxist critics – notably including Lukács, Benjamin, Debord and Baudrillard – to a variety of concepts including phantasmagoria, reification, simulacra or spectacle. Though varied, these accounts are all attentive to the haunting capacities of the commodity or cultures inundated with commodities, at once illusory and lively.

Encryption has a long and varied history of application within the occult, which this chapter begins by surveying, finishing with the gothic literature of the 18th and 19th centuries on which Marx is drawing. Out of this body of textual practice and literature, emerges a structure of relation typical of the occult (fig-9.0), both as a trope of fiction, and as a hermeneutic practice of

[746] Marx, *Capital Vol.1*, p.167
[747] Marx, *Capital Vol.1*, pp.163-177

textual and intertextual decoding. This kind of cryptic figuration, I believe, is invoked by Marx to describe dynamics within the commodity form, and has become integral to digital commodities.

Today, non-access is an integral part of the experience of living within digital capitalism; we are constantly confronted by a conspicuous exclusion which can only be overcome by one or another form of exchange. This alienation is not a generic consequence of 'the digital', but a specific technique, constructed from the latent occluding characteristics of the commodity form, recent developments in digital cryptography and crises of digital over-circulation of information commodities. Existing work on the asset as a successor value-form to the commodity captures some of this novelty, but centring the occult suggests not a displacement of the commodity by the asset, but the emergence of a new form centrally implicated in the determination of use: the encrypted commodity.

Encryption as occult practice

Encryption and the occult (hidden practices and phenomena) hold common histories. Here I offer a sketch of their interrelation. Simple codes and ciphers are a staple of the textual history of magic, as well as occult and hermeneutic practices, in England and much of Europe. These can be found throughout the material record from early-medieval Europe, including in Anglo-Saxon England: a simple substitution cipher is described by Bede in *The Reconning of Time* (written 725), alongside a wide variety of techniques for occulting writing, including riddles, acrostics, and the use of runes.[748] Notably, the function of cryptography in this period is not always simply to withhold meaning but also to create symbolic resonance; biblical cryptography, for instance, is closely linked to the development of hermeneutic modes of reading within both the Christian and the Jewish mystic tradition.[749] In such cases, specific biblical codes (such as the atbash code) were closely associated with, and ambiguously deployed alongside, textual exegesis.[750]

The interrelation of magic and of encryption becomes very explicit in "books of secrets" which first emerged in 12th century Europe, became especially prevalent in the cheap print circulation of the 16th century and continued to circulate into the 17th century.[751] Such books professed to

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[748] Bede's cipher is recounted in: Stephen Harris, "Anglo-Saxon Ciphers", *A Material History of Medieval and Early Modern Ciphers* (London: Routledge, 2018), pp.65-79; Also see E.J. Christie "The Cryptographic Imagination: Revealing and Concealing in Anglo-Saxon Literature", *A Material History of Medieval and Early Modern Ciphers* (London: Routledge, 2018), pp.80-94
[749] This is the argument made by Sarah Myers West in "Cryptographic imaginaries and the networked public", *Internet Policy Review* 7.2 (2018), https://policyreview.info/articles/analysis/cryptographic-imaginaries-and-networked-public
[750] Jerome Levi, "Structuralism and Kabbalah: Sciences of Mysticism or Mystifications of Science?", *Anthropological Quarterly* 82.4 (2009), pp.929-984
[751] Allison Kavey, *Books of Secrets: Natural Philosophy in England, 1550-1600* (Champaign: University of Illinois Press, 2007), p.2; Eamon, pp.26-49

give their readers access to secret, lost or hidden knowledge, often (but by no means exclusively) extracted from Arabic sources.[752] Books of secrets often dramatized their own coded-ness, as one widely cited example puts it: "I am revealing my secrets to you figuratively, speaking with enigmatic examples and signs".[753] Such texts were not always intended to be read literally, instead requiring occult methodologies: reproduced in code, and decoded by only worthy readers. As Laura Marks argues, the idea that hidden knowledge can be read through such texts is integral to their spread and appeal.[754] A number of prominent "secret" texts brought issues of misattribution: the *Secretum secretorum* was wrongfully attributed to Aristotle, for instance and the *Liber aggregationis* to Albertus Magnus.[755] In both cases, the belief appears to have been that translation might reveal hidden knowledge from an established scholarly past.

Like other esoteric literatures, such texts were sometimes subject to encryption.[756] Despite their dramatized obfuscation, though, the contents such books was often mundane – instructions or recipes for crafts (e.g. cooking, magic or metallurgy) – and were not generally difficult for readers to decipher.[757] William Eamon argues that one use of the word "secret" in this context relates specifically to an understanding of nature as "a repository of cult forces", which might be excavated or harnessed.[758] This kind of knowledge is "secret" in the sense that its mechanisms are unknown and unknowable (and therefore it is distinct from scholarly genres), but remains usable. Far more notable in terms of access, is the question of circulation of texts. Eamon describes how the transition from script to print fundamentally transformed the status of books of secrets from a scholarly to a popular, or at least artisan, literature.[759] Even as a "popular" literature, illiteracy would have excluded the majority. In a partly literate society, all writing is encrypted to some; in the Middle Ages and today, social relations underwrite access to information. The expansion of literacy brought with it an expansion of access to knowledge, including to secret knowledge.

In the 14th century, complex cryptographic methods (notably frequency analysis) previously known to the ancient Arab world appeared in Europe for the first time, apparently spontaneously. It has been speculated, though not confirmed, that this expanded cryptographic knowledge and

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752 Ibid, p.2; For the extraction of this knowledge from the Ancient Arab world see: Marks, "Talisman-images", pp.231-259
753 Ibid., p.230
754 Ibid., p.239
755 Eamon, p.30, p.33
756 Elane Leong & Alisha Rashkin, "Introduction", *Secrets and Knowledge in Medicine and Science 1500-1800* (Burlington: Ashgate, 2011), p.9
757 Similarly, Benerdek Lang argues that ciphers in medieval magic literature drew readers into textual engagement: "Ciphers in Magic: Techniques of Revelation and Concealment", *Magic, Ritual and Witchcraft* 10.2 (2015), pp.125-141; Eamon, p.27
758 Ibid., p.27
759 Ibid., p.35

practice was extracted directly from the ancient Arab world in the form of secrets.[760] We do know that the contemporary English word "cipher" comes from the Arabic "sifr" (meaning the character "0"), via medieval Italian and the French "chiffre" (which refers to Arabic number characters in general); an etymological root generally overlooked in the major histories of encryption, in favour of the Greek origin of encryption, "kryptós".[761] Several accounts theorise that the semantic shift was generated directly by the a catholic ban on Arabic numerals, in which zero ("sifr") was considered dangerous, secret knowledge (and so, the character became associate with the practice of obscuring it), although this claim is controversial.[762] Given the general diffusion of knowledge from the Islamic Golden Age, in particular of mathematics, into medieval Europe (for instance, Fibonacci's travel around the Mediterranean and subsequent adoption of Arabic numerals), it seems reasonable to suggest that knowledge of cryptography might have flowed westwards; though if an epistemic route exists, it is not known. David Kahn's history of cryptography describes this spontaneous appearance of frequency analysis, but dismisses the possibility of its deriving from Arabic practice, despite also describing cryptology as remaining active in Syria and Egypt well into the 14th century.[763] Simon Singh is ambivalent, stating it might either have been developed independently or have travelled west, but that evidence confirms neither theory.[764]

Nonetheless, in 1401 letters were composed to the chancellor of the Duchy of Mantua (modern-day Italy), Simone de Crema, that were encrypted via multiple letter substitutions – indicating some knowledge of frequency analysis.[765] Typical for encryption in Europe up to this period, the text itself includes the practice of encryption but no theorisation; it evidences a method but says nothing of epistemology. This first instance of complex cryptography in Europe is occult, then, at least in the sense that we cannot know its origin.

But these letters are also notable because they mark a period, identified by Ioanna Iordanou, of transition from "esoteric practice to applied Scientia".[766] In other words, they mark the emergence, centred around the mercantile culture of Venice, of cryptography as a profession and of encryption as a science. Trade between Venice and the Ottoman Empire (at this time including

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760 Marks, p.236
761 Kahn, p.26; See, for instance: Singh, p.6
762 For claims, see: Georges Ifrah's book *The Universal History of Numbers: From Prehistory to the Invention of the Computer* (New York: John Wiley & Sons, 2001), p.590; for attempts to debunk, see: Phillip Nothaft, "Medieval Europe's satanic ciphers: on the genesis of a modern myth", *British Journal for the History of Mathematics* 35.2 (2020), pp.107-136
763 Kahn, pp.96-100
764 Singh, pp.27-28
765 Kahn, p.107; Ioanna Iordanou, "The Professionalisation of Cryptology in Sixteenth-Century Venice" *Enterprise & Society* 19.4 (2018), p.985
766 Iordanou, p.984

parts of Egypt and Syria) led to the exchange of cryptography techniques (as well as desires to obscure key commercial information), notably a cipher known as the "Cicero substitution cipher".[767] Here and elsewhere, commerce (in this case between Europe and the Ottoman empire) motivates the development of "secret" practice.[768] Following such exchanges with the Ottoman Empire, Venetian cryptography marks an intense period of cryptographic development, contributing towards the development of the (misattributed) Vigenère cipher by Giovan Battista Bellaso in 1553 – thought to be the first "unbreakable" cipher until it was broken by both Charles Babbage and Friedrich Wilhelm Kasiski independently in the mid-19th century.[769]

Another key source for the development of the Vigenère cipher is an alchemical tradition originating in books of secrets: e.g. the abbot Trithemius, who worked on alchemy, cryptography and magic, and whose work was drawn upon in the construction of Vigenère.[770] His *Steganographia* (~1499) is a coded text which ostensibly concerns magic, and has often been received as such – even appearing on the *Index Librorum Prohibitorum* (the list of books banned by the Roman Catholic Church) from 1609 to 1900.[771] The text was only decoded in full in 1988 (by a computer scientist at AT&T Labs, Jim Reeds), who argued that cryptography, not magic, was the text's true subject, and that Trithemius should therefore not be seen as an occult figure.[772]

Most relevant to Marx's description of the commodity is the Romantic esotericism and Gothic literary modes of the 18th and 19th centuries. While some of the information contained in 12th century books of secrets originated in the ancient Arab world, this is not frequently dramatized as esoteric in the texts themselves. By contrast, 18th century Romanticism frequently expresses the occult through notions of a "mystic east" – an explicitly orientalist mode.[773] From the 18th century, representations of an oriental occult became ubiquitous across a diverse set of forms and genres. One might think, for instance, of Lady Mary Wortley Montagu's description of exposed bodies, comprising "the finest skins and most delicate shapes" in a Turkish women's bathhouse in *Turkish Embassy Letters* (1763 – published posthumously), or of the many paintings from this period depicting the far East as mysterious, magical or (drawing on another

[767] Ibid., p.987
[768] Leong & Raskin, p.12
[769] Singh, p.78
[770] For secrecy techniques in medieval alchemy: L.M. Principe, "Robert Boyle's Alchemical Secrecy: Codes, Ciphers and Concealments", *Ambix* 39.2 (1992), pp.63-74; and Megan Piorko, Sarah Lang and Richard Bean, "Deciphering the Hermeticae Philosophiae Medulla: Textual Cultures of Alchemical Secrecy", *Ambix* 70.2 (2023), pp.150-183; For Trithemius, see Singh, pp.46-48;
[771] Jim Reeds, *Solved: The Ciphers of Book III of Trithemius's Steganographia* (AT&T Labs – Research, 1998), https://archive.org/details/solvedtrithemius, p.17
[772] Ibid., p.2; For esoteric alchemical encryption practice: Piorko, et al.; For Truthemius' other work on magic: Noel Brann, *Trithemius and Magical Theology: A Chapter in the Controversy over Occult Studies in Early Modern Europe* (Albany: State University of New York Press, 1999), pp.4-11
[773] Christopher Partridge, "Orientalism and the Occult", *The Occult World* (New York: Routledge, 2014) p.613

Romantic trope) ruinous (fig-9.1).[774] Percy Bysshe Shelley's poem "Ozymandias" (1818) in which "a traveller from an antique land" recounts encountering the ruins of a statue of an ancient king alone in the desert, was conceived on the British Museum's acquisition of *Younger Memnon*, a torso fragment of a colossal statue of Ramesses II – one of many orientalist artefacts to be extracted to Britain around the beginning of the 19th century.[775] Among these was also the Rosetta stone, which served as a cipher for the translation of Ancient Egyptian demotic and hieroglyphic text, previously considered a lost language – and became an object of fascination in Britain.[776] The convergence of oriental and occult depictions during this period is marked, as Christopher Partridge argues: the orientalist mode was "the soil in which modern occultism took route."[777] Indeed, Egyptological exhibitions remained popular throughout Marx's lifetime.[778]

Gothic fiction is named for its ruins. These were typically European (hence "Gothic") but sometimes exchanged for orientalist architecture, and frequently stalked by foreign horrors, as in the classic cases of *Confessions of an Opium Eater* – containing an opium-inspired nightmare of the East wherein the narrator "was stared at, hooted at, grinned at chattered at, by monkeys,

Figure 9.1

Thomas Daniell, *View from the ruins of the fort Currah, on the river Ganges* (1801)

The painting draws on orientalist and gothic idioms, depicting ruins in an imagined Asian landscape

774 Lady Mary Wortley Montagu, "The Corset Stays", *Lapham's Quarterly*, https://www.laphamsquarterly.org/travel/corset-stays [09/05/2024]; Thomas Daniell, *View from the ruins of the fort Currah, on the river Ganges*, oil on canvas (1801), https://www.royalacademy.org.uk/art-artists/work-of-art/view-from-the-ruins-of-the-fort-of-currah-on-the-river-ganges [10/05/2024]

775 Percy Bysshe Shelley, "Ozymandias", *Shelley's Poetry and Prose* (London: Norton, 1977), p.103; Elizabeth Martin, "The Great Sphinx and Other "Thinged" Statues in Colonial Portrayals of Africa", *Victorian Literature and Culture* 50.1 (2022), p.38

776 Robinson, pp.56-73

777 Partridge, p.614

778 Martin, p.39

by paroquets, by cockatoos" – or of Dracula – who arrived at Whitby, and its ruins, from Transylvania by sea.[779] An orientalist mode remains alive in gothic fiction and the horror that took inspiration from it. Lovecraft's fictional book, the *Necronomicon*, is for instance attributed to "the mad Arab Abdul Alhazred".[780] In these cases, the oriental and the occult stand together; Lovecraft was notably disinterested in real occult practice (which he did not research – a mirror of his orientalism), but his writing has nonetheless become influential to later occult thought.[781]

Lovecraft can be subject to hermeneutic exegesis alongside any other occult ephemera, part of what Partridge calls "empty networks of referentiality that undergird the substance of occult literature".[782] There is an echo of Edward Said's description of orientalist knowledge here, as:

> less a place than a *topos*, a set of references, or congeries of characteristics, that seem to have its origin in a quotation, or a fragment of text, or a citation from someone's work on the Orient, or some previous imagining, or an amalgam of all of these.[783]

In both the oriental and the occult, it is the absence of knowing that makes space for a hermeneutic imagination – rendering its referents intriguing, seductive, or terrifying. Genuinely elucidate the occult would undermine its occult character, making it something else, yet it also demands attempts at elucidation: hermeneutics maintain occult dynamics.

Cryptic figurations and occult relations

Crypts are an enduring trope of Gothic fiction. There is an aesthetic intimacy between server rooms and crypts: both are kept cool and dry, often subterranean, evacuated of (living) humans; both contain occult vessels whose contents we cannot grasp without mediation. Encryption expounds upon this logic of exclusion as a coding process, and, as Nadim Samman has highlighted in his art history of encryption, the crypt is a primary figuration within en*crypt*ion itself; their (already mentioned) etymological common root points to a common logic.[784] The crypt is a sacred location from which something disturbing might be disinterred, it is suggestive of spatiality and opacity. We cannot see into the crypt, and we should not peek under its lid, although its being closed creates the possibility of opening it; from the other side, it also contains a body, an inhabitant privy to its inside and contained by it.

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[779] Described in Peter Kitson, "Oriental Gothic", *Romantic Gothic* (Edinburgh: Edinburgh University Press, 2016)
[780] First in H.P. Lovecraft, "The Nameless City", *The Lovecraft Archive* (1921), https://www.hplovecraft.com/writings/texts/fiction/nc.aspx
[781] Partridge, p.496
[782] Ibid., p.498
[783] Edward Said, *Orientalism* (New York: Vintage, 1979), p.177
[784] Samman, p.239

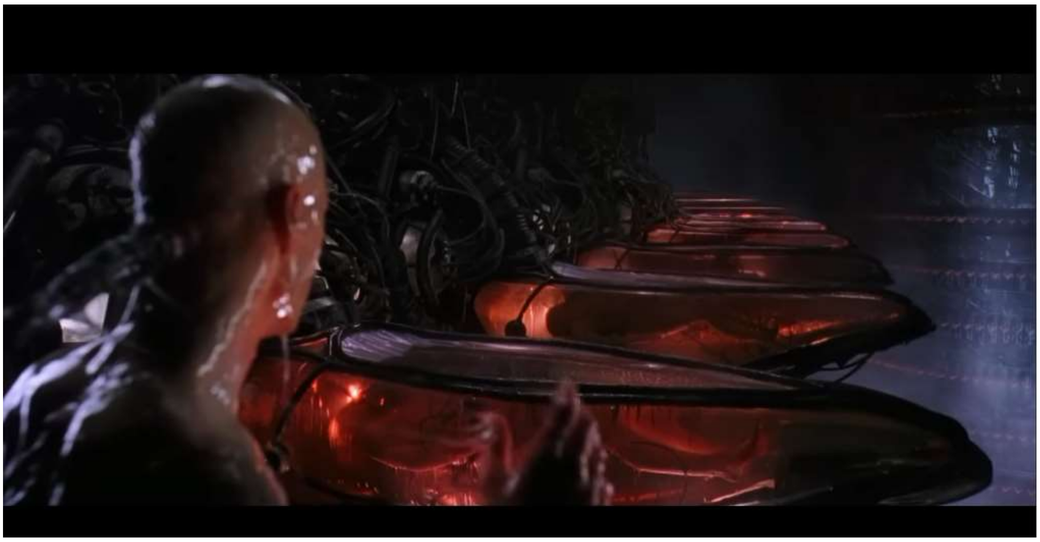

Figure 9.2

Recently awakened, Neo looks out over the crypts in *The Matrix* (1999)

Opening the crypt reveals only a lifeless object, a body. If one wanted to access the deceased, they might turn instead to hermeneutic methods: literary exposition, religious or spiritual ritual, meditation, abstract scientific description, the imagination etc. Encryption similarly organises information along occult lines, withholding the meaning-potential of information and requiring a medium – the cipher, code or even cryptographer – to expose this meaning.

To clarify the figurative utility of Marx's Gothic allusions, it will briefly explore some mobilisations of crypts and of occult relations within the genre. The common etymology of crypt and encryption (suggestive of a common logic) affords encryption a gothic affectation, suggestive of a kind of technological mysticism. It recalls a forgotten power accidentally awoken in a Gothic novel, as in M. R. James' short story "Count Magnus", wherein the protagonist unwittingly releases a demonic aristocrat from his tomb.[785] Dani Cavallaro and Stacy Gillis have both written about the strong aesthetic influence gothic writing holds on the cyberpunk.[786] A description early in Gibson's *Neuromancer*, of Case's accommodation, might be taken as typical of this:

> Now he slept in the cheapest coffins, the ones beneath the port, beneath the quartz-halogen floods that lit the docks all night like vast stages… Tokyo Bay was a black expanse where gulls wheeled above drifting shoals of white styrofoam.[787]

So too, might the *Matrix* scene in which Neo wakes to find he has been encased in one of many coffin-like embryonic pods (fig-9.2).

[785] M.R. James, "Count Magnus", *The Collected Ghost Stories of M.R. James* (New York: Longmans, Green & co., 1931), https://gutenberg.ca/ebooks/jamesmr-collectedghoststories/jamesmr-collectedghoststories-00-h-dir/jamesmr-collectedghoststories-00-h.html
[786] Dani Cavallaro, "Cyberpunk and the Gothic", *cyberpunk and cyberculture: science fiction and the work of William Gibson* (London: The Athlone Press, 2000), pp.164-198; Stacy Gillis, "The (Post)Feminist Politics of Cyberpunk, *Gothic Studies 9.2* (2007), pp.7-19
[787] Gibson, p.7

If cyberpunk often mobilises gothic tropes, there is also a current in gothic literature that is preoccupied by technology. Mary Shelley's *Frankenstein*, for instance, dramatizes the transformation of the human in the wake of electrification.[788] Early experiments in Galvanism demonstrated the capacity of electricity to generate movement in organic (animal) bodies, and Shelley was clearly aware of and interested in these.[789] Her text is keen to emphasise the monster's animation:

> I collected the instruments of life around me, that I might infuse a spark of being into the lifeless thing that lay at my feet… I saw the dull yellow eye of the creature open; it breathed hard, and a convulsive motion agitated its limbs.[790]

This passage is often interpreted as an inverse-electrocution, but the practice of execution by electrocution would not be introduced for half a century.[791] It is not at all clear that even accidental electrocutions had occurred before 1818.[792] More present in Shelley's text is animation, the ontological threat electrical animation holds to conceptions of the humane (and to an immaterial spirit). Not death, then, but life; if the monster cannot only move but also be moved, host complex interiority, then its humanness threatens that we might also be material assemblages of electrified flesh.

Bram Stoker's *Dracula*, published 79 years later, dramatizes electrification as communication. This is reflected in form: letters and diary entries are gradually supplanted by telegrams and phonograph recordings as the protagonists attempt to outpace Dracula's inhuman mobility.[793] "The vampires return to a ticker-tape world of imperceptible communications and televisual speeds", writes Sadie Plant.[794] *Dracula* holds two crypts: Harker is locked out of the vampires' coffins, while Dracula is locked out of electrical communication networks. Harker is paralysed by what he sees emerge from the coffins, an episode which has been given plenty of (especially psychoanalytic) attention.[795] The encounter of Dracula, who turns to dust after his encounter with modern communication technology, has been less privileged in analysis. The vampire is an anachronism in a world of electricity and information; *Dracula* is pulverized in the time-space

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[788] Mary Shelley, *Frankenstein* (London: MIT Press, 2017)
[789] Literary scholars have debated whether this "spark" is one of electricity or fire. Ulf Houe's "Frankenstein Without Electricity: Contextualising Shelley's Novel", *Studies in Romanticism* 55.1 (Spring 2016), pp.95-177 argues against an electric reading of *Frankenstein* but also offers a review of the evidence for such a reading. Either way, Houe's account demonstrates that Shelley is interested in the destabilising influence of science and technology on the human.
[790] Shelley, p.41
[791] T.S. Reynolds & T. Bernstein, "Edison and 'the chair'", *IEEE technology & society magazine* 8.1 (1989), pp.19-28
[792] Ibid., pp.19-28
[793] Bram Stoker, *Dracula* (New York: Doubleday, 1920)
[794] Plant, p.114
[795] E.g: Barbara Almond, "Monstrous infants and vampiric mothers in Bram Stoker's *Dracula*", *The International Journal of Psychoanalysis* 88.1, p.226

compression of networked communications. Hence, the plot of *Dracula* represents a bridge between the Gothic and the cyberpunk. As a trope of Gothic literature, the crypt exists to be opened; in cyberpunk, the code exists to be deciphered. Opening the crypt, in both cases, entails a journey beyond the veil of new spatial-temporal logics; in the Gothic into rationalised modernity (or its other), and in cyberpunk into cyberspace, a new virtual terrain inside the network itself.

But as in the crypt, the question of opacity is vital to cyberspace. Dracula's position – outside an encrypted channel – is apposite, as is his well-noted characterization as a foreign threat.[796] Opacity is here intimately related to questions of access and non-access, and Samman's account is lucid in its articulation of the exteriority of encryption. This is the experience of exclusion produced by encryption which is so pervasive today. A series of digital renderings produced for Farshid Moussavi's 2018 exhibit, *Borders/ Inclusivity*, depict bizarre meshes of security gates (fig-9.3).[797] Such infrastructures utilise encryption as a tool to police physical entry, and the renderings act as a reminder of the ubiquity of such securitised architecture in everyday life, from office or university entrances to self-service checkouts. Of course, these have their corollary in digital systems, to which we are often refused access. Moussavi's renderings are good representations of the opacity of securitised systems, in that they offer nothing more to their viewer than an

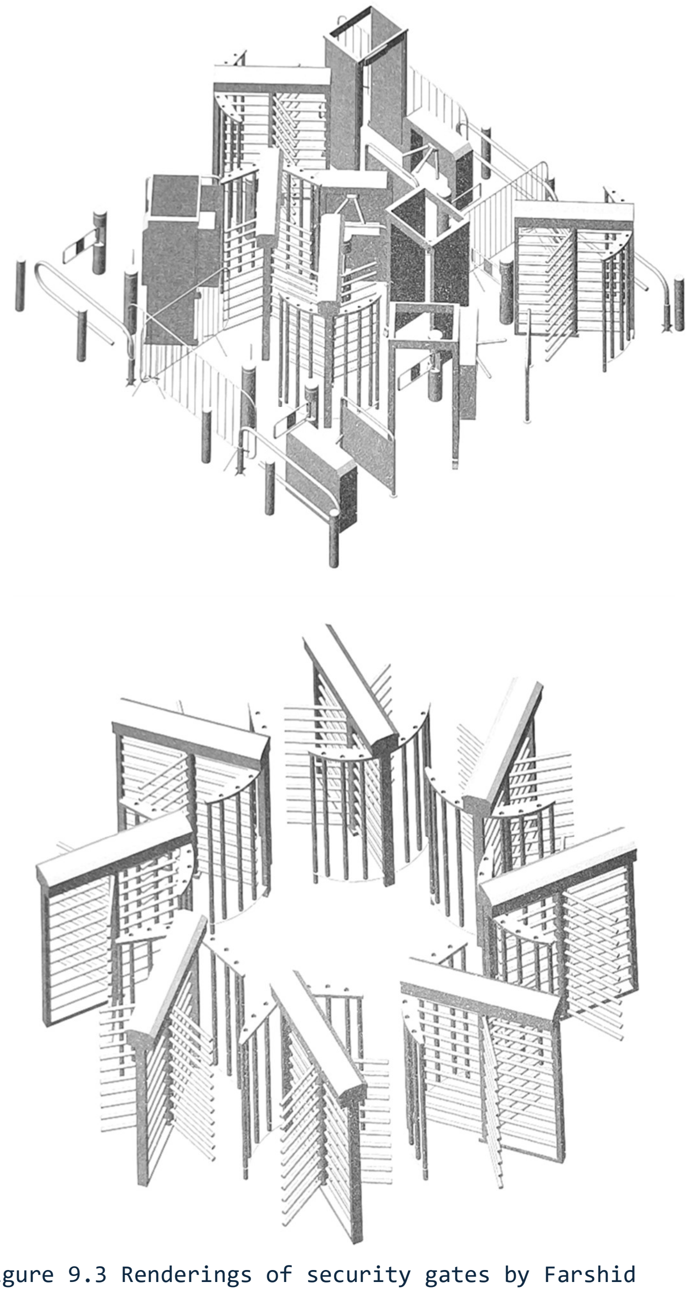

Figure 9.3 Renderings of security gates by Farshid Moussavi in *Borders/ Inclusivity* (2018)

[796] For *Dracula*'s reception as a colonial allegory, see: Anjuli Fatima Rasa Kolb, "Meta-Dracula: Contagion and Colonial Gothic", *Journal of Victorian Culture* 27.2 (2022), p.292-301
[797] *Is this tomorrow? Visions of the Future by Architects and Artists* (London: Whitechapel Gallery, 2019), pp.134-135

impression of exclusion. From the exterior of encryption, such opacity is itself meaningful.

Numbers stations, radio stations which repeatedly output cryptic messages, most often strings of numbers accompanied by musical refrains or synthetic voices, also embody this occult phenomenology.[798] Communications channels have long held an association with haunting; a consequence of their capacity to disembody human sounds and images.[799] The extension of human embodiment into a network of copper and optical cables is often accompanied (from the other side of the channel) by relative degrees of opacity. Katherine Hayles' well-known characterisation of Turing's gender test, in which player A (a man playing a woman) and player B (a woman playing a woman), respond to questions from player C (who is attempting to determine the genders of A and B), as a "magic trick" is a good example of this.[800] According to Hayles, the test tricks its interpreter into accepting a posthuman premise before they even reach that of gender, that a message transmitted in circuit with communications technology is an embodiment of its sender. But for the test to work, it also requires certain kinds of opacity; its players must be located in different rooms. And so, extension through communication systems is intimately linked to estrangement: disembodied voices which exit the channel as something unfamiliar. Numbers stations grasp upon this alienation (likely for practical, not figurative purposes) – making them an ideal candidate for the occult imagination. Indeed, they have not been publicly decoded or explained (though they were likely used for Cold War espionage) – and so hermeneutics reigns.[801] They have been appropriated as source material for Jean Cocteau's *Orphée* (1950), for instance, and as the basis for a number of conspiracy theories, from Dadaist prank to drug cartel communications system.[802] BBC Radio 4's adaptation of H.P. Lovecraft's *The Whisperer in the Darkness* (2023) casts a number of real-life number station recordings as part of an occult conspiracy. Numbers stations, like all crypts, are haunted by the possibility of their contents.

The same number sequences, here, can put towards different ends precisely because they are obscure. Mediums are pivotal within occult hermeneutics: determinate points empowered to enforce regimes of meaning or use. Nothing is demystified by the medium, which controls communication from the middle. So, if I were to ask a priest, a mystic or Lovecraft to mediate my journey into the crypt, the result would differ each time. Similarly, if I subscribe to a digital system

[798] Tony Ingesson & Magnus Andersson, "Clandestine communications in cyber-denied environments", *Journal of Policing, Intelligence and Counter Terrorism* (2023), pp.5-6
[799] This argument is made by Sconce in *Haunted Media; s*uch a "spectral dimension" of communications technology is integral to Derrida's *Spectres of Marx*, p.65
[800] Hayles, *How We Became Posthuman,* p.xiv
[801] Geoffrey Hlibchuk, "The Secret Charm of Numbers: The Clandestine Relationship between Shortwave Number Stations and Twentieth Century Poetry", *English Studies in Canada* 33.4 (2007), p.187
[802] Ibid., p.188

of access, I unwittingly agree to its mediation on my use – what is normally called Digital Rights Management.

The commodity form's occult aspect

What survives of Marx's fiction writing is clearly influenced by Gothic literature, as is his political economic writing.[803] Indeed, stating that occult varieties of alienation are typical to the experience of digital capitalism today (while true) risks obscuring similar logics within previous iterations of capitalism. Literary scholar Andrew Rowcroft has argued that Marx's mobilisation of gothic affectation is not simply stylistic, but "an essential representational strategy for expressing the capitalist social relation" – nowhere is this clearer than in his account of "commodity fetishism."[804]

In Marx's account, commodity fetishism describes a relationship between a commodity and its consumer, in which the fundamental alienation of commodity production (we do not know how commodities were produced) seems to animate commodities in our minds – as Marx puts it, generating "metaphysical subtleties and theological niceties".[805] The literariness of this section of *Capital* is widely noted; indeed, it has often taken as a reason to dismiss commodity fetishism as a disposable aside to Marx's core political economy.[806] But for the right reader Marx's gothic affectation is intoxicating (and has made this one of the most studied passages in *Capital*): for Lukács it contains a description of the reification of social relations; for Adorno and Benjamin it animates phantasmagoric forms like Wagner's music or then-emergent French arcades; for Debord or Baudrillard it grounds an account of mass spectacle and of ideological adherence to capitalism; in the same tradition for contemporary scholars like Jonathan Crary it is the basis of a profound social alienation, and associated systems of control.[807]

While many of these accounts are haunted (the puppets in the phantasmagoria, the absence of any original in the simulacrum, insomnia within the 24/7), none of them directly engage with capital accumulation as a kind of occult practice. Re-reading Marx's writing on commodity

[803] Notably his play, *Oulanem* (1839), available at: https://www.marxists.org/archive/marx/works/1837-pre/verse/verse21.htm [04/10/2024]
[804] Andrew Rowcroft, "The Return of the Spectre: Gothic Marxism in *The City & The City*" *Gothic Studies* 21 (2019), p.192; Marx, *Capital Vol.1*, p.163
[805] Ibid., p.163
[806] Described in David Harvey's *A Companion to Marx's Capital: The Complete Edition* (London: Verso, 2018), p.40
[807] György Lukács, *History and Class Consciousness* (Cambridge: MIT Press, 1986); Theodor Adorno, *In Search of Wagner* (London: NLB, 1981); Benjamin, "Paris, the Capital of the Nineteenth Century"; Jean Baudrillard, *Simulacra and Simulation* (Michigan: University of Michigan Press, 1995); Guy Debord, *Society of the Spectacle* (London: Rebel Press, 1994); Crary, pp.29-30

fetishism helps to foreground the occult characteristics of commodity fetishism. Of a wooden table, for instance, he writes:

> As soon as it emerges as a commodity, it changes into a thing which transcends sensuousness [ein sinnlich übersinnliches Ding]. It stands not only with its feet on the ground, but, in relation to other commodities, it stands on its head, and evolves out of its wooden brain grotesque ideas, far more wonderful than if it were to begin dancing of its own free will.[808]

As in *Frankenstein*, the creation of life is a thing of horror, articulated through physical contortion (in *Frankenstein*, the convulsions of the creature, here the bizarre inversion of the table) and (remarkably for Marx) a kind of anti-human animation, "grotesque" exactly because it evades humanistic rationality. And like Frankenstein, this uncanny animation is adorned in the language of Gothic fiction: the commodity is "grotesque", "mystical", a "sensuous thing", a table which contorts itself and walks on its head.[809] Perhaps confusingly, Marx writes that it is "ein sinnlich übersinnliches Ding" (literally, "a sensual, supra-sensible thing"); so the commodity both appeals to and exceeds the human senses.[810] This aspect which exceeds the human senses is defined instead by social-relations, but if we are to grasp its value we will need a medium: exchange.[811]

But why does Marx obfuscate this apparently straightforward point within the language of Gothic fiction? It is possible to tame the looseness which is undeniably part of Marx's account here – as for instance Lukács does in his theory of reification, which focuses on the becoming material of social relations through commodity exchange.[812] To do so falls short of Marx's aspirations, which are made clear at the beginning of the section: the commodity only appears to be an "extremely obvious, trivial thing", but in actuality it far exceeds the human sensorium. Refuting its simplicity is not the same as offering a straightforward schema for its complexity, however, and in place of a sensuous description of the commodity, Marx reaches to language which is well suited to confrontation with the unknown: that of gothic fiction.

Vital here is what Marx calls the dual nature of commodities, which he characterises as embodying an inherent contradiction between use value (the qualitative value it holds to a user) and exchange value (the quantitative value assigned by the market). When we buy a commodity the overall process of its production and distribution – inclusive of geographical separation, labour rationalisation, specialisation, marketing and much more – leaves us alienated from use

[808] Marx, *Capital Vol.1*, pp.163-164
[809] Ibid., pp.163-165
[810] Ibid., p.163; p.165; For Marx, the sensuous materiality of the object, and its animation via social relations are both real and material; Cf. Baudrillard, for whom simulacra is rendered indecipherable because, as a sign, the commodity refers to nothing; Baudrillard, p.51
[811] Ibid., p.163; p.165
[812] Lukács, pp.83-92

value. Instead, we must convene with a medium (exchange) which derives the commodity a value (exchange value) from social relations – themselves material but not straightforwardly available to human perception. With their production obscured, commodities appear as if by magic in storefronts, fully formed, with the trace of their production erased. Herein the veil of opacity, typical of an occult relation.

Marx is interested in the effects of such opacity on human subjectivity. Its "mystical character", he writes, is "essentially an expenditure of the human brain, nerves, muscles and sense organs."[813] The commodity is sensible ("sinlich") in its use values, supra-sensible ("übersinnliches") in its socially derived exchange values, but also something else: a mystical character expended by the human sensorium.[814] This mystical character is sensuous, but its sensuousness has nothing to do with the actual material existence of the commodity. The "animation" of commodities, then, is neither not simply use or exchange value, but an occult value (at once illusory and real), generated through hermeneutics. Marx describes this relation in terms of cryptography:

> Value… does not have its description branded on its forehead; it rather transforms every product of labour into a social hieroglyphic. Later on, men try to decipher the hieroglyphic, to get behind the secret of their own social product.[815]

So, Marx describes encountering the commodity as involving a decryption of sorts, but what is it that are we deciphering? Marx's metaphor is not of a code, or even a secret message, but the lost writing of an ancient civilisation. The desire to comprehend a commodity from which one is alienated is staged instead as the excavation of an Egyptian tomb; "the secret", the material existence of that commodity, staged as occult (also, orientalist) knowledge.

Commodity fetishism is often positioned as a theory of culture or subjectivity, not of political economy to which it is seen as an aside.[816] In digital capitalism especially, such claims of marginality do not hold up. Occult relations, I argue, are a necessary prerequisite of viable information commodities.

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813 Marx, *Capital Vol.1*, p.164
814 Ibid., p.165; the distinction between the sensible and supra-sensible is not one of material and immaterial but comprehendible and incomprehensible.
815 Ibid., p.167
816 See Francis Mulhern, who takes this as a premise: "Critical Considerations on the Fetishism of Commodities", *English Literary History* 74.2 (2007), pp.472-492; Notably Debord's account, which is often limited to use as a "cultural" theory, despite aspiring to describe a more totalising system; Debord, p.8,p.17

The digital commodity

Within the realm of culture (and the so-called "cultural industries"), capital accumulation has innovated greatly in recent decades.[817] One critical strand discussing this transformation is literature on "assetization." The two most extensive volumes written on the topic were both published in 2020: Lisa Adkinds, Melinda Cooper and Martijn Konings' book *The Asset Economy* and an essay collection edited by Kean Birch and Fabian Muniesa titled *Assetization: Turning Things into Assets in Technoscientific Capitalism*.[818] There are theoretical differences between these accounts (notably how the asset is contextualised – as a product of the financialization and technologization of the economy respectively), but in both cases the authors agree that the commodity has been superseded by the asset as the primary object or mechanism (the "dominant form") of capital accumulation.[819]

"Commodification", they argue, inadequately captures the shifts which have occurred under neoliberal (or "techno-scientific" in Birch and Muniesa's account) capitalism; it is not that more things are being made into commodities, but that many things which were previously produced and sold as commodities are now not being sold, and are instead subject to different mechanisms of extraction, ostensibly based on speculation.[820] Unlike the commodity form which generates accumulation via exchange, they argue, the asset form enables accumulation via the extraction of economic rent or of speculative investment (and so this is not simply rentierism).[821] Extracted out of the realm of finance capital and rendered into a general form, assets, they write, are things that "can be owned or controlled, traded, and capitalised as a revenue stream"; assets are things that contain the potential to generate profit in the future, rather than being traded in the present.[822] They therefore encompass a relatively large and diverse set of objects including copyrights, patents, skills, experience, land, celebrity appeal, followings, portfolios, investments. As long as something can be understood in terms of potential future profit (as opposed to more straightforward exchange value), it can be treated as an asset.

Surveying digital culture today, so much information which once circulated in the form of discrete commodities – music on records or CDs, for instance – has moved towards this kind of mechanism: Spotify for music, Netflix for film and television, Shutterstock in commercial images,

[817] Here I use "cultural industries" specifically to designate cultural activity undertaken explicitly as/through commercial means. For a critique of the "cultural industries" framing, see: Justin O'Connor, *Culture is not an Industry: Reclaiming art and culture for the common good* (Manchester: Manchester University Press, 2024)
[818] Adkins, et al.; Birch and Muniesa
[819] Birch and Muniesa, p.9; Adkins, Cooper and Konings, p.15
[820] Adkins, Copper and Konings, p.5, p.12-15; Birch and Muniesa, p.8
[821] Ibid., p.9
[822] Ibid., p.9

Adobe as an early adopter of a subscription model for software, OnlyFans for pornography, Patreon for podcasts (succeeding talk radio), etc. In each case, we see some combination of rentier access for consumers, and speculative trading of rights within the industry and between service providers. Music was one of the first industries to undergo of this over-circulation crisis and the first to innovate and implement these forms of accumulation: in 2023 67.3% of global music industry revenue was derived from streaming subscriptions.[823] Such a reorientation has emerged from a crisis in the structure of the digital commodity itself; as I found in Part One, this is a consequence of the capacity for information (once compressed and entered into a network) to be copied and transmitted with ease, to such a degree that it has exceeded circulation as a commodity and been shared instead merely as information.

In their account, Birch and Muniesa focus on the "unique and nonreproducible" nature of the asset, but following the kind of the near-infinite replicability of information and attempts to restrain this via encryption tends to foreground the opposite – that these things are innately generic and must be rendered discrete via specific technical means.[824] Of course, their account is focused on more than digital information – land, copyrights, the attention of an audience, etc. – but these things are also not inherently exclusive but must be made so. Land, for instance, requires enclosure to become private property, and copyrights are a means of rendering other things (pharmaceuticals, seeds, music, image, video) legally exclusive. The asset framing occasionally risks rendering the nonreproducible aspect of these things as natural when it is in fact highly technical (as with e.g. encryption). By sidelining these artificial facets, we risk losing sight of what these things are, and where they have come from.

On the one hand, by focusing on what is novel in contemporary objects of accumulation, scholars working under the rubric of assetization effectively foreground new modes of accumulation which have come to the fore through networked communication technologies, and rightly highlight that these objects of consumption within digital capitalism are structurally not the same as those of alternate forms of circulation or older forms of capital accumulation. On the other, by positing the asset as a totally discrete form from the commodity, they overlook the extent to which "the asset" and "the commodity" are interrelated and co-constructive units of commercial culture.

An alternate approach to the juncture sees a transformation to the commodity form emerging from its collision with networked communication, resulting in a new set of forms and practices which resemble both the conventional commodity and asset. In other words, the dominant form

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[823] "Industry Data", *ifpi* (2024) https://www.ifpi.org/our-industry/industry-data/ [10/05/2023]
[824] Burch and Muniesa, p.13

of digital capitalism today (that I call the encrypted commodity) emerges out of features already latent in the commodity of previous centuries, rather than simply appearing as a distinct form (i.e. the asset). Such a form, which I call the encrypted commodity, is defined by a new centrality of occult dynamics.

Encrypted information and the commodity form have historically shared an occult orientation, both embodying the structure described in fig-9.0. The rendering of commodities as information (digital commodities) from the late 20th century onwards had two relevant effects: 1) in combination with massive information infrastructures, has rendered the cost of reproduction and circulation of these commodities negligible, and 2) has exposed them to information processes, including encryption. DES and AES represent generalisable standards (Cf. Chapter Ten) for the production of encrypted commodities in which an occult relation is not a byproduct of production systems but a requirement of circulation as a commodity (the emergence of encryption-as-privation). Such a formal combination altered what the commodity is and can be: the encrypted commodity emerged as a novel form iterated on information and the commodity.

Rather than returning the information circulation to the default mechanisms of pre- and non-digital commodity circulation, encrypted commodities have tended to move to certain accumulative mechanisms. Like assets, the primary mode of accumulation utilized by encrypted commodities is not exchange but rent extraction. Here assetization literature is evidently useful, most of all in its focus on the temporality of financial logics, the centrality of rent extraction and importance of asset-ownership for determining class stratification today.[825]

Indeed, assets are generally distinguished from commodities as value-forms in one key sense: they are speculative, and so must be understood in time. The futurity already implicit in MCM' – a mechanism predicated on the future resale of commodities for a profit – has been widely overlooked by asset scholars. In Adkins, Cooper and Konings' account, for instance, each example of commodity exchange is depicted as entailing a "clean slate" (which might more accurately describe CMC exchange).[826] Assets might meaningfully be distinguished from commodities in that they do not require exhaustion to realise accumulation – they accrue value based on financial speculation without being expended.[827] In fact, use is often an anathema to assets, which would lose their value were they spent (as in *Artist's Shit*). This negation of use-value might be considered an ultimate triumph of occult value, becoming a pseudo-value which cannot be realised. Against assets, animated through hermeneutics, commodities are comparatively

[825] Adkins, Cooper and Konings, pp.69-79
[826] Ibid., p.13
[827] See, e.g.: Dave Beech, *Art and Value: Art's Economic Exceptionalism in Classical Neoclassical and Marxist Economics* (Leiden: Brill, 2015), p.293

lively things, abounding in use-values, which are the root of their sensuousness ("sinnlichkeit") and without which they could not accumulate. The assetization of the commodity would suggest the victory of its supra-sensible ("übersinnlich") aspect – of the occult – but this is not what we see in practice. In reality, most commodities in some sense operate according to asset logics, and few assets ascend to a pure abstraction. One might imagine instead a continuum between unalienated non-capitalist goods and the pure financial asset (fig-9.4), between which capitalist commodities have always existed.

Asset scholars tend to view information as a kind of "intangible asset", within a wider immaterial "knowledge economy", not as something exhausted through use (like the commodity).[828] However, information as a material formation is unfortunately not inexhaustible, not least due to the laws of thermodynamics, and more rigorous attention shows that the digital circulation of commodities does indeed entail the multivalent exhaustion described by Ajay Singh Chaudhary, of ourselves and the planet.[829] It also cannot aspire to the uselessness of the idealised asset; information is steeped in use-values, which in an information-theoretical sense are what render it meaningful and distinguish it from noise. Encrypted commodities represent a novel value-form, arising from contradictions between information and the commodity, alongside the expansion of certain asset logics from finance capital, rather than straightforwardly as an imposition from finance or even big tech.[830]

The encrypted commodity is most novel in its construction of technical regimes of control which directly affect use and delimit the potential for use-value to exceed exchange-value. Always, such systems are built around the prohibition of copying, but this brings with it a general apparatus of control. For instance, if I buy a CD it is generally possible for me to rip the contents and share them with others in person or over the internet; the same is not true if I subscribe to Spotify,

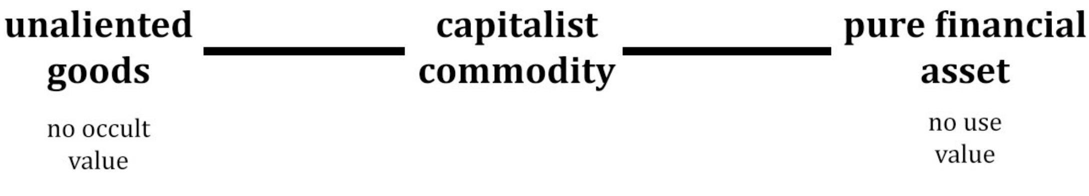

Figure 9.4 Between two idealised forms – the unalienated good and the abject financial asset – sits the commodity, which tends towards occult arrangements but is nonetheless useful and used.

[828] See, e.g. Hyo Yoon Kang, "Patents as Assets: Intellectual Property Rights as Market Subjects and Objects", *Assetization: Turning Things into Assets in Technoscientific Capitalism* (London: MIT Press, 2020), pp.49-77; Birch and Muniesa, pp.30-31
[829] Chaudhary, p.177
[830] Though these have doubtless been a "leading" coalition of capital through the transition. See: Jeremy Gilbert and Alex Williams, *Hegemony Now: How Big Tech and Wall Street Won the World (And How We Will Win It Back)* (London: Verso, 2023), pp.71-74

which (as an occult medium) is able to enforce specific terms on its use through means which transcend the legal. Within the encrypted circulation of digital capitalism, the occult aspect of the commodity, already latent, has come to the fore; in doing so, it has promoted the mediator (capital) to a position of determination over use itself.

Occult archaeology

This chapter has made two core propositions: 1) the existence of an occult relation, a structure (which might be semiotic, mechanical, economic, etc.) organised around mediation by a third party, which controls circulation (communication or logistics) and intercedes the creation of meaning, use-value, etc., and; 2) the development of a novel value-form, the encrypted commodity, in which this occult relation is not just a consequence of the production process, but a necessary, discipling, precondition of accumulation. Central to the novelty of the encrypted commodity is control it exercises over the previously relatively autonomous domain of use.

Early in the 2000s, debates surrounding the supposed immateriality (and absence of indexicality) within digital mediums turned to the occult, notably drawing on Andre Bazin's description of photography as a death shroud.[831] I maintain that notions of "the digital" as immaterial, without indexical links or degradation, are insufficient, but these accounts hold diagnostic value: they gesture towards then emerging logics of digital encryption, and of the encrypted commodity. The invocation of Bazin relates to an idea that film photography is uniquely indexical (following Charles Sanders Peirce, a sign that is produced as a material product of the thing it signifies), but that digital photography lacks any such material link.[832] More than any other form, the encrypted commodity or asset seeks to efface its index, to obscure or even destroy the material marks of its production – in the context of its growing prevalence, an impression of immateriality is unsurprising.

All these things anticipate a centrality for occult relationships within digital capitalism, with implications for political economic, cultural, technical and aesthetic work. A survey of contemporary "digital" disciplines finds a host of methodological problems in the wake of the encryption of digital infrastructures. In the humanities we face archival problems: one can no longer study an important videogame like *PT* (2014), for instance, because it has been permanently wiped from its proprietary platform.[833] Moreso, academic 'access' is routinely mediated by clunky user interfaces, predicated on the prevention of the copy, which disrupt basic

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[831] Bazin is quoted in Doane, p.128
[832] Ibid, pp.143-148 "The idea of a medium seems to slip through our grasp"; Ibid, pp.143-148
[833] Michael Mcwhertor, "Konami pulls P.T. from PlayStation Store, no longer available for re-download", *Polygon* (2015) https://www.polygon.com/2015/5/5/8557807/pt-silent-hills-demo-pulled [07/10/2024]

research processes. In the social sciences (and "digital humanities") API access – once a standard of open internet culture – is being rapidly withdrawn and monetized.[834] The question becomes: how can analysis contend with this opacity, especially when alternate routes hold dubious legality? How does one study something to which they are either refused access, or only given access on specific terms?

The weakness of accounts of digital "immateriality" lies in accepting the situation at face value; instead, this needs to be understood as an issue of occulted materiality (we should accept Marx's claim that both sides of the dual-nature of commodities are material). The beginning of a methodology against encryption is found in David Link's *Archaeology of Algorithmic Artefacts*.[835] Link is dealing with technical objects whose functions have been lost, or which have been themselves lost; as he points out, for instance, not one of Alan Turing's original machines survives today, despite their immense significance in the history of mathematics and computing, representing a clear barrier to their effective analysis.[836] Against the lost, Link constructs an archaeological practice which seeks first to reconstruct apparatuses – be they devices or algorithms.[837] Methodologically, this entails a cycle of genealogical excavation, practical imitation and speculation. For instance, his chapter on the Polish Bomba device (the first device to break the German "Enigma" cipher, destroyed shortly before Poland was invaded in 1939), utilises the historical excavation of evidence related to the device, emulation of hardware and tests of speculative procedures, speculative schematics and illustration, and analysis of resulting machine in order to fashion an description of lost processes.[838] This is an effectively hermeneutic method, but it is also an effective means of summoning lost forms of material practice.

But while both the lost and the withheld entail occult relationships, the kind of opacity encountered in encryption-as-privation is not the same as the obscurity of time. Link's practice involves a speculative recreation of artefacts as a means of speculating on the lost; but the objects of encryption are not lost, they are withheld. Encrypted commodities can be recovered, while lost artifacts likely cannot be. An archaeology of occult objects, whose algorithms are actively withheld and routinely edited, swapped or destroyed, must therefore be political: oppositional methodologies, and frameworks for data ownership which transcend individualised property or generalised access.

[834] Heidi Ledford, "Researchers scramble as Twitter plans to end free data access", *Nature* 614 (2023), pp.602-603
[835] David Link, *Archaeology of Algorithmic Artefacts* (Minneapolis: Univocal, 2016)
[836] Ibid., p.207
[837] Ibid., p.11
[838] Ibid., pp.134

Subscribing (literally and conceptually) to systems of mediated access only supports the withdrawal of information (and of sharing or using information freely), which they are designed to enact. This is the conventional status of commodity fetishism: trying and failing, as Marx says, to "decipher the hieroglyphic."[839] Occult archaeology also cannot be based in hermeneutics – which risk cosmic paranoia and the baseless free-association of ideas. There is, however, another option: jailbreak. Tools like the Digital Methods Initiative's 4CAT – which crawls and analyses social media platforms – circumnavigate platform authorised API routes to data, allowing the creation of parallel, non-proprietary data-streams.[840] Such tools indicate what a methodology of decryption might look like.

[839] Marx, *Capital Vol.1*, p.167
[840] Digital Methods Initiative, "The 4CAT Capture & Analysis Toolkit", *4cat.nl* https://4cat.nl/ [07/10/2024]; Also on GitHub: https://github.com/digitalmethodsinitiative/4cat [07/10/2024]

Chapter ten

Cryptoaesthetics

'Cryptoaesthetics' announce the introduction of cryptography into the human sensorium, and into sensation more generally. They pertain to the economics of composition and of the senses. They interrupt our capacity to hold a live engagement with the world, breaking those cycles of common production which once formed the basis of what we call culture and inserting a new medium, exchange. They constitute an attempt to render the non-rivalrous rivalrous, and to construct markets in domains in which they were once alien. Cryptoaesthetics are a necessary consequence of the commodification of information, and the completion of the ideological project of the 'cultural industries.'

If encryption enacts a negation of information (neginformation), cryptoaesthetics correspondingly describe the negation of sensation. As an aesthetics, they relate to the sensible, but only through its negation or withdrawal from the human sensorium. While encounters with lock-screens and hostile systems are one aspect of cryptoaesthetics, there exists a much larger sub-surface realm (only perceived by codecs) that demands "forensic" (in the terms of Kirschenbaum) approaches to be exposed to our own senses. One can find interesting, marginal cases such as BluRay's BD+ protection which scrambles data, effacing the image itself, but overall, the encrypted is simply not perceived by humans.[841] Cryptoaesthetics therefore relate most clearly to the coordination of how, where and to whom sensation (and expression) is made available. In practice, all this is done in aid of the disciplining production towards specific accumulative regimes.

As this thesis has argued, during the past thirty years a significant investment has been put towards the innovation of the encrypted commodity; this chapter proposes an extrapolation on their construction as devices within such a cryptoaesthetic system. To do so, I unpack the cryptographic techniques deployed in a number of media technologies, taken as indications of both growing industrial interest in the encryption of aesthetics forms and the growing

[841] "About BD+ and SVQ files", MakeMKV, https://www.makemkv.com/svq/ [11/06/2024]

sophistication of cryptoaesthetic practice. I look to five examples: first DES, followed by MPEG and JPEG-2000, then PDF, and finally Spotify. These examples were not all successful – one of them, JPEG-2000, has almost never been used. One intention of the chapter is to demonstrate how long (and expensive) the road to viable digital commodities has been; several generations of codecs were inadvertently building commons before any would successfully close them. Such experimentation has required the application of encryption to different levels of the technostructure: standard, protocol, format, and platform are all considered in this chapter.

I begin by expanding the account of DES I began in Chapters Eight and Nine, examining how it helped to establish a general architecture of enclosed data. As a standard (a set of instructions for implementing a specific encryption protocol, Lucifer) DES enabled a proliferation of encryption; it was also a site of political contestation – subject to what activists called “politics of decryption”. Believing DES to be vulnerable to state surveillance, organisations like the EFF demanded a more complex replacement: the result was AES. Every one of the examples in this chapter (excluding the most primitive, MP3) involved AES in one form or another.

MP3 and JPEG-2000 both indicate early attempts to implement copy protection within a compression protocol. Following the unrestrained circulation of images at the hands of JPEG-1, MPEG (a committee closely associated with JPEG – the committees sometimes met in adjacent rooms, and had overlapping memberships), MPEG strove to create new rights integration with existing media industries, including with the music industry for its audio codec, MP3.[842] A decade later, a new JPEG committee unrelated to that of JPEG-1 attempted to deliver this as a technical mechanism in a new standard, JPEG-2000, using AES. Neither successfully restrained the sharing economies they were set against, but both indicate early experimentation integrating copy protection into media coding techniques. PDF, a format for rendering text documents, extended more sophisticated technics of control: notably a cryptographic regime designed to offer copy protection to authors and rights holders. The PDF’s interest in facsimile production is curious; one way of reading it, I argue, is as an attempt at resurrecting the economy of pre-digital book circulation, and at undermining the mobility of digital text[843]. But this was never fully successful, and like JPEG and MP3, PDF has been a significant vector for unauthorised circulation, here of grey literature.

Today the most sophisticated cryptoaesthetic systems operate as platforms. Spotify was perhaps the first successful model of subscription streaming – indebted to both P2P filesharing and the

[842] Istvan Sebestyen, interview March 2023; Leonardo Chiariglione, interview June 2024
[843] Document title, author, subject, keywords and creation date are all embedded as metadata in the file, another example of facsimile reproduction of the print document; Cf. Matthew Fuller, Nikita Mazurov and Dan McQuillan, “The Author Field”, *How To Be A Geek: Essays on Digital Culture* (London: Polity, 2017) https://monoskop.org/media/text/fuller_2017_how_to_be_a_geek/#c05 [05/01/2025]

established music industry – and is seen by many as a resolution to the music industry's early 2000s piracy crisis. Over the past fifteen years, platforms have become a cryptoaesthetic avant-garde, the cutting edge of mediated access; Spotify (and similar enclosed streaming platforms) sit at the centre of complex digital architectures and legal (copyright) relationships and have no public standards. In cases like this, some kind of decryption becomes methodologically necessary. A comprehensive method is not necessarily forthcoming – analytical clarity, as I argue, demands political intervention – but, if we can't access specific architecture, it is possible to infer the general structure of Spotify's cryptoaesthetic regime.

Encryption as a standard: Lucifer/ DES

Almost every one of the technologies in this chapter relied on the AES for its encryption protocol, initially published as Rjindael in 1998 to replace DES, published 1975 and known as Lucifer during development at IBM. These are standards which describe specific methods of encryption, published by the American National Institute of Standards and Technology (NIST) (and its predecessor, the National Bureau of Standards), approved by their National Security Agency (NSA) and adopted by their government; DES and AES were both widely adopted as industry standards for encryption. While Rjindael responds to a number of weaknesses in the Lucifer cipher (notably key length, which was 56 bits in Lucifer, but can be double to four times that in Rjindael), it was DES which first established the model of encryption as a standard which made both ubiquitous.[844]

Already mentioned in Chapter Eight, as early as the 1960s engineers working at IBM were investigating encryption as a means of preventing the unlicensed copying of software. But – with software still circulating on floppy discs – there was little economic motivation to do so. Copying was not especially easy or widespread (first you needed to acquire a physical copy), and while cryptographic enforcement of licensing was seen as technically possible, it was also seen as onerous on users, expensive for IBM and largely unnecessary.[845] Unauthorized circulation was not such an issue that it justified severe measures like encryption, which were understood to be harmful to users. When, two decades later, IBM completed work on Lucifer, their intention was not rights management at all, but to advance a strong encryption standard for non-military applications.[846] This did not yet represent enclosure of private property (in the Marxian sense) as such, rather it represented the defence of a "private" (personal) realm. The intention was twofold

[844] Daemen and Rijmen, p.v; p.2
[845] Humphrey, p.60
[846] Use by Federal government is required and by non-government organisations is encouraged; US Department of Commerce, "Data Encryption Standard" (DES), *Federal Information Processing Standards* 46 (1977), pp.1-2

– to develop new unbreakable standards of encryption for Federal applications, and to allow any individual to encrypt their personal information in a similar way.[847] This technical history relates to a conceptual one; here I build on Chapter Eight's account of the cultural and representational logic of personal privacy to demonstrate the technical basis it established for a technical and legal defence of private property.

More than the specific design of Lucifer, DES is perhaps most interesting in its formalising of encryption as a standard. As Jonathan Sterne has argued, standards entail a politics (in the meeting and negotiation of state and commercial actors), but they also embody a particular set of inter-organisational norms, and a distillation of social and institutional concerns, themselves clearly political.[848] As a standard, the knowledge to implement DES is public and accessible (at least for a fee which would be trivial to a state or private corporation, but prohibitive to individuals). Standards are "open", though they assume a professional circulation and readership, and are accessible to scholarship in ways that today's proprietary algorithms are not. The standard itself conceives of use as being "in various applications and in various environments" – without proscribing these, and is structured to allow encryption of any data in storage or transmission.[849] Patented portions of the encryption algorithm were also granted nonexclusive, royalty free licenses to allow for free application in any context.[850] The most explicitly stated use-case is data "theft"; while it is unlikely that copy protection was imagined, it is notable that this language is more applicable to property than secrecy.[851]

As an 'unbreakable' encryption standard, DES was a mixed success. Papers speculating on its breakability were published soon after release; by 1993, the cryptographer Michael J Wiener had described a dedicated machine that might be built for less than a million dollars and crack one DES key every three hours.[852] While it is possible other machines had been built in private, the first successful, publicly documented DES cracking machine ("Deep Crack") was constructed by the EFF in 1998 and accompanied by a book, *Cracking DES: Secrets of Encryption Research, Wiretap Politics & Chip Design*.[853] In it, they argued that the fact that a small not-for-profit could construct such a device (for around $200,000 including both labour and materials) demonstrates that larger, wealthier organisations must have already done so – stressing that the theoretical

[847] Allen Gersho, "Unclassified Summary: Involvement of the NSA in the Development of the Data Encryption Standard", *IEEE Communications Society Magazine* 16.6 (1978), p.55
[848] Sterne, pp.131-136
[849] DES, p.2
[850] Ibid., p.3
[851] Ibid., p.2
[852] EFF, *Cracking DES*, p.x
[853] Ibid., pp.xi-xii

basis of their machine has been established for many years.[854] Alongside details of the device, *Cracking DES* laid out a specific "politics of decryption".[855]

The EFF's politics of decryption is interesting (and limited, in interesting ways) and warrants some attention. Both the introduction by cryptographer Whitfield Duffie, and the main text, allege an effective conspiracy on the part of the NSA to circulate weak standards of encryption that it has the resources to crack reliably.[856] The working assumption of the authors is that the NSA has been cracking DES routinely for many years, and has run interference on attempts to establish more secure standards; as Duffie writes, "The NSA doesn't want a strong cryptosystem as a national standard, because it is afraid of not being able to read the messages."[857] This is, of course, totally plausible: it is true, for instance, that DES's 56-bit keys were breakable by brute force, and that the NSA encouraged IBM to choose this key length for Lucifer.[858] However, that the project positions itself against state surveillance, but not against surveillance from private companies or of the construction digital property, is indicative of its wider politics.

Much of the account is written in a paranoid libertarian idiom which elides individual and corporate freedom. A second subtitle on the cover of the book reads, "How federal agencies subvert privacy" (fig-10.1), and (in addition to the central complaint about the NSA) large among the concerns articulated by the book is a US government export control on encryption products – and that the FBI sits on the panel which approves applications.[859] One thing that focusing on these export controls facilitates is an impression that the interests of individuals and of private companies are parallel; it is companies which might "overturn the regulatory scheme that lets the

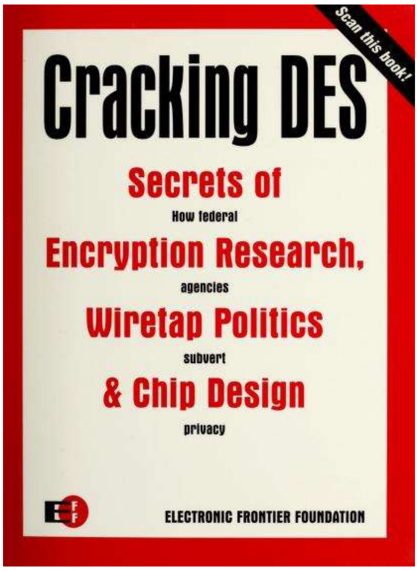

Figure 10.1
Cracking DES (1998) front cover, with a playful allusion to Abbie Hoffman's *Steal This Book* (1971): "Scan this book!". The text positions itself as a kind of book of secrets, claiming it "was written in order to reveal a hidden truth".

854 Ibid., p.9, p.15
855 Ibid., p.ix, p.1
856 Ibid., p.6
857 Ibid., p.ix, p.16-17
858 Gersho, p.55
859 EFF, pp.4-5

FBI abuse the power to control exports."[860] The (federal) state, in their account, is established as an innate risk to personal privacy – conceived of in the same language as Horst Feistel (lead engineer on Lucifer) – though many of their examples apply to the rights of companies, not individuals.

The problem with DES, in other words, is its inadequacy. The demand of the EFF's politics of decryption is ultimately stronger encryption. By breaking DES, they argue, and by ending what they allege to be the NSA's monopoly on breaking DES, they will enable the production of a genuinely unbreakable standard, and speed up work on a successor (AES), which they believe the NSA has blocked.[861] And so, the project is positioned as one of democratisation: "In five years", they write, "some teenager may well build her own DES Cracker as a high school science fair project."[862] This was a successful intervention; just a few years later Rjindael was picked as the basis for AES and published as a standard. Rjindael, which can use either 128, 192 or 256-bit keys, has not been broken by brute force (although quantum computing promises to break at least the shorter keys). The NSA was also directly involved in the development of AES, but – with cryptography export restrictions relaxed – no similar "politics of decryption" exists against it.[863]

What doesn't exist in this politics of decryption is any opposition to the defence of privacy offered by Feistel, or any concern for how private companies (not just the state) might misuse encryption to the disadvantage of the public. This incident predates the development of today's sophisticated digital rights management apparatuses, but (even in 1998) it was being fought on old terms. John Perry Barlow, a key EFF figure, had speculated four years earlier that property would be totally changed by digital circulation, becoming more a matter of "ethics and technology" than of "law."[864] Encryption, he argued, would become the basis of a novel scheme of property in which information would always be available to those who want to access it.[865] Barlow is trying to reconcile a contradiction between a commitment to freely accessible information, and a desire to maintain property as an economic logic (without copy protection).[866]

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[860] Ibid., p.5
[861] Ibid., p.17-18
[862] Ibid., p.15
[863] Bryan Weeks, Mark Bean, Tom Rozylowicz, and Chris Ficke, "Hardware Performance Simulations of Round 2 Advanced Encryption Standard Algorithms" *AES Candidate Conference* (2000), pp,1-55; The nearest parallel is brute force attacks on AES via quantum computing – but these are presented as standard information security process and research, not "politics". E.g.: Lipeng Chang, Yuechuan Wei, Xiangru Wang and Xiaozhong Pan, "Collision Forgery Attack on the AES-OTR Algorithm under Quantum Computing", *symmetry* 14 (2022), pp.1-16
[864] Barlow, "The Economy of Ideas"
[865] Ibid.
[866] Ibid.

Barlow's libertarian ideal was not shared by all advocates of cryptographic digital property. By 1997, a robust refutation of Barlow's utopian vision (and defence of copyright) had been put together by researcher Mark Stefik (of Xerox PARC) in the *Berkeley Law Journal*. Stefik writes that:

> Barlow was correct in thinking that we are on our way to a new economy of ideas. He was wrong, however, in thinking that copyright and other forms of author and publisher control over works in digital form are outmoded. Although he recognized some potential for technological protection of works, he greatly underestimated how great the potential was.[867]

Indeed, Stefik's paper describes in-detail joint legal-technical apparatuses for copy protection, already in development in 1997. Stefik alludes to Barlow – "Ideas want to be free" – before arguing at length that they should not be; instead, he suggests cryptography will allow digital works to retain pre-digital "publisher control".[868] Reading Stefik, the naivety of Barlow's suggestion that in the mid-90s cryptographic property could entail anything other than copy protection is clear. Contrasting Barlow and Stefik's accounts highlights the relative weakness of the EFF's "politics of encryption", attached to a conception of encryption as secrecy-turned-privacy. Such a conception is attached to both wartime cryptography and a politics of individual privacy, but totally naïve to the necessarily exclusive functions of property, or to actual applications of cryptography to achieve this, outlined by Stefik. Companies are treated by this politics as private individuals with personal rights, not as accumulating machines; meanwhile, breaking DES is identified as a means to tear down a state cryptographic regime, with little attention to what comes next. That property might be mobilised against freedom is never considered.

Compression protocols: JPEG-2000 & MPEG

In Chapters Four and Five I discussed the role of JPEG's compressive codec in the emergence of a huge commons of errant images, structurally mobile and resistant to proprietary capture. Returning to JPEG's immediate successors, first the MPEG committee (whose primary work was video compression, and for whom invention of the MP3 audio codec was more incidental) and then JPEG-2000, a direct attempt to tame JPEG, helps to show the birth alternative, managed forms of media circulation. In particular, this will highlight the extent to which different sets of interests (different politics) consolidated towards the construction of different technical processes, despite serving the same ostensible function of still image or sound-coding and compression. As I note in those chapters, the MP3, which has been studied more extensively than JPEG, likely owes much of

867 Mark Stefik, "Shifting the Possible: How Trusted Systems and Digital Property Rights Challenge Us to Rethink Digital Media", *Berkley Technology Law Journal* 12.1 (1997), p.138
868 Ibid., p.138

its psychoacoustic orientation to work on computer vision carried out for JPEG – with the MPEG committee established in an attempt to replicate JPEG's work for video. Baseline JPEG, I argued, established an anti-proprietary base for the circulation of images which is hard to overcome by technical means; it doesn't matter whether or not you legally have access to an image, if it's a jpeg you can copy it and share it.

MPEG had no similar campaign to keep its basic protocols patent-free. MPEG, unlike JPEG, also has a primitive form of copy protection built into its architecture. Early in the process, the MPEG committee founder Leonardo Chiariglione brought Phillips into MPEG.[869] Phillips had already developed the compact disc (CD) with Sony, which included a binary header syntax for copy protection, and this same architecture appears in MPEG. Neither the audio engineers working on MP3, nor representatives of large commercial operations like Phillips, could know what the internet would soon become, and how profoundly it would alter how commodities are structured.

MP3 compression was hugely successful in this new terrain (which, like JPEG, it helped form), but its inherited copy protection was not. Like JPEG (with the baseline standard which became integral to the circulation of still images) only part of the MPEG standard became integral to the circulation of a particular form. MP3 (originally MPEG-1 audio layer 3), which is the most complex of three audio processing techniques within the MPEG standard (and the one capable of the highest rate of compression), was developed by audio engineers working at the German Fraunhofer Institute for Integrated Circuits.[870] During development Fraunhofer made two proof-of-concept command-line implementations of MP3 audio-compression, available for $250 in 1994; one of these was bought by an Australian student (using a stolen credit card) who reverse-engineered the codec and shared it on an FTP server, declaring it: "freeware thanks to Fraunhofer."[871] The leaker's ironic jab at the research institute points towards a different set of priorities than those that underscored the development of JPEG-1, in which community development was taken as complementary to the standardisation work. The MP3 leak was met with anger from Fraunhofer engineers, though it is not at all clear that it would have been widely adopted had it not occurred.[872]

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[869] Leonardo Chiariglione, interview June 2024
[870] Sterne, p.201
[871] István Sebestyén, interview March 2023; also described by Karlheinz Brandenburg in interview with NPR, who worked on the MPEG audio process: Joel Rose & Jacob Ganz, "The MP3: A History of Innovation and Betrayal", *NPR* https://www.npr.org/sections/therecord/2011/03/23/134622940/the-mp3-a-history-of-innovation-and-betrayal [03/06/2024]
[872] Chiariglione; Rose & Ganz

MPEG-1 audio layer 3 ("MP3" as a name or format did not yet exist) quickly became the audio compression of choice on The Internet Underground Music Archive, the first major centre of online music filesharing, established 1993.[873] Recognising an opportunity for profit, Fraunhofer became interested in developing the protocol as a user-facing format, landing on the designation of ".mp3" (to replace the generic .bit).[874] From the perspective of the internal politics of standardisation, the widespread adoption of the process created a situation in which MPEG could work on both video and audio – there was already a separate committee working on audio, mainly with spoken language, not music, in mind.[875] MP3, by comparison, was subject to subjective testing (much like JPEG) as a music format; extensively at the end of the 1980s via Suzanne Vega's "Tom's Diner."[876] One might see this largely acapella American female voice as an audio equivalent of "Lenna" in image processing.[877] In any case, the rapid take up of this standalone product gave the process authority beyond video and, as Sterne argues compellingly, designation of a distinct file extension, ".mp3", made MP3s into a "thing" (even a product) like a PDF or a DOC.[878] From 1994 until the rise of streaming services like Spotify, MP3 remained the format of choice for online digital music distribution.

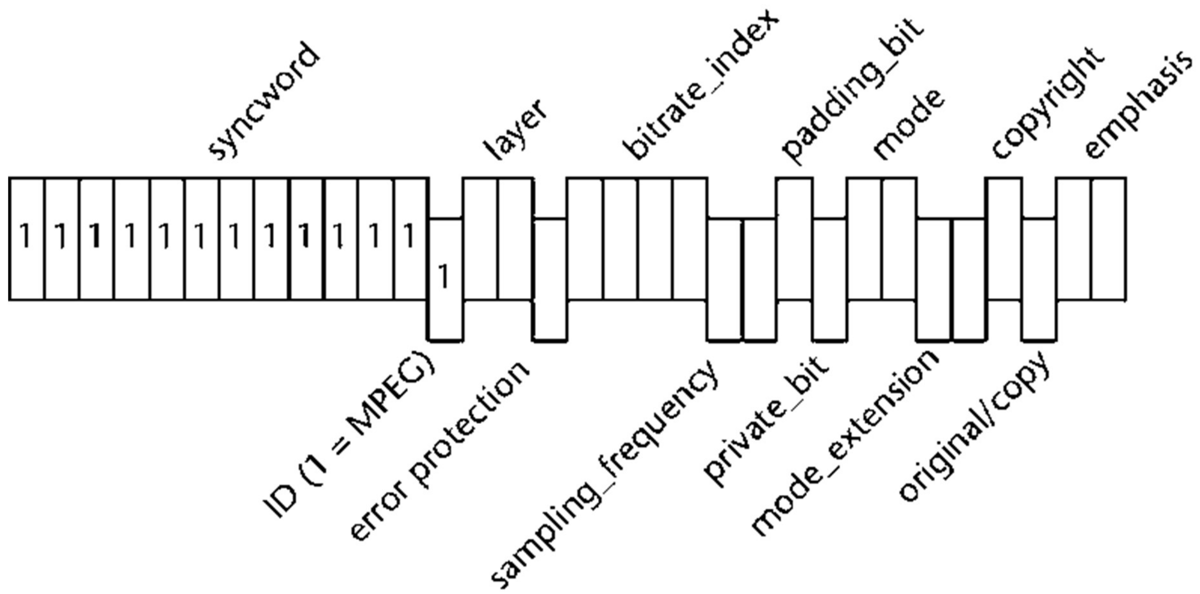

Figure 10.2 MPEG header syntax. A single binary field ("original/copy") is assigned to copy protection. Media players are asked to prevent copying of protected files. In an era of physical media and hardware players manufactured on scale, such a consensual mechanism may have worked, but online music repositories and free digital codecs opted simply to not use the field, imbedded as they were in a culture of ripping, sharing and editing.

[873] Sterne, p.202
[874] Sterne, p.202
[875] István Sebestyén, interview March 2023
[876] Rose & Ganz
[877] See, e.g. Monea, p.63; or Menkman, *Beyond Resolution*
[878] Sterne, p.202

Largely off the back of the open source software movement, and of early filesharing cultures, MP3 was able to quickly become ubiquitous on the internet; nonetheless, its header syntax (and in fact all MPEG files) included simple licensing and copy protection.[879] Inherited via Phillips from CD architecture, this was a simple binary field: copyright yes/no (fig-10.2).[880] This was a strategy born from physical media, and poorly suited to electronic circulation.[881] So, while MP3's development marks a clear mover towards collaboration with media industries to secure property – these were unsuccessful.

Similar ambitions can be seen in the development of JPEG-2000, intended to succeed the original JPEG standard. Key to previous encryption chapters has been the idea of a response to compression embodied in a reorientation towards strategies of encryption-as-privation. Work on JPEG after the publication of the first standard, and the dissolution of the original committee, demonstrates this especially clearly. A new committee was convened in 1997, chaired by the Swiss computer vision engineer Touradj Ebrahimi then of AT&T and formerly Sony – who today teaches a course on "media security", principally concerned with rights protection and access control.[882] Following on from the unrestrained circulation of JPEG, and the failure of MP3 to effectively integrate the format into a rights regime (resulting in yet more sharing), JPEG-2000 introduced new forms proprietary control. In particular, JPEG-2000 sees the introduction of additional proprietary coding, and, from 2007 onwards, encryption into the codec.[883]

ISO/IEC 15333-8 (first published 2007), the standard which defines Secure JPEG-2000, mobilises encryption as a means of copy protection.[884] A short introduction offers a helpful contextualisation of the problem as it is perceived:

> In the "Digital Age", the Internet provides many new opportunities for right-holders regarding the electronic distribution of their work (books, videos, music, images, etc.).
>
> At the same time, new information technology radically simplifies the access of content for the user. This goes hand in hand with the all-pervasive problem of pirated digital copies – with the same quality as

[879] Leonardo Chiariglione, interview June 2024
[880] Illustration taken from Sterne, p.197; Copyright information in header syntax described in ISO/IEC 11172-3:1993, p.29
[881] Starne, p.142, p.197
[882] Course booklet available at: https://isa.epfl.ch/imoniteur_ISAP/!GEDPUBLICREPORTS.pdf?ww_i_reportModel=1696552884&ww_i_reportModelXsl=1696552963&ww_i_itemplan=3866755332&ww_c_langue=en [04/11/2024]
[883] MPEG was also revised, notably MPEG-DASH (published 2012) and MPEG-CENC (published 2016), which allow for multimedia streaming over the internet and integrate encryption for copy protection.
[884] "ISO/IEC 15444-8:2007" [Secure JPEG-2000], Joint Photographic Experts Group (2007)

the originals – and "file-sharing in peer-to-peer networks, which gives rise to continued complaints about great losses by the content industry.[885]

The sharing economies facilitated by protocols like JPEG and MP3, via rampant unauthorised copying, have undermined the commodity function of what the MP3 standard calls the "work." Roland Barthes' definition of works (as opposed to "texts") as ossified things strongly associated with the authority of their authorship and presumed interpretations is prescient here.[886] A reading follows that this information is too much like a text and not enough like a work, and so no longer serves as an effective base of accumulation. "The new Digital economy" (counterposed to digital sharing), the standard argues, requires copyright and, implicitly, its technical enforcement via encryption.[887] This description, which positions the users of digital works against their owners ("rights-holders", not creators or authors) is an apt description of the technical and economic horizon embodied in the standard. Quite literally, JPEG seeks by technical means to extend the legal function of copyright (legislation which controls the right to copy) – and it is worth recalling here the first five words of the *Copyright, Designs and Patents Act 1988*, which defines copyright law in the UK: "Copyright is a property right."[888] As Cornelia Vissman writes in her study on law and media technology – "files establish an order that they themselves do not keep"; an apparatus of enforcement is needed to render information as property, and Secure JPEG 2000 proposes its codec become such an apparatus.[889]

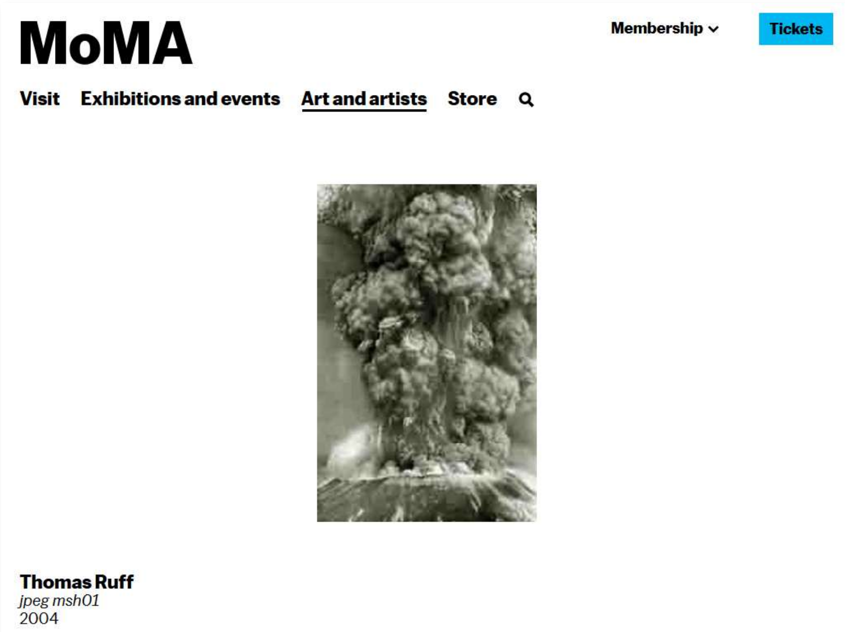

Figure 10.3

Thomas Ruff's *jpeg msh01* (2004) as displayed on the MoMA website.

The image cannot be copied, but oppositional methods are plentiful: the image might be screenshotted, or the page source viewed to locate an image url.

[885] Secure JPEG-2000, p.xiv
[886] Barthes, "From Work to Text", pp.1326-1331
[887] Secure JPEG-2000, p.xiv
[888] 'Copyright, Designs and Patents Act 1988' *Blackstone's Statutes on Intellectual Property* (Oxford: Oxford University Press, 2014), p. 22
[889] Vissman, p.13

Secure JPEG-2000 specifies three cryptographic means of copy protection: digital signatures which inscribe a file with its ownership (or mark an 'original'), "confidentiality" via encryption of the file and "conditional access" which restricts users to only part of the data – such as to a low-resolution image preview.[890] Unlike with the MP3, overcoming these mechanisms is not at all trivial. Images cannot be decoded without access to the cipher, or can be circulated in a form which highly restricts use. But what JPEG-2000 omits is any specific mechanism to stop that most basic information function: the copy. Once decrypted, there is nothing to stop Secure JPEG-2000 from being converted into another format – and this format has not been widely adopted in any industry. One can find attempts to prevent the copying of JPEG images in situ, generally achieved through crafty web-coding; for instance, Thomas Ruff's *jpeg msh01* on the MoMA website, which cannot be right-clicked to view or copy (fig-10.3). As when printed in the gallery, Ruff's work is deprived of a central aspect of JPEG aesthetics, movement (though I can take a screenshot).[891] But this practice is not widespread and overwhelmingly in the domain of visual representation free images remain the norm. The problem for would-be exchange value extractors is economic: non-proprietary files travel further and faster. There is still accumulation within such an economy, but it is of sound, of culture, of information (as well as of emissions), not of money or capital. Digital rights management cannot rely on user enthusiasm for its regime – which sees them dispossessed – to be effective.

Format: PDF

Though such revisions to JPEG and MP3 were unsuccessful, they represent experimentation with cryptoaesthetic regimes, attempts to impose a "new digital economy" on an already existing culture of non-commodity circulation.[892] There is some irony to the standard's invocation of the newness of this economy, while simultaneously attempting to guarantee the continued commodity function of the pre-digital work (the book, the record, the video, etc.) in digital circulation. Indeed, it is not at all surprising that new media forms are often made in the image of existing ones – an observation which has motivated several influential studies into so-called "new media" forms.[893] MP3 and JPEG (which are compression protocols, but imply distinct formats), are neither the only nor the most effective attempts to bring the work into digital circulation. In the PDF (Portable Document Format), one can see an early consideration of the question of

[890] 'Original' here indicates an original version, not a discrete file; Secure JPEG-2000, pp.7-9
[891] Thomas Ruff, *jpeg msh01* (2004) https://www.moma.org/collection/works/149384 [12/06/2024]
[892] The phrase "new digital economy" would become popular after the financial crisis, when digital accumulation was seen as a route to recovery. See, e.g., PwC, Citi, Cisco, AT&T, SAP and Oxford Economics, *The New Digital Economy: How it Will Transform Business* (2011), https://www.pwc.com/cl/es/publicaciones/assets/the-new-digital-economy.pdf [12/06/2024]
[893] Bolter and Grusin

circulation and an attempt to extend forms of authorial control into information forms. As I'll now describe, this leads to the development of new cryptographic methods and the establishment of a cryptoaesthetics.

In his study on the PDF, *Plain Text*, Dennis Tenen highlights that while the letters "Hello World" take up only 11 bytes of data as plain text, in the PDF format they require over 24,000 bytes.[894] This additional information, he argues: "is not addressed toward the receiver of the message but toward the channel itself."[895] Such data includes fonts, layout, graphics, images, watermarks and (as Tenen gestures towards) a number of elements not immediately visible to readers including hypertextual links, digital signatures, encryption and rights information, accessibility features and metadata for integration into larger data systems.[896] As part of their interchange, PDFs can also (sometimes but not always) be duplicated, annotated and highlighted by users, copied from and printed.[897] The PDF standard, first published in 2008 (16 years after its initial release by Adobe) offers a statement of intent:

> `The goal of PDF is to enable users to exchange and view electronic documents easily and reliably, independent of the environment in which they were created or the environment in which they are viewed or printed.`[898]

PDF is a format for the interchange of "electronic documents", not texts. And this additional data is being mobilized towards a few things: 1) the construction of this electronic document form, 2) the protection of digital rights, 3) some (limited) interactive elements and 4) metadata for integration with external systems.[899] It is the first two in which I am primarily interested.

The standard defines electronic documents as:

> `electronic representation of a page-oriented aggregation of text, image and graphic data, and metadata useful to identify, understand and render that data, that can be reproduced on paper or displayed without significant loss of its information content.`[900]

These are first of all aggregations of text and other visual representations, in the form of a page (not, for instance, a scroll). Not mentioned is something intuitively obvious to most users: PDFs are facsimile reproductions of dominant non-digital forms of textual representation: the book,

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[894] Tenen, p.24
[895] Ibid, p.95
[896] "PDF ISO 32000:2008" [PDF], *Adobe Systems Incorporated* (2008), p.vii; See also John Warnock's original whitepaper: "The Camelot Project" (1990), Available at: https://knowledge.wharton.upenn.edu/wp-content/uploads/2022/03/warnock_camelot1991.pdf
[897] Ibid., p.vii
[898] Ibid., p.vii
[899] Ibid., p.vii
[900] Ibid., p.7

pamphlet, sheet, report, etc. Lisa Gitelman, in her media history of documents, describes it as a "peculiarly backward-looking format".[901] Indeed, via design and initial context of circulation, pdfs feature a to-be-printed-ness, even as this is an increasingly marginal portion of their use.[902]

PDF's place in a tradition of non-digital textual representation (itself older than the book or the printing press) affords it an air of neutrality which we should not be taken in by.[903] Other digital document forms do not reproduce so strictly the formal features of print – DOCs, TXTs – so the key question here is of what is afforded in this kind of reproduction.[904] As Tenen writes, machine control languages are "imperative. They do not stand in for action; they are action."[905] Formats like PDF determine much of their use, affecting not just the bounds of creation (affordances) but also interaction. Against utopian hopes for post-media – such as the stochastic horizontality voiced by Feliz Guattari – the PDF shapes digital text into the linear, non-ergodic form of the document.[906] It does so by explicitly stratifying the functions of author and reader: the author 'prints' the document to PDF in a determinate moment, and the reader receives the document in as much as possible the form it was printed.[907] As a kind of message this is like that conceived by Shannon: neither dialogic or ecological, but singular and linear – with stratified sender and receiver.

Even if PDF allows for limited interactivity – as with digital forms – this is always with permissions from the author. When I 'print' an article or essay to PDF, for instance, I do so explicitly to ensure the output looks like I want it to. Many of PDF's interactive components are not available for free: for the presumed free reader the only guaranteed right of access is to read the document, and not even that in some cases. Cornelia Vismann writes of books (as opposed to files), that "They preclude all use and reuse, and it is precisely this dysfunctionality that highlights their literal function."[908] The book renders text immobile – as does the PDF.

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901 Gitelman, p.4
902 Ibid., p.123
903 McLuhan's *Gutenberg Galaxy* and Elizabeth Eisenstein's *The Printing Revolution in Early Moden Europe* describe this tradition from print, with the latter also covering late scribal practice. The codex is much older, though, present in the late Roman empire and the monasteries of Medieval Europe. Harold Innis' *Empire and Communications* is a historical account of contestation between parchment and paper as mediums, which might meaningfully be extended into the digital present.
904 I don't address here other facsimile forms, notably EPUB and Amazon's proprietary Kindle format; see, e.g. Simon Peter Rowberry, *Four Shades of Grey: The Amazon Kindle Platform* (London: MIT Press, 2022) – these can read as mechanisms of publisher control of digital texts in parallel to PDF; p.xviii
905 Tenen, p.94
906 Felix Guattari, "Towards a Post-Media Era", *Mute* (2012) https://www.metamute.org/editorial/lab/towards-post-media-era [12/06/2024] originally published 1996
907 cf. Hall on "determinate moments" in encoding/decoding processes; "Encoding and Decoding…", p.260
908 Vismann, p.162

As Gitelman describes them, PDF consolidates the bureaucratic relations of corporate publishing – most of all in the production of 'grey literature' (reports, white papers, memos, newsletters, etc.).[909] We should note, then, that the PDF is not seeking a return to authorial authority so much as reproducing its social forces. Central to such a regime is the act of printing, in which a document can be fixed for circulation and after which collaboration or dialogue is not possible. The PDF as a format seeks to reproduce this determinate moment within the digital circulation of text, and is therefore a format with a "reactionary, not a revolutionary, feel" – quoting Gitelman.[910] This is the reason some open-source communities have rejected PDF; not just its proprietariness, but what are perceived as the regressive ways in which it structures author-reader relationships.[911] And yet, the PDF is today synonymous with the illegitimate circulation of text online; on shadow libraries and through interpersonal sharing, one constantly encounters such PDFs. Not-the-least contributing to this is PDFs indebtedness to document (not book) publishing, and one way to read it is as an expansion of the mechanisms of grey literature to include mainstream 'print' forms, previously the domain of the commercial publishing industry.

As an *electronic* document, the PDF also contains a number of (generally not visible) features which aren't present in print: layers of metadata "directed towards the channel", but also the capacity for functions which are absent from print texts, such as internal links and the ability to

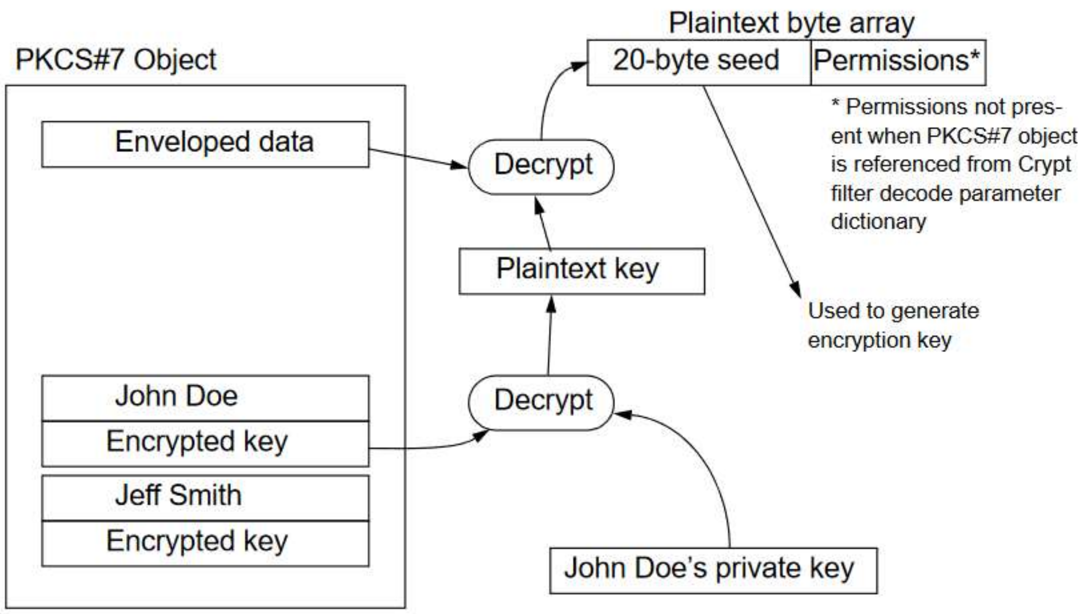

Figure 10.4 Schematic of the PDF content control process from the standard. This is applied regardless of whether password protection is required, or access is open to all users, and allows partial access to other PDF features, such as copying, annotation, etc.

[909] Gitelman, p.116; pp.130-131
[910] Ibid., p.131
[911] Ibid., p.131-132

search or crawl text. Likewise, its authorship politics is reflected in a specific cryptoaesthetic regime. Like Secure JPEG-2000, PDF deploys AES encryption to "allow the creator to retain control of the document and associated rights."[912] In practice, this means wrapping the document's contents (so called "enveloped data") in encryption, and applying predefined permissions at the point of decryption by the pdf reader (fig-10.4).[913] This decryption process both reveals the file's contents to the user and controls how they can interact with it. Access is not binary but unpacked into an array of actions which can be selectively withheld from all/specific readers: editing the text, copying text, annotating and even printing can be prohibited to unauthorized (or to all) users.[914] If a particular rights management regime wants to make copying impossible, they can. Access to the text, in these cases, can only be through the interface of a PDF reader.

Tenen's book contains one politics of decryption: pdf abolition (or at least, abstinence). The PDF's affordances, in his account, are not a fair trade for the occult forms of control it exerts on expression, or the authoritarian ways in which it treats readers. He argues that we should reject PDF and, in its place, write and read in plain text. Writers and readers might use whatever technology they want to sort, organise, generate or edit the text, but we should circulate it as unadorned text, with no secret codes operating behind or beyond the human senses.[915] There is appeal to such textual ascetism: it suggests a route out of the PDF's cryptoaesthetic regime, and one into a more even set of relationships between, author, publisher and reader. It is a project to end the tyranny of print (and the relations it represents) as transplanted into digital formats like PDF. Though for this to be worth giving up all the metatextual features that formatted text offers is, I think, a stretch. Afterall, bold tags in HTML might determine to some extent the presentation of text displayed on a user's screen, but they do not generate meaningful unfreedoms. One can advocate for minimal restriction via format, without strictly requiring all text to be totally plain.[916] Moreover, after questioning the authoritarianism of the page, we shouldn't neglect to do the same for the scroll: there is nothing more or less natural about this arrangement – the question is one of affordances.

PDF demonstrates a kind of economic thinking about communication; economic in the sense that it is interested in the circulation, dissemination and mobilisation of text. This is articulated in the communicative moment of printing and guaranteed through an early cryptographic control

[912] PDF, p.vii
[913] Ibid., p.66
[914] Ibid., p.59
[915] Tenen, p.3
[916] As in Roopika Risam and Alex Gil's concept of "minimal computing", oriented towards "institutional and infrastructural constraints", including natural resource restraints, and advocates for replacing overbearing UIs, software services and intensive competition with plain coding and bespoke tools which promote agency and purposefulness in application; "Introduction: The Questions of Minimal Computing", *Digital Humanities Quarterly* 16.2 (2022)

mechanism. But, returning to an earlier point, it is somewhat undermined by the rampant illegitimate circulation of texts as PDFs. PDF has shown a remarkable capacity to resist digital commodity circulation; if it encodes certain ideals, about fidelity, about format, about the structuring of data, one can also mobilise PDFs against these ideals.[917] At the most extreme, some PDFs are totally unstructured scans of text which cannot be crawled. Many PDFs (likely more than MP3s or JPEGs) do circulate as commodities, but many others circulate for free within digital commons.[918] The PDF endures partly as grey literature, shared directly between readers or widely via shadow libraries for free and without effective copy protection.

Platform: Spotify

Neither MP3, JPEG-2000 or PDF has been able to effectively fend off digital cultures of common information, which have either absorbed them or ostracised them (as in JPEG-2000). The most sophisticated cryptoaesthetic regimes today implement cryptography at a higher level, on closed economies of files. In the domain of music, Spotify has pioneered encryption-as-a-platform, encompassing both user interface and a content delivery architecture. This more sophisticated cryptoaesthetic regime is implemented at a higher order of abstraction than the 'file' – which is never knowingly encountered by users – to control access at the point of engagement.

Spotify is an example of what is often called a platform: a business model and technical assemblage on or through which separate parties can interact and exchange.[919] Spotify hosts music from a variety of publishers, labels and musicians, which listeners access via its application. 'The platform' is where all these things come together, where they are mediated: content is delivered and accessed, as is advertising, subscriptions are worked out, data is gathered and processed, and used to calculate payments to rights holders, etc.[920] As a theoretical lens, 'the platform' can be all-encompassing, and studies like Nick Srnicek's position them as the monopolistic structure at the centre of digital capitalism today.[921] It could easily have become a central metaphor for this thesis, for instance – though codecs are both a more enduring and more

[917] See Nikita Mazurov's thesis, which assigns PDF a key role within a strategy for rendering information mobile; *Strategies for Unbridled Data Dissemination: An Emergency Operations Manual*, PhD Thesis (2015), p.15; pp.75-79
[918] JPEG, alongside E-PUB and HTML, is a standard format on shadow libraries like Z-Library or Library Genesis.
[919] For early work on the platform see: Jean-Charles Rochet & Jean Tirole, "Platform Competition in Two-Sided Markets", *Journal of the European Economic Association* 1.4 (June 2003), pp.990-1029; Also, Srnicek, p.30
[920] Ibid., p.30
[921] Ibid., p.9

granular form.[922] While their scale is different, I believe attention to codecs has much to offer analysis of "the platform". It is only through cryptoaesthetics, for instance, that Spotify the platform can appear more real than Spotify the media infrastructure, which it seeks actively to obscure.

Spotify is not an accessible object of study; this fact is integral to its architecture and to its economics; to its cryptoaesthetics. It is typical of the occult environment discussed in Chapter Nine, and as such exploring a platform like Spotify requires a journey into the crypt. Maria Eriksson et al.'s *Spotify Teardown* (2019), the most complete account of Spotify as a platform and infrastructure, encounters exactly this methodological barrier.[923] In-keeping with its occult orientation, Spotify's API (Spotify Apps API) was discontinued in 2014 – a story repeated across "big tech" platforms.[924] Against this opacity, Eriksson et al. construct a suite of creative methods: they follow, for instance, the outward traces of data integration with Facebook in both platforms' user interfaces; use a packet analyser (Wireshark) to eavesdrop on the transmission of streaming data (and locate CDNs – content delivery networks, essentially distributed server networks used for media delivery); and map the complex license and publishing context for "aggregators", third

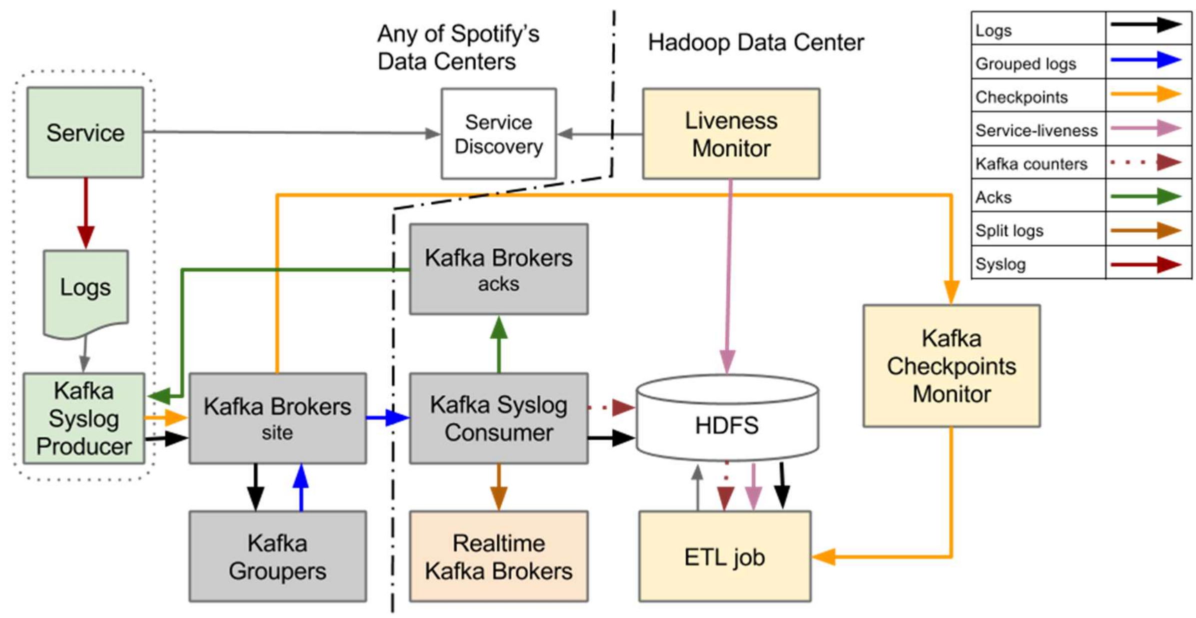

Figure 10.5 Diagram of Spotify's "event delivery" architecture (as of 2015). It describes the distribution of event information between the wider server network and a Hadoop data core (also distributed between two data centres globally), which periodically collects and analyses user data in aggregated "buckets."

[922] Other considerations included that 'the platform' is less long lived than information theory or than protocols, and so less well suited to historical analysis. Platform captures some forms of networked circulation (e.g. commodity circulation) better than others, sometimes inadvertently naturalising them.
[923] Eriksson, et al. p.79
[924] Ibid., p.84

parties which promote and mediate artists relationships with Spotify; among many others.[925] But *Spotify Teardown*'s investigation can't offer a specific description of the content delivery architecture used by Spotify. This is not because of a lack of rigour in their work; rather, this information is not publicly available or accessible. We know Spotify use Ogg Vorbis instead of MP3 for instance, largely because Spotify has stated this publicly; the platform takes advantage of free and open protocols but is not in itself free or open.[926]

For my own part there is no standard I can pick through to clarify Spotify's architecture (as I have done for MP3, JPEG and PDF); my account of its cryptoaesthetics is therefore reliant on the small base of self-documentation published on Spotify's technical blog, largely focused not on the delivery of media itself, or on physical infrastructures, but on the organisation and mobilization of user data within the platform.[927]

Spotify operates a complex "event delivery" architecture (fig-10.5), in which "events" (which describe user behaviour, e.g. playing a song or many more granular operations) are retrieved from a diffuse network and used across the platform in a number of ways.[928] These include the personalisation of products (such as algorithmically generated playlists), the creation of metadata (such as clusters of listening habits) and a dataset for machine learning, the development of advertising and business strategies, artist payment, and improvements to search, among others. As *Spotify Teardown* describes, the mobilization of this data is as integral to Spotify's business-case as the music; as they describe it, music is delivered "from elsewhere", whereas metadata is a direct offer to users.[929] This is a legal arrangement (downstream of Grand Upright Music Ltd.'s 1991 case against Biz Markie; cf. Chapter Eight), not a technical one: when you stream music on Spotify, it is delivered by Spotify servers (or rather, capacity on Google Cloud servers, rented by Spotify) not from, for instance, Universal Music Group – although Universal in this example is likely to have provided Spotify with the initial file, and would retain the right to withdraw it from the platform.[930] Spotify does therefore operate a complex infrastructure of media delivery, even as it monetises this via data collected from the input of users, which is scrubbed, encrypted, and sold back to them as an algorithmic service. *Spotify Teardown* argues that personalisation (and related data-processing) is Spotify's core product.[931] Data services are presented as the primary

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[925] For data integration with Facebook see: Ibid., p. 84; for Wireshark, pp.104-113; for "aggregator" mapping, pp.90-92
[926]Ibid., pp.88-89
[927] Anastasia Khlebnikova, "Data Platform Explained Part 1" *Spotify R&D* (2024), https://engineering.atspotify.com/2024/04/data-platform-explained/
[928] Igor Maravić, "Spotify's Event Delivery – The Road to the Cloud (Part 1)", *Spotify R&D* (2016) https://engineering.atspotify.com/2016/02/spotifys-event-delivery-the-road-to-the-cloud-part-i/
[929] Eriksson, et al., p.81-83
[930] Ibid., p.90
[931] Ibid., pp.136-137

thing entangling users Spotify's ecosystem, but without an account of encryption as the disciplining condition of its monopoly on this data, their account underplays the extent to which such data is enclosed and obscured; Spotify's data is not at all accessible outside of its proprietary services, which mediate use along the lines described in Chapter Nine, tightly determining use.[932]

Sensory deprivation

This chapter is about regimes of sensory control; it has dedicated significant attention to technical systems, infrastructures and economies, and comparatively less to the visible and audible surfaces of such systems. There are good reasons for this: I'm interested in demonstrating technical mechanisms which precede human sensation, and therefore concern the possibility of aesthetics. There is a conceptual difficulty to such pre- or supra-sensible aesthetic phenomena, which can only be overcome via an expanded conception of aesthetics as the domain of perception (in which sensation becomes meaning).[933] In an ontological mode which is not bound to the human, codecs themselves perform aesthetic transformation; indeed, information processing itself can be understood as a kind of aesthetic phenomena.[934] As neginformation, encrypted data entails a withdrawal of the possibility of meaning, and therefore has little to offer the human senses explicitly. It is helpful to think, rather than what they produce, of what sensations cryptoaesthetics exclude.

Spotify's architecture has changed over time. It started as a peer-to-peer media distribution service, largely populated with rips from The Pirate Bay.[935] Its music delivery was partly delivered peer-to-peer until 2014.[936] How can a P2P pirate service become the first behemoth of encrypted commodity sounds? At launch in 2008, Spotify professed to offer a move "from ownership to access"; in other words, it sought to build a business case around the culture of peer-to-peer filesharing.[937] It would take a few years of experimentation, negotiation and legal challenges before an accommodation with music labels and distributors ("the industry") would be made; from Spotify's side, this was characterized by a move towards subscription models and towards

[932] Ibid., p.83; User personalisation is central to Spotify's valuation of its own platform (81% of users cite this as the feature they love most), though it also sells products to other parties: artists can pay an additional % of royalties for promotion in discovery algorithms, while advertisers can buy targeted ad placement; "Spotify Shares Our Vision to Become the World's Creator Platform", *Spotify* (2022) https://newsroom.spotify.com/2022-06-08/spotify-shares-our-vision-to-become-the-worlds-creator-platform/ [07/01/2025]
[933] The etymological root of aesthetics is the Greek "aisthētikos", i.e. relating to perception by the senses. This root is closer to colloquial use of the word, though obviously does not adhere to a classical conception of aesthetics as the perception of beauty; "Aesthetics", Chambers Dictionary of Etymology (1988)
[934] Such as that offered by posthumanism; cf. Braidotti
[935] Eriksson, et al.., p.43
[936] Ibid., p.89
[937] Ibid., p.45

an architecture without peer participation in content delivery (of course, peers still participate in data gathering), from the music industry's side it was characterized by encouraging Spotify to move towards subscriptions, and a growing belief that this offered a "solution" to piracy, which had undermined previous modes of commodifying music.[938] As a subscription service paid via automated electronic payments, Spotify can "feel like free", without actually being free.[939]

And as a system which mediates use, Spotify's architecture holds different affordances to the clunky P2P networks it seeks to displace. Like PDF, it stratifies creators and consumers. Three functions, trivial with the MP3, become impossible through Spotify: copying, sampling and editing. Spotify prevents the most basic time-series transformations: speeding up or down, without mentioning more complex waveform transformations.[940] And a consequence of all this is a loss, not just of functionality, or of free access, but of a wealth of sounds that could have been made but were not; the absence of music.

Cryptoaesthetics are embedded in the circuit of technical media, sense perception and subjectivity formation:[941] by rendering increasingly difficult those aspects of music-making and listening which are not governed by the logics of work (e.g. professional musicians), and have not been rendered as commodity consumption, music is increasingly stratified into distinct modes arranged for the convenience of accumulation. In the absence of a culture of music (of music as a collective project) our senses become numbed, a germ of non-capital relations lost, and the world grows ever quieter.

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[938] Ibid., p.60; Anxiety from the music industry about piracy predates digital circulation, see: Johns, pp.431-462

[939] Eriksson, et al., p.51

[940] Cf. Kittler, who sees these as a primary aesthetic revolution in digital computation; "Real Time Analysis…", p.6

[941] Recalling Benjamin, "The Work of Art…", p.234

Chapter eleven

Cypherpunk horizons: political machines, cryptography and the information commons

Sometime from 1995 to 1997… software seemed to displace theory as a tool for thought

Benjamin Bratton, *The Stack* (2015)

Cypherpunks write code

Eric Hughes *A Cypherpunk's Manifesto* (1993)

Previous chapters have suggested that compression and encryption (technologies both "looked for" by particular groups of interests, and also running autonomously in the world) play important determining roles in the domains of aesthetics, economy, social life and subjectivity. While technical solutionism tends to situate technology as a benign progressive force, some tendencies have sought to use technology as a kind of horizon. Such political technologies warrant further investigation; this chapter addresses the technical afterlife of one such group, the cypherpunks.

"Cypherpunks write code": they were, as in the Californian Ideology of which they were part, attached to a notion of technological determinism.[942] But their determinism should be extracted from the wider solutionism captured in Barbrook and Cameron's essay; technology, for the cypherpunks, is a tool for realising politics (not a simple benign force).[943] They wanted to build machines to make their utopia, idealising the automatic over social, cultural or legal structures. This is what Bratton means by software "as a tool of thought" – attempts to conceptualise and realise futures via technological models (not e.g. as literary representation in utopian fiction, an

[942] Barbrook and Cameron; Hughes
[943] See e.g. Ramiro, p.8

expression of intent in the manifesto, or a social microcosm in the commune).[944] Like the best horizons, successful technical horizons don't only speculate or make demands on the future, they seek to instantiate it through example, in this case through the technostructure.

The cypherpunks self-identified as a political bloc concerned with cryptography, and communicating via a mailing list.[945] With irony, given their identification with the cyberpunk hackers of Wiliam Gibson's *Neuromancer* ("cypherpunk" is a portmanteau of "cyberpunk" and "cypher") their politics was one of encryption, not decryption. Strong encryption, they argued, has been monopolised by the state and ought to be both stronger and more widely accessible. As a group largely populated by computer programmers, this meant first of all experimenting with cryptography; the EFF's "politics of decryption" (discussed in Chapter Ten) fits squarely within a cypherpunk mode, for instance, and attempts to crack DES were discussed regularly in the mailing list.[946] For the internet to be free and open, they believed, it must also be private. Technically, this required widespread access to and adoption of cryptography. There is a clear tension here, between, "openness" and the application of a "neginformation" technology which restricts the movement of information.[947] But their commitment to the ideal of free information (somewhat incoherently) also attached the cypherpunks to emerging information commons and to open online communities.[948] Timothy May writes in his *Crypto-anarchist Manifesto*, for instance, that encryption will form "the wire clippers which dismantle the barbed wire around intellectual property".[949] Both these tendencies can be found among the pre-collapse cypherpunks. Even if contradictory, the intellectual world of the cypherpunks has been ascendent, significantly influencing contemporary technological imaginaries.

I don't latch on to the cypherpunks to valorise their politics (which I don't share), or to uncritically reproduce the overdetermining function they assign to technology, but rather out of interest in their technologies which, as horizonal technologies, have affected the technological terrain of today. This chapter addresses two technologies developed by cypherpunks which embody well

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[944] Cf. Jodi Dean, *The Communist Horizon* (London: Verso, 2012); Bratton, p.xvii; itself an allusion to Howard Rheingold's book idealising computing as a progressive expansion of human intelligence, *Tools for Thought* (1985) https://www.rheingold.com/texts/tft/ [16/10/2024]
[945] Andre Ramiro, "Cypherpunk", *Internet Policy Review* 11.2 (2022), p.4
[946] E.g. "1998-01-11 - RE: DES 2 challenge: Are you going to help?", *cryptoanarchy.wiki* https://mailing-list-archive.cryptoanarchy.wiki/archive/1998/01/53c8b51fed5e149f48918090f83a7304afc4a61ec7e5e8d812757cb6a7bfd3fe/ [16/10/2024]
[947] A conception of openness in which the "open market" figures centrally; See: Nathaniel Tkacz, *Wikipedia and the Politics of Openness* (London: University of Chicago Press, 2015) pp.17-18
[948] See: Howard Rheingold, *The Virtual Community: Homesteading on the Electronic Frontier* http://www.rheingold.com/vc/book/intro.html [24/07/2024]; Barbrook, "Cyber communism", p.5
[949] Timothy May, *The crypto anarchist manifesto* (The Anarchist Library, 1988) https://theanarchistlibrary.org/mirror/t/tc/timothy-c-may-crypto-anarchist-manifesto.lt.pdf [17/01/2024], p.3

the contradictory nature of their politics and afterlife. The first is cryptocurrency (especially Bitcoin and Ethereum) and associated experiments in the cryptographic inscription of other aspects of accumulation, via for instance the smart contract and the non-fungible token (NFT). These technologies embody attempts to realise what I call an enregistering process, a control mechanism which renders compliance automatic and machinic. The second is the BitTorrent protocol, and related archives of free information. These instead embody a politics of digital commoning, which aspires towards the mobility and accessibility of information.

The cypherpunk moment

The cypherpunks emerged in the 1980s within the broader Californian Ideology milieu (often called cyberlibertarianism or technolibertarianism): described by Barbrook and Cameron as a hegemonic bloc in 1990s technological development coalesced around right-wing libertarian conceptions of freedom (from the state), a naive technological solutionism and some "new left" concerns – racial, gender and sexual equality, liberalisation of drug laws, etc.[950] For some, Barbrook and Cameron's paradigm remains a central text on the "spectre of technological determinism" to this day; for others, including Barbrook himself, it is a specific historical critique of "dotcom… neoliberalism", which burst with that bubble.[951] Today's big-tech hegemony comprises a rather different coalition to that of the Californian Ideology, but its ideals remain highly influential. The decomposition of the Californian Ideology, and of the cypherpunks within it, helps clarify the ideology of technological development today.

Julian Assange's (founder of WikiLeaks) book venerating the movement, *Cypherpunks: Freedom and the Future of the Internet*, encapsulates its politics sympathetically via a series of interrelated binaries: "communication versus increased surveillance", individual privacy against state bans on encryption, the commons against state and corporate data.[952] Within such a formation, the information commons and those participating in it need to be protected from state and corporate surveillance (and shutdown) via encryption.

But the cyberpunks' conceptual nexus was less stable than Assange's presentation suggests. Though the cypherpunks positioned their project as one for information's "freedom" and against overreach from "government, corporations, or other large, faceless organisations", there is a tension in their articulations of privacy – and a related cryptographic regime – as a means to

[950] Though we can doubt their efficacy, earnest presentation of egalitarian concerns as desirable – e.g. Barlow, "A Declaration of Independence…" – do set them apart from today's right-wing libertarians
[951] This is how the text is often taught to undergraduates; Cf. Simon Joyce, Charles Umney, Xanthe Whittaker and Mark Stuart, "New social relations of digital technology and the future of work: Beyond technological determinism", *New Technology, Work and Employment* 38.2 (2023), pp.145-390; Richard Barbrook, *Imaginary Futures* (London: Pluto Press, 2007), p.6
[952] Julian Assange, et al. *Cypherpunks: Freedom and the Future of the Internet* (New York: OR Books, 2012)

realise this. Eric Hughes' *A Cypherpunk's Manifesto* opens with such an invocation: "Privacy is necessary for an open society in the information age. Privacy is not secrecy."[953] As already argued, encryption wasn't transformed straight from a tool of secrecy to one of property, but via an intermediary: privacy. Explicitly, Hughes signals such a reorientation (from secrecy to privacy), and suggests that privacy for the individual constitutes a key freedom. But privacy as freedom (from surveillance, or scrutiny) is not the same thing as freedom for information – a distinction lost in some more excited accounts. Hughes articulates this contradiction well:

> Information does not just want to be free, it longs to be free. Information is Rumor's younger, stronger cousin; Information is fleeter of foot, has more eyes, knows more and understands less than Rumor.[954]

Information is a threat to the privacy (freedom from interference) of the individual exactly because of its tendency to travel. Beneath the surface, Hughes contests the effects large-scale information systems and networked communication are having on subjectivity. The cypherpunks defend the liberal individual over any kind of collective – be that the state, the corporation, or a popular collective which remains beyond view, never considered as a possibility.

Hughes' account argues that "privacy in an open society requires anonymous transaction systems" – simultaneously equating society to a market, and proposing an anonymous transaction system as the first step to realising an "open" internet.[955] He cannot conceive of an interaction which is not a transaction, nor of a sphere that is not a market; cypherpunk conceptions of privacy are frequently oriented towards property, and engagement in the market, which is envisaged as a freedom in itself. Even in Timothy May's ostensibly "anarchist" account, which imagines "a liquid market for any and all material which can be put into words and pictures", there is no suggestion that the implicit establishment of a market might undermine the open (or even free) character of an information system.[956] Against the libertarian conception of freedom as one's right to exercise property, we might place a conventional Marxist claim that private property structurally entails exploitation and extraction (as borne out in the history of the web).[957]

Defences of markets permeate open and even free software movements, captured well in Richard Stallman's catchphrase, discussed in Chapter Eight: "free as in free speech, not as in free beer".[958] Nathaniel Tkacz has traced the interrelations between conceptions of openness and the "open

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[953] Hughes
[954] Ibid.
[955] Ibid.
[956] May, p.2
[957] See: George Brenker, "Freedom and Private Property in Marx", *Philosophy and Public Affairs in Marx* 8.2 (1979), pp.122-147; also, for the privatisation of the web: Ben Tarnoff, *Internet for the People: The Fight for Our Digital Future* (London: Verso, 2022)
[958] Stallman, *Free Software*, p.41

market" in American software development and tech culture, frequently attached to the idea that the market engenders freedom for knowledge.[959] Repeatedly, these movements have been unable to think through any social medium other than exchange (even, ironically, when communicating via means that do not entail market logics). Individuals only become collectives when mediated by the market, through binary, one-to-one, peer-to-peer, exchanges. One could trace a history of this mode of thinking about technological collectivity (as denial) starting with certain readings of Marshall McLuhan's "global village", which view that village as a marketplace (the "electronic agora" – the meeting place in Athens which was also a market).[960]

After the fall of the Californian Ideology, illusions that a marketized, propertied, "free" (from the state) internet can also be a fair, equally distributed commons have dissolved. Just one expression of this is the 2017 resignation of the EFF from the World Wide Web Consortium (W3C) over their publication of the Encrypted Media Extensions standard, which defined a common API for the integration of encrypted copy protection in HTML (fig-11.1).[961] The EFF accused W3C of facilitating the introduction of digital rights management (DRM) into the previously open ecosystem of the Web browser: "By doing so [W3C] offered the use of its patent pool, its staff support, and its moral authority to the idea that browsers can and should be designed to cede control over key aspects from users to remote parties."[962] Their concern, in other words, was the extension of control via encryption, the restriction of use and the curtailment of the liveliness of information that is typical of cryptoaesthetics. Such an opposition to the corporate exploitation of information, formerly central to the Californian Ideology milieu, would not have been thinkable twenty years earlier.

Out of this collapse there are already new coalitions, which this chapter touches upon: on the one hand a new iteration of libertarianism – a crypto-libertarianism – invested in the mobilisation of cryptography to pursue more conventional techno-libertarian goals; on the other is a politics

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[959] Tkacz, pp.17-18
[960] See for instance, Rheingold, Introduction http://www.rheingold.com/vc/book/intro.html [24/07/2024]; or Barbrook and Cameron, p.48
[961] See: Cory Doctorow, "An open letter to the W3C Director, CEO, team and membership", EFF (2017) https://www.eff.org/deeplinks/2017/09/open-letter-w3c-director-ceo-team-and-membership [21/06/2024]; David Dorwin, Jerry Smith, Mark Watson and Adrian Bateman, "Encrypted Media Extensions" *W3C* https://www.w3.org/TR/encrypted-media/ [21/06/2024]; Open Source Initiative, "Principles of DRM Nonaggression for Open Standards" https://web.archive.org/web/20190217234031/https://opensource.org/osr-drm [17/02/2019]; Richard Stallman, "The W3C's Soul at Stake", *Free Software Foundation* (2013); Ars Staff, "HTML5 DRM finally makes it as an official Recommendation", *Ars Technica* (2017) https://arstechnica.com/gadgets/2017/09/drm-for-html5-published-as-a-w3c-recommendation-after-58-4-approval [10/07/2024]
[962] Doctorow

engaged in the construction and maintenance of digital commons. Both were already identifiable in the cypherpunk milieu, but it is history which has made their contradictions untenable.

Crypto-libertarianism

Episodes like the EME controversy mark the arrival of what I call crypto-libertarianism: a continuation of techno-libertarian experimentation with cryptographically assured information-capitalism, but explicitly opposed to the creation of commons and rhetorically divorced from aspirations for equality. The aspirations of this tendency can be traced through its key technologies: experiments in the cryptographic maintenance and management of capital accumulation, crypto-currency and the surrounding milieu. Attempts to displace the state with technological governance. I'm going to examine this genealogy starting with Bitcoin –the first crypto-currency and advertised on the cypherpunk mailing list – and through experiments in Ethereum with cryptographic protection of contracts (the "smart contract") and commodities ("the NFT").[963]

Bitcoin's whitepaper, published 2008 by the pseudonymous Satoshi Nakamoto described a "peer-to-peer version of electronic cash", a cryptographically secured form of electronic money which can be transferred anonymously and is guaranteed by a technical process, rather than a state.[964] Bitcoin is "mined" by users, who expend computational power to solve complex mathematical problems and identify, via a somewhat trial and error process, a new decryption key. This process is the only way new Bitcoins are made.

In place of a central bank, Bitcoin stores all its transactions on a distributed ledger: the blockchain. Each time a user solves the problem, they add an additional block to the blockchain, recording transactions which have occurred, and in-exchange are given Bitcoin (around 6.25 as of November 2024, but this will diminish over time). The act of mining new blocks also reproduces the blockchain, which acts as a ledger of all previous transactions. (We might note a semantic trick here – "peers" are not individuals but large mining rigs, today mostly commercial operations). This is the "proof of work" consensus mechanism: the large amount of work required to add to the blockchain is supposed to disincentivise manipulation, while the Bitcoin reward is supposed

[963] Satoshi Nakamoto, "Bitcoin P2P e-cash paper" *Cryptography Mailing List* (November 14, 2008) https://satoshi.nakamotoinstitute.org/emails/cryptography/12/ [25/07/2024]; Vitalik Buterin, "Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform", *Ethereum.org* (2014) https://ethereum.org/content/whitepaper/whitepaper-pdf/Ethereum_Whitepaper_-_Buterin_2014.pdf [04/11/2024]
[964] Satoshi Nakamoto, "Bitcoin: a peer-to-peer electronic cash system" (2008) https://www.ussc.gov/sites/default/files/pdf/training/annual-national-training-seminar/2018/Emerging_Tech_Bitcoin_Crypto.pdf [04/11/2024]

to incentivise miners to maintain the blockchain.[965] Such routine minting is intended to provide stable and predictable inflation to the monetary system, though as David Golumbia has argued, wild fluctuations in Bitcoin's value suggest this is spurious.[966] So, while Bitcoin in use functions like a speculative asset, its originators and proponents clearly aspire towards the more fundamental economic functions of currency.

First of all, Bitcoin is designed as a solution to perceived problems of "trust", such as American libertarian conspiracy theories in which the Federal Reserve carries out back-door taxation via monetary policy (such as quantitative easing), driving inflation and eroding wealth.[967] Bitcoin's ledger is distributed between the CPUs mining allowing users, proponents claim, to exchange money via a digital medium without relying on a third party (e.g. the state) to guarantee the transaction – though the idea that neither the protocol, nor owners of mining rigs, constitute "third parties" is itself spurious.[968] We should note the intense financialization of this system: actors cannot be trusted to act voluntarily, so they must be coerced, via pay, for their contribution to the consensus – and a contract for this is built into the architecture of the protocol. Don't be fooled by Bitcoin's association with peer-to-peer technology; this is free market absolutism masquerading as collectivism – it is crypto-libertarianism. The absolute, cut-throat, winner-takes-all economy such a system endorses is built for paranoid capitalists: externally, proof of work militates against the state (and taxation), while internally Bitcoin incentives coerce participation in the blockchain.

All this "work" comes with costs. In fact, 'mining' Bitcoin now consumes more energy than mining the equivalent market value of all precious metals including aluminium: 173.42 TWh of electricity across 2020 and 2021, emitting 85.89 Mt of CO2eq and using 1.65km3 of water in the same period.[969] Such consumption means the running of Bitcoin (without mentioning other cryptocurrencies) has roughly an equivalent ecological impact to that of powering a medium-sized country. That all this is in aid of transcending the state and monetary policies perceived (within the libertarian world view, not mainstream or Marxian economics) as wealth taxation,

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965 Ibid.
966 David Golumbia, *The Politics of Bitcoin: Software as Right-Wing Extremism* (Minneapolis: University of Minnesota Press, 2016) p.29
967 Golumbia, pp.14-25
968 This is Nakamoto's framing, but recurs throughout related academic literature, e.g.: Dalia Elwi, Osama Abu-Elnasr, Ahmed Tolba and Samir Elmougy "Co-operative Mining System to Improve Bitcoin Scalability" *IEEE Access* 11 (2023), pp.58715-58728; Golumbia, p.29
969 Max Krause and Thabet Tolaymat, "Quantification of energy and carbon costs for mining cryptocurrencies" *Nature Sustainability* 1 (2018), pp.711-718; Sanaz Chamanara, S. Arman Ghaffarizadeh and Kaveh Madani, "The Environmental Footprint of Bitcoin Mining Across the Globe", *Earth's Future* 11.10 (2023), pp.1-8

should be taken as indicative of the project's originating politics: an obsession with accumulation and the hoarding of wealth, at times tipping into millenarian fantasy or apocalyptic paranoia.

Satoshi Nakamoto is a curious formation: a pseudonym (or cryptonym), possibly operated by a small group of engineers, he is the centre of much speculation and an effective cult of personality.[970] Nakamoto's engineer(s) has been wise to stay tight-lipped: that his identity has successfully been kept anonymous and indeterminate (even occult) has helped generate a technological mystique around Bitcoin and blockchain. He is likely American, despite presenting himself as a Japanese man. In the accounts of his proponents, Nakamoto appears as an avatar for the encrypted, and Bitcoin as a singular work of genius birthed from the web. "I'm better with code than words", he writes.[971] But even in character as a coding-savant, Nakamoto's statements contain a clear political conception of the work.

Privacy animates Nakamoto as it did other cypherpunks, Horst Feistel's work on Lucifer (DES) or the EFF's DES cracker. For Feistel, the mobility of digital information represented a threat to "individual privacy", which might be contained through encryption.[972] As the EFF extrapolated on Feistel's logic, the threat to individual privacy came specifically from a state institution, the NSA.[973] For the cypherpunks, the right to privacy is a necessity for "open" digital culture; the private individual requires protection from the extreme mobility of information.[974] Nakamoto articulates Bitcoin as a linear progression the politics of DES:

> `Before strong encryption, users had to rely on password protection to secure their files, placing trust in the system administrator to keep their information private. Privacy could always be overridden by the admin based on his judgment call weighing the principle of privacy against other concerns, or at the behest of his superiors. Then strong encryption became available to the masses, and trust was no longer required. Data could be secured in a way that was physically impossible for others to access` [975]

Encryption, he suggests, has established privacy from "other concerns" or "superiors" (which, within the libertarian imagination, undoubtedly includes the NSA). Privacy is set in opposition to trust (always in social or governmental mechanisms, not technical ones), which is viewed as an affront to an individual's information-freedom. But Nakamoto's conception of personal freedom

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[970] *The Satoshi Nakamoto Initiative* website, for instance, has compiled every whitepaper, forum post, email and piece of code attributed to the fictional engineer – a pool of quotes is subtitled "indexed wisdom from the quotable Satoshi."; https://satoshi.nakamotoinstitute.org/ [25/06/2024]; a Google search turns up hundreds of forum posts and articles speculating on Nakamoto's identity.
[971] Nakamoto, "Bitcoin P2P e-cash paper"
[972] Feistel, "Cryptography and Computer Privacy"
[973] EFF, *Cracking DES*, p.21
[974] Hughes
[975] Satoshi Nakamoto "Bitcoin open-source implementation of P2P currency" *P2P Foundation* (2009) www.p2pfoundation.ning.com/forum/topics/bitcoin-open-source [12/07/2024]

and privacy is curious, constituted both by "securing [personal] files" and "money". The self is extended to encompass certain forms of information-property. The realm of the private, in other words, has drifted from the protection of private life (i.e. the home), towards a more general defence of property (the house), which is treated as part of (or at least revealing of) the self. It is the rhetoric of a conventional (American) libertarianism: freedom, always and only for property. Nakamoto is repeatedly clear that the central goal of the project is the extraction of the money system from the state, although he generally will not refer to it directly, rather to its institutions.[976]

Nakamoto's reflections on peer-to-peer technology are revealing, motivated primarily by the resilience of "pure P2P networks like Gnutella and Tor" against government closure."[977] His enthusiasm extends to resilience against the state, not to democratic mechanisms or to information commons.[978] Even in an idealised, distributed system (unlike the consolidated one which actually exists), Bitcoin at best invites its participants to collectively bear witness to their exploitation by or of others. Golumbia therefore argues correctly that Bitcoin is "a tool for existing power to concentrate itself."[979] The protocol does nothing to disrupt the anti-democratic structures of capital; in fact, by attempting to separate itself from the state (and from law), it only dismantles barriers to extraction and exploitation (in the form of regulation). Bitcoin may be ostensibly open-source but, as Primavera De Filippi and Benjamin Lovelock have argued, "governance by infrastructure" raises corresponding questions about the "governance of infrastructure".[980] In practice, governance of Bitcoin is carried out by this small group of architects and thought leaders, not by any meaningful collective.[981] Rather than displacing governance, the Bitcoin protocol itself comprises a form of governance (defined by these architects), making its architecture of great significance.

Bitcoin envisages money without a state. Much Marxist theory posits that the state is integral to capital accumulation, but the programme here (regardless of its claims) is to replace the state

[976] Ibid.
[977] Satoshi Nakamoto, reply to "Bitcoin P2P e-cash paper" *Cryptography Mailing List* (2008) https://www.metzdowd.com/pipermail/cryptography/2008-November/014823.html [12/07/2024]
[978] For work on cryptocurrency as a democratic mechanism, see: Sebastian Gambs, Samuel Ranellucci and Alain Tapp, "The Crypto-democracy and the Trustworthy", *arXiv.org* (2014); For critique, see: Leah Downey and Stefan Eich, "Crypto-politics and counterfeit democracy" *Finance and Society* 9.1 (2023), pp.69-72
[979] Golumbia, p.63
[980] Primavera De Filippi and Benjamin Lovelock, "The invisible politics of Bitcoin: Governance crisis of a decentralised infrastructure", *Internet Policy Review* 5.3 (2016), p.13; Also, Maria Bustillos, "Inside the Fight over Bitcoin's Future" *New Yorker* (2015) https://www.newyorker.com/business/currency/inside-the-fight-over-bitcoins-future [12/07/2024], pp.7-10
[981] De Filippi and Lovelock, p.15

with technological governance, not to abolish governance itself.[982] Money, however, is only one component in the process of capital accumulation; Ethereum – as described in its 2014 whitepaper – builds on the design of Bitcoin to create an environment in which a similar liberation for property and for contracts might be achieved.[983] That is, a world in which property and contracts are guaranteed automatically by protocol, not law.

The development of Ethereum was influenced heavily by the programmer Nick Szabo.[984] Ostensibly writing about homesteading – note a casual oscillation between land metaphors and the politics of actual land-acquisition – Szabo argued that writing (inscription) historically created the possibility of recording of property ownership, but (echoing Nakamoto's concerns about "trust") is vulnerable to being tampered with (as ever in these narratives, by the state).[985] He theorized that a distributed database might maintain records of property without the need for a state, protecting ownership even in the case of "nuclear war"; a millenarian fantasy in which capitalism outlives the thoroughgoing deterioration of the earth – and to which the massive carbon footprint of blockchain is perhaps serendipitous.[986]

The intensity of the techno-libertarian aversion to the state is curious. The issue is, as Nakamoto claims, fundamentally one of "trust". Even if it will ensure the reproduction of capital in general, a social democratic state remains a risk to individual property. Szabo's concern is that "political instability or oppression" might result in the confiscation of land. He is animated by a question of reliability (trust): the state (that is, the bureaucracy of governance, attached democratic mechanisms and the military force with which it is upheld) is contestable and has been contested, and hence a threat to the individual capitalist. Paper bureaucracy, he suggests, is subject to politics while the blockchain is unmovable.[987] For the paranoid capitalist, therefore, protocols might be a more absolute guarantor for accumulation.

Except that if a single actor or collaborating actors were to operate more than 50% of mining operations at a time, they could edit the ledger.[988] Such an attack has not been performed, but the

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[982] Especially in Leninist traditions; the bourgeois state, he argued, is always "inevitably the dictatorship of the bourgeoisie". Vladamir Lenin, *State and Revolution* (Lenin Internet Archive, 1999) https://www.marxists.org/ebooks/lenin/state-and-revolution.pdf [12/07/2024]
[983] Buterin
[984] Nick Szabo, "Secure Property Titles with Owner Authority" (1995), https://nakamotoinstitute.org/library/secure-property-titles/ [12/07/2024]
[985] Cf. *The Virtual Community: Homesteading on the New Frontier*, which describes emerging online communities uncritically as homesteads; Or, innovations of a "Frontier" by the EFF; One can follow this into the communes of 1960s California counterculture and beyond, into a tradition which views land as a necessary precondition of utopia; Fred Turner "Where the Counterculture Met the New Economy: The WELL and the Origins of Virtual Community" *Technology and Culture*46.3 (2005), pp.485-512; Szabo
[986] Ibid.
[987] See: Nigel Dodd, "The Politics of Bitcoin", *Money in a Human Economy* (New York: Berghahn, 2017), pp.189-208
[988] Golumbia, p.29

conditions for it have been met several times.[989] In reality, any such technostructure would itself constitute a kind of state, with protocols and scripts functioning as law and governance.[990] To maintain the techno-libertarian view, one must therefore imagine the state as not already technological and limit oneself to narrow definitions of the state and of law.[991]

Regardless, Ethereum argues for something like Szabo's decentralised property ledger to be built into a blockchain, which it calls "smart contracts".[992] Conceived variously as "'cryptographic' boxes that contain value", and "'autonomous agents' that live inside the Ethereum execution environment", these are lines of code in the blockchain that self-execute upon the transfer of a defined amount of Ether (fig-11.2).[993] Like conventional contracts they record an agreement between two parties, but they also form the mechanism for delivery of that agreement. Smart contracts, the whitepaper theorises, might govern transactions, wallets, wills or even employment contracts.[994] It describes, for instance an application of Ethereum for decentralized file storage, what it calls a "decentralized Dropbox contract":

> Ethereum contracts can allow for the development of a decentralized file storage ecosystem, where individual users can earn small quantities of money by renting out their own hard drives and unused space can be used to further drive down the costs of file storage.[995]

Ostensibly, this describes an architecture for pooling storage capacity. But the problem solved in this example is not one of designing a decentralized storage protocol or architecture, which are not given any attention; it is one of monetizing that architecture. As a horizon, Ethereum is run

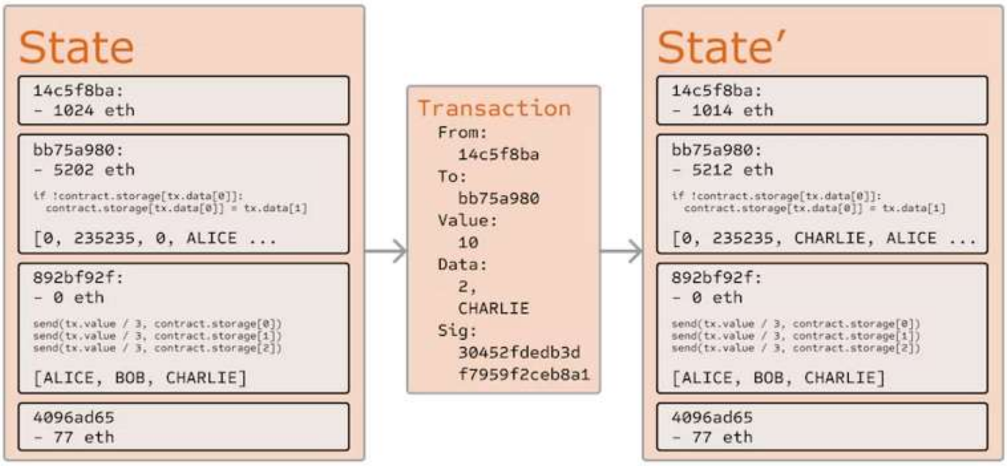

Figure 11.2

Diagram of a smart contract in Ethereum, in which the transfer of Ether is used as a mechanism to trigger the execution of code

Taken from the Ethereum White Paper.

[989] Ibid., p.29
[990]As in a dystopian iteration of the Bratton's planetary-scale computation; Cf. Lawrence Lessig's argument that code operates as law; *Code and other laws of cyberspace* (New York: Basic Books, 1999), p.3
[991] Golumbia, p.9
[992] Buterin
[993] Ibid.
[994] Ibid.
[995] Ibid.

through by a dream of free-flowing capital – the automatic and incessant financialization of every operation of life. This is the "incessant, frictionless operation[s]" of Jonathan Crary's *24/7*, but always rendered as transactions.[996] It is the reason that the much-touted idea that blockchains (as they currently exist) might be mobilised as a democratizing tool rings hollow – even the act of the vote, within their architecture, must be modelled as a transaction.[997] This is the "electronic agora" in action: voting as market power. Who needs democracy when we can build a marketplace?

Cryptographic systems like Ethereum seek to replace the state as the guaranteeing structure of capitalism, and so entail (or aspire towards) novel mechanisms of control. I indulge here in a brief detour to help illustrate these mechanisms.

Enregistering processes

> Anyone can look through the glass and watch the inscription taking form on the body[998]

Kafka's short story "In the Penal Colony" features a strange device, "the harrow", which carves transgressed rules directly into the flesh of its subjects. There is no proportionality or fairness in the harrow, but while obviously grotesque and cruel, the device is judged just by its operator. The harrow is transparent, he claims, anyone can witness the judgement being delivered.[999] One curious feature of the harrow is its integration of inscription and execution: there is no distinction in its operations between the deciding of a sentence and its delivery, which are mechanically linked to one another. In this sense it is analogous to an ideal of the crypto-libertarian imaginary in which agreements are absolutely guaranteed, not through law or force, but as a matter of technical possibility; this is what Szabo calls for in property, what "smart contracts" claim to achieve, and is even anticipated in John Perry Barlow's call for intellectual property mechanisms that "rely far more on ethics and technology than law."[1000]

Cryptocurrencies contain an attempt at a new society, as Foucault observed in Bentham's plans for the panopticon (fig-11.3).[1001] We can read governance mechanisms in blockchain – escalating

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[996] See, e.g., Ruth Catlow, et al. *Artists Re: Thinking the Blockchain* (London: Furtherfield, 2017); Crary, p.29
[997] For a critique of security in blockchain based voting systems, see: Sunoo Park, Michael Specter, Neha Narula and Ronald Rivest, "Going from bad to worse: from internet voting to blockchain voting" *Journal of Cybersecurity* 7.1 (2021); Also see: Mohammed Hajian Berenjestanaki, Hamid Barzegar, Nabil Ioini and Claus Pahl, "Blockchain-Based E-Voting Systems: A Technological Review" *electronics* 13.1 (2023)
[998] Franz Kafka, "In the Penal Colony", *The Complete Short Stories* (London: Vintage, 2005), p.147
[999] Ibid., p.147
[1000] Buterin; Szabo; Barlow, "The Economy of Ideas"
[1001] Michel Foucault, trans. Alan Sheridan, *Discipline and Punish: The Birth of the Prison* (1977), pp.201-205

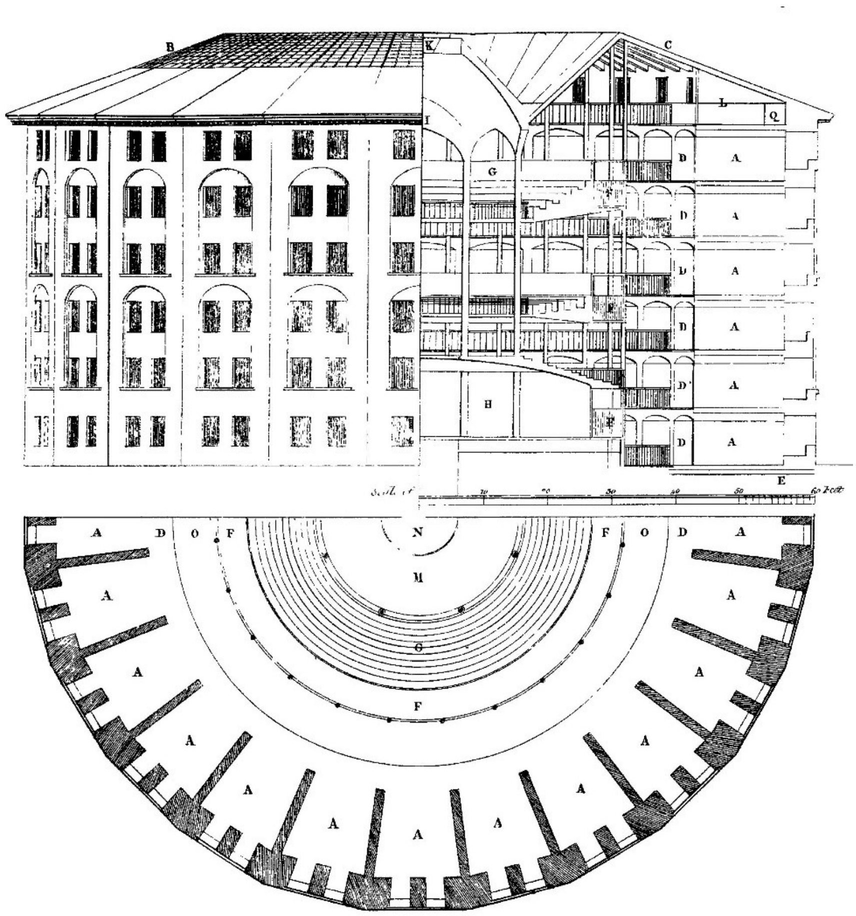

Figure 11.3

Bentham's Panopticon – in Foucault's analysis the panopticon creates the conditions under which active surveillance is not necessary, since prisoners will always surveil themselves.

In smart-contracts, with property and exchange integrated into the protocol, peers are invited to participate in the act of recording the unjust and the unequal – newly rendered as a distributed consensus. Ethereum's horizon, to put it another way, is not nighttime robbery by conventional criminals, but daylight robbery by so-called "sovereign citizens"

beyond Deleuze's "society of control".[1002] In the panopticon "conscious and permanent visibility" coerces the prisoner into policing themselves, while the society of control features more complex forms of coercion (salaries, debt, the surveillance technologies) condition subjects to participate in capital accumulation without the need for discipline.[1003] Unlike the panopticon, predicated on asymmetrical obscurity, the harrow is predicated on a duplicitous transparency: anyone can see the inscription, and anyone can observe the blockchain ledger; in fact, we are encouraged to participate in its consensus.[1004] "Trust" is solved (or rather transformed) via the creation of an immutable record; such a regime leaves no space for mutualistic or solidaristic formations, only observance.

For Deleuze money's transition from a "gold… as a numerical standard" to "floating rates of exchange" typified the transition from a society of discipline to one of control – cryptocurrencies aspire to a similar transition away from fiat currency towards a new system of pre-determined algorithmic valuation (proof-of-work).[1005] The Ethereum blockchain suggests, rather than forcing enthusiastic participation in the market, that it might become something like the act of falling: we

1002 Gilles Deleuze, "Postscript on societies of control", *October* 59 (1992), p.4
1003 Deleuze, "Postscript…", p.7
1004 "anyone can look through the glass and watch the inscription taking place "; Kafka, p.147
1005 Deleuze, "Postscript…", p.5

are not coerced by gravity but immersed in it. Such protocols aspire to the mechanical (automatic) imposition of capital accumulation onto a technostructure which has just as often produced commons.[1006]

This constitutes an expanded inscription process which I call an "enregistering" process, from the French "enregistrement", a more expansive word than its English equivalents, encompassing the material process of recording (e.g. cutting grooves into, or pressing, a vinyl record), the product of that process (e.g. a recording) and the keeping of an official ledger (e.g. of births, deaths, marriages or transactions).[1007] Blockchains produce records and, in doing so, form the world around them. They are material processes that bind and organise production; the inscription of an economy onto information itself. The blockchain ledger aspires to be an immanent technology, one which cuts into its objects, marks them directly and cannot be extracted from them. It is under this cutting edge that information might finally be made un-free. The magic trick of Ethereum is to brand the withdrawal of all non-market interactions a 'distribution'.

The development of an enregistering process for accumulation sits at the centre of Ethereum's political horizon. There is no mechanism within the architecture of smart contracts that might construct a fairer, more equal economy. The whitepaper can discuss "proof-of-stake" (a consensus mechanism in which consensus is weighted by currency holdings) as an alternative to a "proof of work" (the consensus mechanism developed for Bitcoin, where consensus is weighted by computational work) in abstract, technical terms without any reflection on the relative political function of these different 'distributed' mechanisms because (as in Nakamoto's project) Ethereum's peer-to-peer aspects are a means and not an end.[1008] No major blockchain technology has experimented with abandoning these evidently profoundly unequal consensus systems in favour of a "one member one vote" style consensus mechanism.[1009] As a principal of governance, Ethereum-like blockchains can only entail a massive shift of power from the collective towards a small number of individuals; this is the same conclusion reached by Golumbia, that the crypto-horizon pushes for "an intensification of the power of capital to escape legal and democratic oversight."[1010]

The project remains incomplete, however. Ethereum, as first proposed, offered schematics for the technological mediation of a number of the functions of the capitalist – the transfer of money,

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[1006] The absence of surveillance from the social horizon of the crypto-libertarians – in fact frequent opposition to it – distinguishes this from existing computational systems of domination; cf. Shoshana Zuboff, *The Age of Surveillance Capitalism* (London: Profile Books, 2018)
[1007] Appropriated from Gilles Deleuze and Félix Guattari; *Anti-Oedipus* (London: Bloomsbury, 2000), p.4
[1008] Buterin
[1009] Dionysis Zindros, "The Illusion of Blockchain Democracy: One Coin Equals One Vote", *nesta* (2020) https://www.nesta.org.uk/report/illusion-blockchain-democracy-one-coin-equals-one-vote/part-two/
[1010] Golumbia, p.72

recording of property, maintenance of contracts, management of labour – without the need of a state to guarantee those things.[1011] A central mechanism of capital accumulation still remains outside this ecosystem, though: the commodity.

The Non-Fungible Token (NFT) entered the mainstream in 2021 – primarily as a kind of "crypto-art", digital art which was being traded speculatively (as an asset) and sometimes ballooning to massive exchange values, equivalent to millions of dollars.[1012] This meteoric rise precipitated a similar fall: the bubble popped, and by Sept 2023 95% of NFTs had no value at all.[1013] To many, NFTs are now synonymous with this bubble, or else seen as nothing more than a scam; clearly there many examples which vindicate such a position.[1014] But I'm not interested in NFTs as Ponzi schemes; more can be learned from them as an experimental value-form. Centrally, they define a schema for the cryptographically guaranteed ownership and exchange of commodities.

Non-fungible tokens (NFTs) are defined by their standard (ERC-721) as a kind of token – essentially individual entries on the blockchain (fig-11.4) – which contain or correspond to "assets".[1015] While the NFT was conceived for use with any kind of asset it has become synonymous with "crypto-art", encompassing many commodity-like-things, including sounds,

Figure 11.4

Diagram of NFT architecture within a larger blockchain, taken from the EFC-721 standard.

[1011] Not specifically covered in this account are Decentralized Autonomous Organizations (DAOs) – "a virtual entity that has a certain set of members or shareholders which, perhaps with a 67% majority, have the right to spend the entity's funds and modify its code." DAOs are organisations managed via blockchain; Buterin

[1012] Jacob Kastrenakes, "Beeple sold an NFT for $69 million" *The Verge* (2021) https://www.theverge.com/2021/3/11/22325054/beeple-christies-nft-sale-cost-everydays-69-million [16/10/2024]

[1013] Brandon Vigliarolo, "95% of NFTs now totally worthless, say researchers" *The Register* (2023) https://www.theregister.com/2023/09/21/95_percent_nfts_worthless/ [120/07/2023]

[1014] See, for instance: Dan Olsen, "Line Goes Up – The Problem with NFTs", *Folding Ideas* (2022), https://www.youtube.com/watch?v=YQ_xWvX1n9g [10/07/2023]; Or, for cryptocurrencies as scams: Golumbia, p.68

[1015] As discussed in Chapter Nine, this is a class which often also encompasses commodities; ERC-721 Non-Fungible Token Standard", *Ethereum* (2023) https://ethereum.org/en/developers/docs/standards/tokens/erc-721/ [10/07/2024] texts, images, compositions and designs. So, while NFTs are traded as financialised assets, they are also would-be containers of use-value.[1016] NFTs, in theory, allow the integration of such information-commodities into Ethereum's Smart Contract infrastructure.

We can image a smart contract which, via a proprietary application, requires a small amount of Ether to be exchanged in order to access and play-back a track. This could be made to occur every time listening occurs, and automatically distribute payments between property holders in the case of covers or samples, on the basis of further Smart Contracts. In the 20th century Adorno, after seeing the copyright warning on a hit record, complained that: "anyone who harboured the illusion that an object existed especially for him [sic]… will dismiss the idea".[1017] Adorno realises that the information content of a record does not belong to its ostensible owner; while the history of commodity music is littered with examples of copyright simply being forgotten about, the NFT suggests it might be made automatic, and Adorno's vision made absolute.[1018]

Vinyl record playback entails a material process in which the vibrations of a needle within cut grooves generate sound; the NFT proposes a total material integration of exchange into this process. It directs itself therefore not just to a system of administration (as copyright), but also towards the record itself. Here the power of a successful enregistering process for digital commodities becomes clear: smart contracts, and the NFT, propose an actionable mark – code not text – through which listening might become materially inextricable from a transaction. The grooves of the needle become themselves the ledger, and as intimate an act as listening governed by the market.

But the NFT is not an effective realisation of this horizon. Memes about "copy and pasting" NFTs are one expression of this, as are legal cases against NFT owners attempting to mint images already subject to copyright.[1019] Owning an NFT without legal mechanisms for property enforcement (which is exactly what the project seeks to circumvent) is meaningless.[1020] Technological solutionism is exposed as a naive denial of an outside to the technical system (here

[1016] Which means overlooking the shallowness of the existing NFT market in favour of visions of what it might be.
[1017] Theodor Adorno, "Commodity Music Analysed", *Quasi Una Fantasia* (London: Verso, 1998), p. 45
[1018] The "amen break", for example, was originally sampled from the The Winston's 1969 song "Amen, Brother" in the 1980s, before being cut up and reassembled in Jungle and Drum and Base. The original copyright holders received no royalties for the track, which they were not aware had been sampled until the mid-1990s; Nate Harrison, "Can I Get an Amen?" (2004), Recorded on YouTube: https://www.youtube.com/watch?v=XPoxZW8JzzM [17/07/2024]
[1019] For copy & pasting of NFTs see: Aaron Mark, "How to Troll an NFT Owner", *Slate* (2021) https://slate.com/technology/2021/11/nft-image-ownership-right-clicking-saving-copying-trolling.html [04/07/2024]; For one such copyright claim see: Lang Yue, "The first NFT copyright infringement decision handed down in China", *Allen & Overy* (2022)
[1020] Golumbia, pp.50-51

law). Michel Serres' critique of information is pertinent here: "noise… through its interruption, wins the game."[1021]

Still, the NFT demonstrates an aspiration towards an all-encompassing technostructure for which the "free" market is a final authority. In the face of NFTs' inability to self-enforce, as well as their vulnerability to legal property enforcement (copyright), some have sought to reinforce crypto-assets with existing legal mechanisms. Rather than supersede law (and the state that enforces it) via technical means, such accounts align these parallel systems and view technological solutions as means of enforcing copyright.[1022] This marriage seems like a likely route for crypto-politics and technology to progress; if it does, it will represent a total failure of crypto-libertarianism to achieve its horizon of a cryptographically assured market beyond the state, while simultaneously strengthening the grip of capital on information.

Peer-to-peer technology

But crypto- isn't the only technical horizon with roots among the cypherpunks; exploring wider suggests alternate genealogies. Here I examine BitTorrent, a peer-to-peer (P2P) filesharing protocol released by Bram Cohen in 2001.

In a server-client model computers share information via a central server; by contrast P2P architectures share information in a horizontal, decentralised fashion. This wasn't invented by the cypherpunks – indeed it is anticipated in designs not only for the Web, but also for instance in Ted Nelson's Xanadu and even in the architecture of early US military funded networking protocols, such as the Transmission Control Protocol (TCP).[1023] The politics of P2P can differ greatly: the US Defence Advanced Research Projects Agency wanted a communications architecture which could withstand nuclear war; whereas, in the 1990s Dutch squatting scene, decentralised tools were seen explicitly as embodiments of DIY culture.[1024] Nonetheless, the cypherpunks espoused P2P and horizontality as desirable.

BitTorrent, like Bitcoin, started life as an offshoot of cryptographic research. Cohen was working on a peer-to-peer encryption system: data was broken up, encrypted and distributed between the computers of all those using the software.[1025] If any machine were captured, and its contents

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1021 Serres, p.4
1022 See, e.g.: Ifeanyi Okonkwo, "NFT, copyright and intellectual property commercialisation", *International journal of law and information technology* 29.4 (2022), pp.296-304
1023 Abbate, *Inventing the Internet*, p.5
1024 See: Ibid., pp.132-133; Also: Amanda Wasielewski, *From City to Cyberspace: Art, Squatting, and Internet Culture in the Netherlands* (Amsterdam: Amsterdam University Press, 2021), p.12
1025 Clive Thompson, "The BitTorrent Effect", *Wired* (2005) https://www.wired.com/2005/01/bittorrent-2/ [24/07/2024]

cracked by brute force, the majority of each file would remain safe on other devices. Large numbers of peers (in other words, a collective) would need to consent for any file to be retrieved.

The start-up failed, but Cohen repurposed the process: instead of using peer connections to conceal files, he designed a protocol to distribute them. BitTorrent shares files in small parts (chunks), which can be retrieved from any other user sharing the file. With no centralised server, the protocol relies on multiple users working together – a "swarm" -of up to several hundred or thousands of users, simultaneously sharing information. Torrents are coordinated by a tracker – a simple programme – but data itself is shared in a distributed fashion between participants without the kind of hierarchy implied in a server-client structure. This filesharing protocol would become popular in the limited bandwidth of the early internet, especially among those sharing files for free.

There's some similarity in the technical framing of BitTorrent and Bitcoin; they are both "peer-to-peer" technologies developed in the context of cryptography, and both associated with the cypherpunks. If Nakamoto claims to be "better with code than words", Cohen certainly is; when he conceptualises the work, it is generally as a fun, complex problem – engineering appears on his blog side by side with puzzle designs and solutions – not a tool which exists in relation to a politics or a culture.[1026] Cohen is typical of the "techno-solutionist" orientation of the Californian Ideology; if Nakamoto and Cohen describe themselves and their work in similar terms, this is likely because, behind the cryptonym, they are similar kinds of people, occupying similar professions in similar places and with similar class positions. Indeed, Cohen's name is occasionally floated in online speculation about Nakamoto's identity.[1027]

Cohen first published the protocol on the Yahoo! message board as a link to a simple HTML site, describing BitTorrent as peer-to-peer "tool for copying files".[1028] That Cohen's own torrent client (also called BitTorrent) is under a proprietary license and run through with adware suggests he either does not understand or has little interest in the non-capital routes of circulation that

[1026] Bram Cohen, *Livejournal* https://bramcohen.livejournal.com/?skip=50 [22/07/2024]

[1027] Cohen's rejection of extreme libertarianism makes this less likely. His former roommate Len Sassaman, who worked on the open encryption tool Pretty Good Privacy (PGP), is a more credible candidate; For speculation on Cohen, see: "My thoughts on why Bram Cohen is probably Satoshi", *Reddit* (2021) https://www.reddit.com/r/chia/comments/mwnxz2/my_thoughts_on_why_bram_cohen_is_probably_satoshi/ [22/07/2024]; For Cohen's rejection of libertarianism, see: Bram Cohen, "BusinessWeek profile" *Bram Cohen Livejournal* (2008) https://bramcohen.livejournal.com/?skip=50 [22/07/2024]; For Sassaman's connection to Nakamoto and Bitcoin: Evan Hatch, "Len Sassaman and Satoshi: a Cypherpunk History", *Medium* (2021) https://evanhatch.medium.com/len-sassaman-and-satoshi-e483c85c2b10 [22/07/2024]; Andrew Orlowski, "Cryptographer Len Sassaman, RIP", *The Register* (2011) https://www.theregister.com/2011/07/06/len_sassaman/ [22/07/2024]

[1028] Quoted in: Ernesto Van der Sar, "BitTorrent Turns 20: The Filesharing Revolution Revisited" *Torrent Freak* (2021) https://torrentfreak.com/bittorrent-turns-20-the-file-sharing-revolution-revisited-210702/ [22/07/2024]

BitTorrent soon become embedded in.[1029] There is a case to be made that BitTorrent exceeds his imagination. While BitTorrent and Cryptocurrencies are sometimes associated with one another (both distributed, "peer" based protocols) they embody radically different, opposed politics. The inadequacy of this milieu's vocabulary has a lot to answer for: neither the "peers", nor the structure of their relations, are anything alike. I've already argued that the alleged democratic horizontality of the "proof of work" mechanism, which weights consensus by computing power (itself a proxy for capital), is illusory. While without a central server, blockchain governance is centralised in the protocol and participation allocated to terms of compute.

BitTorrent is also not totally horizontal, and maintains a few classes of peers: "leechers", "seeders" and "peers". Leechers download information but do not contribute to the swarm; seeders leave their client running for others to download, while peers upload and download simultaneously. A swarms 'health' relies on voluntarily committed computing power and bandwidth after downloads are complete.[1030] Globally – pirate websites had 215 million visits in 2023 – seeding might be considered one of the great historical expressions of the socialist mantra: "from each according to their ability; to each according to their need".[1031] Trackers should be read as a redistribution mechanism (and one which dynamically follows this principle). In effect, BitTorrent functions as a socialisation protocol, rerouting information-commodities from vectors of capital accumulation towards common archives.

Despite their differences, BitTorrent and Bitcoin are both P2P protocols. "Peer-to-peer" architecture is not necessarily equitable or horizontal, and is totally compatible with a libertarian framework, expressing exactly the kind of relation they aspire towards: an unmediated one, between individuals (though both are in reality mediated by a protocol, by infrastructures and by cultures). P2P might describe the meeting of two individuals in a marketplace. "Peer-to-peer" is ultimately inadequate for expressing the relation engendered by BitTorrent, which requires more than the meeting of individuals (try to download a torrent with just one seed, and see how long it takes). BitTorrent requires swarms, and active cultures or platforms for the distribution and maintenance of trackers. We might more productively think it as a peer-to-collective technology.

[1029] Free and open alternatives are more popular among filesharing communities, e.g. qBittorent or Deluge

[1030] Popular torrents can survive with only peers, but obscure files need dedicated seeders. Early trackers such as OiNK (and some private trackers today) enforced strict seeding rations, largely now dropped; Andrew Sockanathan, *Digital desire and recorded music: OiNK, mnemotechnics and the private BitTorrent architecture* PhD Thesis (Goldsmiths, University of London, 2014), pp.301-312

[1031] Muso, *Piracy By Industry* (2023); Luc Bovens and Adrien Lutz, "'From Each according to Ability; To Each according to Needs': Origin, Meaning and Development of Socialist Slogans", *History of Political Economy* 51.2 (2019), pp.237-257

The category of "peer-to-peer" is a product of a Californian Realism: even while working on technologies of powerful collectivity, Cohen is shackled to the language of individuality.[1032] The term obscures the distinct rules of interchange and kinds of relation coded by BitTorrent – in which there is no built-in payment for seeders (as in smart contracts), nor a weight of paranoia that requires complex solutions to problems of "trust", and crypto-protocols – and crypto-protocols. There are no transactions in the BitTorrent protocol, only the voluntary maintenance and sharing of information. By making grassroots filesharing trivial, and in the particular logics of sharing it utilises, BitTorrent engenders collectivity: one might enter a torrent as a peer, but will soon be part of a swarm.[1033]

Information commons

The absence of a solution to the problem of "trust" in the BitTorrent protocol points to its operating within a different social base – with different logics – than crypto-libertarianism. Bitcoin is a device for the circulation of money within a market economy; BitTorrent, by contrast, requires and is deployed within a broad-based culture and diffuse information-commons.

Such a cultural base extends into aesthetic practice, and is found across a number of mediums:

> Fuck it, jailbreak the Tesla[1034]

Injury Reserve's anti-proprietary anthem, "Jailbreak the Tesla", celebrates digital piracy and rejects, joyfully, the creeping presence of encrypted media and technology. If the logics of encrypted media can be expanded into more and more things, even a car, it suggests, the strategies of decryption developed for digital culture can too. The classic image of American automotive freedom, the car – as in, for instance, Tracy Chapman's "Fast Car" – is mapped onto a decrypted digital culture.[1035]

The Tesla isn't hijacked, hacked or stolen; it's jailbroken – a process of breaking a device (generally a phone, and especially iPhones) from the proprietary restrictions built into its software. Jailbreaking is invoked as an act of liberation, entangled with the freedom of travel and most of all, of speed: in the beat tyres screech and key-fobs chirp as Richie with a T raps, "make the autopilot do a donut, go dumb." But the specificity of this imaginary is also important: escape is

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[1032] In attempt to kickstart BitTorrent, Cohen flooded the early network with pornography. If he was a product of the liberal politics of computer programming, this also entailed a gendered understanding of media consumption. See: Thompson

[1033] For more on the cultural politics of the "swarm", see: Jussi Parikka, *Insect Media: An Archaeology of Animals and Technology* (University of Minnesota Press, London: 2010), p.xviii

[1034] Injury Reserve, "Jailbreak the Tesla", *Injury Reserve* (2019)

[1035] Tracy Chapman, "Fast Car" *Tracy Chapman* (1988) built on the recollection of specific anti-proprietary software (invoked alongside nostalgia for childhood freedom). Ritchie with a T, raps:

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Ninth grade, yeah. Prime days, yo
[…]
Had the iPod Touch with the redsn0w
Cydia, but you could pirate all the apps though
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Redsn0w was a jailbreaking tool for iOS devices which hijacked exploits in the operating system to allow "arbitrary code execution", the ability to run code directly on the device, including installation of third-party operating systems or software. Here Cydia acts as replacement to the App Store with software from outside the Apple ecosystem. Jailbreaking releases the phone from a its proprietary ecosystem, facilitating access to new features, huge volumes of media, viruses and spam alike. The joy is not only one of access (as invokes by Spotify) but a facet of ownership generally excluded by proprietary systems: autonomy over use. Buying a Tesla will not grant users autonomy over the vehicle, which is also an encrypted information-commodity (features like self-driving mode are locked behind a subscription paywall), only jailbreaking can.[1036]

Jailbreaking suggests a rubric for reclaiming information-commodities from their intellectual property holders, re-bundling software with hardware. It did this for the phone; as more things undergo a similar bifurcation (including cars) it might do it for them too. The jailbreak is a strategy for regaining that ownership which intellectual property forbids: unrestrained use, external to and unmediated by the market. There is still mediation, as always, and not without unwanted effects – Cydia was also often buggy, and full of malware – but this is not a control system in the same sense. "Jailbreak the Tesla" imagines a world in which the sweeping technologization of life only generates more opportunities to for jailbreaks, for escape from proprietary control. Technology becomes liberatory (fulfilling a vision of "freedom") only after the defeat of the forces of encryption.

The track itself is its built from layered samples: the beat is taken (clearly) from the Teriyaki Boyz' 2006 track, *Tokyo Drift*, and adorned with the aforementioned beeps and screeches, and appropriation typical of the sampling, ripping and mixing which constitute hip-hop's sound-aesthetics.[1037] Such practices have generally required and contributed towards information commons; this was true for those scouring record stores in the 1980s and 90s, for digital piracy

[1036] Brandon Vigliarolo, "Tesla slashes vehicle and self-driving-ish software prices as share prices plummet", *The Register* (2024) https://www.theregister.com/2024/04/22/tesla_cuts_prices/ [18/07/2024]
[1037] Teriyaki Boyz, "Tokyo Drift (Fast and Furious)" *The Fast and the Furious: Tokyo Drift Original Soundtrack* (Universal, 2006)

and production booms in the 2000, and remains true today.[1038] Information commons are vital to, to the layering, parcelling and transformation of meaning in hip-hop.[1039] Andrew Sockanathan has described a prevalence of use and enthusiasm for the Oink's Pink Palace (OiNK) private torrent tracker from industry insiders and musicians; it offered them, as all its users, access to obscure and ultra-rare music they could not get elsewhere.[1040]

Unlike crypto-libertarians, digital commons movements are not organised around niche ideological fanaticism or any single intellectual or design tradition, but rather a common set of interests: access to an information. To one extent or another archivists, shadow librarians, P2P file sharing communities, especially dedicated seeders, videogame repackers, rippers, the developers of cracking software like MakeMKV, Wikipedia contributors and editors, the users of many user-generated-content platforms, such as GitHub, are all involved in the maintenance of information commons. Between them, these groups contribute huge volumes of voluntary labour to the maintenance of free information, which can be access for free. Some of these identify themselves in specific political traditions (e.g. shadow librarians, with the public library movement of the 19th century), but just as often work is instead arranged towards content itself (e.g. anime torrenting boards, or videogame emulation).[1041] Such work frequently requires creative appropriation of existing technologies towards the creation and maintenance of information infrastructures.

Though not all commons rely on it (sanctioned projects like Wikipedia or smaller libraries like Monoskop), BitTorrent is integral to much of the surviving information commons. Once legal force is brought to bear – when domains are seized, or offices raided – BitTorrent demonstrates remarkable endurance (recalling DARPA's interest in horizontal networking). So long as there are people willing to participate, torrents can be remade, and the commons can be reborn. When OiNK was forcefully shut down in 2007, for instance, its trackers were quickly re-established by enthusiasts.[1042] But there are limits to this resilience: as an infrastructure, torrents need to be maintained, and as raids and takedowns erode these infrastructures, many trackers never go back

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[1038] See: Paul D. Miller "In Through the Out Door: Sampling and the Creative Act", pp.50-20, and Jonathan Lethem, "The Ecstasy of Influence", pp.25-52, in *Unbound Sound: Sampling Digital Music and Culture* (Cambridge: MIT, 2008)
[1039] See: Salamishah Tillet, "Strange Sampling: Nina Simone and Her Hip-Hop Children", *American Quarterly* 66.1 (2014), pp.119-137; Also: Tricia Rose, *Black Noise: Rap Music and Black Culture in Contemporary America* (Middletown: Wesleyan University Press, 1994)
[1040] Sockanathan, pp.36-38
[1041] Dennis Tenen and Maxwell Foxman, "Book Piracy as Peer Preservation" *Computational Culture* 4 (2014) http://computationalculture.net/book-piracy-as-peer-preservation/ [22/07/2024]
[1042] Sockanathan, p.35

online.[1043] That online commons are the sole possible route to access to this kind of media (since their ostensible owners are not interested in publishing them) is testament to the archival value of these databases and demands that we regard raids, domain seizures and infrastructure destruction as great acts of archival vandalism, as digital book burning.[1044]

Like crypto-libertarians, the commons movement has often attached itself to conceptions of openness and freedom. One might look to the P2P Foundation, for instance, which deploys the "open" as a central tenet, at times interchangeably with the "common".[1045] For the P2P foundation this is still expressed in a quasi-post- or anti-capitalist "non-capitalist marketplace."[1046] For a different mobilisation, one could look to shadow librarian and activists, Marcell Mars, Manmar Zarroug and Tomislav Medak's "Public Library (an essay)"; they are also comfortable expressing this project via invocations of freedom, and they quote the French revolutionary slogan "Liberté, égalité, fraternité".[1047] Mars, Zarroug and Medak place the information commons (here the shadow library) into a different epistemology of liberty, quoting Melvil Dewey's, "Free Schools and Free Libraries for every soul."[1048] Most of all, they reject any notion of the free market as a legitimate mechanism for realising such freedom: "the commodification of knowledge, education and schooling" are an effective curtailment the ideal of universal access to knowledge embodied in the public library – which is now "endangered… doomed to extinction".[1049] The public library, they argue, was not just a product of, but also a location for, socialisation. If information is to act as a vector of freedom, they argue, it must be according to the principle of universal access to knowledge, of the socialisation of knowledge.[1050]

Towards a politics of decryption

The crypto anarchist manifesto (1988) echoes Eisenstein in calling print a "revolution", to which it sees cryptography as a successor.[1051] While the rise of cryptography has revolutionised digital culture, it has not put an end to intellectual property, as May suggests.

1043 Ernesto Van der Sar, "Music Group Confirms What.CD Raid, Claims Millions in Losses", *Torrent Freak* (2016), https://torrentfreak.com/music-group-confirms-what-cd-raid-claims-millions-in-losses-161118/ [24/07/2024]
1044 For instance Steyerl who finds films not available via legal routes
1045 Michael Bauwens, "Towards a Commons Transition Policy: Re-aligning Economiocs and Politcs for a Commons Centric Society" *P2P Foundation* (2016) https://revista.ibict.br/p2p/article/view/1784/1986 [04/11/2024]
1046 Ibid.
1047 Mars et al.
1048 Ibid.
1049 Ibid.
1050 Ibid.
1051 May, p.1; Eisenstein, pp.33-35

At one time, open movements might have seemed an adequate response to a marketized internet. Adrian Johns, writing in 2009, has suggested exactly this: that digital piracy and attempts to police it dialectically resolved into the open-access and source movements which would soon displace intellectual property: "Encryption techniques could be hacked, and were."[1052] But Johns' vision has unfortunately been discredited by history. Nathaniel Tkacz' account of openness exposes a reliance on closure (e.g. by cryptographic methods outlined in my thesis) to protect the "open" market.[1053] In particular, it highlights the inadequacy of "privacy" – integral to liberal notions of "openness" – for delivering access, distribution and innovation in knowledge.[1054] Against talk of an information revolution, encryption might be better conceived as a counter-revolution and the present as a post-counter-revolutionary moment. Openness has fallen short of its idealised agora; the revolution failed. One response could be a politics of decryption.

Anglophone Marxism has often been sceptical of the emancipatory capacity of networked communication. In reference to Californian figures and cypherpunk enthusiasts like Howard Rheingold, art historian Julian Stallabrass suggested in 1995, for instance, that cyber-optimism expressed only "the situation of the individual… more specifically of business people and their camp followers (engineers and intellectuals) spinning universalizing fantasies out of their desire to ride the next commercial wave."[1055] More recently, Alexander Galloway has argued similarly that decentralization constitutes a distributed form of control – and Ethereum's architecture embodies this well.[1056] Enregistrement technologies do entail the mechanical (automatic) imposition of capital accumulation onto a technostructure which has just as often produced commons, attempting in the process to circumnavigate any social democratic instincts from the state. But in rejecting the decentralization of "networks" flatly – as though all networked relations are the same – Galloway indulges a notion that the internet is naturally private (that it is born of and for capital) and that networks are, naturally, markets.

In reality (as Barbrook and Cameron show) the originating basis of cyberspace was always generous state investment, DIY experimentation and the sociality of participants – in other words, the coming together of commons.[1057] Capital was not at all totalising in the development of BitTorrent; whatever the horizons of its ostensible inventors, this is a tool of socialisation. Both Stallabrass' and Galloway's visions fail to realise the fallibility of capital's experiments with

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[1052] Ibid, p.506-509
[1053] Tkacz, pp.32-38
[1054] Ibid., p.18
[1055] Julian Stallabrass, "Empowering Technology: The Exploration of Cyberspace", *New Left Review* 211 (1995)
[1056] Alexander Galloway, "The Reticular Fallacy", *Culture and Communications* (2014) http://cultureandcommunication.org/galloway/the-reticular-fallacy [24/07/2024]
[1057] Barbrook and Cameron, pp.54-56

Bitcoin/ blockchain	BitTorrent
The market	Culture
Accumulation	Distribution
Mining rigs as "peers"	Seeds and Leeches as "peers"
Payment as incentive	No incentives
Systems require transactions	Transactions not possible
Resilient to redistribution	Resilient to content protection

Figure 11.5 Summary table of Bitcoin and BitTorrent's 'horizontal' architectures

information. This chapter has outlined the distinct social relations embodied in two peer-to-peer technologies, Bitcoin and BitTorrent (fig-11.5); whether and how information is free is still subject to contestation, by capital and the commons. Abandoning any horizon for information is to resign oneself to a cryptographic silence, and gift the commons to Capital. Decentralized protocols like BitTorrent are one available means for the emancipation of information-commons, as is the curational work of shadow librarians, and decryption software like MakeMKV. Left-wing politics must contend with such tools of communing as one historical legacy of the cypherpunks, alongside the crypto-barbarism of blockchain.

Meanwhile, intellectual property is inadequate and must be dismantled. A politics of decryption might ignore promises of individual access, and instead front a renewed call for collective ownership, of culture and of data. It might seek to move beyond legal structures oriented around individual privacy, such as the General Data Protection Regulation (GDPR) in Europe and the California Consumer Privacy Act (CCPA) in California, which define ownership of personally-identifiable data, but has nothing to say about the collectively generated data on which digital platforms run.[1058] Cornelia Vissman identified the emergence of the legal right to personal data ("right to informational self-government") with the advent of electronic media; perhaps the development of large data processing infrastructures and economies is the moment to demand common rights.[1059] Socialisation offers an alternate political base to openness or privacy, in which the custodianship, not commodification, of information systems is held central.

Attempts to reconcile crypto-techniques with conventional legal copyright enforcement are especially worrying; crypto-libertarians are unlikely to get their utopia but may well bolster the powerful corporations and bourgeoise state they claim to oppose. Horizontal or vertical, the

[1058] "General Data Protection Regulation (2016)", *Official Journal of the European Union* (2016), pp.1-88 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679 [03/07/2024]; "California Consumer Privacy Act (2018)" *California Legislative Information* (2018) https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?division=3.&part=4.&lawCode=CIV&title=1.81.5 [03/07/2024]
[1059] Vissman, pp.149-150

stakes are similar: without the socialisation of information, information will fall into novel depths of crypto-barbarism.

(De)coda: Socialising information

What is essential is…
to socialise information

The Computerization of Society,
Simon Nora (1978)

I began this thesis by invoking the cloud: an imaginary, corporate strategy and network architecture that obscures the material processes of networked culture. Against the stultifying effects of the cloud, we might recall Turing's vision of the computable as profoundly material, as that which "can be written down by a machine".[1060] From its outset, informatics – of culture especially – has proposed a transformation of its objects, which must be rendered as computable before the most primitive analysis. The computable is an important category, one that suggests we be attentive to the transformations engendered by computational processes; in practice, such transformations have often served niche interests and baroque ideological currents: the late 20th century telecommunications industry or the still ascendent crypto-libertarianism, for instance. One intention of this project has been to expose some of these currents.

But the development of information processes and infrastructures has, at times, been organised towards more desirable ends. In addition to reflecting on the overarching arguments, and key contributions of the thesis, this final reflection intends to draw together a few threads and comments which have looked towards a different articulation: the socialisation of information.

In 1978, in a flawed and highly remarkable document, titled *The Computerization of Society* (*L'Informatisation de la société*), French senior administrator Simon Nora laid out a vision for the telematic transformation of his society, arguing explicitly for a "socialisation of information."[1061] Four years later this vision was manifest in Minitel, an early computer network, important predecessor and sometime competitor to the Web.

[1060] Turing, "On Computable Numbers", p.230
[1061] Nora, p.125

The English translation of Nora's paper remarks on its presentation of information, as a matter for policy, not the market, as alien to a presumed American readership.[1062] Indeed, Nora's vision of telematics was highly specific: a view (familiar to readers of a Californian Ideological orientation) that access to information would inevitably produce "emancipation and democracy" but translated into the language of French bureaucracy. Not least its scale is novel: between the global and the village, Nora identifies the "information agora" with the French state.[1063] Most of all, he believes that feedback mechanisms ought to be established between governance-from-above and knowledge-from-below (in this sense, these technocratic plans resemble Stafford Beer's cybernetic experiments in Chile five years earlier).[1064] The document is beset by a naive view that expanded information systems can co-exist with (and will in fact depreciate the power of) the market; a claim which has not been borne out by the history contained in this thesis.[1065] Yet there is also a vision for technical development as mediated by politics, a cultural and planned economic defence against American market dominance and private governance.[1066] Nora wants to realise McLuhan's electronic agora – something we might reject on its own terms – but he does not hold the same naiveties as his American counterparts: without intervention, he warns, telematics will serve "rigidity, authority and domination."[1067]

Despite its inadequacies, Nora's paper makes a potent intervention to our technological imagination for two reasons: 1) it articulates a 'modernist' form of thinking – a planned network for social good – which the privatisation of today's information systems has rendered unthinkable, and 2) it articulates this not as an inevitability of information (though he does sometimes express naive determinisms), but as a possible outcome of its contestation.

Reconstructing codecs

One finding from my research project is the centrality of codecs in the production (and hence shaping) of information through circulation. Codecs, I've suggested, reflect the vying determinisms at play in our digital culture – and might even be a point for intervention.

Chapter Two established codecs as a methodological and conceptual focal-point for the thesis. Drawing on Stuart Hall's encoding/decoding model of culture, I argued that codecs constitute "determinate moments" in the circulation of information, the consolidation of disparate

[1062] Nora, pp.xi-xvi; An anecdotal aside: the original owner of my second-hand copy has written in the pencil that they bought it in Rockefeller Centre in New York in 1985, perhaps indicative of its circulation
[1063] Nora, p.11, p.140
[1064] Ibid., pp.134-6; Stafford Beer, *Designing Freedom* (Toronto: House of Anansi Press, 1974); Medina, pp.195-139
[1065] Nora, pp.133-136
[1066] Ibid., pp.7-8
[1067] Ibid., p.11

determinisms, rules and logics into technical devices.[1068] A key weakness of Hall's model is its lack of media specificity, motivated by a fear of "technological determinism" though, as I have argued repeatedly, ignoring such questions itself constitutes a vulgar social determinism.

Instead, I argued for an expanded conception of information in which codecs are understood as the meeting-points of channels, determinate moments in wider circulations of causality. Compression and Encryption, I argued, are general categories of codecs – aligned to general logics – which have both been radically altered by, and radically altered, economic, social and cultural life in the 20th and 21st centuries. It is an important observation that while such devices, and their plans/protocols, are infrastructural, their articulations are not fixed; repeatedly, in a history of information processes, one finds transformations in the underlying logics of technical development borne from changes to its context, in economics, institutions and politics (this is technology "looked for", as described by Raymond Williams – though there is also technology happened across, or stolen).[1069] Methodologically, codecs offer locations through which analysis can draw unexpected concerns, determinisms and structures together.

Important examples can be found in 20th century commercial and wartime research. In Chapter One I argued that, before and after the First World War, news media, military communications and colonial logistics expanded telegraph networks for the electronic distribution of information, and began optimising methods for the transmission of text, sound and images. In World War II, cryptography matured as a science and practice, culminating in Claude Shannon's theorisation of encryption; after the war, Shannon applied this knowledge to the commercial circulation of information in the form of telephony, effectively inventing data compression. I argued that Shannon's 'efficient coding' can be viewed as a typical exercise in what the Marxist geographer David Harvey has called time-space compression, following Marx's description of the "annihilation of space by time".[1070] Such annihilation is the compressive side effect of the accelerating circulation of commodities, itself pursued to minimise bottlenecks between production/consumption, and maximise the efficiency of capital accumulation. Telephone companies (charging per minute) were able to circulate more information over the same limited channel via efficient coding, increasing the accumulative capacity of a limited channel. In Chapter Three, I set Harvey's theory in conversation with theories of technological and cultural acceleration, arguing that disorientation and overstimulation are common responses to the escalation of networked communications. Such compressive effects defy easy disciplinary distinctions, shifting between economics, aesthetics and subjectivity.

[1068] Hall, "Encoding and Decoding…", p.260
[1069] Williams, *Television…*, p.14
[1070] Harvey, *Postmodernity*, p.147; Marx, *Grundrisse*, p.539

While the specific concerns of Shannon and his colleagues have had a lasting structuring effect on networked communication and computing, designs for information processes have since shifted. After Shannon, the development of perceptual coding techniques – with various ‘new media’ applications in mind, and straddled between European social democratic, American free market and Japanese corporatist interests – entailed a departure from Shannon’s ontological claims, with a more complex hybrid of interests. Chapters Three and Four revealed that JPEG engineers, drawing on a cybernetic model of human vision, constructed a coding process oriented towards an idealised human decoder. Across a broad continuum of computer vision engineers, anatomists, psychologists of vision and image processing experts, I argued, human vision came to be understood as an information process, based on which image codecs were constructed. Coding techniques were developed which anticipate lossy compressions in the human visual system, allowing for compressions in data with minimal artefacting of images themselves. There are two significant consequences of such perceptual coding techniques: first an ontological challenge to Shannon’s isolated model of the channel into which part of the human anatomy is now inserted, and second the possibility of circulating detailed perceptual data over the same small channels that telephone signals had previously been distributed. Such codecs should be viewed as core enabling technologies of a multimedia internet, ‘new media’ and the phantasmagoric audio-visual culture of our present. Both the technical and institutional accounts I offer of JPEG are novel, contributing to the “general history of compression” instigated in Jonathan Sterne’s work on the MP3.[1071] My account of perceptual coding oriented towards a human visual system model offers a useful addition to Sterne’s primarily audio-oriented account.

Within the JPEG-1 standard, I argued, one can identify several coded logics. There is a conception of ‘efficiency’, inherited from Shannon, as well as a number of arbitrary rules of expression inherited from film photography. But there is also, for instance, a codification of gendered and racialised modes of image resolution via a subjective testing process that exclusively utilised images of young, light-skinned women. Most significantly, JPEG’s process is oriented towards what I call legibility: the production of images which can be understood by human viewers, even well after lossy compression has marked their surface. Such a logic extends to the interchange format for JPEG, which requires table data be stored at the front of the file (reducing overall compression) to ensure any JPEG codec will be able to decode the image.

Functionally, JPEG makes the construction of proprietary image codecs difficult. JPEG images contain no copy protection, and copying or transmitting them is trivial. Hence, they have contributed significantly to what I’ve called an over-circulation crisis for capital, in which the

[1071] Sterne, p.5

efficient circulation of commodities has made it harder, not easier, to realise capital accumulation. Such a situation complexifies the concept of time-space compression; contestation within the JPEG committee demonstrates the presence of multiple economic, institutional and political interests in development, most clearly articulated in the internal contestation over whether JPEG should be free of proprietary coding methods. Some engineers – especially those at the French nationalised CCETT – articulate their roles as serving public good, not specific corporate interests.

In parallel, as I showed in Chapter Eight, cryptography was rapidly reconceptualised from the 1970s onwards: from a technology of secrecy, first to one of privacy, and ultimately into novel methods for the securing of information as property. A rhetorical defence of private life (against the new availability of photography and ease of transmission) fed into the construction of general encryption standards like DES and AES. Meanwhile, a general politics of encryption emerged (sometimes referring to itself as a movement, the cypherpunks) which argued the cryptographic securing of communication and transactions was necessary for the construction of an open internet. There is a clear tension in this politics, between an articulation of openness and these applications of encryption.

As secrecy, privacy or property, encryption has the difficult task of preventing the spread of information. In this sense, I argued, encrypted information functions inversely to information conventionally conceived, as a "neginformation" function, which destroys the capacity for meaning. When it is applied to information intended for the human senses – to art or music – it comprises what I've called a cryptoaesthetics, a regime of sensory control which denies human perception and is therefore only identifiable through forensic methods.

A central form in today's digital capitalism, I argued in Chapter Nine, is the encrypted commodity, from which cryptoaesthetics are manifest. Encrypted commodities, I argued, bring to the fore an occult structure (historically more marginal in conventional commodities) in which the technical mediation of access enables new forms of control over distribution and use. In Chapter Ten I examined the techniques that have been developed to achieve this, notably the importance of an open standard of encryption for the cryptographic experimentation of the last thirty years. The encrypted platform, I argued, has emerged as the form most capable of enforcing the circulation of information as commodities. Such platforms restrict access to proprietary user interfaces (DRM), and limit access to those specific operations allowed by the software, limiting the copy above all else.

Information processing has been iterated and modulated many times in the past century. Today we are faced with compression and encryption-as-property as its major expressions, as organising technical logics for digital culture and the circulation of information. A description of their emergence in this form, as well as the technical cultural and economic currents they embody, is the primary novel contribution of my thesis.

The 'free'

A pervasive hope of my thesis has been to identify articulations of coding systems that breach or mutate the logics of compression and encryption, realising something beyond a simple dialectic of accumulation and enclosure. Indeed, I've found a more complex array of intentions, logics and infrastructures that contribute to this overall character, but also to the contested history and contestable future of networked information systems. Alongside the coding of digital commodities, occult information systems and market dynamics, one can also find the valorisation and maintenance of information held in common. Very often, this comes attached to notions of the free. Like openness – its moderate cousin – freeness is widely used and vaguely plastered around cultures of software engineering and technology development.[1072]

Freedom is a slippery concept tied up with ideological horizons and social relations. Freedom for one group, behaviour or concept necessarily entails restriction to freedom in other domains (well demonstrated in Tkacz' account of openness' contradictory logics).[1073] While invocations of freedom (or related ideals, e.g. liberty) are a running theme of both American and European technological culture, and so recur differently inflected throughout the thesis, I have discussed cultural articulations of freedom in particular length in Chapter Eight. I argued that invocations of information's freedom can be inflected in either structural or political terms. Structurally, information's 'freedom' tends to describe its capacity to be copied and distributed, a quality (inseparable from its processing via compression) which has been met as often as frustration as it has virtue. Indeed, with irony considering their rhetoric of openness and freedom, frustration with this capacity – either due to its lack of concern for individual privacy, or for private property – functioned as a core motivator behind the cypherpunk politics of encryption. Politically, information's freedom has tended to defer to the ideals the political projects it appears within. As touted by McKenzie Wark, information's freedom is that of creativity, whereas as touted by Richard Stallman it is an extension of free speech, and so on.

While this is a product of information's capacity for movement, some Marxist theorists of aesthetics such as Susan Buck-Morss or Jonathan Crary have described contemporary media as an overstimulating phantasmagoria of sounds and images which creates numbed, restrained subjects (as an effective barrier to human liberty). I argued in Chapter Six that such a number of aesthetic strategies have emerged in response to this perception of society at speed, most notably

[1072] See: Tkacz, pp.1-4
[1073] Ibid., pp.33-38

slow practices across film, food, television, music and among a range of other commodified cultural practices. But contemporary digital capitalism, I argued, has been adept at subsuming slow practices; today even idleness can be monetized. I examined this phenomenon in relation to the idle genre of mobile games, looking at the complex strategies of distraction and retention such games utilise to recoup so-called 'free time' – time beyond work – to the realisation of accumulation. Indeed, I read the 'freeness' of free time as key battleground in our compressed digital culture, in which few operations do not contribute in some way to the production, circulation or consumption of commodity flows.

If neither slowness, openness, nor even freeness can offer coherent relief to compressed subjectivity, we will need to be precise about the forms we want to see realised and in what ways we want to live together, with and through technology. And in this sense, some ideals associated with the open or free might be more concrete and desirable than others. The ideal that information should be widely available is, for instance one which fits entirely coherently within a project of socialisation. Libraries offer different freedoms than markets; in chapters eight and eleven I drew from the digital library movement. Here one encounters a distinct invocation of the free, via Melvil Dewey: "free libraries for every soul".[1074] Dewey's utopian conception of public libraries, in which anyone can have free (from the market, from payment) access to knowledge has been invoked as a basis on which to base a contemporary project for the socialisation of information. But the socialisation of a library attends to more than the distribution of knowledge: it suggests on the one hand universal access, provision and care – for people and knowledge – and on the other a free space, which anyone can occupy to work, study or to be involved in community activities: classes, clubs, groups, etc. The public library entails, in other words, a public space; difficult questions remain about how the same can be achieved within the deeply private infrastructures of the internet.

Political machines

Codecs are both consolidations of social forces and productive agents in their own right, and so we ought to be attentive to what spectres animate them. Inflected by different politics, codecs have been developed which explicitly contest the terrain of digital culture (seek to produce new kinds of network relation). These codecs embody experiments in novel kinds of automatic politics, emanating from the protocol (the codec's design) outwards.[1075] One contribution of the thesis has been a reflection on the possibility and effectiveness of political machines of different kinds.

[1074] Mars, et al. "Public Library (an essay)"
[1075] This distinction, between the schematic protocol and the embodied codec, is defined in Chapter One.

In Chapter Eleven I traced the emergence of an ideal technical process, which I named enregistering, in which the inscription, execution and most importantly compliance to a code might be fully and automatically integrated. As described in Chapter Two, the etymological origin of code is "codex", which under the Roman emperor Justinian I came to describe both his laws and the medium of their inscription; enregistering proposes an extension of this logic to encompass the articulation of such laws in the world (though proponents of such processes often present them as extra-legal). So called problems of "trust", and attempts to solve them, emerge in techno- and later crypto-libertarian ideology as a dream of total governance – tyranny – by engineers. While such an ideal is not in reality achievable, it has entailed the innovation of new forms of authoritarian control on expression, use and action. Enregistering is best exemplified by the crypto milieu via experiments with blockchain, especially within Ethereum. Smart contracts, for instance, create an architecture for the automatic execution of code upon the transfer of currency, one component in an idealised system in which democratic institutions are displaced by codecs which singularly serve the interests of property or accumulation.

I've suggested that BitTorrent, despite emerging from a similar context, is a different kind of political technology that exceeds the imagination of its engineer. It has been widely used in online filesharing as an efficient, resilient and equitable means for distributing information, without the need for mediation from a market, or for complex forms of financial coercion ('trust' solutions). It serves as a typical example of the appropriation and mobilisation of an information processing technology for the realisation of a culture, and a key tool for the maintenance of digital culture. But the appropriation of tools like BitTorrent alone has not continued to expand common information; online libraries, for instance, are in an ongoing process of decline – targeted by legal action, physical raids, a lack of resource and steady archival decay – entailing the permanent loss of knowledge.[1076]

Such fragility points to the importance of archival labour, and to a need for 'modernist' thinking, for a project not unlike Melvil Dewey's: the active construction of social (and technical) infrastructures. The public library is a design for the distribution of knowledge, and for a space in which knowledge processes (dissemination, education, discussion) can take place. Both the privatization of internet infrastructures, and their obfuscation through the cloud, constitute a powerful form of capitalist realism, against which alternate infrastructures and imaginaries are needed. Already in 1978, Nora articulated well the extent to which technological discourse only

[1076] For difficulties maintaining such knowledge, see: Henry Warwick, "The Slow Cancellation of Online Libraries", *Institute of Network Cultures Blog* (September 2024) https://networkcultures.org/blog/2024/09/22/henry-warwick-the-slow-cancellation-of-online-libraries/ [02/11/2024]

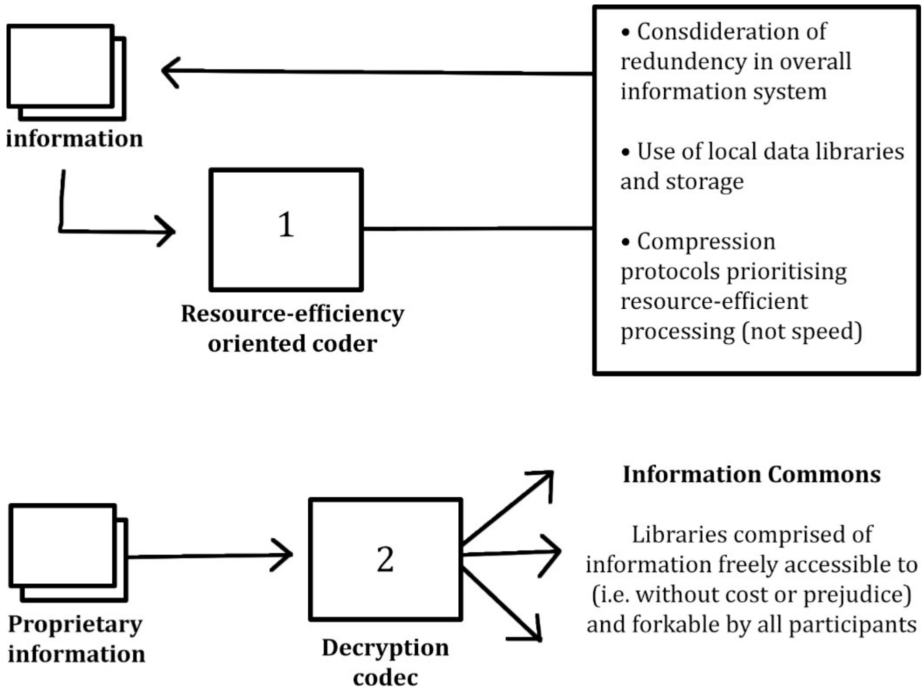

Figure 12.1

Sketches of two speculative (i.e. not existing) codecs:

1) A resource-efficiency oriented coder which circulates information on the basis of minimal resource use.

2) A decryption codec which renders proprietary information free.

Intended as indications, not schematics.

permitted expressions of collectivity via the market, positioning public investment in informatics (realised in Minitel, and protocols like JPEG-1) against this.

Nora's naive determinism is seductive: "computerization means information, information means culture, and culture means emancipation and democracy."[1077] Indeed, information has historically made expansions and circulation of culture possible; but, in a cryptographic media landscape, this can no longer be guaranteed as a structural feature of the form. Meanwhile, his presumption that abundant information will itself entail democratisation has clearly not happened, but his indication that such an aspiration must be built towards is one we might draw upon, if we desire something other than technological fatalism. Libraries are a more effective means for preserving and distributing knowledge than markets. Necessarily, such thinking requires the vulnerability of proposition, and a form of (guarded) utopianism which has become unfashionable. Beyond efficient circulation and privation, we might begin to imagine codecs which prioritise resource-efficiency, common ownership or collective agency (fig-12.1).[1078]

Two crises

Digital scholarship today – in the all-encompassing generality of that phrase – is beset by crises.

1077 Nora, p.11

1078 Cf. Roopika and Gil's "minimal computing" for non-resource-intensive computing; for collective agency, Cf. Beer; For precedent in speculative codec design (though one instantiated in software), see Paul B. Davis' 2009 proprietary compression algorithm, *Codec*, which transforms pixel values to match those of one of his earlier works (transforming them into something uncannily like it). Available at: https://www.seventeengallery.com/artists/paul-b-davis/ [08/01/2025]

There is an API crisis: the withdrawal of access to digital data in favour of monetized data-systems and obscured practices. Digital archives are in a state of decay, and offline institutions are facing drastic funding cuts and contraction. While conceptions of the “open” internet were always flawed, it is hard to avoid nostalgia for a time when objects for research were at least available. Together, digital technology and the defunding of humanities research has generated a crisis of methods, with lines drawn up between the close and the distant, between data and text as bases for analysis. Beside the privatisation of knowledge, such epistemological conflicts become trivial.

Meanwhile, in no small part linked to the things we study, there is a crisis in biosphere. I discussed in Chapter Seven two relevant concepts: ebullition and exhaustion. At the planetary limits of resource extraction and carbon emission we face ebullition, the boiling over of our economy in such a way that cannot be reinvested as growth. Ebullition is driven by the same process as compression: endless accumulation. Even now, accumulation exhausts us and the planet, straining the productive capacities of universities and the researchers within them, and compressing our horizons.

One might consolidate these things into two interrelated crises for digital scholarship: the plundering of the commons and the exhaustion of the earth. Such crises manifest as local issues – enmeshed in the specific industrial conditions of academia, and in the teething pains of ‘digital’ disciplinarity – but one hope of my thesis is to set these local crises within a broader history.

The privatisation of knowledge and the exhaustion of the earth demand political responses. Codecs represent one possible point of intervention. Analytically, we might begin by fleshing out a methodology of decryption; practically, we might draw plans for new codecs (fig-12.1). Both might be mobilised within a politics for the socialisation of information.

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