The crystal world: executing a new media materialism

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The Crystal World: Executing a New Media Materialism

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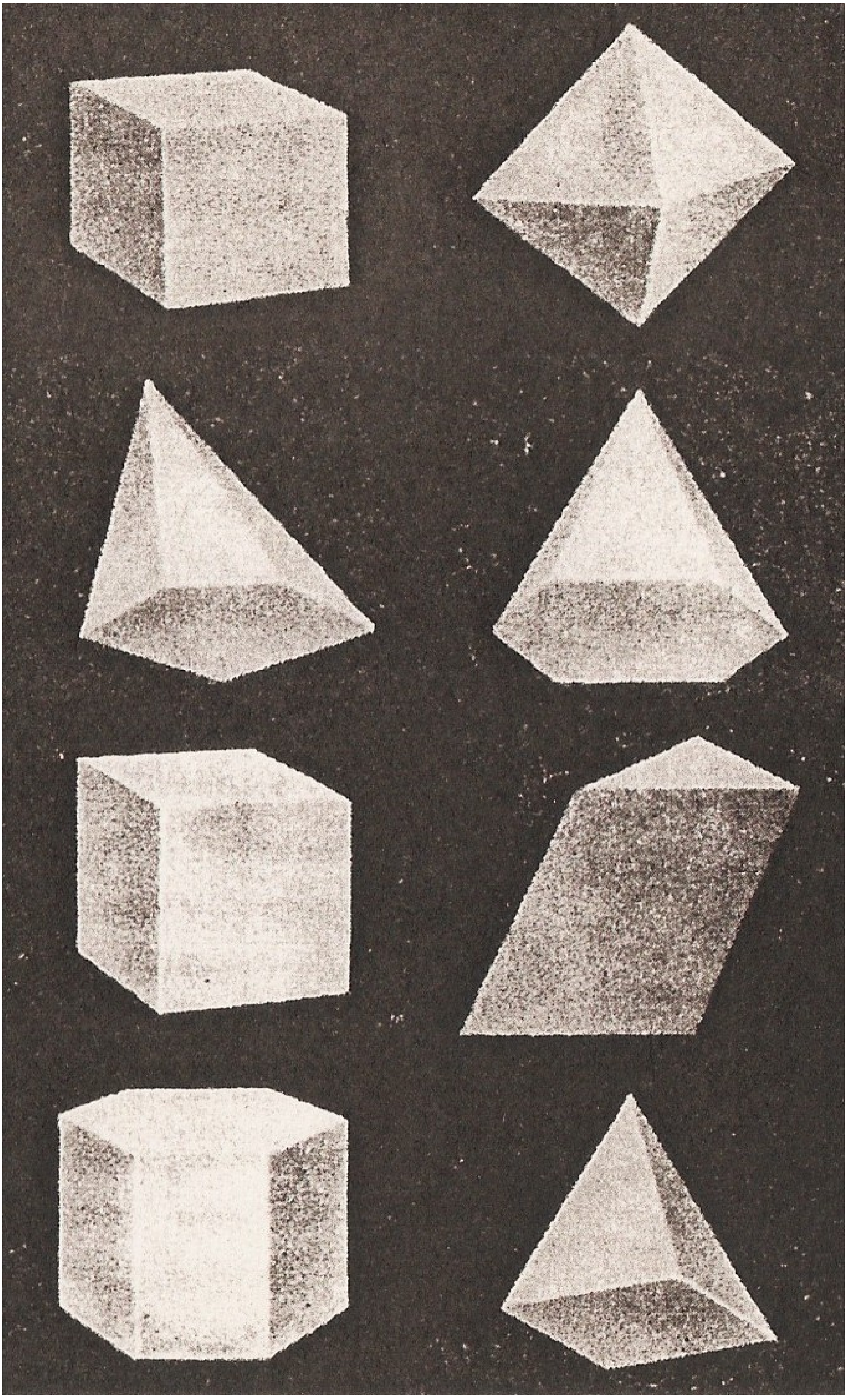
Submitted in fulfillment of the requirements for the

Degree of Doctor of Philosophy

March 2013



Abstract

This thesis presents practice-based research to establish new forms of social and artistic production through examinations of the materiality of the technical media, namely the computer, that underpins new media art.

Contemporary new media art practice has tended to focus attention on software or hardware interfaces, interactivity and network communications. Whilst explorations of these specific affordances of computational media have been important they have generally avoided a more informed engagement with the material structures that frame, underpin, and ultimately shape the works produced with these media.

The hypothesis of the research is that a richer understanding of the creative potentials of computational media as a form of practice can accrue from an active engagement with these material foundations in which any computational device employed in a media art practice is embedded.

Thus the research presents a novel methodology for approaching new media art, driven by an imperative to engage with the computational, not from some abstract and universalised point-of-view, but up close with a focus on the materiality of its media and thus on matter itself.

Hence a second assumption in the research is that this lacunae has impacted on the geology of ideas around new media theory and practice, and includes a failure to account for the intractable difficulties around the material production of the technical media that underpins new media art.

Following Karen Barad, the research employs, a diffractive methodology - a practice of presenting computational materiality through insights and traditions while paying attention to their differences, including the material effects of their constitutive exclusions .

Using this methodology, new forms of production have been achieved with the participation of diverse groups of people in workshops, “open laboratories”, and two

exhibitions. It is intended that the methodology can be adapted, used and developed by practitioners in new media art, philosophy, media archaeology, museology, ethnography and anthropology.

Cover illustration, *"Geometry"*, 2011, courtesy of Soizig Marie Carey http://soizigmarie.com/

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Research Practice Documentation

With reference to the research practice, online documentation from each project event is listed here. All iterations are easily accessible from the first URL, The Crystal World Project Website. Unless otherwise stated, all other listed URLs are front pages from each iteration of the project which have links to their various components, including illustrated post-descriptions, image archives, and impressionistic videos.

The Crystal World Project Website	The Crystal World
Decrystallization (May 2011)	Decrystallization
(direct link: impressionistic workshop video documentary)	Decrystallization Video
Recrystallization (July 2011)	Recrystallization
Chemical-Material Performances (July-October, 2012)	Oto_Documentation ICA_Documentation
The Suffolk Psychogeophysics Summit (August 2011)	Artificial Fulgurites
The Crystal World v.01 (February 2012)	Description
The Crystal World v.02 (July-September 2012)	Description
(direct link: impressionistic exhibition video documentation)	The Crystal World v.02 Video

In addition Version One of The Crystal World Reader is available to download via an index page:

The Crystal World Reader (Last modified July 2nd, 2012)	The Crystal World Reader v.01

Preface

Recent developments in “new materialism,” an emerging trend in twenty-first century philosophy, have come to the fore in various discourses, impacting, among others, the arts, feminism, science studies, and cultural theory. In the realm of the computational, the author of this research was reminded of how several works executed in the last decade with a long term friend, the artist Martin Howse (as both *ap* and *xxxxx*), address some of the issues and tensions of new materialism in their themes and outputs.

Martin had elaborated a project regarding where software might be said to be executed: in the social, in hardware (there is no software), in the environment (“code is environment, environment is code” was a particular slogan Martin coined as a working strapline), and these explorations, combined with concerns expressed in other work as a sculpture conservator about cultural inscription and material authenticity, primed this research through the long standing question of how is cultural meaning inscribed (and re-inscribed) in the material? That is, how are the behaviours of materials so codified as to signify something other than their localised morphologies, even if those morphologies deform over time? Thoughts turned to and coalesced around the materiality of the computer as a rich source of prospecting around this question within new media art.

Where notions of abstractions away from and beyond the circuit board had interplayed in *ap/xxxxx's* previous work, mining into the materiality of the board thus became the framing ideology of this research. Although Richard Feynman and Matthew Fuller had commented on how layers of abstraction emanate from the Level 1 of the circuit board, similarly other layers can be disinterred through examinations of the materials composed in that circuit board. This, thankfully, can then move discussion away from the abstracted universality of the Turing Machine, where the material is merely contingent, to one of asking just what are the materials, the rocks and minerals, upon which we inscribe computation?

Acknowledgements:

Special thanks to: my supervisors, Dr Tom Corby, Dr David Cunningham, and Alison Craighead; Martin Howse, Ryan Jordan, Nihal Yesil, Kirsty Stansfield; Jim Prevett/SPACE London; Ela Kagel/Supermarkt, Berlin; Oliver Baurhenn and Jan Rohlf /Club Transmediale Festival, Berlin; Tamami Iinuma and Tanya Mar; Laure Betris and Sally de Kunst/Belluard Bollwerk International, Switzerland; Bruno Vianno and Cinthia Mendoza/Nuvem, Brazil; Rob Myers and Marc Garrett/Furtherfield; Anthony Iles and Josephine Berry-Slater/Mute; and to all those participants integral to the project.

Declaration

This is to confirm that Jonathan Kemp is the author of this thesis. Unless otherwise stated, all references cited have been consulted by the author. The work, of which this thesis is a record, has been created by the author, and this research not been previously accepted for a higher degree.

Jonathan Kemp

Signature:

Date:

Introduction

Research scope:

The research has been designed to explore particular framings of the technical media that underlie all new media art *viz.* computers, so as to enhance understandings of their material foundations (as mineral niche systems).

It is the hypothesis of the research that a richer understanding of the creative potentials of computational media as a form of practice can accrue from a deeper investigation of and creative engagement with these material foundations in which any computational device employed in a media art practice is embedded. The contribution this hypothesis presents is a theoretical and practical framework for both the analysis of new media art (NMA) and creation of new works through a reconsideration of NMA's critical relationship to its material substrates.

Contemporary new media art practice has appeared to focus attention on software or hardware interfaces, interactivity and network communications. Whilst explorations of these specific affordances of computational media have been important they have tended to avoid a more informed engagement with the material structures that frame, underpin, and ultimately shape the works produced with these media. Thus this research is purposed to identify, investigate, and implement a range of materialist and constructivist strategies with which to explore these substrates as the means of production for new social and artistic works within new media art.

The research hypothesis is based on the assumption that while NMA's technological and aesthetic innovations rely on arrays of material substrates, an account of such materiality has been generally left out from its theory and practice. For example, the arc of NMA practices incorporated around an ethos of “free software” or “open hardware” have not provided any similar account along the lines of what might be described as “open materials”. Hence a second assumption of this research is that this bracketing out has impacted and skewed the geology of ideas and practice within NMA.

The scope of the research for investigating the hypothesis is concentrated around:

i) understanding current theoretical framings of new media art in order to test the assumptions of the research hypothesis;

ii) exploring how new media art practices are reflections on and situated in wider philosophical practices, in order to

iii) investigate the material architectures of computational media through practical investigation into their material substrates in order to test the hypothesis,

iv) and develop a range of creative strategies that both involve and are made freely available to other new media art practitioners and a wider interested public.

The research is thus premised on a series of practical investigations into the materiality of components on the level of the computer circuit board in work charged with confirming the hypothesis, that it offers practitioners valuable affordances for the means of production for new social and artistic works within new media art outside of any normative and functional usage.

Given this hypothesis, it should be noted that although a detailing of new media art's emancipatory promises or its technological toxic legacies is outside the scope of this research, such themes have explicitly modulated investigations into the materiality of new media art in some of the studio practice executed in the project.

Methodology and Methods:

The research is practice-led and designed to enable the generation of qualitative insights into the research issues and objectives, along with a transparency through all preparatory workings and practice documentation being made available for public and peer scrutiny through their online publication.

The thesis presents theoretical and practical work executed in the research, namely:

a) the production of the contextual review in which to situate the research in both historical and theoretical contexts, as described in objective i), and within a wider philosophical context, as described in objective ii).

The theoretical framework of the review has been driven by reflection upon recent trends in philosophy with a critical focus on some of the concerns derived from recent new materialist philosophies - one output has been the incorporation of the concept of “diffraction”, with its reference to the distribution of agency, as an important methodological tool for production within the research process.

b) Studio practice, including public workshops and open laboratories, has been designed to meet objective iii) and iv), to discover if work based around experimentation and exploration of the material viz. selected mineral substrates of computer hardware afford new creative strategies for practitioners.

Where these explorations have been through public events they have been made possible because of the new collaborations made with other practitioners who share similar theoretical concerns to the researcher.

c) In order to fulfil the mandate of open distribution, as described in objective iv), all practical work has been extensively documented and published online in the form of easily accessible, comprehensive and clearly navigable dedicated wiki site and public AV repositories. This documentation, including audio, video, image, and project documents, provides material for the tracking, analysis, and interrogation of the practice by interested parties.

The publication of this documentation has been implemented to ensure clarity around the conditions of work production and to present a methodological transparency to the research executed in both studio and public practice.

Criteria for successfully executing this research is measured by well attended and supported events; positive appraisals of those event's creative outcomes; and continued critcal and peer support for project development from a broad range of constituencies.

Research Thesis

The first chapter of the thesis, *Computational Materiality*, presents theoretical bases relevant to the research. The core issue in the research, that NMA has generally left unaddressed the materiality of its underlying technical media, is tested through a review of some of the theoretical influences and canonical studies in NMA from over the last two decades. A closer intellectual strain, that of media materialism, is introduced before the chapter moves to provide an account of classical studies of computers at the level of their substrates, with reference to Turing Machines, von Neumann architecture, and bio-computation.

The chapter then surveys recent philosophy of what can be called the post-human turn, before the penultimate section will link these latter sections to some more recent new media theory. The concluding section situates the research objectives with reference to the theoretical background as presented, before introducing a novel framework of *diffraction* for the production and analysis of new media art.

Chapter Two, *Executing a new media materialism*, further details this framework and how it underpins the research, before going on to describe the practical project *viz.* a series of workshop events and open laboratories.

The first workshops, “Decrystallization” and “Recrystallization”, are described and discussed to highlight key elements that relate to the research themes. Two brief sections, “Chemical-Material Live Performance System”, and “The Suffolk Psychogeophysics Summit”, detail performance and experimental strands, before the last section of the chapter introduces and discusses two iterations of “The Crystal World”, and concludes with a final discussion which re-iterates the project's performative relation to the material, with reference to agential indeterminacy and instrumentalism.

The final chapter, *Methodological Diffractions, Perverse Confluences,* picks up this theme to emphasise the discontinuity in representing these materialities within any operative diagrammatic through an examination of collaborative methodologies that have diffracted the project. The chapter sketches out various strands of co-operative social production, beginning with free software and open hardware initiatives, before elaborating on some of the political and epistemic problems in attempting to re-map such practices as acts of critical practice or as means of subjectivation. The last section of the chapter diffracts the project with the tradition of “refusal”, before the thesis is concluded with a brief coda.

Summary

In summary, the materiality of NMA's technical media defined the research field for this study. A practice methodology has been developed around a concept of diffraction and executed in a series of collaborative environments as new forms of new media art production. Although the lived experiences of those experiments are performative and often non-transferrable, the research presents both a practical and theoretical resource for the further interrogation of technical media of new media art.

While also contributing to the development of my own artistic practice, this novel research methodology has the potential to inform practitioners and theorists of new media art, along with other artists embarking on academic research.

Chapter One - Computational Materiality

Introduction:

In this chapter the core issue in the research is presented: that although new media art's (NMA) technological innovation depends on a seemingly inexhaustible material reconfiguration, an account of such materiality has been generally left outside of its theoretical and practice based taxonomies and conventions.[1]

Notwithstanding that some practices in NMA are often progressive in their concept, technique and relationship to their means of production, and can successfully generate alternative, self-organised, and open structures for their creation and distribution, there has, nonetheless, been a consistent bracketing out of any sense of the material basis of such art.

It is the assumption of this contextual review, as related to the main objective of the research, that this lacunae has impacted on the geology of ideas around new media theory and practice, and includes a failure to account for the intractable difficulties around the material production of the technology that underpins NMA. For example, that the primary substrates of computer technology (and its associated networks) originate in the earth from where it is extracted in chains of production hidden in the finished product (the rub to any notions of "immaterial labour") predicates the argument that any promise of emancipation through technology needs to incorporate an analysis of these conditions before it declares itself as such. In other words, if media technologies already incorporate a materialism that includes both solids and non-solids (eg. minerals and electromagnetic waves) and declares their particular configuration to be emancipatory, then they also incorporate a materialism which, among other things, leaks a toxicity over both people and lands at all points in their production cycles.

Although neither a detailing of technology's emancipatory nor toxic imports is the object of this research project, modulations of technology are implicitly referenced in some of the

1 The term "new media art" is used here to encompass designations such as Computational Art, Digital Art, Electronic Arts, and including Software Art, and to refer to both practice and theoretical studies.

practice executed for it (detailed in Chapter Two: Executing a new media materialism), given that its main aim is to investigate the affordances that the primary materials of the computational can offer new media art practitioners. Hence another assumption at work in the chapter is that NMA has generally been unwilling to conceive of its own media as being, at base, decomposable into arrays of materials and practices that mediate each other.

Media (from the Latin *medius* "middle element") can be defined as anything used for carrying information between senders and receivers. Thus "new media" have included diverse things such as clay tablets, tattoos, incised stonework, papyrus, illuminated manuscripts, the printing press, the telescope, the camera, X-radiography, and the electric light. All such media can be described in terms of their physical materials and processes and the localised relationships that generate them as an information carrying object at any given point in time.[2]

However, given the thrust of this chapter, there are three things to be said in relation to this definition of media.

Firstly, as Wendy Hui Kyong Chun notes in her introduction to *New Media, Old Media: A History and Theory Reader*,[3] the use of the word "media" has tended to have an anthropocentric symmetry (intelligibility) explicitly emphasised in its usage; secondly, that as the discourse of NMA has emerged from the dominant and occidental intellectual climate of the 1980's, from its beginnings NMA theory has positioned itself on the phenomenological side of this symmetry and askance from providing an account of the materiality of NMA as understood here. Thirdly, where this definition posits media as being between senders and receivers with humans being at least in one of those roles, then it also obscures any suggestion that there is a continuum that runs between the physical

2 Anthropology and archaeology in a way do a bit of this. Media archaeology specifically attempts to do this with a methodology that is anti-teleological, and materially grounded.
3 Wendy Hui Kyong Chun, introduction to *New Media, Old Media: A History and Theory Reader*, ed. Wendy Hui Kyong Chun and Thomas Keenan, (Oxford: Routledge, 2006), 3.

materiality of any media and the information that that media carries. Arguably, the materials, voltages and electromagnetic waves in, for example, computers, are inseparable from the signals and abstracted symbols and meanings of human society. With this view those lower down the scale, the *unter*-signifying components like voltage behaviours and the thermodynamics of minerals, cannot thus be conceived of as belonging to one abstract level of say, hardware, but should be seen as having a motility far beyond just those other levels of software interface or code (I will return to the discussion of levels in the later sections of this chapter). This then is the central object of the research, to open up the machine methodologically so as to recast its materiality and physics.

Hence this chapter will first drive through a brief survey of some of the theoretical influences apparent in NMA before addressing several canonical studies that they have enframed over the last two decades. The chapter will then move to discuss variants of a third intellectual strain, media materialism, before providing a detailed account of classical studies of computers at the level of their substrates with reference to Turing Machines, von Neumann architecture, and bio-computation. It will then make reference to some recent work in philosophy that attempts to register a distribution of human and non-human agencies at work in the world, in what can be called the post-human turn. The penultimate section will link these latter sections to some very recent studies in new media, before a concluding section will situate the research objectives with reference to the theoretical background thus far presented.

Theoretical strains:[4]

In the USA a neo-positivistic trend emerged to suggest that NMA is at the interface with art, science and technology, and thus constitutes a socially useful field of experimentation. This trend has a lineage broadly represented by, for example, institutions and artists centred around the journals and work of the foundation the International Society for the Arts, Sciences and Technology (Leonardo/ISAST), whose mission statement declares that it "creates opportunities for the powerful exchange of ideas between practitioners in art, science and technology";[5] and the MIT Media Lab, where an "exploration" of new technologies is an explicit purpose for Media Lab researchers to "design technologies for people to create a *better* future" (their italics).[6] This promise, that new media art can be instrumental in realizing both new social structures of communication[7] and improve futures,[8] is underwritten, one supposes, by the basic tenet that communication is to be understood as a cultural practice between people on the same mental map engaged in similar representational semantics and thereby engaged in the same discourse, and henceforth digital, ethics.

However, in other quarters there also came an attitude more rooted in European intellectual traditions of the academic humanities derived from post-structuralism and often in various combinations with post-marxist approaches (including those of Roland Barthes, Giles Deleuze and Felix Guattari). In this tradition digital media are seen as embodying a non-linearity that allows for multiple interpretations of data and where interactivity has been fêted as creating an open-ended content where author audience binaries disappear. These aspects, as found in new media art's hybridised, contextually-based, live or time-

4 This section is not cast as a *genealogy* in the Foucauldian sense of a rigorous account of the various works mentioned. Rather it is designed to indicate some of the geo-cultural caches that have dominated new media theory and account for the bracketing out of much of the material basis of new media art.
5 http://www.leonardo.info/isast/isastinfo.html accessed September 20th, 2010.
6 http://www.media.mit.edu/about/mission-history accessed September 20th, 2010.
7 For example see: John Searle, *The Construction of Social Reality*, (New York: Allan Lane, 1995).
8 Richard Barbrook. *Imaginary Futures*: *From Thinking Machines to the Global Village*, (London: Pluto Press, 2007).

based productions, have been, at the very least, taken to represent a snowballing defiance against traditional (*viz.* bourgeoise and capitalist) aesthetic theories which were seen to be rooted in essentialist-based concepts of viewer, artist, and the art object.[9] Furthermore, much stronger claims for the truly democratic and vanguard nature of NMA could also be often found in the proclamations coming from those practitioners and groupings centred around theoretical attractors such as "electronic civil disobedience"[10] and “temporary autonomous zones”.[11]

Thus these two strands of theory can be seen to be at play in several noteworthy occidental studies emanating from the late 1990's and developing through into the first decade of the 21st Century. For instance, in Steven Holtzman's 1997 study, *Digital Mosaics,*[12] there is the suggestion that the 'new' non-linearity of digital art offers both a new language for expression and a new zone of operation for the spectator's body as the corporeal processor of aesthetic effects (echoing, I think, elements of neo-positivism). Whilst making some similar prognoses, Sean Cubbitts 1998 *Digital Aesthetics*[13] and Lev Manovich's 2001 *The Language of New Media*[14] are both heavily indebted to film theory as the hegemonic and historical source for their variable descriptions of the digital and non-linear hybridisation of space and time. Cubitt turns any notion of technological dystopia into a manifesto for “amateur culture” to free “ the narcissistic umbilical” so that “digital aesthetics [can] emerge from under the shadows of corporate culture”,[15] and aid in the call to arms for a new genuine democracy of the commons. In contrast, Manovich's "digital

9 NMA is not alone in its defiance. For example, Navajo sand paintings and Amazonian baskets equally challenge any such essentialism for the description of art. See Constance Classen and David Howes, “The Museum as Sensescape: Western Sensibilities and Indigenous Artefacts,” *Sensible Objects: Colonialism, Museums and Material Culture*, eds. Elizabeth Edwards, Chris Gosden, and Ruth Phillips (Oxford: Berg, 2006), 199-222.
10 First coined by the Critical Art Ensemble in their eponymously titled book in 1996.
11 Hakim Bey, *TAZ: The Temporary Autonomous Zone, Ontological Anarchy, Poetic Terrorism, (*New York: Autonomedia Anti-copyright, 1985).
12 Steve Holtzman, *Digital Mosaics: The Aesthetics of Cyberspace*, (New York: Simon and Schuster, 1997).
13 Sean Cubbitt, *Digital Aesthetics, (*New York: Sage, 1998).
14 Lev Manovich, *The Language of New Media*, (Cambridge, MA.: MIT Press/Leonardo Books., 2001).
15 Cubbitt. *Digital Aesthetics*, 149.

materialism" prosaically places new media "within the history of modern visual and media cultures." He describes all digital outputs as being simply components in the history of the moving image, in a bottom-up theory that maps out how it is the spectator who is split in between these new and more powerful worlds of digital simulation, illusion, representation and reality.[16]

If the first content of any new media must be a prior media, as Manovich in effect argues in the case of the cinematic, then it is a recursive fashioning of digital media through a two-way exchange with prior autographic media like painting being "remediated" that stimulates the spectator's senses in very new ways according to Jay Bolter and Richard Grushin's 2000 work, *Remediation: Understanding New Media.*[17] For them digital media can both call attention to itself and immerse the viewer so that it is hidden from sight - this is their "double logic of remediation," where "each act of mediation depends on other acts of mediation. Media are continually commenting on, reproducing, and replacing each other, and this process is integral to media. Media need each other in order to function as media at all".[18]

For Mark Hansen, in his 2004 book *New Philosophy for New Media,*[19] it is the spectator's body that is the mechanism that frames information of the now against the maelstrom of alternative perceptions and representations. Hansen claims that this both shifts aesthetics away from the visual (especially the cinematic, contra Manovich) to the affective and thus makes the body indispensable to technological media because as the latter becomes more de-differentiated the body "deploys its own constitutive singularity (affection and memory) not to filter a universe of preconstituted images, but actually to *enframe* something (digital information) that is originally formless".[20]

16 But not (the tyranny of) "interaction" as others have pointed out in criticism of Manovich's tome.
17 Jay Bolter and Richard Grusin, *Remediation: Understanding New Media*, (Cambridge, MA.: MIT Press, 2000).
18 Ibid. 55.
19 Mark Hansen, *New Philosophy for New Media*, (Cambridge, MA.: MIT Press, 2004).
20 Ibid. 8. It is worth mentioning here that the turn into the second decade of the new century brought a turn

If, at the beginning of the 21st Century, this latter modality, information,[21] has been re-introduced then when characterized as “fluid”, “aware” and involved in “concrete exchanges” with a “potential for convergence”[22] it turns digital aesthetics back to digital ethics. As a result various equations have been proffered for privileging aleatory gift economies over and above the previous decade's sites of hyper-individuation[23] - it is with such a emancipatory spirit in mind that, for example, Mark Tribe and Reena Jana, in their 2006 book, *New Media Art,*[24] select themes of collaboration, identity, appropriation, open sourcing, teleprescence, hactivism and interventionism as *the* defining characteristics of the new art.

Media Materialism:

Shifting along the underside of these two broadly painted and phenomenologically skewed inheritances has been that third tradition of media-as-medium theorists who argue that changes in media technologies, be it oral, writing, print, television, or computational, necessarily transform human cultures. Marshall McLuhan, in *Understanding Media,*[25] made early claims concerning this relationship between the material characteristics of specific media and broader cultural, psychological, social or political developments.[26]

McLuhan's understanding of "media" and "medium" not only challenged apparently fixed dichotomies between material things and notions of the mind, but also heavily emphasised

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in the writings of both Mark Hansen and Richard Grusin, what might be called the non-human turn, which is a discussion that this chapter will move towards in subsequent sections.

21 Notwithstanding Manovich's static “database as symbolic form”, in, for example, the conference *Information is Alive: Art and Theory on Archiving and Retrieving Data* and its eponymous publication from NAI, 2003 edited by Arjen Mulder and Joke Brouwer.

22 These terms are borrowed from Rodrigo Nunes, “The global moment: Seattle, ten years on”, *Radical Philosophy,* 159 (2010): 2-7.

23 Except, perhaps, in the case of those works created in the utilitarinan spirit of the Free Software Foundation. See http://www.fsf.org/ accessed March 3rd, 2010.

24 Reena Jana, and Mark Tribe, *New Media Art*, Cologne: Taschen GmbH. 2006. Also available as an open editable open-source wiki book, https://wiki.brown.edu/confluence/display/MarkTribe/New+Media+Art last modified September 16th, 2012.

25 Marshall McLuhan, *Understanding Media* (London: Sphere, 1969), 91-99

26 *Understanding New Media* is McLuhan's one time colleague Prof. Robert Logan's 2009 yet to be published update of *Understanding Media*. See http://www.physics.utoronto.ca/Members/logan accessed September 20th, 2010.

the temporal connections, translations, and mergers between media. Media was cast both as "extensions" of the human that shaped perception of their environment, and as generative forces that can make a "change of scale or pace or shape or pattern into human association, affairs, and action".[27] Perhaps the Gutenberg printing press, by introducing reproduction and homogeneity, had thus led inexorably to the practice of nine to five working.

If it seems plausible that any medium can frame or structure human knowledge,[28] then, and with echoes of the Sapir-Whorf hypothesis,[29] the idea that differences in the way languages encode cultural and cognitive categories affect the way people think is similarly plausible. McLuhan suggested in *Understanding Media* that those familiar with the Latin alphabetic writing system read printed text from left to right and are therefore conditioned to a more general linear-analytical way of thinking,[30] while more recently, researchers at MIT and Stanford University have concluded that people do “access spatial information when making temporal order judgements, and the kind of spatial layout people mentally create for time differs depending on culturo-linguistic artifacts”.[31]

Although overshadowed in the succeeding decades by a dominance of post-modernism and its primarily discourse and textually oriented approaches, McLuhan's claims about the

27 Mcluhan. *Understanding Media.* 16.

28 With this in mind Marshall McLuhan's famous statement 'the medium is the message' can be taken as pointing to a research program in which every medium is regarded as a condition of possibility of a specific way of knowing and experiencing. There are numerous relevant findings in the research of, among others, Eric A. Havelock, Elisabeth Eisenstein and Walter Ong on the effects of language as a medium for thinking and communication. McLuhan's 1962 *The Gutenberg Galaxay: The Making of Typographic Man* makes the same argument. McLuhan's colleague Robert Logan continues to describe a relativism where: “Words as concepts are a form of *artificial memory* which create *artificial connections*. Words bring order to a chaotic mind filled with the memories of a myriad of experiences. Language is an emergent order.” Robert Logan, “The Extended Mind Model of the Origin of Language and Culture”, in *Proceedings of the Evolutionary Epistemology, Language and Culture 2004 Conference.* http://www.physics.utoronto.ca/Members/logan/gontier3.htm accessed September 3rd, 2010.

29 Edward Sapir, "The status of linguistics as a science", *Language*, 5, 4 (1929): 207-214.

> No two languages are ever sufficiently similar to be considered as representing the same social reality. The worlds in which different societies live are distinct worlds, not merely the same world with different labels attached.

Also see Paul Kay and Kenton Willet, “What is the Sapir-Whorf Hypothesis?”, *American Anthropologist* 86, 1. (1984): 65–79.

30 McLuhan. *Understanding Media*. 91 - 99

31 Orly Fuhrman and Lera Boroditsky, “Mental Time-Lines Follow Writing Direction: Comparing English and Hebrew Speakers”, *Proceedings of the 29th Annual Conference of the Cognitive Science* Society, (2007): 1007-1010. See also: Barbara Tversky, et al. “Cross-Cultural and Developmental Trends in Graphic Productions”, *Cognitive Psychology* 23 (1991): 515–7.

effects of media have, from the mid-1980's, been reinvigorated by the work of mainly German-speaking theorists including Vilèm Flusser[32] and Friedrich Kittler.[33] It is Kittler's synthesis of media history, information theory, Michel Foucault, and McLuhan's summoning of the power of media to restructure human sensibilities, that is the most notorious as it has been taken to represent a strong form of technological determinism. In Kittler's reading of Foucault it is the *Aufschreibesysteme* or "systems of notation" that are reconsidered as being primary in the shaping of those immaterial and discursive forces that are otherwise read as being the sole causes of the restructuring of sensibility. Such a resolute "media materialism"[34] continually emphasises that it is the analysis of the material basis of technology that must take place before any other meanings can be given and that "discourse analysis ignores the fact that the factual condition is no simple methodological example but is in each case a techno-historical event".[35]

Against such analysis one could pursue variants of the social constructivist's argument (eg. Social Construction of Technology SCOT[36]) that human behaviour and society structure the creation of material and technological things and thus all implementations of technology, including computational or media arts, are amplifications of human symbolic lifeforms. Thus any technological apparatus can be read (or reverse engineered) to reveal itself as being purely an expression of human agency and logic of one sort or another.

But for Kittler this is the anthropocentric illusion under which any such study in "understanding media" is always apparent unless an analysis of the technology found in the processing of any send/receive signal is privileged to underwrite any subsequent

32 eg. Vilem Flusser, *The Shape of Things.* 3rd ed., translated by Anthony Matthews. (London: Reaktion Books. 2010).
33 eg. Friedrich Kittler, *Gramophone, Film, Typewriter,* translated by Timothy Lenoir. (Stanford, CA: Stanford University Press, 1999); *Optical Media,* translated by Anthony Enns. (Cambridge: Polity 2010).
34 Friedrich Kittler. *Literature Media Information Systems*, (Amsterdam: G&B Arts International, 1997).
35 Friedrich Kittler, *Gramophone, Film, Typewriter,* Ibid. 229, and quoted in, Jussi Parikka and Erkki Hutamo, eds. *Media Archaeology: Approaches, Applications and* Implications, (Berkeley: University of California Press. 2011), 18.
36 See eg. http://www.stswiki.org/index.php?title=Social_construction_of_technology_%28SCOT%29 accessed December 10th, 2010.

account of meaning and social action. However this is not the simple technological determinism that is often assumed, rather the admonition "a medium is a medium is a medium"[37] equally urges the understanding that the social is itself a kind of media structure present within a network of technical media, but one where its epistemic effects cannot be understood without first understanding its technical means.

To the extent that there is a specificity in the means of production for NMA in that computational machines are the condition of its possibility, then at the very least one might anticipate that any studies of NMA, like those cited in the preceding section, would include an account of that machinery.[38] However, this has so far rarely been the case. With, then, the above arguments now signposted - that media determine situations, and more specifically that the technical media of discourse channel the phenomenological world that we experience - I will now begin to consider something of the technical means of the computer in NMA via a review of the literature detailing its behaviours in relation to its primary materials.

Understanding Media: Computational Materiality

I will digress momentarily here to ask the question of whether it is possible or desirable to characterize one level of the computer, be it electrical charges or binary code, as being somehow more fundamental and necessary to understanding how computers behave? The suspicion is that such fundamentalism would be to adopt at best a formalist strategy (as if this was necessarily a bad thing) as we could equally begin by examining transistors or logic gates, or if we scale upwards, the particular design logic of the Integrated Circuits (ICs), which can also be explained in terms of another candidate, abstract logical design -

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37 Friedrich Kittler, *Discourse Networks: 1800/1900*, (Stanford, California: Stanford University Press, 1990), 229.

38 Interestingly Clement Greenberg argued in "Modernist Painting" that modernism calls attention to the conditions and limitations of a medium in order to produce from these something new, something positive out of the nature of the medium itself. This is akin to a 'medium purity' argument. The article was originally published as one of the Forum Lectures Washington, D. C. for the Voice of America in 1960. Available online at http://www.sharecom.ca/greenberg/modernism.html accessed March 3rd, 2010.

which might take the form of the Universal Turing Machine and its particular implementation in the von Neumann architecture (I will return to this below). And if we do focus on explaining this particular implementation, as in a 'zone of the middle dimension'[39] then we're forgetting that materially ICs are actually fashioned from metal tracks etched into monocrystal silicon wafers through photolithography, and then packaged into a ceramic or plastic housing with exposed electrical pins, and all this by way of those chains of production involving machines and people. In other words to explain something in terms of its basic parts doesn't render those middle zone properties any less real than those entities that account for them, "anymore than zinc and sulphuric acid cease to react in a certain way when we explain their reaction in terms of the atomic reaction".[40]

So if any materialist research project conceives of a computer on the basis of its most fundamental parts then there is this problem in identifying what are those bits. A non-trivial sense of this would be that such a project would need to embrace a kind of scientific naturalism, because it reduces objects to a fairly shallow set of what become ultimately humanly accessible properties ie. as definable within the scope of scientific explanation, argument and controversy.

Until the late 1990's the structures of computational programming had long been overlooked by NMA as an artistic material having been understood as a purely functional element of digital technology.[41] After the GNU/Linux operating system itself was awarded a prize by the jury of the art and technology festival Ars Electronica festival in 1999,[42] the

39 cf. Wilfrid Sellars 'Empiricism and the Philosophy of Mind, edited by Robert Brandom, Harvard University Press.: Cambridge, MA, (1956) 1997. http://www.ditext.com/sellars/epm.html accessed December 10th, 2010.

40 Roy Bhaskar, *A Realist Theory of Science* (Oxford: Routledge, (1975) 2008), 50.

41 An example of work from this period includes Web Stalker by the digital artist group I/O/D (members included Colin Green, Simon Pope, and Matthew Fuller), produced in 1997, where instead of rendering webpages as people were accustomed to Web Stalker displayed their internal control codes and visualised their link structuring. http://bak.spc.org/iod/ accessed March 11th, 2011.

42 The award of The Golden Nica, first prize in the ".net" category, to the programmer Linus Torvalds for the development of the Linux operating system recognized the importance of software and art while emphasizing that software is not just a question of code, but of producing culture and a means of engaging in a social context.

The fact that Linux is one of the first products derived from the Internet that had an enormous first formal recognition of art work based around algorithmic programming code did not come about until the inauguration, in 2001, of the award category “Software Art” at Transmediale01 by Florian Cramer and Ulrike Gabriel. In 2002 Cramer went on to write how, in his opinion, significant cultural elements of the computational have been wilfully neglected in many studies and that any further account of NMA is misplaced without an account of its code, its programming, and its programmers, all of which, he advanced, determine the final artwork.[43]

Where code and programming are, in part, constitutive of NMA, then analysis of their relations to the social has also appeared in much later gestures in the field, notably with Matthew Fuller's expansion of Richard Feynman's[44] exposure of the layers of abstraction embedded in any computational device from its circuit board, where 0's and 1's are determined by voltage levels, via the operating system and beyond into the social.[45] Fuller suggests that the interrogation of any technical device can creatively reveal layers of power-related abstraction and so, inevitably he says, help redefine the social relations that are produced around it. He elsewhere writes that other relationships can be both exposed and created through experimentation with different media “assemblages” shunted together in “dirty conjunctions”.[46] This suggests a long term project to reticulate component agencies in political registers, much as Graham Harwood's recent projects, including “Coal

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> impact on the ‘real’ world was one of the most important reasons for the jury. Additionally, the jury wanted to make a statement with this Golden Nica: this prize is not meant for the most beautiful web page but for any project on and in the net. Furthermore it should also nurture the discussion whether or not a source-code itself can be an art piece.

Jury Statement, .net category, Ars Electronica, 1999. http://90.146.8.18/en/archives/prix_archive/prixJuryStatement.asp?iProjectID=2600 accessed March 11th, 2011.

43 Florian Cramer, *Concepts, Notations, Software, Art*. Online publication. 2002 http://www.netzliteratur.net/cramer/concepts_notations_software_art.html accessed February 8th, 2010.

44 Richard Feynman, *Lectures on Computation*, eds. Anthony J.G. Hey & Robert W. Allen, (London: Penguin, 1984), 4. The article Feynman cites is Peter Denning and Robert Brown's “Operating Systems”, *IEEE Computer special issue for 100th Anniversary IEEE*, (1984), 173-190. Feynman describes Level 1, the electronic circuitry, to Level 13, the operating shell system; Fuller suggests further outward levels that include licensing, network and marketplace variants.

45 Matthew Fuller, *Behind the Blip: Software as Culture*. (New York: Autonomedia, 2003), 21.

46 Matthew Fuller, *Media Ecologies, materialist energies in art and technoculture* (Cambridge, MA.: MIT Press, 2005).

Fired Computers (300,000,000 Computers – 318,000 Black Lungs)" with Matsuko Yokokoji and Jean Denmars from 2010, have done in plotting the transformations that materials in technology have effected upon the flesh, the social, the political and the economic.[47]

The way that this research project detaches itself from the formalist impasse is by considering that any nesting of parts as described above does not imply a difference in value in so far as working at different scales does not make any one component less important nor more powerful in determining some other component's position or workings. Furthermore, that the focus of the research is on the primary substrates of computer, the sixty six or so minerals used in instantiating the technical machine of NMA, is an *imprimatur* derived from the author's wish to mine under Feynman and Fuller's taxonomic Level 1 of the circuit board.[48]

Hence this section will comment on classical works in computational theory (Turing, Feynman) that detail the logico-mathematical ontogenesis of computers as universal and closed systems through their precise inscription into such materials. The section will then move on to consider more recent computational real world instantiations *viz.* bio-

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47 Graham Harwood et. al. *Coal Fired Computers*, downloadable booklet, March 2010, http://yoha.co.uk/cfc accessed November 4th, 2010.

48 Sixty six minerals, more or less, according to one study': *Minerals in Typical Computers* from the National Mining Association, a US trade organisation, http://mine-engineer.com/mining/minerals_Computer2.htm accessed November 12th, 2012. Data and interpretations are sketchy, and chains of production hidden (which, in reference to the Coltan Wars, one of the 'Miscellaneous Provisions' of the US 2010 Dodds -Franks Act was to make US companies come clean about where and what raw materials come from the Democratic Republic of Congo). More recent papers use net energy analysis and life cycle assessments to focus on energy usage in production and afterlife of materials used in computers. A study in 2004 by Dr. Eric Williams for the United Nations University, Japan, estimated that the total weights of chemicals and water needed to produce one desktop computer to be 22 kilograms (48 lb) and 1,500 kilograms (3,300 lb), respectively, and that "an overall conclusion that can be drawn from this review of studies is that the figure for fossil fuels used to produce one desktop computer in the late-1990s was probably in the 200- to 300-kilogram range": Eric Williams, "Energy Intensity of Computer Manufacturing: Hybrid Assessment Combining Process and Economic Input-Output Method", *Environmental Science & Technology*, 38, (2004), 6166-6174. Another 2002 study, is the evocatively titled, "The 1.7 Kilogram Microchip: Energy and Material Use in the Production of Semiconductor Devices", *Environmental Science and Technology*, 36, 24, (2002):5504-5510. Later studies sent by Dr Williams to the author execute the same statistical analysis of probable energy usage rather than any quantative analysis of raw mineral type and usage, eg. "Economic-balance hybrid LCA extended with uncertainty analysis: case study of a laptop computer", *Journal of Cleaner Production* 19 (2011): 1198 – 1206.

computers through a consideration of how their biological materials and behaviours have been characterized as non-universal and open information processors.

Computation is in principle described as information processing, that is, of information input, information conversion and information output and although, by this definition, not limited to classical digital processes, is assumed as a standardized process by which input data are converted according to prescribed rules (for example, algorithms)[49] and are rendered into output data. Within computation the term “digital”, and its contrary, “analogue”, are frequently used to denote the difference between a numerical-digital and a physical model and help to separate out theoretical abstract computation from any particular concrete computational, and thus material, iteration.

Hence classically, digital computation, as framed by mathematicians, is the design of logico-mathematical computational models. These are abstract, symbolic, discrete and closed (pre-defined), as well as deterministic (Boolean, bivalent) and sequential. Concerned with things like what is computable, the halting problem,[50] and universality, such modelling and the discussions surrounding them dominated mathematical discourse in the 1930's, sometime before real analogue and material computers were systematically implemented. For example, in 1936, when Alan Turing asked what kind of machine can compute, he eventually formulated the answer by way of “Turing Machines”[51] and their

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49 This definition was formalised in 1989 as:

> The discipline of computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application. The fundamental question underlying all of computing is, “What can be (efficiently) automated?

Douglas Comer, et. al., “Computing as a discipline” *Communications of the ACM* 32 No.1 (1989): 9-23 http://www.cs.gmu.edu/cne/pjd/GP/CompDisc.pdf accessed April 7th, 2011.

50 That is, that no computer can tell in general whether or not a given Turing-complete computer program stops after a finite amount of time on a given input. The halting problem shows that there are problems that cannot be solved by a Turing machine. The problem has its roots both in problem two of David Hilbert's “23 Problems” - how to prove that the axioms of arithmetic are consistent - and Kurt Gödel's first incompleteness theorem, which provided a negative answer to this problem. For the seminal collection of Gödel, Turing, et. al papers see *The Undecideable*, ed. Martin Davis, (New York: Dover, 2004). Hilbert's problems are detailed, for example, on Stephen Wolfram's MathWorld website http://mathworld.wolfram.com/HilbertsProblems.html accessed April 10th, 2011.

51 The epithet they were given by Alonzo Church in 1937 in a review of Turing's paper of the same year. Turing first called them "*a*(utomatic)-machines" before settling on “Logical Computing Machines”. cf. Turings definition of a TM in an online facsimile of his original paper: Alan M. Turing, “Intelligent machinery,” National Physical Laboratory, Tech. Rep., 1948.

mother-ship, the Universal Turing Machine (UTM)[52] where by if anything could be computed it could be done by the UTM and vice versa, if something could not be computed by the UTM then it was (procedurally) unsolvable (what should be described formally as the Church-Turing *hypo*thesis).[53] The nearest this solution came to any sense of materiality was that it was abstracted from the idea of paper tape being divided into squares with one of a finite number of easily distinguishable symbols being able to be written on each square, and the tape being run backwards and forwards, erased and rewritten.

With this model Turing had determined that there is a “sufficient set” of basic procedures that produce universality on whatever UTM they were implemented, and further, as Richard Feynman characterized it, "that the set of complex tasks that can be performed using a "sufficient" set of basic procedures is *independent* of the specific detailed structure of the basic set".[54]

Thus the UTM, relevant to computers as they are conventionally engineered, is a model where computation is assumed to be a universal logical or mathematical property, and that any conglomeration of material substrates on which computation takes place is only a finite implementation detail.

Turing hoped that his abstracted-paper-tape model was so simple, so transparent

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http://www.alanturing.net/turing_archive/archive/l/l32/L32-002.html, accessed April 12th, 2011, where a Turing Machine consists of:

> ...an infinite memory capacity obtained in the form of an infinite tape marked out into squares, on each of which a symbol could be printed. At any moment there is one symbol in the machine; it is called the scanned symbol. The machine can alter the scanned symbol and its behavior (sic) is in part determined by that symbol, but the symbols on the tape elsewhere do not affect the behavior (sic) of the machine. However, the tape can be moved back and forth through the machine, this being one of the elementary operations of the machine. Any symbol on the tape may therefore eventually have an innings.

It follows that a Universal Turing machine is able to simulate any other Turing machine.

52 Alan M. Turing,. “On Computable Numbers, with an application to the Entscheidungsproblem”, *Proceedings of the London Mathematical Society*, (Ser. 2, Vol. 43, 1937), in *The Undecideable*, 116-154. In the paper Turing imagines TM's to be people not machines who execute deterministic mechanical rules "in a desultory manner".

53 Although the Church-Turing Thesis appears to be empirically true, it is non-determinable.

54 Feynman, *Lectures on Computation.* 2, my italics.

> and well defined, that it would not depend on any assumptions about physics that could conceivably be falsified, and therefore that it could become the basis of an abstract theory of computation that was independent of the underlying physics.[55]

In principle, this kind of computational theory does not care to involve the physics of the computer user, nor of the teleprinter, nor the paper in the UTM, because it is an argument mobilised to express self-evident universal truths free of any ambiguity, physical or otherwise, as a model of computation, and not of computers. Real machines are, of course, never universal in this abstract sense, since they are always finite and subject to material physical limitations, including finite memory storage and finite processing times.[56]

So when the Turing machine is realized in such a real world machines,[57] it is in a machine designed to behave in a manner as isomorphic as possible with the model, so that its "moving parts" can represent the current state, the state machine transitions, the moving head, the tape, and the tape symbol reading, writing and erasing mechanisms. This kind of engineering can be extremely intricate, since there is no reason to believe *a priori* that

55 David Deutsch, *The Fabric of Reality,* (London: Penguin, 1997), 252

56 Turing never defined computers by only inputs and outputs, recognizing with delight the surprises a computer gives:

> Machines take me by surprise with great frequency. This is largely because I do not do sufficient calculation to decide what to expect them to do, or rather because, although I do a calculation, I do it in a hurried, slipshod fashion, taking risks. Perhaps I say to myself, "I suppose the voltage here ought to be the same as there: anyway let's assume it is." Naturally I am often wrong, and the result is a surprise for me for by the time the experiment is done these assumptions have been forgotten. These admissions lay me open to lectures on the subject of my vicious ways, but do not throw any doubt on my credibility when I testify to the surprises I experience.

Alan M. Turing, "Computing Machinery and Intelligence," *Mind* 59 (1950): 450–51

57 This is not to say that I am here attempting to outline a definitive history of computation/computers. Several other people were working around the same time on computational problems including Konrad Zuse, the inventor of both the first programming language and the first stored-program computer. His pioneering work used a binary system to solve complex engineering equations in his Z3 machine, begun in 1938 and completed in 1941, where 1800 relays stored sixty-four 22-digit binary numbers with an additional 600 relays for both calculating and control units. Instructions were fed to the computer on perforated 35-mm celluloid film (old movies), and each instruction set (program) could be changed by changing the film. Zuse worked in intellectual isolation over the 30's and 40's, recalling much later that "I started in 1934, working independently and without knowledge of other developments going on around me. In fact, I hadn't even heard of Charles Babbage when I embarked on my work".

Konrad Zuse, "My first computer and first thoughts about data processing", Speech at Symposium in Lund/Sweden on *Computer Design Past, Present, Future*, 1987. http://bryanttang.per.sg/cs378/wk6/wk6_1.html accessed May 15th, 2011.

That the Z3 was Turing complete was shown in 1998: Raúl Rojas, "How to make Zuse's Z3 a Universal Computer", *Annals of the History of Computing IEEE*, 20, 3, (1998): 51 – 54. http://www.zib.de/zuse/Inhalt/Kommentare/Html/0684/universal2.html accessed May 16th, 2011.

physical materials will behave in accordance with some independent, unrelated abstract model. As Richard Feynman notes fairly early on in his *Lectures on Computation,* “sometimes the physical volatility of the components you use to build your equipment will give you freaky variations” so that, for example, signals arrive late and do the wrong job.[58]

In driving forward this point Feynman in the *Lectures* proposes that the study of computation (*viz.* Computer Science) does not consider natural objects nor mathematics as its subject (although it uses mathematical reasoning extensively), but rather that it is actually something more akin to “engineering as it is about getting something to do something”.[59] Feynman does not want to deal with just abstractions *per se* as he wishes to get deep down inside the “guts” of computers because it's there that any abstract universal model is implemented. As Feynman puts it, a computer can be built out of anything, so its guts can be made of beads and wire, or control valves, and organised in a variety of ways. The only caveats are that the input needs to get in in a binary form (1's, 0's) and whatever the final output is, the last bit of it inside the machine is also in a digital form – if these conditions hold then a Turing universality can be given. It is only after detailing the behaviours inside these real computers, Feynman says, that the mathematician's questions can then be raised, such as what are the limits of computability and how these limits might relate to what is the sum total of knowledge that we can have about the world around us.

In the *Lectures* Feynman restricts himself to discussing physical computers that implement a “stored-program machine” architecture. Such state machine architecture is based around a single central processing unit (cpu), a separate read-write memory storage structure (“random access memory”) that holds both the set of task-performing procedures (executable instructions) and the data upon which the data path is operating, and a data bus through which everything goes in and out through a “fetch and execute” sequential cycling

58 Feynman. *Lectures on Computation*, 46.
59 Feynman. *Lectures on Computation*, xiii .

of those instructions and data. The instruction set is well defined so as to enable the system (data bus, cpu and memory) to execute a number of different algorithms composed as sequences of machine instructions (programs) loaded into the memory, and its these that operate on the data also contained in the memory. Although this sequential ordering limits operational bandwidth,[60] a machine with such a "von Neumann architecture", (named after John von Neumann),[61] is enabled to perform any of a set of predefined operations from the instruction set (rather than just one dedicated operation) and in so doing mirrors the operation of the abstract form of the most simplest form of a stored-program machine using sequential algorithms, the Turing machine.

In discussing how such computational machines physically function Feynman begins by explicating some of the primitive procedures that are required to form the simplest operations (adding two numbers, transferring two numbers from one memory store to another) necessary to then be able to "go up a level" to the next order of complexity so as to produce operations like multiplication and so on. This principle of hierarchical levels of complexity/abstraction[62] had been suggested by the slightly earlier work of Peter Denning and Robert Brown, who in a 1984 *IEEE Computer* article "Operating Systems"[63] had

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60 Operational bandwidth (*viz.* the rate of transfer of functions or instructions) is restricted because reading an instruction and reading/writing data from/to the memory cannot occur at the same time since the instructions and data use the same bus system. In an alternative architecture, the "Harvard architecture" the instruction set is stored in a different memory from the data (strictly speaking, a different memory address) and each is accessed via a separate bus, allowing instructions and data to be fetched in parallel. This architecture was first implemented in the very early Harvard Mark 1 computer developed by Howard Hathaway Aiken, along with James Ware Bryce and other engineers at IBM in 1943-44. No pure Harvard architecture machine is Turing complete, and they are used in very specific applications, with, for example, their contemporary usage as digital signal processors (DSP's), where speed is of the essence in handling highly optimized audio or video processing algorithms. Most contemporary domestic computers (and thus those most commonly used for new media art) implement a hybrid of the Harvard and von Neumann architectures in that the processors have a cpu cache which partitions the instruction set and data. Processors like the x86 exemplify this "Modified Harvard architecture".

61 See: John von Neumann, *First Draft of a Report on the EDVAC* , Contract No. W–670–ORD–4926 Between the United States Army Ordnance Department and the University of Pennsylvania , 1945. http://qss.stanford.edu/~godfrey/vonNeumann/vnedvac.pdf; and John von Neumann et al. *Preliminary Discussion of the Logical Design of an Electronic Computing Instrument,* Report to U. S. Army Ordnance Department, 1946. http://www.cs.unc.edu/~adyilie/comp265/vonNeumann.html, both accessed May 16th, 2011.

62 Feynman uses both terms in the *Lectures on Computation*.

63 Brown and Denning, "Operating Systems". 173-190.

established thirteen levels of complexity, from, as Feynman paraphrases it, the Level One of the electronic circuit to thirteen, the Operating System (OS) shell,

> which manipulates the user programming environment. By a hierarchical compounding of instructions, basic transfers of 1's and 0's on Level One are transformed by the time we get to Thirteen, into commands to land aircraft in a simulation, or check whether a forty digit number is prime. We will jump into this hierarchy at a fairly low level, but one from which we can go up or down.[64]

Most people work with computers at even higher levels of abstraction,[65] that is, where in any machine design details of those primitive procedures are hidden in a higher level of abstraction.[66] Sticking with the example of multiplication, it can be seen to be an operation made up from simple additions iterated at the lower level, and then run always as a “multiply” subroutine. Such subroutine operations like multiplication that get rendered like this in high level languages[67] are always translated back down to the lower levels of Assembly Language and Machine Code[68] by programs called 'compilers' or 'interpreters' - where an interpreter works at what to do step by step as the program runs, interpreting each instruction in terms of the cruder language, a compiler takes the program as a whole and converts it all into machine code before the program is run. Going up and down the levels means that ultimately human-oriented high level programming languages are shorthand instructions that are translated down to the computer in Assembly Language specific to the

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64 Feynman. *Lectures on Computation*, 4.

65 Fuller. *Behind the Blip: Software as Culture.*
Fuller's thesis includes the argument that many more layers of abstraction are embedded in any computational device well beyond the OS and into the social, and thus ripe for (re)assemblage as tools for critique.

66 According to the abstraction principle where:

> Each significant piece of functionality in a program should be implemented in just one place in the source code. Where similar functions are carried out by distinct pieces of code, it is generally beneficial to combine them into one by abstracting out the varying parts.

Benjamin Pierce, *Types and Programming Languages*, (Cambridge, Mass.: MIT Press, 2002), 339, quoted on http://en.wikipedia.org/wiki/Abstraction_principle_%28programming%29 accessed April 8th, 2011.

67 *viz* a language designed to address the problem/user rather than the hardware on which it runs.

68 Assembly Language is the human readable representation of Machine Code, the operation code of the specific machine.

computer architecture, which then need to be further translated down into machine language by the “assembler” program.

Having established this hierarchy of commensurable programming code/languages, Feynman next wants to discuss how it is that such operations can be built and implemented at Level 1 in the materials of the electronic circuits. It is important to note why Feynman details how the physical behaviours/parameters of the materials of a computer's electronic circuits can be inscribed, or rather made commensurable with these abstract and universal operational models. He is not so much interested in providing an individual account of each of those primary materials, rather having already noted earlier how there can be a material volatility in any such computer, he wishes to describe via the basic laws of physics the real world Turing equivalence (ie. what makes an *effective*[69] computing system)[70] of computing machines by scaling those volatilities within the logico-mathematical tradition of universality.

Thus the pursuit of this effectiveness means for him to detail how every logical state of a computer device *must* correspond to some physical state (but not vice versa), and that there then must be a minimum amount of energy required for each logical step taken by a machine. So whilst any physical structure on which computation is implemented must labour under the physical constraints of the material from which it is constituted, these are

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69 Turing's thesis replaces *effectiveness* with that of *computability by Turing machine,* so that computation in a precise technical sense coincides with *effectiveness* in its informal or intuitive sense. See:
George S. Boolos, John P. Burgess, and Richard C. Jeffrey, *Computability and Logic* 5th ed. (New York: Cambridge University Press, 2007), 23 – 34; and
Jack Copeland *The Church-Turing Thesis* http://www.alanturing.net/turing_archive/pages/Reference%20Articles/The%20Turing-Church%20Thesis.html accessed April 10th, 2011.
Informally put, a method, or procedure, M, for achieving some desired result is called *effective* or *mechanical* if
a) M is set out in terms of a finite number of exact instructions (each instruction being expressed by means of a finite number of symbols.
b) M will, if carried out without error, always produce the desired result in a finite number of steps;
c) M can (in practice or in principle) be carried out by a human being unaided by any machinery save paper and pencil;
d) M demands no insight or ingenuity on the part of the human being carrying it out.

70 So looking through a telephone book for a specific person for their phone number is not, nor does it need, a Turing-equivalent computation.

calculable and are encompassed in the general constraints affecting all materials arising from the laws of physics, and including the speed of light; conservation of energy; entropy; energy and mass density.

For Feynman it is only through such calculations that a computer's behaviour (including its microscopic quantum mechanical processes) can be expressed to show that how “we arrange the elementary component parts”[71] sufficiently implements the closed logico-mathematical model of the Universal Turing Machine. Furthermore, he argues that all such real word implementations also have a profound relationship with information and communication. Claude Shannon's Theory of Information[72] can be treated from a “laws of physics” point of view because Shannon was initially interested in how to send messages down real wires without losing their content. Thus in asking “What is the minimum energy required to carry out a computation?” Feynman provides a physical model to help illustrate a physical definition of the information content of a message as a “basic atomic message”,[73] and uses the physics of gases to quantify such expenditure in relation to probability theory and entropy to confirm Shannon's Theorem (or the “noisy-channel coding theorem”), that it is possible to transmit information with a residual error rate arbitrarily close to zero.[74]

Quantum mechanics (QM) throws up a fundamental problem for Turing's universal model in how to reconcile a picture of the universe where everything happens simultaneously with our perception that we seem to follow a sequence of definite experiences. This has led to the Turing thesis being reframed for the “quantum computer” by David Deutsch,[75]

71 Feynman, *Lectures*. Ibid, 212.
72 Claude Shannon, “A Mathematical Theory of Communication”, *Bell System Technical Journal*, 27, (1948): 623-656. http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf accessed December 10th, 2009. It is possible to send information at the rate C through the channel *with as small a frequency of errors or equivocation as desired* by proper encoding, (original italics).
73 Feynman, *Lectures.* Ibid, 138, fig 5.1.
74 Feynman, *Lectures.* Ibid, 106, and 151.
75 David Deutsch, “Quantum Theory, the Church-Turing Principle and the Universal Quantum Computer ” *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences,* 400, 1818, (1985): 97-117 http://www.cs.princeton.edu/courses/archive/fall06/cos576/papers/deutsch85.pdf accessed April 7th, 2011.

developing the notion which Feynman, in recognising the problem, is credited for thinking up in a 1981 conference speech.[76] Not surprisingly such modelling is *sans* a Feynman *Lectures*-like account of the quantum physics of any possible physical implementation, but is where, for example, Scott Aaronson supposes how quantum decoherence would introduce substantive errors because of an unwanted interaction between a quantum computer and its environment. Furthermore Aaronson notes how recent researchers agree that quantum computers would suffer from many of the same algorithmic limitations as any Turing classical computer.[77]

Whatever any limitations may be, it is the continuing drive for modelling[78] that underscores a categorical difference between any such model and any computational device that might implement it - notwithstanding Turing's original notion of “computation” established as the formalization of the way humans think and process information, that is, for the formal description of the logical operations of human thought.[79] If something can be modelled it can be known, but not really submitted to proof in the sense of any compelling causality.

However in addressing Gödel’s incompleteness theorem, that every system of logic is somehow incomplete, Turing himself foresaw the profound limitations of the Turing machine and in a 1939 paper he demonstrated how they can never be the most powerful computing abstract mechanisms.[80] Such mechanisms would actually be Turing machines

Deutsch reformulates the Church-Turing thesis as a physical principle where “every finitely realizable physical system can be perfectly simulated by a universal model computing machine operating by finite means” in order to show that a Turing machine can not fulfil this principle as it is finite, but systems are continuous, whereas as a Quantum Turing Machine does.

76 Richard Feynman, “Simulating Physics with Computers”, *International Journal of Theoretical Physics* 21 (1982): 467–488 http://www.phy.mtu.edu/~sgowtham/...02/IJTP_v21_p467_y1982.pdf accessed April 10th, 2011.

77 cf. Scott Joel Aaronson , “Limits on Efficient Computation in the Physical World ”, (PhD diss., University of California, Berkeley, 2004), some elements of which appeared in the article, The Limits of Quantum Computers, *Scientific American*, 298, 3, (2008): 62–69.

78 That is, formal modelling, cf.. Boolos, Burgess, and Jeffrey, *Computability and Logic,* 137-162.

79 Those doing the 'computing' in Turing's 1937 paper are human or mechanical agents. cf. Turing on “intelligent machinery”, where machines with human-level understanding is detailed: Turing. *Intelligent machinery.*

80 Alan M. Turing, “Systems of logic based on ordinals”, *Proceedings of the London Mathematical Society*,

with oracles (a mathematically abstracted *o*-machine, precursor to the contemporary "hypercomputer") as they can formally solve the halting problem as well as other undecideable problems. Such a machine cannot be completely described by first-order logic because its oracle is akin to something like a super-intuition - Turing makes it clear that the intuition he is discussing is related to the human act of seeing the truth of a formally unprovable Gödel statement, but it is non-procedural in "that it cannot be a machine".[81] This appears to be problematic for the Church-Turing thesis, as it proposes that no other computational machine ie. procedural device, can answer questions on halting or un-decideability, and so where the *o*-machine is formalised (as a black box) it would mean that the thesis breaks down.

In this we can see an early hint of a very different kind of computation implicit in Turing's later work. In the last years of his life Turing worked in mathematical biology, trying to determine what mechanisms caused the emergence of different organic forms from a common cell homogeneity. In 1952 he published "On the Chemical Basis of Morphogenesis" in which he modelled morphogenesis in a novel reaction-diffusion theory.[82] He hypothesized that cell homogeneity is subjected to state changes and thus differentiation through various physical-chemical stresses and reactions, and that diffusion, the spreading through tissue mass of chemical morphogens from regions of higher concentration to those of lower concentration, is a dynamic and unstable process. By modelling such patterns of differentiation in cells, specific structures and forms might then be determined and interpreted.[83] An undeveloped thread running through the paper was his

(Ser. 2, Vol. 45, 1939), in *The Undecideable*. 154-223.

81 Ibid. 166, as there are no formal tabular descriptions for its internal configurations. In effect it is a subroutine available to an algorithm, that is guaranteed to compute some function even if we have no idea how.

82 Alan M. Turing, "On the Chemical Basis of Morphogenesis", *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 237, 641, (1952): 37-72. http://www.dna.caltech.edu/courses/cs191/paperscs191/turing.pdf accessed April 12th, 2011.

83 Part of this summary is based on Stephen Childress, *Turing's model of chemical morphogenesis* http://www.math.nyu.edu/faculty/childres/case2.pdf accessed April 13th, 2011.

recognition that modelling an organic system composed of a large multitude of elements interacting through elementary and varied forces evades final proof as it "omits many features, e.g. electrical properties and the internal structure of the cell",[84] because of an exponential amount of mathematical complexity involved for that formal modelling.

The capabilities of nature are such that biological systems have long been highly significant to computer science and are well rehearsed – for example, and echoing Turing's 1952 work, that the emerging growth patterns of plants are the outcome of natural cellular automata and that therefore cellular automata go beyond any virtual status in "artifical life".[85] Cellular automata were developed as a pastime of the mathematician Stanislaw Ulam who, in the late 1940's, created games in which 2-D and 3-D structures were generated through simple rule systems. Although simple self-replicating machines have been subsequently designed,[86] at that time von Neumann adopted and formalised Ulam's games as a means of exploring the possibility of a universal self-replicating machine. His work demonstrated that many mathematical and computational systems, such as Turing machines, could be simulated by them. There are strong similarities between the operations performed in cellular automata and the basic instruction sets of assembly languages and Stephen Wolfram has largely built on this work, simplifying von Neumann's automata and demonstrating that very complex behaviours can be generated from simple programs.[87]

Added to these and other studies in virtual biocomputation there has been a large quantity of research into real world examples including investigating whether the unconscious

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84 Turing. *On the Chemical Basis of* Morphogenesis. 38.

85 The phrase "artificial life" was coined by Christopher Langton in researching "the possibility that life could emerge from the interaction of inanimate artificial molecules" simulated through the use of cellular automata. Christopher Langton, "Studying Artificial Life with Cellular Automata", *Physica D: Nonlinear Phenomena*, 22, 1-3, (1986): 120-149. http://www.swarmagents.cn/thesis/doc/hufeng2010410112128.pdf accessed May 16th, 2011.

86 For example, "Langton's loops", a non-universal automaton of eight states created by Christopher Langton in 1984, where instead of trying to implement self-reproduction as a particular case of construction universality, as in von Neumann's "Universal Constructor", Langton attempted to define the simplest cellular automaton capable exclusively of self-reproduction.
Christopher Langton, "Self-reproduction in cellular automata", *Physica D: Nonlinear Phenomena*, 10, 1-2, (1984): 135-144.

87 Stephen Wolfram, *A New Kind of Science*, (Champaign, IL: Wolfram Media Inc., 2002), 400-413.

collaboration of insects with the reproduction of plants and the co-evolution of the species has in effect optimised a multi-objective algorithm that solves two natural problems at once.[88] Erwan Le Martelot references work going back over thirty years that detail "how proteins, cells, organs, and tissues can work together to elaborate immune systems; where ant colonies are driven by individual agents acting individually and randomly, yet they can accomplish complex and precise tasks; and where flocks of birds or shoals of fish can split when encountering an obstacle, then move towards a source of food with no individual knowledge or understanding but giving an illusion of a specific group behaviour".[89]

Recalling the definition of computation given earlier, these and other studies in neural networks, the evolution of populations, or whatever other form of organic-like computation, have advanced the proposition that such substances and behaviours are naturally computational as they process information.[90]

What is also highlighted is the material disjuncture between these two forms of computation, the biological and the Turing machinic. Where both might appear theoretically and mathematically equivalent at certain levels of abstraction/complexity they are so practically dissimilar that they are incompatible as in the differences between, for example, the way humans process information and that of a classic von Neumann machine.

88 Heather M. Whitney, and Beverley J. Glover. *Coevolution: Plantinsect*, in vol 2, *Handbook of Plant Science*, (Oxford: Wiley-Blackwell, 2007). http://onlinelibrary.wiley.com/doi/10.1002/9780470015902.a0001762/full accessed April 14th, 2011.

89 Erwan Le Martelot , "Investigating and Analysing Natural Properties Enabled by Systemic Computation within Nature-inspired Computer Models", (Phd diss., University College London, 2010), 18.

90 For example, Susan Stepney writes:

> Many novel forms of computational material have been suggested, from using slime moulds to solve graph searching problems, to using packaging foam to solve differential equations. I argue that attempting to force such novel approaches into the conventional Universal Turing computational framework will provide neither insights into theoretical questions of computation, nor more powerful computational machines.
> Instead, we should be investigating matter from the perspective of its natural computational capabilities. I also argue that we should investigate nonbiological substrates, since these are less complex in that they have not been tuned by evolution to have their particular properties. Only then we will understand both aspects of computation (logical and physical) required to understand the computation occurring in biological systems.

Susan Stepney, "The neglected pillar of material computation", *Physica D: Nonlinear Phenomena*, 237, 9, (2008): 1157-1164. http://www.cs.york.ac.uk/pdfs/NSC_pillar.pdf accessed April 10th, 2011.

91 John von Neumann was well aware of the important differences between the two forms: on the one hand computers made of transistors and vacuum tubes, accurate in computation; on the other hand brains made

In Turing machine computation, a specifically developed algorithm is established to conduct a computational procedure. Organic-like computational machines are categorically different to algorithmic machines. Such organic-like systems expand the notion of computation beyond the narrow sense of Turing machines, (ie. the procedural behaviour of algorithms), as, according to Peter Wegner, many biological machines can be surveyed as being *like* "Turing machines extended by addition of input and output actions that support dynamic interaction with an external environment".[92] This suggests that they cannot be Turing-complete because, bearing in mind Turing's comments, these very interactions become too rich for formalisation, that is, they "transform closed systems to open systems and express behaviour beyond that computable by algorithms".[93]

Informally expressed, where any Turing machine is universal, symbolic, discrete, pre-defined, deterministic and serial/sequential (parallel computers are treated as equivalent here), its real world machine processing is time sensitive, fragile, and fault intolerant as it is subject to bugs and errors, and it is necessarily a closed, non-dynamic and limited interactive system.

In contrast, if Turing's human is not the only organic computer,[94] other dynamic biological organisms defined as computational agencies are going to be mostly non-symbolic, continuous (except in death, the final halting problem), open, that is constantly adapting and evolving due to energy/information flows, stochastic, asynchronous, homeostatic in

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of neurons, less accurate in computation but to orders of magnitude more numerous. He thought that these differences necessarily lead to significant differences in the organisation of the two systems.: where computers are good at sequential computation, brains operate on a more parallel basis. See: John von Neumann. *The Computer and the Brain*. (New Haven, CT: Yale University Press, 1958).

92 Peter Wegner, "Why Interaction is More Powerful Than Algorithms", *Communications of the* ACM, 40, 5, (1997): 80-91 http://citeseer.ist.psu.edu/viewdoc/download;jsessionid=34E82EB447271D7B75A0D22C9E96096E?doi=10.1.1.57.9269&rep=rep1&type=pdf accessed April 12th, 2011.

93 Ibid. 83, and cf. Footnote 24.

94 In Turing's words: "We may compare a man in the process of computing a ... number to a machine." Turing. *On Computable* Numbers. 117.

being self-maintaining and robust, often distributed, and often very complex.[95]

Furthermore, where a Turing machine can be implemented on any suitable arrangement of substrates, no matter how “unnatural” that implementation may be, organic-like systems are said to directly exploit their material substrate to perform their computations.

As Turing perhaps anticipated, if these interactive/computational behaviours (asynchronous and chaotic ie. presenting non-linear feedback loops) are beyond algorithmic expression and as they articulate the difference between open and closed systems, they thus go beyond the procedural (formality is the defining condition of the Church-Turing (hypo)thesis) by instantiating some “real” *oracle*-like behaviours.

In fact for the last two decades or so some computational theorists have argued that the modelling of these interactive biological computations means abandoning classical predicate logic in favour of eg. paraconsistent logic because of the necessary incompleteness of all such interactive systems.[96] Thus, in returning to the guts of the material substrates of computation (but not yet à la Feynman) we can now look at computational materiality in a very different way, as *in materio* computation, where, for example, as the Turing/Feynman basic set of logic gates, AND, OR and NOT, are not implemented, then the same is also true for Turing completeness.

It is not always clear how much of a revolution this really is. Bearing in mind the levels of complexity and abstraction built upon the physical mechanisms of computation, computation is necessarily rooted in the changes in any substrate on a fundamental quantum-mechanical level.[97]

95 See: Erwan Le Martelot, Peter J Bentley, “Modelling Biological Processes Naturally using Systemic Computation: Genetic Algorithms, Neural Networks, and Artificial Immune Systems”, in *Nature-Inspired Informatics for Intelligent Applications and Knowledge Discovery*, ed., Raymond Chiong, (Hershey, PA: Information Science Reference, 2009), 204-24. http://www.cs.ucl.ac.uk/staff/p.bentley/LEBECH1.pdf accessed April 11th, 2011. See also Susan Stepney's, *The Neglected Pillar of Material Computation.*

96 cf. Peter Wegner. “Why Interaction is More Powerful Than Algorithms”; Dina Goldin, Peter Wegner, “Paraconsistency of Interactive Computation”, *Proc. Workshop on Paraconsistent Computational Logic (PCL)*, Denmark, (2002): 109-118. http://www.cse.uconn.edu/~dqg/papers/logic02.ps; Graham Priest, G., Koji Tanaka, *Paraconsistent Logic*, The Stanford Encyclopedia of Philosophy. ed. Edward N. Zalta. http://plato.stanford.edu/archives/win2004/entries/logic-paraconsistent. Both accessed April 14th, 2011.

97 Konrad Zuse first suggested that the Universe is computational, specifically a kind of cellular automata

However, and leaving aside the debate as to whether natural phenomena are the products of computation, formal languages, whatever they are, appear above the lower levels of complexity and abstraction, and always in relation with other information processing systems (human or machine) as they represent something to such systems and function as carriers of meaning. So if computational theory now replaces formal language description of abstract automata (Turing machines) with information processing using eg. *o*-machines as black boxes and/or paraconsistent logic (and subsuming Turing machines as a subset of such information processing devices), tractability (*viz.* getting something to do something else) nevertheless depends on the constraints of homeostatic[98] and morphogenetic[99] paradigms co-joined with some roadmap of inductive bias[100] as its methodological underpinnings.[101]

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in his 1969 work, *Rechnender Raum*: Konrad Zuse, K, *Rechnender Raum*, Braunschweig: Vieweg & Sohn. 1969. Translation by Aztec School of Languages,, MIT, *Calculating Space*, Cambridge, Mass.: MIT Press. 1970. ftp://ftp.idsia.ch/pub/juergen/zuserechnenderraum.pdf accessed February 14th, 2010. Others who argue that the Universe is computational most notably include, Stephen Wolfram, Ed Fredkin, Jurgen Schmidhueber, and Seth Lloyd.

98 That of negative feedback loops cf. Claude Shannon, *A Mathematical Theory of Communication*, Ibid., and of Norbert Wiener et. al's Cybernetics, where:

> We thus see that for effective action on the outer world it is not only essential that we possess good effectors, but that the performance of these effectors be properly monitored back to the central nervous system, and that the readings of these monitors be properly combined with the other information coming from the sense organs to produce a properly proportioned output to the effectors.

Norbert Weiner, *Cybernetics, or Control and Communication in the Animal and the Machine*, 2nd edition, (Cambridge,Mass.: MIT Press, 1961): 96.

99 As discussed, morphogenetic paradigms place an emphasis on material performance and process (rather than what those might represent) through positive, deviation-amplifying but *short range* feedback circuits that increase organizational diversity and can create new forms/elements, but always integrated.

100 David Hume famously suggested that logic never justifies the induction of laws from instances. Informally, in terms of the computational, induction is a learning process stopped at a certain point, decided on symbolic (pragmatic) grounds. The result will not be a perfect answer, but a good enough one. “From idealized logical machines providing perfectly correct general solutions to idealized problems, computing devices develop towards embodied real-world machinery providing good enough solutions to specific problems”. Gordana Dodig-Crnkovic, “Significance of Models of Computation, from Turing Model to Natural Computation”, *Minds and Machines: Journal for Artificial Intelligence, Philosophy and Cognitive Science*, forthcoming 2011, draft version. http://www.mrtc.mdh.se/~gdc/work/SignificanceOfModels-GDC-REV2.pdf. Also see: Kevin T Kelly, “Uncomputability: the problem of induction internalized”, *Theoretical Computer Science*, 317, 1-3, (2004): 227-249. http://www.cs.queensu.ca/home/akl/cisc879/.../05051011141516883.pdf. Both accessed April 14th, 2011.

101 This chapter might be considered as being underpinned in the same way in that it uses the reconstruction and framing by an individual using *quotation*-as-information (in negative/positive *short range* feedback loops that offer both closure and variety through constrained deviation) as the epistemological foundation to an observer-dependent research interacting with a wider (academic) environment.

This reasonable crystallization of computation-as-interaction is necessarily subordinate to an anthropocentric modelling (eg. the ancient art of bio-mimicry) to gain the desired programmability on the properties of these organic-like substrates so that they can be used to compute for humans, that is, used to task-solve our problems, not just their own.

So although such computation may be non-universal and extruded from the properties of some physical substrates - between the hylomorphism[102] of classical computational theory and computer architecture (remembering Feynman and Turing's lack of interest in specific material substrates), and "the physics of novel computing substrates based on unreliable non-silicon and non-Boolean computing components"[103] - it still, as explicated in this section, requires a systematic (and/or systemic) programmability to operate on at least two levels: implementing *a* model of computation (eg. formalizing the *o*-machine),[104] and implementing a particular problem solving function (but where the condition of iterability is not always a necessary condition).[105]

So far in this chapter I have sketched out, via literature reviews, the two dominant intellectual strains that have framed the various seminal works in NMA studies cited;

102 From the Greek terms for wood or matter (*hyle*) and form or shape (*morphê*) where a thing is causally produced by the imposition of formal order on chaotic or passive matter or matter that is inert and undifferentiated. See Aristotle, "Book Zeta", *Metaphysics* translated by Hugh Lawson-Tancred, London: Penguin, 1988. See also Flusser's discussion in Flusser, "Form and Material" in *The Shape of Things*, 22-29.

103 Christoph Teucher, Assistant Professor, Portland State University, USA, Department of Electrical and Computer Engineering writing on the 2010 course *Advanced Embedded In Silico and In Materio Computing* http://www.teuscher-lab.com/ext/teaching/65, accessed April 15th, 2011.

104 Thus modelling has taken inspiration from nature for "the development of novel problem-solving methods (artificial neural networks, swarm intelligence, artificial immune systems, computing on continuous data, membrane computing, artificial life, evolvable hardware, self-organizing systems, emergent behaviors, machine perception)" as well as from examples of computation by natural materials, including "information processing in evolution by natural selection, in the brain, in the immune system, in the self-organized collective behavior of groups of animals such as ant colonies, and particle swarms, quantum computing, molecular computing, DNA computing, biocomputing, neural computation, evolutionary computation, biological computing/organic computing". Dodig-Crnkovic, *Significance of Models of Computation.*

105 I have in mind the class of DNA computers known as "instance machines" that deal with one instance of a problem, sometimes in just "one shot" as they do not require re-setting and anyway can exhaust their internal sources of free energy: See especially "Table 1. Contrasts between universal and instance machine computing ", p. 702: Klaus-Peter Zauner, Michael Conrad, "Parallel Computing with D N A: Toward the Anti-Universal Machine", *Parallel Problem Solving from Nature*, Berlin. ed. H. M. Voigt et. al., 1141 (1996): 696—705. http://eprints.ecs.soton.ac.uk/11896/1/ZaunerKP96AntiUniMach.pdf accessesd April 14th, 2011.

argued for the importance of a third intellectual strain, media materialism, via several variants, because of its general thesis that technical media create *epistemic effects* (in both the sense of effecting the conditions and, following Foucault, the grounding of knowledge); and then characterized landmark work in different forms of computational modelling to indicate the hylomorphic (and hence, anthropocentric) relationships implicit to their substrate materials in their implementation. In the following section I intend to revisit these epistemological constraints thus far described via some excursions into recent philosophy that attempt to register a distribution of human and non-human agencies at work in the world.

The Non-Human Turn:

Bruno Latour's strategy against anthropocentricism is to question to what degree human actors actually execute intention and meaning: for example, a man alone doesn't fly, rather it is an assemblage of human and non-human actors (in conjunction called *actants)* that fly. Thus an action is defined in these terms as being the result of all the agencies involved in assemblages of what can be called material-semiotic networks, so that, for example, it is not the chimp but the chimp and the stick that both point into the water.[106] Furthermore, the chimp itself is an actant, that is an assemblage of other actants nested in a similar way to how a subroutine is nested by the abstraction principle as applied in computer programming (see footnote 69, p.20 above). A chimp's intentionality and agency, or indeed a human's, is thus theorised as being a lot rarer than language would suggest, as both creatures are really made up of many nested actants and assemblages of actants which escape such a singular intentionality or will towards.

In such an ecology the fabric of reality is described as being constituted by the range of

106 And see his description of the sheep, the shepherd and his dog where he contrasts the control of the sheep through the role of the shepherd and the sheep dog (power), and their control because of a barbed wire fence. Bruno Latour, *Reassembling the social: an introduction to actor-network-theory.* (Oxford: Oxford University Press, 2005), 77.

associations made between actants, actants which can include humans, mountains, viruses, snow, seals, ice-picks, microphones, molecules and from which other objects, other object-assemblages, can arise including those of non sensible sonic frequencies and micro flora and fauna, as well as those of art and love, all in something like a "universe made up of actants wrapped in actants wrapped in actants wrapped in actants".[107] Media are determined to be an extension to any object-assemblage, not just humans, and so non-human objects “extend” into other non-human or human objects in endless permutations, some more temporary than others and where media, in this wider sense, continually structure all of the relationships between entities.[108]

However, a problem with the kind of ontological positioning at play in such object-assemblage theory is raised by asking why and how such interaction takes place?[109]

Jane Bennett answers the question by suggesting that every object-assemblage that exists possesses a will to persist in its own being. Things have a “vital materialism”, a vital agency not possessed by distinct objects, but rather found, *pace* Spinoza, in the distributions of matter in those variable assemblages and conglomerates and in which any non-totalizable affective “bodies enhance their power in or as a heterogeneous assemblage”.[110] An example Bennett cites is that of electrical power grids, which she sees as a continually modulated assemblage of human constructions (physical and semantic)

107 To playfully appropriate a sentence written by Graham Harman in *Guerilla Metaphysics: Phenomenology and the Carpentry of Things, (*Chicago: Open Court, 2005), 85. Harman used the word “object” rather than “actant”.

108 I have here bracketed out any disambiguation and discussion of *causation* and *objecthood* as it is beyond my purpose in this chapter.

109 This question was posed by Ray Brassier in relation to the Object Oriented Philosophy (OOP) of Graham Harman, a philosophy indebted to Bruno Latour's actor-network-theory but which suggests that objects actually always exceed their relations.

> You have this kind of infinite nesting of objects within objects within objects … Every relation between objects itself unfolds within another object… what you have then is a kind of egalitarian objective univocity, a kind of ontology of pure objectivity: there are nothing but objects, objects nested within one another, and the really significant metaphysical challenge is explaining their interaction.

Brassier, Ray, et. al. “Speculative Realism”, *Collapse: Philosophical Research and Development*, 3, (2007): 316. For more on Harman's OOP and his relation to Latour see: Harman. *Guerilla Metaphysics*; and Graham Harman, *Prince of Networks: Bruno Latour and Metaphysics.* Victoria: Re-press, 2009.

110 Jane Bennett, *Vibrant Matter, (*Durham, NC: Duke University Press, 2010), 23.

and powerful non-humans that include electrons, trees, fire, and electromagnetic fields, as well as (from a human point of view) such anomalies as power blackouts. Such actants not only act in some way as constraints but also as efficacies, that is, in a way less like an intentionality and more as a power that makes a difference or produce an effect that "calls" for a response. Such a power is shared by humans and non-humans alike (as she says Spinoza contended) and thus agency is much more of a case of distributed and emergent causation rather than a singular human action. As if by way of a proof Bennett then suggests that we can legitimately talk about the reality of non-human agency precisely because linguistic communication necessarily entails mediating a variety of heterogeneous assemblages such that giving a talk can, for example, depend on graphite, the millions of other people, both dead or alive, from her Indo-European language group, as well as the electrical currents that are active in her brain and laptop.

This kind of vitalism opposes any notion of hylomorphism because it captures the kind of creative and energetic inner materialism characterized in Deleuze and Guatarri's *A Thousand Plateaus: Capitalism & Schizophrenia*. Here the quenching and forging of metal which takes place before the fixing of form is described along with the process of successive phases of de-carbonisation undergone by metal once removed from a mould.[111] Hylomorphism fails to capture any sense of this topological mutation and it is one of Bennett's more mundane contentions that in our encounters with vital matter there is a kind of relativity operating, where such slow motilities are contrasted with a higher rate of change and velocity of those humans perceiving or encountering them, so that 'objects' appear as objects because of appearing at one threshold of observation and not at any others. Something "material" is never only fixed, rather "nomadic", passed around in variations with fuzzy borders not only because of actions applied but because of the

111 Deleuze, Giles, and Felix Guattari, *A Thousand Plateaus: Capitalism & Schizophrenia*, trans. Brian Massumi, (London: The Athlone Press, 1988), 410-411.

protean activeness of, in this case, the metal itself.

Bennett makes the point that while every assemblage may well be an ecosystem not every ecosystem is democratic as such a polity would expect the release of human-centred priorities. Thus no human assemblage can realistically “horizontalize” the world completely (the same argument can be levelled against any ethics derivable from de Landa or Harman's versions of a “flat ontology” of objects) and hence her vital materialism's realpolitik is one based on “a polity with more channels of communication between members”. Such channels, she suggests, can be realised through, following Jacques Rancière, “repartitions of the sensible” so that non-human actants can radically shift, disrupt or catalyze a (human) public, so that, for example, what appear to be nonsensical questions can now be legitimately asked such as to whether or not the typical American diet led to a widespread belief in the propaganda leading up to the war in Iraq?, or “can HIV mobilize homophobia or evangelical revival?”[112]

Bennett's real aim of enquiry is to amplify and include other agencies in a political register that indirectly leads to a “better” world (echoing something of Graham Harwood 's et. al. artistic projects referred to on p. 19), that is, to incorporate non-human assemblages and agencies as expressions of a generalised processual intelligence that does not just remainder them as part of the environment on which human activity takes place. She recognizes the normative implications of such a project in that it is this power of abstraction that will always be wielded by the human, but argues that it should be understood as a critical gesture to allow everyday non-human things to become more visible. If the attentiveness to the power of these things she calls for is the indirect political strategy pursued in the book, its ontological landscape remains fairly sparse, as although interaction is given some heuristic detail, the mechanisms of how actants form and hold themselves together, both as individuals and as members of an assemblage, and how

112 All quotations from Jane Bennett, *Vibrant Matter.* 104-107.

iterable structures like humans can be accounted for in any assemblage theory are left unaddressed.

Notwithstanding these ontological issues, in general ideas about distributed agencies and process ecologies have gained traction in NMA and have recently led to some theorists recasting their earlier work. In the next section I will consider how these reframings have impacted on the argument made at the beginning of the review, that there has been a lacunae in NMA as it has failed to engage with the material substrates of its technical media in or for its aesthetic or political expressions.

Mediations:

What could these new and post-Latourian materialisms mean to NMA? Clearly an idea of the ecology of assemblages might help, for example, a media archaeologist set about describing the various material and social configurations that surround the ontogenesis of some computer protocol in uncertain or non-obvious ways as part of a larger project to help explicate how a particular culture is produced (I have no one thinker nor project in mind when I write this). These new materialisms also might help NMA artists to create and force some scalable and dirty interventions within some of these assemblages, perhaps in the hope that they are weighted with a ceaseless critical stance simply because of their execution (for further explication of what I mean here see Chapter Two: Executing a New Media Materialism).

For new media theory this shift in agential efficacy has been registered in some recent treatments. If Bolter and Grusin's *Remediation* exported the thesis that “our culture wants both to multiply its media and to erase all traces of mediation: ideally, it wants to erase its media in the very act of multiplying them”[113] then after 9/11 Richard Grusin has since politicised these analyses to suggest that media are now essentially governmental. In

113 Bolter and Grusin, *Remediation.* 5.

2010's *Premediation: Affect and Mediality After 9/11*[114] Grusin argues that "mediality" should be related to Foucault's concept of governmentality, as media post-9/11 chiefly operate in mobilizing and managing populations. He abandons the concept of media-as-object that underpins *Remediation* in favour of one of media being non-representational and affective media assemblages that act as material translators of what can be called "anticipatory atmospheres", those preconditions that emerge and are intensified within historically specific social, political, and technical media regimes. With this Grusin suggests that the future has already been pre-mediated before it turns into the present in order, he argues, to insulate the (western) world from the shock of, among other things, 9/11.

Similarly Mark Hansen argued recently during Transmediale11 that new concepts are needed to account for an expanded notion of media as processes rather than objects, especially as many such processes are sub-perceptual to humans.[115] Where Bolter and Grusin had necessarily classed media as objects to make their argument in *Remediation*, Hansen argues, echoing Grusin above, that media should now be considered to be continual processes that constantly register in the production of subjectivities. This conception, he argues, radicalises the subject/object body centred approach that he himself theorised in *New Philosophy for New Media*. Bodies and subjectivities are now placed in the "flat ontology" of an entirety of what he calls "atomspheric media", an environmental experiencing which continually acts on those bodies below the level of the five senses, and which might then inform the emergence of some higher order perception, or just continue in their distinct and subtle influencing. This appears to be traversing similar territory as laid out by Bennett, especially as evinced in her suppositions about what kinds of questions it

114 Richard Grusin, *Premediation: Affect and Mediality After 9/11*, (Basingstoke: Palgrave Macmillan, 2010).

115 Mark Hansen,"Delimination of Life", Panel Presentation, Transmediale 2011, February 6th, 2011, Berlin, http://www.transmediale.de/content/delimination-life-mark-b-hansen-us accessed April 14th, 2011.

might no longer sound outlandish to ask. However rather than thinking of environment as being composed of nested assemblages, Hansen seems to be pursuing a notion derived from Alfred Whitehead where environment can be conceived of as an irreducibly extended and agential entity on which the body is both acted on by and in process with. So where previously Hansen had privileged the body as the enframer of digital information, he now contests that it is part of a sensory hybrid informed by "atomic" sensibilities at various scales that it can not directly experience nor quantify, and thus the new challenge for theory, as he perceives it, is how to efficiently detail this media environment.

As these authors and others in various ways acknowledge, this environment is complicated given that digital code mediates all such techno-social media assemblages.[116] Thus media are no longer seen as middle elements, those direct carriers of information and distributors of discrete meanings between senders and receivers (cf. Introduction to this chapter). Rather media are being re-characterized as complex assemblies of solids and non-solids, apparatus and interfaces that act across a range of perceptual scales on humans and each other, mixing their own circuits of agencies, translation protocols (*vide* Latour) and affects.[117] Reading media in this way, as being composed of complex agencies that affect epistemic orders, somehow produces its own subject as it is itself a nascent moment in theoretical history; thus a recursive study of these (and other) recent Latourian, media archaeological approaches might reveal more about the conscious and unconscious

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116 cf. Kittler, *Gramophone, Film, Typewriter.* 1-2.

> ...something is coming to an end. The general digitisation of channels and information erases the differences among individual media...Inside the computers themselves everything becomes a number: quantity without image, sound, or voice. And once optical fibre networks turn formerly distinct data flows into a standardized series of digitised numbers, any medium can be translated into any other.

117 In the *The Philosophy of Software* David Berry suggests that this means there is an explicit question about the ontological status of what the computational is in regard to the natural sciences.

> ...the ontology of the computational is increasingly hegemonic in forming the background presupposition for our understanding the world...To distinguish between entities that are computational or may be represented or modelled computationally from the ones which are non-computational...

David M. Berry, *The Philosophy of Software: Code and Mediation in the Digital Age*, (Basingstoke: Palgrave Macmillan, 2011), 128-129.

dispositions of their authors in so far as they are part of the phenomena that they produce.

The problem these NMA studies have carried forward is their perceived epistemological mandate to accurately represent their object of study, and this suggests that it could only be a very different kind of work that could begin to investigate the material basis of NMA's technical media. In Bennett's polity she acknowledges a large degree of formalism at work in her project, implying that any use of formalism is itself necessarily problematic. However, the suggestion I am going to make here is that the best way to describe some of the material dynamics of NMA's technical media is via Karen Barad's theory of apparatus, in which formalism is seen to be necessary and ontic.

In her exegesis of what she calls the quantum physicist Nils Bohr’s Philosophy-Physics, Barad argues that what can be represented can only be the result of experiment which, to an extent, shapes its own results. For Bohr and subsequently Barad, it is always the measuring apparatus that cuts the agencies of observation from the observed object, so that “observations do not refer to properties of observation-independent objects (since they don't pre-exist as such)”.[118] Reality is thus inherently indeterminate until it is measured by some apparatus, in a form of what she calls “agential realism”, which is itself necessarily formalised. This indeterminacy is ontic and only subsequently epistemological as, in the example Barad uses, not knowing simultaneously position and momentum is not a perceptual limitation but a question of simultaneous existence.[119] At the same time, in so far as any act of observation makes a "cut" between what is included and excluded in such observation, separating out from entanglement and rendering some "things" visible and others not, it is of inherently ethical-political significance. Her theories thus have a far reaching importance for not only science and the philosophy of science, but also social

118 Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, (Durham: Duke University Press, 2007), 114.
119 Ibid. 118.

studies including feminist, gender, and queer theories. According to this reading there can be no accurate representation other than that which is determined via our measuring apparatuses because boundaries between things do not exist outside of these measurements, or cuts. I return to explore this further in the next chapter on practice.

Diffractions

In this research the main proposal is that the material substrates of NMA's technical media, the computer, can allow for a rich seam of affordances for new artistic and social productions through the disassembling and reconfiguration of the computers “crystalline” orderings of material *viz.* minerals.

In situating this proposal with the assumption of the research, that there has been a bracketing out of any sense of the material basis in NMA, this chapter has detailed some of NMA's theoretical legacies apparent in some canonical studies made over the last two decades. Variants of a third theoretical influence, media materialism, along with studies into the materiality of Turing machines and bio-computers, have been characterized and subsequently discussed with regard to the anthropocentric modelling of material substrates. This discussion has then been refined to reflect some recent work on “the post-human turn” in philosophy and associated new media theory, and has suggested that there is still an issue in these latter studies as they still assume an epistemological mandate to accurately represent their object of study. Finally, an alternative method of framing computer materiality has been suggested via the work of Karen Barad, one in which formalism is recognized as being unavoidable in any material discursive practice.

With this in mind what is important for this research is the way in which the main proposal is executed and since it is centred around the material, then such execution is readily open to examination through a plurality of practices. Hence recent research workshops have begun to explore some of these materials, and the chapter on practice details a series of experiments and events that attempted to *diffract* some of the minerals from computers through the variable lenses of different traditions and practices. For example, and by way of introduction, in the workshops gold was configured in many combinations with things like acids, heat, and electricity, electronics, computers and economics, belief, chance and science, and so on, all acting in a physical-philosophical enquiry that was not designed to ask how to understand gold from some one or other theoretical perspective, but rather suggests that gold can only be understood as a thing to be manipulated by practice.

Thus instead of highlighting one set of practices and its discourse, the polities in which such materials are distributed, the research deliberately attempts to multiply them. The thought is that if any one of these discourse-practices was foregrounded then there is only the one stranded or bundled view of that material presented, but if elements of multiple practices are introduced then multivalenced objects appear and disappear.[120] Then perhaps an ethnographic or forensic pathology might be spawned, or the intervention just left without any attempt at epistemological normativity (how to know properly), which assumes that some thing precedes practice rather than being a part of it. This then is the general drive detailed in the next chapter on practice, that things are brought into being, used, multiplied, and for that are always highly topical, formalised and political.

120 A similar idea was presented in relation to museum objects: Jonathan Kemp, “'Practical Ethics v2.0”, *Conservation: Principles, Dilemmas, and Uncomfortable Truths* eds. Alison Bracker and Alison Richmond, (Oxford: Elsevier, 2009), 60-72.

Chapter Two: Executing a New Media Materialism

This chapter summarises current practice relevant to the key concepts of the research introduced in the last sections of the previous chapter, *viz.* a series of workshop events and open laboratories. Those theoretical underpinnings are examined and related to those events in the "Introduction". The completed "Decrystallization" and "Recrystallization" workshops are described with following discussion subsections that highlight key elements that relate to the research themes. Reasons are made clear in these discussions as to why the experiences of the workshop participants remain largely unquantified throughout the research. A brief section, "Chemical-Material Live Performance System", describes a performance project that has derived from the research. The next section, "The Suffolk Psychogeophysics Summit", details experiments that are linked to the open laboratory series, "The Crystal World", which is then described in the last section of the chapter and includes a final discussion to re-iterate the relation of the theory to the concluded research practice.

Introduction

In *Meeting the Universe Halfway*, Karen Barad attempts to extrapolate a set of ontological claims about the world via an extension of Niels Bohr's epistemology, arguing that practices embody theories, and, as they are specific in time, differentiate and exclude some concepts at the expense of others. Barad develops an idea of entanglement as "intra-action", suggesting, for example, that the concept of momentum exists only in the intra-action of experimental apparatus and the particle, rather than as the interaction between distinct identities. In the chapter "Agential Realism", Barad then goes on to define the nature of the apparatus of such theories and practices:

> 1) apparatuses are specific material-discursive practices (they are not merely laboratory setups that embody human concepts and take measurements);
>
> 2) apparatuses produce differences that matter - they are boundary-making

> practices that are formative of matter and meaning, productive of, and part of, the phenomena produced; 3) apparatuses are material configurations/dynamic reconfigurings of the world; 4) apparatuses are themselves phenomena (constituted and dynamically reconstituted as part of the ongoing intra-activity of the world); 5) apparatuses have no intrinsic boundaries but are open-ended practices; and 6) apparatuses are not located in the world but are material configurations and reconfigurings of the world that re(con)figure spatiality and temporality as well as (the traditional notion of) dynamics (i.e. they do not exist as static structures, nor do they merely unfold or evolve in space and time).[1]

Barad thus argues that apparatuses are both agential and performative. They are agential not in the closed-down sense of being a property of individual entities such as humans, quarks, shoes, rocks and ice, but rather in the sense of “intra-acting”, that is, a “doing” or “being” as particular configurations of material possibilities that contribute to what Barad calls a “different mattering in the world”.[2] These apparatuses are also performative in so far as they intra-act with the ways in which humans temporarily 'cut' the world into sections (she means here localised resolutions) to reveal (or to leave concealed) this or that about it. Using the examples of “wave” and “particle”, she argues that neither refers to any inherent property of light that somehow precedes intra-action, to the extent that as she understands it, there cannot be such independent things with such inherent characteristics. Rather “wave” and “particle” refer to two different sets of (measuring) apparatus that effect different cuts to delineate the “measured object” - “in other words, they differ in their local material resolutions of the inherent ontological indeterminacy”.[3]

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1 Barad, *Meeting the Universe*. From the section "Toward an Agential Realist Understanding of Apparatuses', 146.
2 Ibid. 178.
3 Karen Barad, “Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter”, *Signs: Journal of Women in Culture and Society:* 28, no. 3 (2003): 831.

Inspired by Barad, media archaeologist Jussi Parikka has subsequently suggested that by substituting the word “apparatus” with “media” in the text quoted above, a “very good and material-dynamic way to understand the ontology of media technologies”[4] is provided as the grounds for a “new apparatus theory” of media, and, by implication, of new media art. This is a proposition I want to consider further in what follows.

However before describing the core practice of this research, one caveat about what this practice might appear to be should first be made: a lot of new media art appears to operate under the assumption that by engaging with the formal elements of that practice, for example on levels of code and software, hardware, or interface, somehow a kind of political engagement or critique is enacted simply because things are used for what they were not intended so as to reveal their regulatory parameters. Examples I have in mind range from the recent tranche of work under a rubric of so-called 'critical engineering' including Julian Oliver and Danja Vasiliev's “Newstweek” project, which reveals more about insecure wifi networks than anything else; and including older canonical works such as Adrian Ward's 2002 auto illustrator project, which was designed to “enlighten us as to the meaning of software as a tool and, on the other, cross the boundaries existing between the creator of a work and the work itself”; and to the early work of jodi (Joan Heemskerk and Dirk Paesmans) who typically modified video games like *Quake* to render them into their basic units and then reassemble them counter-intuitively.[5] Parikka's call for a “new apparatus theory” appears particularly apposite when such self-recursion is seen as a particular kind of cut that can heavily skew new media art's relation to its materiality.[6]

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http://www.jstor.org/pss/10.1086/345321 accessed July 24th, 2011.

4 Jussi Parikka. “Apparatus Theory of media à la (or in the wake of) Karen Barad”. *Machinlology* (blog), http://jussiparikka.net/2009/07/16/apparatus-theory-of-media-a-la-or-in-the-wake-of-karen-barad/ accessed April 11th, 2011.

5 http://newstweek.com/overview, http://swai.signwave.co.uk/, http://wwwwwwwww.jodi.org/ all accessed November 9th, 2011.

6 Parikka's own take on “media archaeology” had, at one time, appeared to be less concerned with technological materiality and more concerned with excavating the Foucauldian definition of archaeology as in, for example, his book *Insect Media*, (University of Minnesota Press, Minneapolis, 2010), which offers a series of reorientations on how to think about contemporary technological and social organization

Hence the aim of this chapter is to describe and contextualize a series of experimental events that investigate new media arts' material basis, an investigation first of all prompted by the predominant use of computational devices in all new media art, and further by, as I see it, lacunae in the literature where such material foundations remain obscured.

As outlined in Chapter One: Computational Materiality, computers execute instructions that have been abstracted from various mathematical or biological models. In *The Art of Programming,*[7] Donald Knuth makes an analogy between programming computers and following a recipe. This analogy can be extended to suggest that if looking at the ingredients and techniques of making a meal reveals more about that meal than just by looking at it on a plate, then, just as a meal is an end-product so a computer similarly disguises its history and any sense of the means of its production. However the analogy only holds up where a recipe begins to reify those means, those groups of things and processes, into probabilities around the complexing of materials, humans and symbols (for example, duck, orange, water, oven, gas etc) from other less material and more symbolic

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through discursive comparison with early ethological texts. More recently, as in the 2011 *Media Archaeology: Approaches, Applications and Implications*, co-edited with Erkki Huhtamo (University of California Press, Berkeley, 2011) Parikka, in introducing the novel discipline of media archaeology, suggests that where there is an Anglo-American tradition drawn to Foucault's notion of archaeology understood as that of examining discourse to reveal the loci of social and cultural powers; there is also the German variant of media archaeology, centred around Friendrich Kittler, where Foucault 's notion needs to be adjusted in so far as such a discourse analysis cannot make sense before the material means of its production is understood as a series of techno-historical events. Other readings of what media archaeology *can be*, pointed to by Huhtamo and Parikka, include Siegfried Zielinski's *anarchaeology*, an extremely localised analysis that resists both systematization and theorization, but which offers some productiveness through its heterogenity and non-linear descriptions of media and technology. Thus Parikka's call, if it is in earnest, would seem to need to be situated somewhere around either Kittler or Zielinski's material and localised dynamics: the practice detailed in this chapter perhaps suggests the need for such a particularised accounting.

7 I was made aware of the analogy in reading Geoff Cox's 2006 PhD thesis, *Antithesis: The Dialectics of Software Art*, DARC, Aarhus University, 2010, where he makes reference to it to emphasise sharing as being systemic in free software culture. Donald Knuth, *The Art of Computer Programming: Volume 1, Fundamental Algorithms (*Reading, Mass.: Addison-Wesley, 3rd edition,1997), preface:

> Here is your book, the one your thousands of letters have asked us to publish. It has taken us years to do, checking and rechecking countless recipes to bring you only the best, only the interesting, only the perfect. Now we can say, without a shadow of a doubt, that every single one of them, if you follow the directions to the letter, will work for you exactly as well as it did for us, even if you have never cooked before.

Quoted from *McCall's Cookbook: The Absolutely Complete Step-By-Step Cooking,* (New York: Random House, 1963).

complexes (like “Duck à l'Orange”). In that chapter I emphasise how much of the literature is bound up in this kind of analogy but that, as Knuth suggests, while it might work in a limited way on the highly abstracted level of code and programming,[8] it has nothing to add when attempting to examine and understand a pile of bared computer motherboards. Motherboards certainly exhibit some of the formal complexities involved in embodying computational logic in materials through the arrangement, patterning and linkage of various and regular looking components, but nothing much is revealed about their raw materials nor in turn about their production.[9]

Materials are not ontologically independent of the way in which other things mediate them, nor does a material's mediation by another entity exhaust or define that material. As such, a material can never be fully comprehended in terms of the purpose to which that other entity puts it to use. Thus one of the adjunct products of the research practice is the making visible, by way of its (clumsy) renderings, some of the aleatory contingencies which the cuts made by contemporary new media art theory and practice tend to obscure - not only do such cuts render certain elements of the world invisible, but they also render themselves invisible by presenting the distinction they operate under as a given, as with the *modus operandi* of the new media art referred to in the caveat at the beginning of this introduction, where a politics is assumed in the revelation of formal parameters.

The primary practice of the research are a series of events held throughout 2011 and 2012. The first event, “Decrystallization”,[10] was a workshop that took place over two days at the end of May 2011 in London, which was then followed by “Recrystallization”,[11] a three day workshop executed in Berlin in July 2011. The testing and development of related concepts

8 See the discussion of the levels of abstraction in a computer as detailed in the Contextual Review: Computational Materiality with reference to Richard Feynman and his reuse of the slightly earlier work of Peter Denning and Robert Brown.

9 Especially *vis à vis* the inherent contradictions in value, arguably expressed through an ideology of emancipatory capital that jars with the oppressive underdevelopment of cheap labour in their production.

10 http://xxn.org.uk/doku.php?id=decrystallization:description Last modified June 3rd, 2012.

11 http://xxn.org.uk/doku.php?id=recrystallization:description Last modified October 18th, 2011.

was consolidated during The Suffolk Psychogeophysics Summit, an event which the author co-organised in late August 2011,[12] before the first version of "The Crystal World" was held over six days in February 2012 as a part of the Club Transmediale New Media Festival, Berlin.[13] A subsequent version of "The Crystal World" was held in London, from July 17th until September 1st 2012.[14] Each section of the chapter will detail each of these events in terms of why and how they were convened and how they operated, with relevant discussion sections on how they moved the research forward.

12 The Suffolk Psychogeophysics Summit. Last modified September 6th , 2011. http://www.psychogeophysics.org/wiki/doku.php?id=summit2011:description

13 http://www.ctm-festival.de/ctm-festival/exhibition/the-crystal-world.html accessed October 24th, 2012.

14 http://crystalworld.org.uk/ is the project website. Post-description of the Berlin version is here: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:post-description Last modified April 1st, 2012; and of the London version, here: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:postdescription Last modified October 17th, 2012.

Fig. 1. Decrystallisation Workshop, London, May 2011: Preparation of *Aqua Regia* (nitric/hydrochloric acid mix) being added to crushed processors to make a gold solute as a stage on the way to attempt to recover gold metal.

Decrystallization:

Decrystallization etymologically means the breakdown of a solid crystalline structure. The concept has been annexed, for example, in neurophysiological studies to represent the deterioration of bird song where the variability of the spectral structure of the bird's syllables has become very small, that is, crystallized, and the bird sings these syllables in a highly predictable order. Researchers, for example,

> found that perturbing auditory feedback during singing in adult zebra finches caused their song to deteriorate slowly. This “decrystallization” consisted of a marked loss of the spectral and temporal stereotypy seen in crystallized song, including stuttering, creation, deletion and distortion of song syllables.[15]

15 Anthony Leonardo & Masakazu Konishi , “Decrystallization of adult birdsong by perturbation of auditory

The conceit of the workshop was that if computers and the minerals from which they are made are considered as equally crystalline, that is, as highly predictable structures, it then follows that their decrystallization is possible through the introduction of vigorous and noisy perturbations as constructive forces that dissemble any potential for the recuperation of such structures through, for example, their (re)creation or morphogenesis from workshop processes and products.

Pre-workshop Formulation:

The London-based workshop took place over two days in May 2011 and was convened by the author[16] around an online distributed publicity text[17] that announced its thematic premises.

Beginning with an image and quotation from Mead and Conway's 1980's book on Very Large Scale Integration Systems (a book from which Richard Feynman draws heavily in his *Lectures on Computation* when discussing the physics of computational components), the text introduced a visualization of order and entropy in structures:

> Suppose a system consists of two containers holding a total of 10 blue molecules and 10 red molecules. There is only one way in which the molecules can be arranged so that all 10 blue ones are in one container, and all 10 red ones are in the other. On the other hand, there are a very large number of ways we can arrange to have 5 of each color in each container.[18]

The publicity text then alluded to scientific, symbolic, and symbiotic notions of crystals

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feedback", *Nature* 399, (1999): 466-470 http://jackknife.med.yale.edu/nsci590-2005/pdfs/leonardo1999.pdf accessed July 27th,.2011.

16 Decrystallization was conceived by the author, Jonathan Kemp http://xxn.org.uk; the workshop was executed with the assistance of electronic noise artist Ryan Jordan, http://ryanjordan.com both accessed November 1st, 2012.

17 Originally published online by the author, April 2011, http://xxn.org.uk/doku.php?id=decrystallization Last modified 6th June 2011, and distributed across various new media art mailing lists including to spectre, eu-gene, dorkbotlondon, piksel, openlab, and mute-social, April 2011.

18 Carver Mead, Lyn Conway, "Entropic View of Computation", *Introduction to VSLI Systems*, (Cambridge, Mass.: Addison Wesley, 1980), 366.

and decrystallization:

> If life starts from aperiodic crystals that encode infinite futures within a small number of atoms, then the digital crystallization of the flesh by capital limits futures to the point of exhaustion. The workshop begins from the premise that the decrystallization of the digital through positive feedback disrupts and escalates entropy through such systems. Mindful that such activities can also be used to consolidate capital through the use of stolen negentropic energies, the 2nd day of the workshop will investigate the re-vivification of computation's raw minerals through mutation and irregular assemblage by participants.

Finally, the online text introduced a brief outline of workshop activities:

> Day One Workshop : decrystallizing the computational - participants will recycle pcb's/IC/pins/connectors for minerals including copper/gold/silver/platinum/palladium. Day Two Workshop: escaping the pathology of the crystal - participants will create raw/renditioned mineral assemblies using piezoelectrics, positive feedback, colloidal dispersions; end of workshop will be followed by gold/silver drinks and lo-no amp performances.[19]

This publicity text also advised potential participants that they would be taking part at their own risk as the workshop would include both high heat and highly toxic processes. A link was given to a Resource page[20] which outlined the various chemical processes that might be used in the workshops, along with their associated risks, and all the relevant

19 http://xxn.org.uk/doku.php?id=decrystallization Last modified August 10th, 2012.
20 http://xxn.org.uk/doku.php?id=decrystallization:resource (dead link), originally published April 20th, 2011 and now incorporated in http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:techniques. Last modified July 9th, 2012.

material safety data sheets.[21] Other Resource items included a Reference subsection[22] with links to texts that were considered important as background to the workshops, including, for example, articles by Félix Guattari,[23] Erwin Schrödinger,[24] and Claudia Mongrini[25] that in some way elaborated notions of both the crystal and its decrystallization. Video links given in the same subsection included a recent talk on the "crystallization" of digital capital given by Franco "Bifo" Berardi,[26] at Berlin's Transmediale.11 festival for "art and digital culture", and the Afterlife video project by Matthew Appleton and Denzil Armour-Brown. In the latter "the impact of electronic waste on the global community" was interpreted as exemplifying the negative feedback loops that were perceived by this author to "consolidate Capital through the negentropic use of stolen energies" as they are inherent in industrial electronic-waste (e-waste) operations, especially those that are unregulated.[27]

Methodology:

The potential for a reciprocity between all participants was an implicit assumption for the workshops. The notion of participant was felt to be all inclusive and the role of "workshop leader" was hoped to be free of any conventional pedagogical role outside of a health and safety induction. Whilst the author had prepared techniques and materials for the range of potential activities outlined in the original workshop call, the workshop was never

21 True to a workshop format, subsequent emails to participants included descriptions of the health and safety risks that were involved in these processes along with what safety equipment would be provided. Participants were also notified that they take part at own risk and that after health and safety information had been at the beginning of the workshop they were to sign a liability disclaimer form.

22 Now incorporated in http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:reference Last modified October 25th, 2012.

23 Félix Guittarri, *The Proliferation of Margins*, translated by Richard Gardner & Sybil Walker, New York: Semiotext(e) 10, 1990.

24 Erwin Schrödinger, *What is Life?*, (Cambridge University Press; Cambridge, 1944).

25 Claudia Mongrini, "The art of critique in the age of precarious sensibility", http://th-rough.eu/writers/mongini-eng/art-critique-age-precarious-sensibility accessed May 3rd, 2011.

26 Franco "Bifo" Berardi, "Life at Work: Bioeconomy and the Crisis of Cognitive Capitalism", Panel Discussion, Transmediale 2011, Berlin; Panel, February 5th, 2011, http://vimeo.com/20198222 accessed April 3rd, 2011.

27 A link was also made to a Greenpeace International report on the conditions of labour within some e-waste operations in China and India: Kevin Bridgen, et. al., *Recycling of Electronic Waste in China and India*, (Greenpeace International, Amsterdam, 2005). http://www.greenpeace.org/international/Global/international/planet-2/report/2005/10/recyclingelectronicwasteindiachinafull.pdf accessed May 8th, 2011.

designed to be just a particular type of pedagogical space in which to execute rigorously a predefined set of concerns and activities (as was made concrete in the lack of any explanatory overview for the two days). Instead the idea was to present a constructive space in which elemental themes might be taken up by participants in conversation-based groups who would attempt various experiments, with the process-governed distributions of materials and equipment within the space. Thus one table was surrounded by junked motherboards and tools for pulling them apart; a clean table was laden with glassware, test tubes, and chemicals; two other tables were placed outside along with equipment including gas torches, spirit burners, bricks, and containers of oxides and acids; in another area of the studio, for any crushing operations, a rough metal plate was laid on the floor along with a metal mortar and pestle.

Workshop Description:

Translating the premises set out in the publicity text was loosely begun on Day One of the workshop as fifteen or so participants[28] began to take apart the stock of laptop mother boards and associated parts with hand tools in what would become a continuous background (sorting) operation for the two days. Central processing units (CPUs) and edge connectors were targeted for their gold content, along with other micron thick gold plated male/female connectors, bridge connectors, peripheral buses and memory slots. Integrated circuits (ICs), and some capacitors were selected for their potential silver and palladium content, while various copper and iron ferrite coils and any useful looking sheet metal components were retained for use in any further processes of disaggregation and/or for reconfiguration with other salvaged elements.

Where these mechanical means had furnished sufficient quantities of the various

28 Participants invited from the open call included fine artists, musicians, gamers, new media artists, and a mathematician.

components some of the chemical processes were begun.[29] Broadly described, several electro-chemical and inorganic chemical processes were followed in attempts to primarily recover gold and silver from the computer junk, and involved electrolysis; the acid leaching and dissolution of metals such as silver, tin, copper and lead; the precipitation of selected metals; and the use of reduction-oxidation reaction ("redox") exchanges between solids and liquids. These processes had been assimilated and transcribed into handouts by the author from a variety of print and online sources ranging from metallurgy,[30] industrial e-waste applications,[31] various online accounts of the medieval Aqua Regia (Latin for "Royal Water") process for the dissolution of gold in acid,[32] and included the description of acids used for the "killing" and recovery of precious metals in ancient India.[33]

Whilst some participants continued recovering components from the motherboards, others donned the appropriate personal protective equipment (PPE), and began the intensive work of provoking reactions between liquids and solids, with attempts at accelerating them through the use of heat and low voltage electricity as appropriate. For example, hammered and crushed ICs were covered with concentrated Nitric Acid and gently heated in order to dissolve their base metals, including silver and copper. The remaining debris was subsequently added to other gold-bearing components such as CPU pins (denuded after bathing the CPUs in Nitric Acid) to solutions of Aqua Regia, in which to dissolve any gold and platinum for subsequent precipitation.

29 Details of the processes used in Decrystallization are now incorporated in http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:techniques Last modified 9th July, 2012.

30 Željko Kamberović et. al. "Hydrometallurgical process for extraction of metals from electronic waste-part I: Material characterization and process option selection", *Hydrometallurgy:* 15, no 4 (2010): 231-243, http://www.metalurgija.org.rs/mjom/vol15/No%204/3_Kamberovic_MJoM_1504.pdf accessed May 9th, 2011.

31 Christian Hagelüken and Christopher W Corti "Recycling of gold from electronics: Cost-effective use through 'Design for Recycling'", *Gold Bulletin,* 43, no.3 (2010): 209-220 http://www.goldbulletin.org/assets/file/goldbulletin/.../Hageluken_3_43.pdf accessed May 9th, 2011.

32 *Aqua Regia*, Latin for "Royal Water", is the combination of one part Nitric Acid with three parts Hydrochloric Acid which will dissolve the 'noble metals' gold and platinum, of which single acids are unable to do. It is a process attributed to the anonymous 13th Century alchemist, Psuedo-Geber.

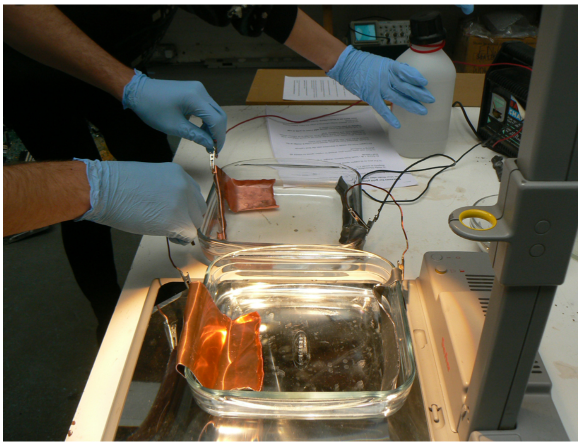
33 Acharya Prafulla Chandra Ray, *History of Chemistry in Ancient and Medieval India*, (Calcutta: Indian Chemical Society, (1902) 1956).

Fig. 2. Day One: Smashing processors, ICs and other usable components from junk motherboards using hand tools.

Fig. 3. Day One: One location for the removal of selected parts from junk motherboards.

Fig. 4. Day One: Adding nitric acid to crushed integrated circuits for dissolution of silver and copper.

Fig. 5. Day One: Heating the Aqua Regia and crushed processors to accelerate the dissolution of gold and other base metals.



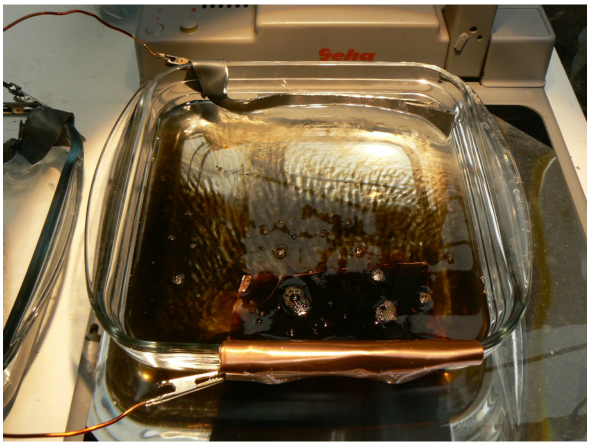


Fig. 6. Day One: Preparing copper (+) and lead (-) electrodes and 12v computer psu for the electrolytic recovery of gold from processor pins.

Fig. 7. Day One: Electrolysis of recovered pin connectors in sulphuric acid.

On Day Two participants, while continuing to work with some of the processes introduced on Day One, began re-purposing recovered metals partly in preparation for the proposed final night salon event. High heat from a gas torch was used to forge salvaged copper parts into platelets, and then to produce a cuprous oxide layer on one side, and zinc scraps were similarly oxidised on one side, with both these oxidised metals, as crude semi-conductors, deployed as negative resistance audio oscillators[34] for the night's salon noise performances.[35]

Other metals filed by participants were used to construct coherers[36] which "cohere" metal particles through radio wave discharges in a way not yet completely understood.[37] The coherers were then used in the salon event in combination with the negative audio oscillators by both audience and participants as noise generators through being connected to radio receivers and activated by barbeque lighters.

Prior to the concluding performances of the salon, colloidal dispersions of gold and silver were prepared by the author for both participants and public to drink. Pre-workshop research identified the history and safety of such dispersions, along with the various electrolytic methods of production. Technically called hydrocolloids because their target substance is microscopically dispersed in water, two 500ml dispersions were made on the night with pure silver and gold electrodes (as opposed to the possibly contaminated gold or silver recovered from computers) to ensure the well being of all who took small sips of them. This form of communion was staged to effect the theatrical perturbation of

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34 Jim Lesurf, "Negative Resistance Oscillators", http://www.st-andrews.ac.uk/~jcgl/Scots_Guide/RadCom/part5/page1.html accessed May 1st, 2011. Nyle Steiner, "Zinc Negative Resistance Oscillator", http://www.sparkbangbuzz.com/els/zincosc-el.htm accessed April 20th, 2011.

35 Whilst such arrays give a nod to the history of the computer, this particular use disavowed any potential for its recuperation.

36 Nyle Steiner, "Simple Homemade Coherer", http://www.sparkbangbuzz.com/els/coherer-el.htm accessed April 21st, 2011.

37 After "Bradly's Coherer" first appeared arounf 1890 theories about why it works are still being published including this paper by Eric Falcona and Bernard Castaing, "Electrical conductivity in granular media and Branly's coherer: A simple experiment", *American Journal of Physics:* 73, No. 4 (2005): 302-307.

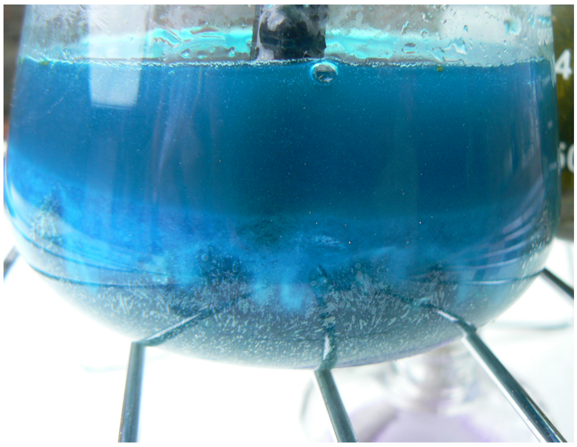


Fig. 8. Day Two: Using nitric acid to leach base metals including silver from processors.

Fig. 9. Day Two: Silver chloride formation after addition of salt to gently heated nitric acid leachate , in preparation for redox plating of silver onto iron.

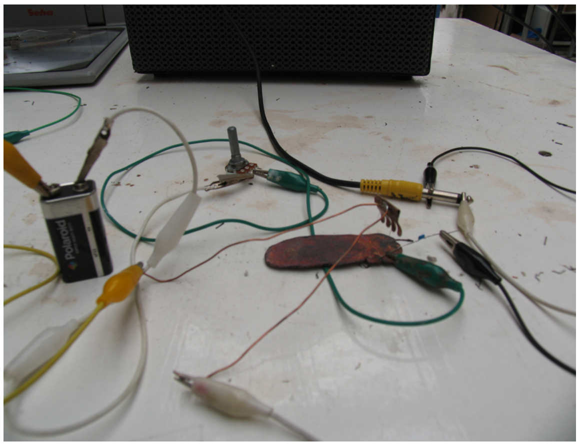
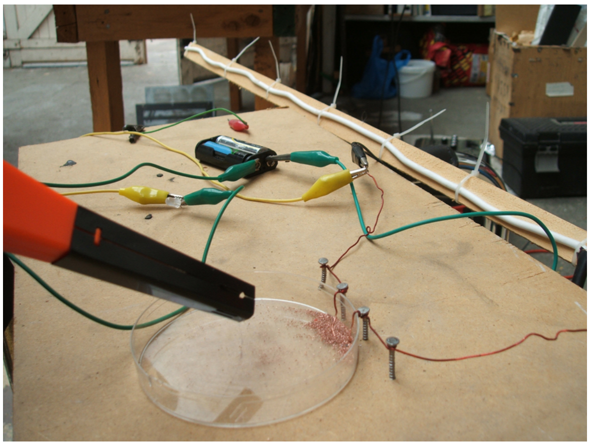


Fig. 10. Day Two: Using gas torches to melt recovered copper to make crude cuprous oxide semi-conductors.

Fig. 11. Day Two: Testing copper/cuprous oxide semi-conductor for audio effects.



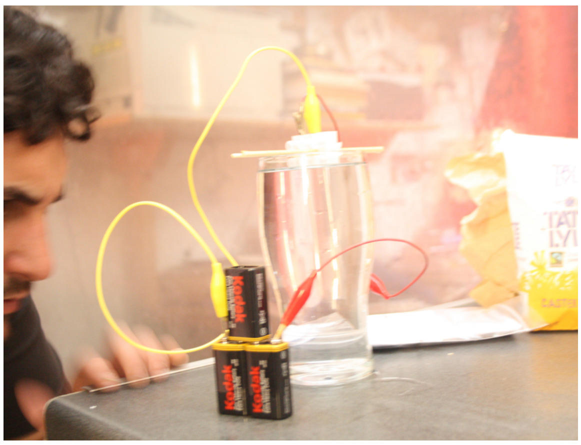


Fig. 12. Day Two: Testing a coherer made from copper filings for audio signals via a piezoelectric discharge from a bbq lighter.

Fig. 15. Day Two Salon: Electrolytic preparation of colloidal silver with 27v, deionised water, and two silver electrodes.

cybernetic feedback recursion, as gold colloid solutions have been supposed, historically, to not only cure various ailments, but more importantly, improve mental attitude, concentration and poor memory.[38]

Workshop Documentation:

The workshops were documented with a variety of cameras including two webcams set to time-lapse mode, a digital video camera, and various digital stills cameras. All still images were collected together over the days immediately after the workshop and were then edited and reformatted for online display in a general archive of images,[39] in an illustrated descriptive page,[40] and in some large format *sui generis* images of the workshop.[41] These latter pages were to be used as content for future discussion with any potential partners or sponsors for related events. A short impressionistic video documentary, overdubbed with a non-descriptive commentary, was published online via the project website and an online video-sharing repository.[42]

Discussion:

Questions as to “What are the workshops about?” or “What are the workshops supposed to achieve?” arguably miss the point. The workshops did not begin with a quest for an optimalized set of answers to some well formulated question such as “how best to recover x from y”, but rather approximated the recovery of x from y by way of executing techniques and procedures inexactly transcribed from a variety of sources including normative science. There were instructions and procedures to be adhered to, especially for

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38 Somewhere in this is a Turing Machine based joke. For the Indian Vedic tradition of metal *potables* see Ray, *History of Chemistry in Ancient and Medieval India.* 180 -181

39 Jonathan Kemp. http://material.xxn.org.uk/doku.php?id=decrystallization:images Last modified July 3rd, 2011.

40 Jonathan Kemp. http://xxn.org.uk/doku.php?id=decrystallization:description. Last modified June 13th, 2011.

41 Jonathan Kemp. http://material.xxn.org.uk/doku.phpid=decrystallization:documentation. Last modified August 4th, 2011.

42 https://vimeo.com/30814196 accessed October 25th, 2012; http://xxn.org.uk/doku.php?id=decrystallization:video Last modified November 20th, 2011.

the use of dangerous chemicals, but these were pragmatic guidelines rather than cast iron rules set out for generating deductions, and there were many unforeseen workshop events, including some over excitable chemical reactions and exotic crystal formations.

In this way it could be said that the workshops attempted to engage with material that wasn't already known in the pedagogical 'cut' made by contemporary frameworks of deliberative consensus - that is, those accumulated inter-subjective agreements on what is objective and which actualize particular ways of seeing the world. Such a sketch might echo something of Deleuze and Guattari's distinction between “royal” and “nomadic” (“minor”) sciences, where the former is understood as a stabilized and imperial power formation, and the latter is characterized as a pragmatic practice that activates the variations of matter that can lead to surprising and unpredictable consequences.[43] I will return to this theme in the next workshop Discussion below.

Where the practice executed in Decrystallization might have avoided some of those more “royal” cuts, it also exhibited a greater (amateur) pedagogical element than the author had hoped for, given the heterodoxy implicit in its formulation. Although this diminished over the two days,[44] it was inevitable in varying degrees because of its structural predisposition in the workshop preparations, where the movement from extraction to reconfiguration via concrete experiments was more than loosely plotted. This was one element to be refined in the next iteration of the project, Recrystallization.

43 Deleuze and Guitarri are particularly interested in eroding notions of essentialism and so the distinction between “royal” and “nomad” science, where the former relies on universalisable models and the latter on particularised material processes, characterizes their project to avoid all forms of transcendentalism. They demand that for whatever entity (a mountain, a bird) you must be able to account for the chemical, biological, historical processes that produced that object (eg. mountains by tectonic processes, birds through evolutionary processes) and it is by producing such an account that any appeals to notions of “essence” are made redundant.

44 The author worked with participants on the bulk of the chemical and heat techniques, while Jordan worked mainly with electrolysis and in the construction of the audio generative elements to the workshop and salon.

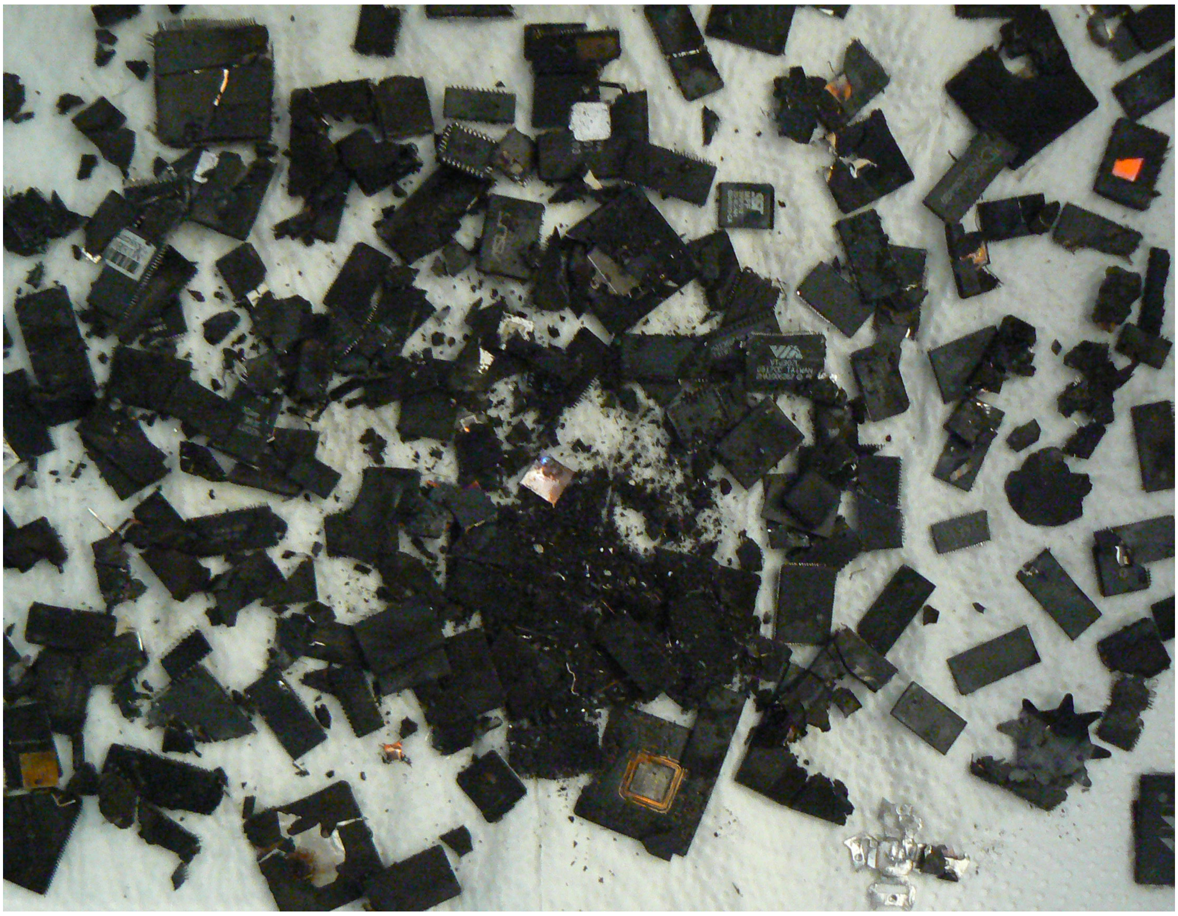

Fig. 16. Recrystallisation Workshop, Berlin, July 2011: Crushing of recycled ICs before dissolution of gold and silver content.

Recrystallization

"Recrystallization" has distinct science-based etymologies, each reflecting variations on the idea of metamorphic changes that are usually purifying (as in chemistry) but sometimes destructive (as in metallurgy). In mineralogy,

> recrystallization results in the development of a particular *fabric* in the rock, although the original fabric and individual minerals may be partly preserved as relics. Recrystallization also promotes the development of new crystalline phases.[45]

In preparing for Recrystallization, those structural issues that had arisen in Decrystallization began to be addressed in a revised and expanded workshop iteration.

45 Kirsch, Helmut. *Applied Mineralogy: for engineers, technologists, and students,* trans. K.A. Jones, (London: Chapman & Hall, 1968), 65, original italics.

Pre-workshop Formulation:

This Berlin workshop was planned to take place over three days in July 2011 and Martin Howse,[46] a long term artist collaborator based there, made a presentation of the Decrystallization documentation along with the Recrystallization proposal to secure both in-kind support and a gallery space from the German art collective, Supermarkt.[47]

The proposal, prepared by the author,[48] and subsequently used as the online pre-workshop publicity, began with a quote from J. G. Ballard's 1966 novel, The Crystal World:

> By some optical or electromagnetic freak, the intense focus of light within the stones simultaneously produced a compression of time, so that the discharge of light from the surfaces reversed the process of crystallization.[49]

This was pasted under a cropped image of a green crystallizing leachate taken during the London workshops.[50] The original premises of Decrystallization were slightly "recrystallized":

> If life itself starts from aperiodic crystals that encode infinite futures within a small number of atoms, then the digital crystallization of the flesh by Capital limits these futures to the point of exhaustion. Recrystallization begins with the double premise that if computers and the minerals from which they are made are considered equally crystalline, then the decrystallization of the digital through positive feedback disrupts and

46 From 2001 -2009, as *ap*, and *xxxxx*, I collaborated and co-organised many projects with the artist, writer, and performer Martin Howse. http://www.1010.co.uk/org. An archive of these projects can be found here: http://xxn.org.uk/doku.php?id=xxn&idx=archive both accessed January 24th, 2013.

47 Supermarkt e.V. (in Gründung), Brunnenstrasse 64, 13355 Berlin, http://www.supermarkt-berlin.net Last accessed 25th October, 2012. Otherwise this was a self-funded initiative with some income generated by workshop fees.

48 With additions by Howse, including a thematic reinforcement via a Thomas Pynchon quotation and workshop suggestion of re-purposing computer parts as tools for further c-waste cannibalization.

49 J. G. Ballard, *The Crystal World*, (Fourth Estate, London, 2011), 148.

50 Jonathan Kemp. Uploaded August 14th, 2011. http://xxn.org.uk/lib/exe/fetch.php?media=recrystallization:recryst_sm.jpeg

> escalates entropy through their structures and forward into their present pathology, Capital.

The proposed activities were introduced as being:

> Three sets of concurrent, feedbacking play and activities across three days:
>
> 1) Attempting to recover minerals and metals (including copper, gold and silver) from abandoned computers through execution of various volatile and chemical processes
>
> 2) The re-crystallisation of these minerals in novel arrays using raw/renditioned mineral assemblies including piezoelectrics, positive feedback, colloidal dispersions
>
> 3) The re-purposing and embedding of components and structures within wider geological and geophysical systems

The main part of the publicity text ended with the promise that "the final day of the workshop will be followed by silver/gold drinks and public lo-no amp performances".[51]

The publicity text then advised potential participants of some of the risks involved in the chemical processes likely to be executed in the workshop, links to descriptions of those processes,[52] the relevant safety data sheets, and an updated bibliography page.[53] An email informed participants what safety equipment would be present and that after a brief health and safety induction, they would be asked to sign a liability waiver form.

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51 Originally published online by the author, June 2011, last modified August 14th, 2011. http://xxn.org.uk/doku.php?id=recrystallization:pr and distributed across various new media art mailing lists including to spectre, eu-gene, dorkbotlondon, piksel, openlab, and mute discussion lists, June/July 2011.

52 Jonathan Kemp. http://xxn.org.uk/doku.php?id=recrystallization:berlin_resource, published June 27th, 2011. Now incorporated in http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:techniques Last modified July 9th, 2012. These include distinct and additional or updated processes from the Decrystallization workshop.

53 Now incorporated in http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:reference Last modified October 25th, 2012, and including eg. Peter Sheng's "Recovery of gold from computer circuit board scrap using aqua regia", *Waste Management and Research*, 25, no. 4 (2007): 380-383 http://wmr.sagepub.com/content/25/4/380 accessed June 4th, 2011.

Methodology:

As with the Decrystallization workshop in London, procedures and processes were nominally explained by the three workshop leaders[54] as participants were shown distinct areas within the space designated for the different types of workshop process (roughly, mechanical, chemical, metallurgy, and electrical). Transcriptions of some of those processes were provided but the potential for reciprocity between participants, as opposed to any pedagogical emulation, was again assumed, and thus no overarching explanations of the event, with their attendant metaphors, were considered integral to the functioning of Recrystallization. The participants' willingness to intra-act with things and other people within an improvised setting free of pedagogical or recursive constraints, was also implicitly assumed. I will also return to this theme in the Discussion below.

Workshop Description:

The workshop was prefaced by a health and safety induction that covered the stocked chemicals and what to do in the case of an emergency. The twelve or so participants and the three workshop leaders then began to mechanically recover useful looking components for their minerals and metals from the supply of junked desktop computers and motherboards. Recovering these components from the computer waste (which I will call here c-waste in order to distinguish it from e-waste, the more general term for all electronic waste), especially for their gold and silver content, could easily be seen as maintaining a cybernetic logic circuit of value where outputs become inputs according to an all pervasive logic of feedback that has arguably come to determine the behaviour of late capital.[55] However, in Day One of the workshop such *mis-en-scenes* of capital accumulation,

54 Jonathan Kemp http://xxn.org.uk; Martin Howse http://www.1010.co.uk/org; Ryan Jordan, http://ryanjordan.com
55 See, Benedict Seymour "Short Circuits: Finance, Feedback and Culture", Mute, (2011), http://www.metamute.org/editorial/articles/short-circuits-finance-feedback-and-culture accessed January 8th, 2012.

rehearsed in small scale versions of processes derived from those e-waste industries, and including their attendant health and safety issues, began to be transduced via the first disjunctive looping where elements of the c-waste, namely old hard drives, were re-purposed into grinders and sanders as the means of recovering other useful elements from the same junk. Once a stockpile of parts (such as computer casings, ICs, processors, capacitors, copper wire, aluminium heatsinks, fans, edge connectors, and male connector pins) had accumulated further processes of transduction were begun and continued over the three days – including variations in the electro-chemical and inorganic chemical processes first executed during Decrystallization, along with further cannabilizations of computer components. As in the London workshop, the move from the extraction of useful components, metals, and minerals to their recrystallization in other "(il)logical circuits", was made via various evaporates, leachates, filtrations, diffusions, smeltings, solids, conglomerates, and their sonifications. Such perturbations culminated in the final salon event, which included the preparation and drinking of gold and silver colloidal dispersions, and a public evening of ad hoc noise performances made by various participants using the re-purposed hard drives and hand crafted negative audio oscillators made during the workshop, and broadcast via small amplifiers and speakers.[56]

Workshop Documentation:

The workshops were documented with a variety of cameras: one fixed overhead webcam was used to continuously video the three days of activities, and various digital cameras were intermittently deployed both in still and video modes.[57] As with Decrystallization, all digital material was collected, edited, and reformatted for online display on a descriptive

56 Decrystallization and Recrystallization have been discussed in online articles by Will Scrimshaw, "Undermining Media", in *Artnodes*, 12 (2012), http://artnodes.uoc.edu/ojs/index.php/artnodes/article/view/n12-schrimshaw, and Jussi Parikka, "Exhumation as Artistic Methodology", on *Machinology*, 2012, http://jussiparikka.net/2012/02/07/exhumation-as-artistic-methodology/ Both accessed February 6th, 2013.

57 The collected video footage was roughly edited but considered inappropriate for online usage.


Fig. 17. & 18 Day One: Participants recovering selected components from junk computers.

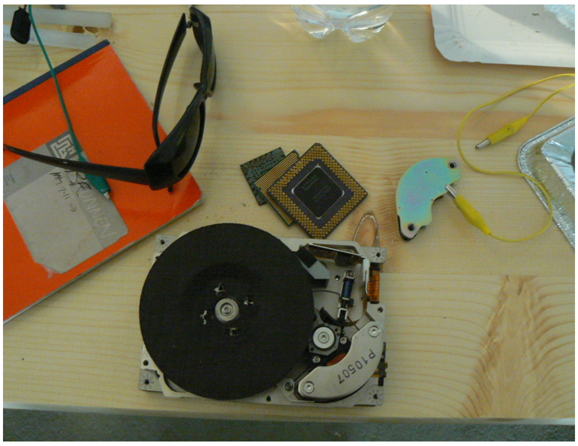
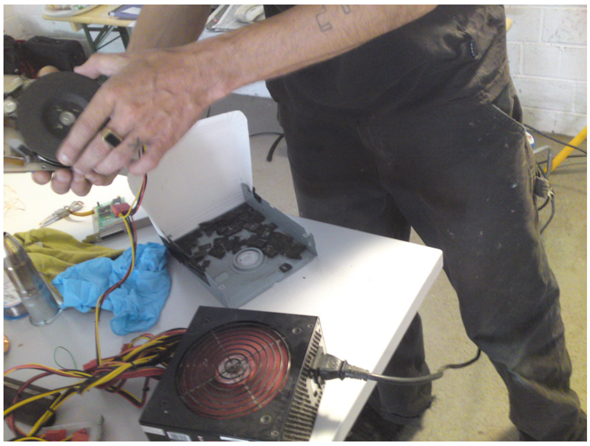

Fig. 19 & 20 Day One: Hard drives being re-purposed as grinders, sanders and audio signal generators.

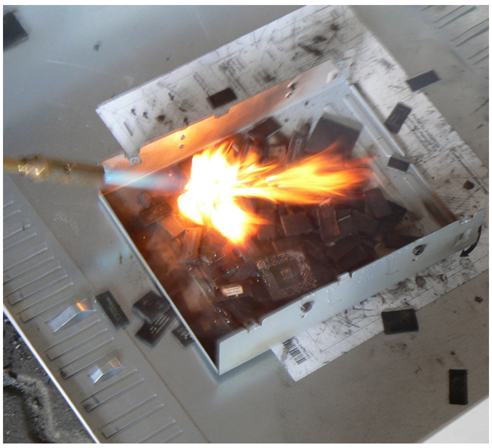

Fig. 21, 22, & 23 Day Two: Heating crushed ICs; preparing Aqua Regia: over excitable Aqua Regia and crushed ICs after heating.

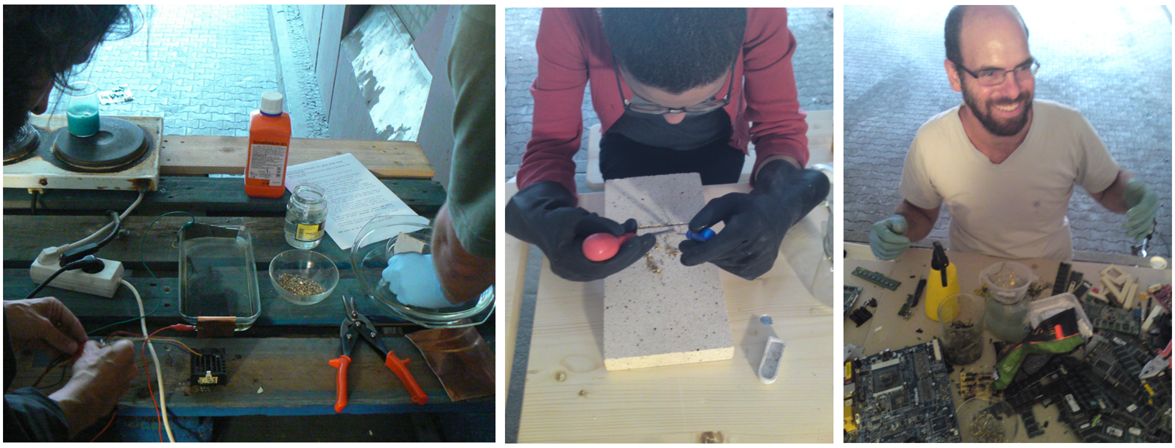

Fig. 24, 25 & 26. Day Two: Electrolysis of gold plated pin connectors using re-purposed computer components; recovery of gold foils from edge connectors after Nitric Acid bathes.

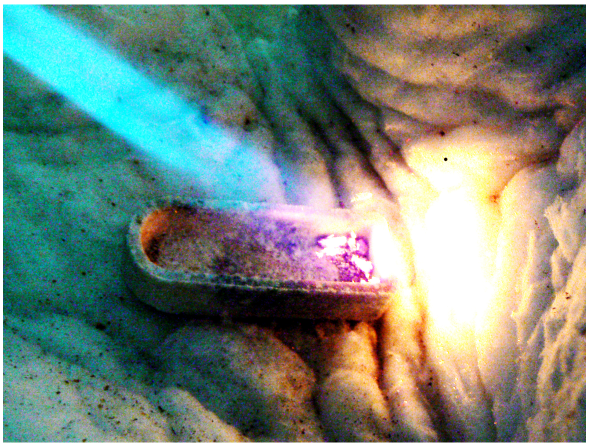

Fig. 27. Day Three: Attempting to melt recovered gold.

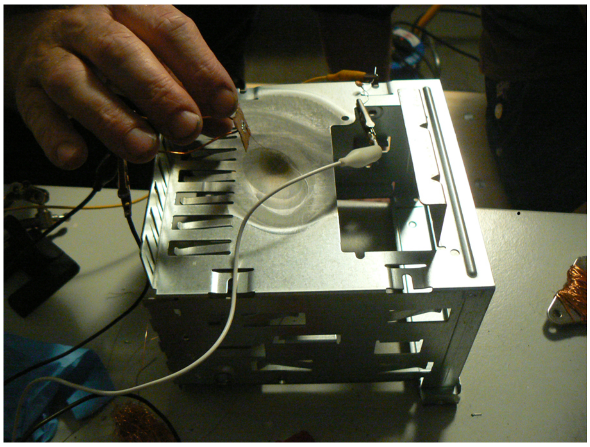

Fig. 28. Day Three: Testing of a zinc/zinc oxide negative oscillator made from re-purposed components.

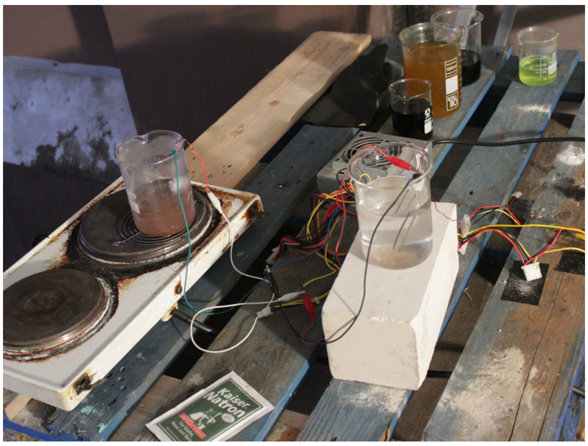

Fig. 29. Day Three Salon: Preparation of gold and silver colloidal drinks.

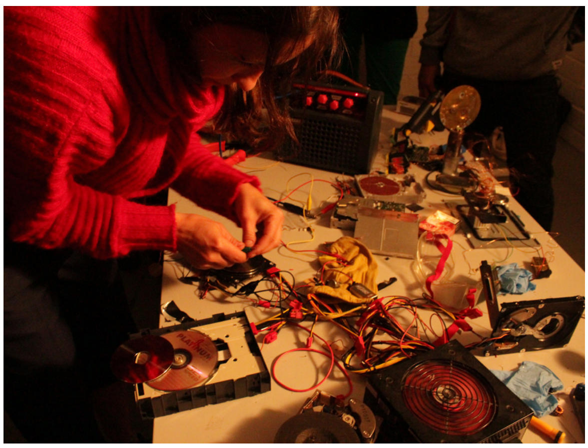

Fig. 30. Day Three Salon: Performance with re-purposed computer cd and hard drives.

page[58] and in some large digital sui generis images of the workshop.[59] This documentation was used in discussions with the hosts of the subsequent versions of The Crystal World.

Discussion:

Although Recrystallization persisted in Decrystallization's structural predisposition towards some instruction around certain processes, this was not seen as problematic given that the workshops were not about describing normative, deductive ("royal") solutions to problems (a getting it right). Alternatively, it should also be stressed here that the project was never conceived as an investigation into collectivised modes of learning, and, as such, no provision was made for any attempt to interrogate participants' experiences. If there are insights to be gained from qualitative surveys about whether the assumed provision of a kind of egalitarian autodidactic space in the workshops was successfully executed so that, for example, participants felt that they not only had something to learn for themselves, but also to learn from the others and the workshop environment, then the notion of intra-acting would have been misunderstood and its wider constituency ignored under some kind of unspoken anthropocentrism.

If humans work with other things, where "things" might describe anything from chemical molecules to particle or wave phenomena, then these things have an agency only as what Karen Barad has called the "intra-acting components" of ontological phenomena. As she elaborates,

> phenomena do not merely mark the epistemological inseparability of "observer" and "observed"; rather, phenomena are the ontological inseparability of agentially intra-acting components. It is through specific agential intra-actions that the boundaries and the properties

58 Jonathan Kemp. http://xxn.org.uk/doku.php?id=recrystallization:description Last modified August 14th, 2011.

59 Jonathan Kemp. http://xxn.org.uk/doku.php?id=recrystallization:documentation Last modified August 14th, 2011.

> of the "components" of phenomena become determinate and that particular embodied concepts become meaningful".[60]

Thus, where conceptual hangers like "capital" and "cybernetics" have been deployed in pre-workshop materials, it was in order to mobilise a set of variable practices, rather than as the means for the interrogation of structural agencies around which to elaborate a critique. That is to say that deployments that resort to positing concepts like capital, power, society, (including variants of Pierre Bourdieu's *habitus*) as already theoretically embodied components cannot elaborate any thing other than a formalised critique, in so far as they assume such things as already existing causes.[61] From this, and in the context of the practice, a diffractive analysis can be rehearsed if sampled from the changing material relationships forged between workshop components, including participants, over the course of the three days. This approach was assumed by the author to make the workshop become less logical from within a cybernetic paradigm as arguably its processes and products became removed from any optimization as short range bursts of palliative feedback that resettle or reorientate that paradigm. For example, the differential concepts of 'gold' and 'gold pin connectors' expose a relationship over time between geological and cultural worlds, in which, in this context, the latter was distinguished by the differing commodity and technological relationships fostered in the workshop around gold as a raw mineral as the participants went about recovering it from the c-waste.[62] The notion of what gold is in itself occupies an amorphous ontological space criss-crossed with those cuts generated by and including the logics of geology, commodity value, and product component.[63] Under the

60 Karen Barad, "Posthumanist Performativity", 815

61 And as is argued in the Contextual Review, even a fine grained detailing of causal interactions involves a necessary degree of indeterminacy, and thus some degree of descriptive formalism is unavoidable, as theory never fulfils its mandate of fully explaining the reality it addresses.

62 Marx described commodities as the products of human labour in which the abstraction of exchange value has rendered invisible the social relations that produced them.

63 A brilliant and particular dissection of these and other relations generated around gold is found in the anthropologist Michael Taussig's 2004 book, *My Cocaine Museum* which tells of generative instabilities in the relations between, amongst other things, Colombia, Afro-Colombian miners, swamps, heat, rain, stone, gold and cocaine.

arrangement of the workshop participants sought to recover the metal from its entanglement in the technological through both the use of intuitively executed mechanical means, and attempts at reifying descriptive recipes to provoke unfamiliar material processes. Unlike their industrial counterparts the participants' material labour was not rationalized so that the gold became settled into one 'logical' conceptual space (eg. commodity value) over and above another. Consequentially the technical organization of those processes did not generate a deterministic *qua* instrumental organization of their labour in the pursuit of, in this case, gold. Thus, where gold was recovered in the workshop, it was seen as being bound up in these other things - for example, in acid leachate residues and carbonized amalgams after high heat applications. Thus technical processes, like that of transfiguring base metals through leaching and then purifying the predominantly chloric auric acid solution to get rid of any traces of those base metals, were articulated within a multidimensional network of components that included those of space (like the gallery lay out and our semi-autonomous occupation), time (the non-standardisation of each workshop day), material (including the détournement of recovered commodities into dietary supplements), actions (the breaking down of customary recycling tropes), and design (as in the non-polarization of manual and mental labour). These relationships were, as indicated above, partially structured beforehand through the preparation of processes and the location of resources, but arguably did not predetermine some particular outcome within meaningful conceptual boundaries. Rather these articulations reflected the ongoing iteration of intra-actions and reconfigurations made within the workshop apparatus.

This rehearsal is thus not just a sketched account of some scaled economies of labour, do-

Michael Taussig, *My Cocaine Museum*, (The University of Chicago Press, Chicago, 2004).

If gold is articulated through a variety of molecules, phases, qualities, and shapes that compose it, “that which is in the thing,” ontologically this tells us nothing about “that in which gold is”, namely, all the various situations in which gold can be found. It might be easier to suggest that gold is the difference between these two positions.

it-yourself culture or even the social production of a commons, it is also about an expanded notion of agency: for example gold is not a passive substance awaiting human inscription (commerce, culture, language) rather, as the workshop processes for its recovery, transformation, and internalisation experienced by the participants have shown, it is active in how it must be handled, and it always represents a history of intra-action with this or that other thing or technology. Gold is itself best described as a medium (akin to Barad's cut), an interface between this and that series of articulations, rather than, for example, only as being this or that physical structure, and as such, at any time its localised and open description get closer to addressing Parikka's call, detailed in the introduction to this chapter, for a material-dynamic way to understand the ontological instability of new media technologies and practices.[64]

After two minor detours in the next two sections, this chapter will refocus on how the expansion of the project as The Crystal World addresses such dynamics and rounds out some of the structural predispositions of De/Recrystallization.

64 viz. that their structures are subject to material intra-active agency recrystallized in their reproduction, and are not simply instruments for human use. These become features to which other things (including humans) adapt/are adapted in a recursive instability.

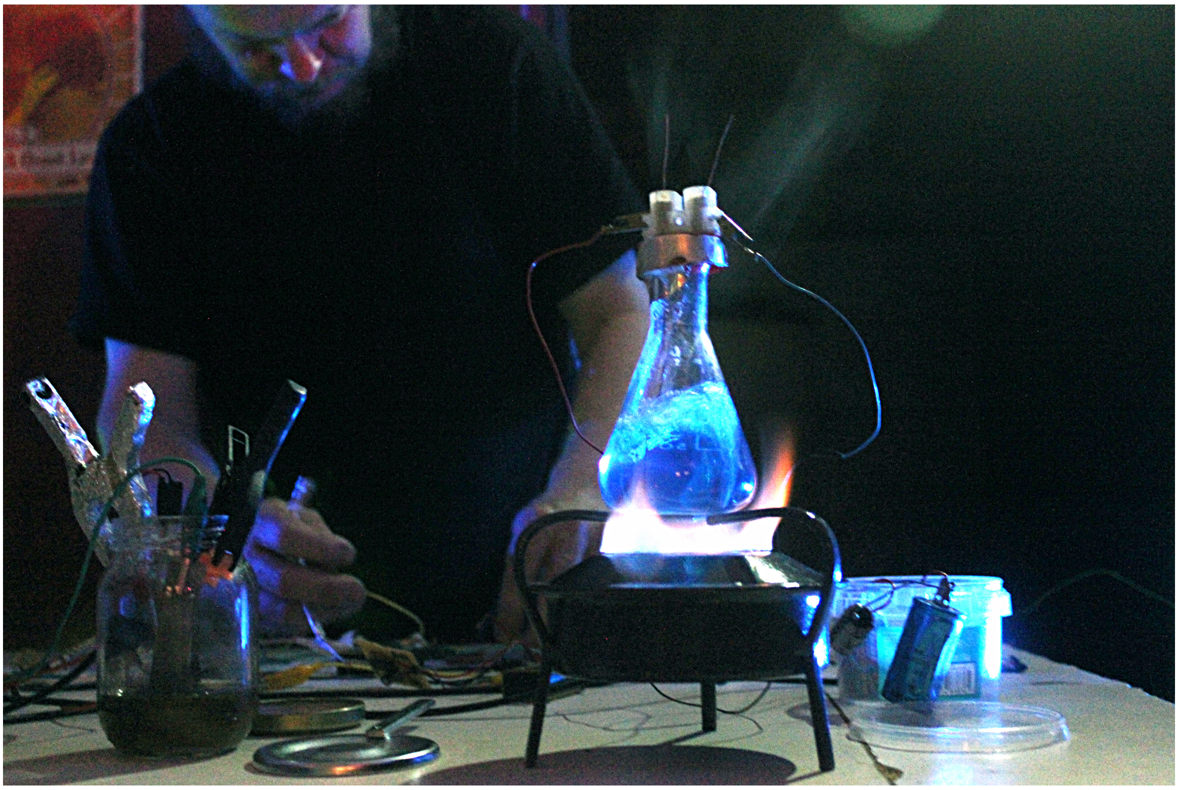
Fig. 31. Chemical-Material live performance system, Rio de Jainero, Brazil, May 2012.

Chemical-material live performance system

A related body of work has been a series of live sonic performances begun in March 2011. Groups of computer-derived minerals have been manipulated in real time to generate amplified noise through mixing, heating, electrolysis, and the application of direct current. Reactions have been harnessed to act as variable components in simple oscillator, schmitt trigger, nand gate circuits, as well as being detected through the use of passive infrared sensors and contact microphones, before amplification and broadcast. An intention has been to research substitutes for some of the circuits in the reactions of related chemicals and minerals, as in the case of, for example, chemical oscillators made from a reaction between the contact made between iron on mercury immersed in sulphuric acid.

Short public performances have taken place, variously, at a noise festival in Norway; the "Ecosex" wedding of Annie Sprinkle and Beth Stephens in Barcelona; in Rio de Janeiro; and various London venues including the ICA and Cafe Oto in the summer of 2012.[65]

65 Details and recordings from these performances can be found by following the appropriate links on the front page of my home site: http://xxn.org.uk

Fig. 32. The Suffolk Psychogeophysics Summit, August 2011: site of prepared lightning pole and selected and buried computational minerals at Orford Ness, Suffolk.

The Suffolk Psychogeophysics Summit:

Artistic colleague and collaborator Martin Howse initiated the long term project neologistically described as psychogeophysics, a novel discipline that détourns practices derived from both psychogeography and geophysics and where, as Howse defines it:

> With psychogeography [http://en.wikipedia.org/wiki/Psychogeography] easily defined as a playful examination of the total effects of geography and place on the individual, ["the study of the precise laws and specific effects of the geographical environment, consciously organized or not, on the emotions and behavior of individuals." Guy Debord. Introduction to a Critique of Urban Geography, 1955] *Psychogeophysics* extends such research to embrace geophysics [http://en.wikipedia.org/wiki/Geophysics], defined as the quantitative observation of the earth's physical properties, and

> its interaction with local spectral ecologies. Geophysics equally encompasses archaeological geophysics, with measurement of such properties allowing for the mapping of previous traces through techniques of particle/wave detection and data forensics.[66]

Although the core techniques framed by the term psychogeophysics are outside the scope of the research presented here, the Suffolk Psychogeophysics Summit, convened between August 28th and September 3rd 2011, provided a framework in which further investigations into the reconfiguration and excitation of some of the minerals derived from computers could be developed. "New Psychotronic Generators", was a project the author developed that overlapped with the some of the concerns of the Summit. The project description, published online before the Summit began, describes that:

> Attempts will be made to harness and/or recreate lightning as the engine for creating new geological mixes to be formed on the base geology of the Suffolk countryside. Admixtures of copper, gold, magnesium, magnetite, silicon, silver will be embedded in silica-based escarpments in preparation for both mundane and spectacular methods of harnessing colossal electrostatic discharges. The custom fulgurites will be made available for further experimentation and bioplasmic investigation (for example, through Kirlian photography).[67]

Configurations of minerals (including metals) derived from computers, were embedded within wider geophysical systems, within the Suffolk countryside. Mixes of carbon, copper sulphate, graphite, iron ore, lead, magnesium, magnetite, silica and silicon were buried into a host substrate at three locations: the sandy soil at Grimes Graves, the Neolithic black flint

66 Martin Howse, "What is Psychogeophysics?" http://www.psychogeophysics.org/wiki/doku.php?id=wikipedia Last modified April 13th, 2011.
67 Jonathan Kemp, "New Psychotronic Generators." http://www.psychogeophysics.org/wiki/doku.php?id=summit2011:new_psychotronic_generators Last modified August 25th, 2011.

mine site in Thetford Forest, Norfolk; the coarse shingle beach near one of the “pagoda” military research buildings at Orford Ness, Suffolk; and on the concrete apron of a disused hangar at RAF Bentwaters, Suffolk. At both the Grimes Graves and Orford Ness sites a 1.5m steel conducting pole was embedded into the host substrate so that its tip was surrounded by the buried minerals, while as much as possible of the pole remained above ground. At the disused RAF Bentwaters site this arrangement was modified to take advantage of an already existing lightning conductor found on one of the disused hangars: here the minerals were placed in a bag around the end of the conductor and buried in a mound of pebbles recovered from around the hangar.

Real time weather system reports were monitored for the area for another component of this project: the direct forcing of lightning to strike an area of prepared minerals. Rockets, copper wire and slow burning fuses had been prepared in anticipation that storms would take place during the week. The plan was to fire a rocket with a copper wire attached to it and to a bucket of minerals, up into the base of the storm to provoke a direct lightning strike that would travel down the wire and into the minerals. The weather proved benign and such transmutation remains immanent.

This project explicitly acknowledges this and other aleatory contingencies for its resolution: *viz.* the creation of what can be inexactly termed “a new crystallography”, in so far as the purpose of the conductive metal and mineral arrangements is for the synthesis and creation of custom “fulgurites”. When lightning strikes a sandy soil or a beach, the lightning bolt's path into the earth can sometimes transform any silica-based minerals into glass-like tubes, called fulgurites; the conceit of this project is that other minerals with lower melt points can thus be entrained in the molten silica as the strike hits the substrate, thus making any “new crystals” available for further investigation and use.[68]

68 The intention was to revisit the three test sites over the coming year (2011-2012), especially if storms were indicated by the real time weather data being tracked. At the time of writing (October 29th, 2012)

Fig. 31. Aerial view of Grimes Graves, Norfolk. (Image taken by author from an information board).

Fig. 32. Placing computer mineral mix under a lightning conducting rod for the creation of custom fulgurites, Grimes Graves, 2011.

The Grimes Graves site was considered particularly important, given this project's name: psychotronic generators can be considered as things which intervene in some way into the activity of the human nervous system in so much as they are intended to modify the sequences of individual and collective behaviour on an informational level. Grimes Graves was the site of extensive neolithic flint mines whose black flint production of stone axes, knives, and scrapers was, it is suggested, highly ritualized.[69]

In what was designed as a “proof of concept” another part of the project was executed during the Summit whereby artificial custom fulgurites were made using a bucket of sand (recovered from the nearby Rendlesham Forest, Suffolk, site of an infamous UFO incident in the 1980's) as the substrate in which a trench was made and filled with the same selection of computer-derived minerals before being lightly covered with the sand. One exposed end of a high voltage cable was loosely fixed to one end of the trench whilst another similar cable was attached to a piece of wood; both of the cables exited from a 9

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this has yet to happen.

69 Peter Topping. *Grimes Graves.* (London: English Heritage, 2011): 24-25. Further communication with Peter Topping (University of Newcastle), and Prof. Michael Edmonds (University of York), confirm the current belief that flint extraction and flint waste disposal cycles were highly ritualised. Professor Edmonds writes that, in relation to archaeological theory from the 1970's, “Grimes Graves and other major stone sources were regarded as places of industrial expertise” - the earlier site reports consulted by the author reflect this technological assessment of finds from the site: Ian Longworth et. al., *Excavations at Grimes Graves, Norfolk, 1972 – 1976*, Fascicules 3 and 5, (London: British Museum Press, 1991 & 1996).

kilowatt 25 milliamp neon light transformer. Once the current was switched on an arc was drawn across the mineral and sand trench by judiciously holding to the cable end attached to the wood and then drawing back from near the other fixed cable end in the trench. As a result dark and fragile synthetic fulgurites of a few centimetres were formed (Fig. 4 below).[70] Subsequent iterations of these experiments in 2012 in the two versions of The Crystal World (detailed in the next section) have used salvaged microwave oven transformers (MOTs) linked together for higher ampages and voltages to produce a much larger example of approximately 12 x 2 cm (Fig. 34 below).

Fig. 33. Artificial Fulgurite: The Suffolk Psychogeophysics Summit, 2011.

Fig. 34. Artificial Fulgurite: The Crystal World, London, 2012.

70 Images of creating artificial fulgurites during The Suffolk Psychogeophysics Summit. http://www.psychogeophysics.org/wiki/doku.php?id=summit2011:saturday Last modified September 7th, 2011.

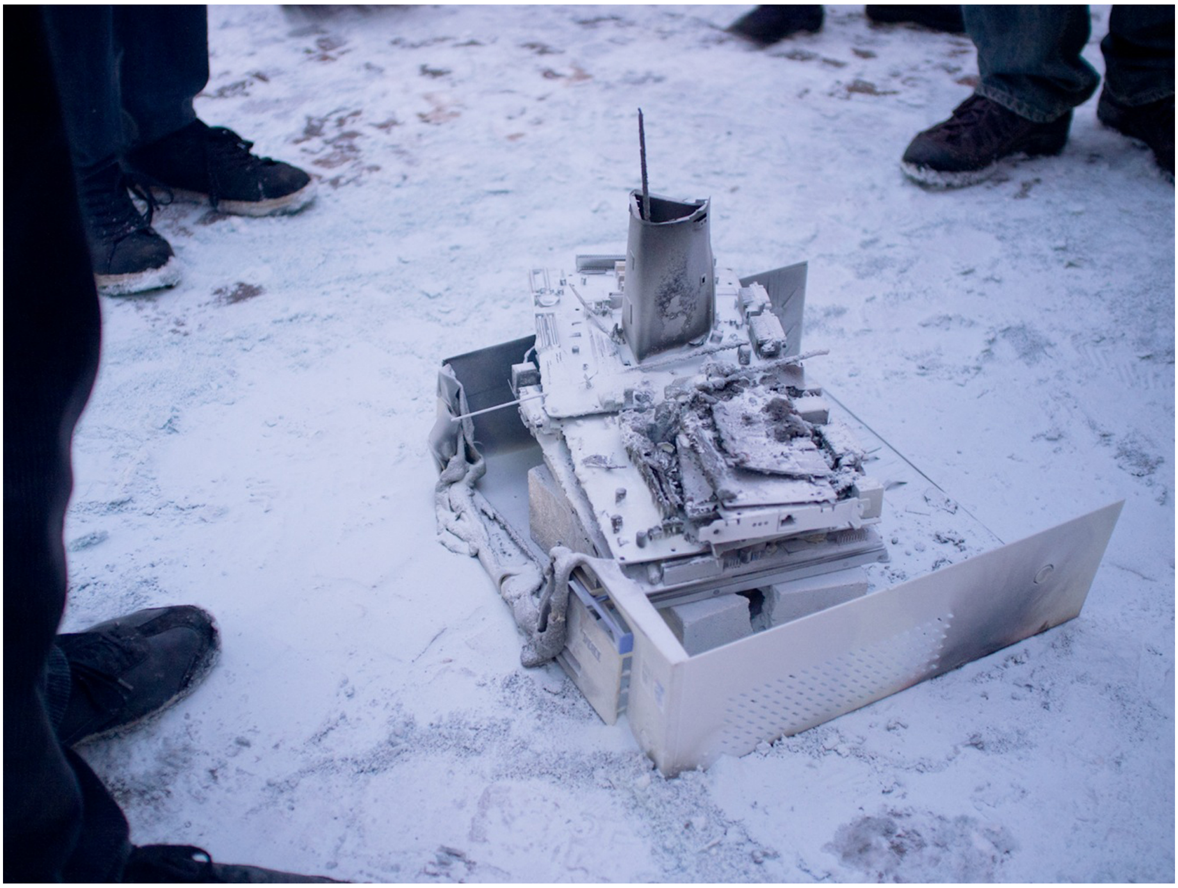

Fig. 35. Aftermath of thermite detonated over junk computers and mineral ores, The Crystal World, Berlin, 2012.

The Crystal World v.01

The experiments around aleatory processes detailed in the preceding section were executed with the intention to feed forward into a new series of events, The Crystal World (CW), where distinct imperatives are at play. Firstly, where Recrystallization reinforced the double premise of the project that computers and the minerals from which they are made can be considered equally crystalline, and, along with Decrystallization, focussed on computers, CW has been formulated more explicitly by the author around explorations of the raw ores and minerals from which computers are made. Secondly the event was conceived and resourced as an open-laboratory where all participants pooled knowledge and resources insofar as possible, thus obviating much of the amateur pedagogy of the two previous workshops.[71]

71 The project was initiated by the author in collaboration with the Berlin-based artist Martin Howse and Ryan Jordan.

I will return to these premises in the final discussion section that follows description of two iterations of The Crystal World, here Berlin, and then London.

Pre-laboratory Formulation:

A six day open laboratory was to operate during the Club Transmediale New Media Arts Festival (CTM12) in February 2012 in Berlin, with a subsequent exhibition offered for two weeks after the lab to take place alongside a separate but related exhibition by Ralf Baecker.[72]

The CW publicity, through a reading of Ballard's novel of this title, suggested the idea that contemporary life is somehow made immobile through the highly ordered computer mechanisms, algorithms and structures that underpin it with an inhuman speed and complexity.[73] In Ballard's novel, which is set in an unknown African country, people gradually succumb and crystallize into a bejewelling landscape, merging with the flora and fauna. Only the military man, Radek, attempts to fight back by dropping into the river to try and dissolve the crystals that enclose him, before he too is encrusted and left in a state between life and death. Ballard's crystal forest expands across the globe and as the physical process grows entropically, its people get sacrificed to this inertial sameness. On this reading, the question Ballard raises is, is it possible to escape the propagation of such entropic forces across nature and the psyche? In preparation for the Berlin iteration of The Crystal World, texts purported that the project would execute a series of explorations from which to focus on the question; premised as being centred more on the mineral, the author offered the promise that:

72 The Crystal World Open Laboratory ran from January 30th - February 5th 2012, with a subsequent exhibition of its apparatus and products left "as-is" in situ exhibition in the same five rooms until February 19th http://archive.ctm-festival.de/ctm-festival/exhibition/the-crystal-world.html. Ralf Baecker's Irrational Computing exhibition ran throughout the duration of the lab and CW exhibition in an adjacent room. http://www.rlfbckr.org/work/irrational_computing Both accessed January 25th, 2013.

73 Jonathan Kemp http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:description Last modified October 29th, 2012.

> During the six day open laboratory activities will include rare earth or mineral precipitations, high heat synthetic geology and inductive crystallography, anthropocenic fossilizations, water crystal cryptography, kirlian photography, hi-voltage fulgurite construction, odic diffractions, and the ingestion of colloidals to stem the contemporary plague.[74]

An open call solicited expressions of interest, noting that there would be public presentation and performances, "with laboratory process to be exposed during an exhibition at Kunstraum Kreuzberg over the following weeks".[75]

Respondents to the call offered a range of enthusiasms, backgrounds, and potential investigations, from which a final selection was made and included fine artists, sound artists, new media artists, a writer, a photographer, a neuroscientist, and a computer scientist.[76]

As preparation for the event a compendium reader, The Crystal World Reader v.01, was produced by the author. Opening with Ballard's 1966 *The Crystal World*, and including texts referred to in the De- and Recrystallization bibliographies (eg. Schrodinger, Mongrini), the reader expanded on these background references by incorporating a range of relevant ancient, Victorian, modern, and contemporary theoretical and technical texts.[77]

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74 Jonathan Kemp. http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:description Last modified June 16th, 2012.

75 The open call was published on December 29th, 2012 http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:opencall and distributed across various new media art mailing lists including to spectre, eu-gene, dorkbotlondon, piksel, openlab, and mute. Last modified January 6th, 2012.

76 Selection was made by the lead artists Jonathan Kemp, Martin Howse, and Ryan Jordan. A list of participants is here: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:description#participants Last modified February 9th, 2012.

77 The Crystal World Reader v.01 http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:reader Last modified July 2nd, 2012. Collated, edited, and with an introduction by the author, twenty four texts were presented for online download (including three suggested texts by Martin Howse). From the *Introduction:*

> The Crystal World apparatus wilfully interrogates specific practices used in the digital crystallization of the flesh, seeking to dis-inter its sclerotic boundaries through attempts at the generation of new phenomena in open ended dynamic re-configurings of the crystalline and geo-biologic. (p. 3).

Laboratory Description:

An area of five rooms in Kunstraum Kreuzberg, Bethanien, Berlin[78] was given over to the lab, and spaces were loosely designated for specific types of activity including clean work and analysis, high heat work, chemistry, construction, storage, and display. A vitrine of raw mineral ores derived from computers was prepared and various activities executed by the fifteen participants over the next six days would interrogate selected minerals and ores. Often mimicking the dangerous processes undertaken in their industrialised extraction, processing, and disposal, elements of the lab participants' interventions and conjunctions continued, as with the previous workshops, to distort those logic circuits of value through staging multiple diffractions of its components.[79] Various experiments were executed, often in collaborative groups, and included: oyster mushrooms grown on a substrate of crushed printed circuits boards (pcbs), galena, magnetite, local earth, and straw in a mycelium cultured semi-conductor project; synthetic bio-fossilizations using different computer production by-product leachates and silicate solutions injected into eukaryotic cellular material (onion cells are like all animal cells, including human); various high heat metallurgical experiments using small furnaces and modified microwave ovens, including subsequent attempts to encourage biological growth over melt products of pig iron and sintered silicon. Other activities included precipitating crystal arrays from super-saturated and saturated solutions for further excitation including audible signal processing;[80] the use of a 4kV 500mA high voltage transformer to make a more diverse and larger collection of

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78 These rooms were equipped by the CTM12 festival production with furniture and equipment as specified by the author and Howse.

79 Some of the following experiments are derived from pre-event project ideas by the author, with additional proposals by Martin Howse; http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:projects Last modified January 28th, 2013. Others were generated by participants within the lab: for an illustrated summary of actual lab activities, see: http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:post-description Last modified April 1st, 2012.

80 eg. Signal generators were constructed from crystal precipitations of alum, mono-ammonium phosphate, ferrous sulphate, salt connected via copper, aluminium, or magnetite, with additional pyrite and galena cats whisker receivers, and then to a PA.



Fig. 36, 37 & 38. Vitrine of mineral ores used in computers; room set aside for analytical work and equipped with digital microscope, signal generator etc; high heat area equipped with microwave ovens, ceramic tube kiln, digital furnace, gas torches etc; CW, Berlin, 2012.

Fig. 39. Main planning/discussion/project room, CW, Berlin, 2012.

Fig. 40. Mycelium cultured semi-conductor experiment, CW, Berlin, 2012.

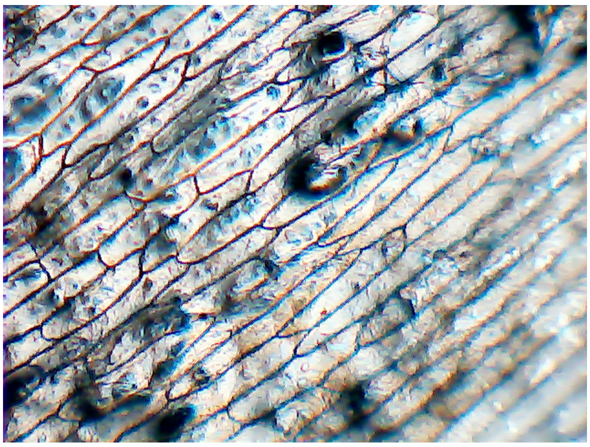


Fig. 41. Digital microscope image of synthetic bio-fossilization project, CW, Berlin, 2012.

Fig. 42. Attempting to smelt silicon using modified pizza oven bricks, , microwave oven, 2012.

Fig. 43. Pouring copper after melting crushed malachite, CW, Berlin 2012.

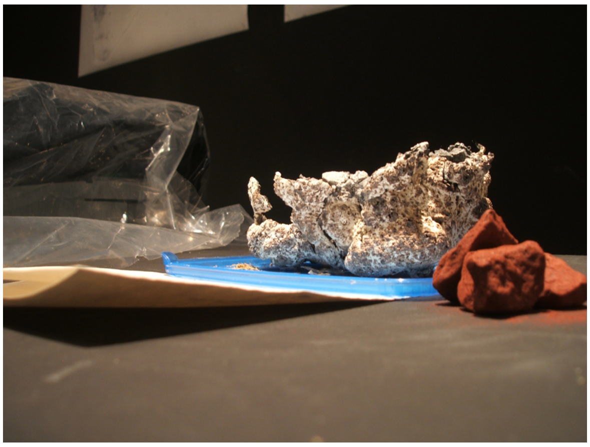
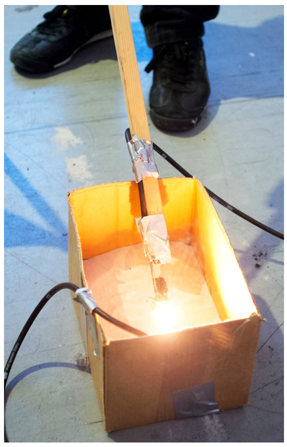


Fig. 44. Pig iron smelted from haematite, overlaid with bio-infestation, CW, Berlin, 2012.

Fig. 45. Experiments in crystal formation from super saturated solutions derived from computer minerals. CW, Berlin, 2012.

Fig. 46. Audio signal amplification of crystallization product excitations, CW, Berlin, 2012.

Fig. 47. Part of introduction to The Crystal World by lab participants, public opening, CW, Berlin, 2012.



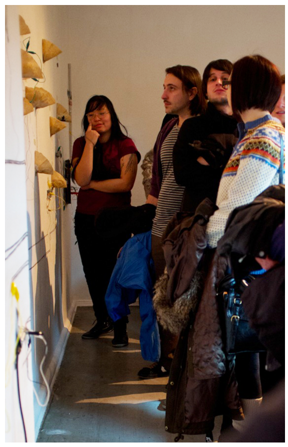


Fig. 48, 49 & 50. Earth battery live experiment; live artificial fulgurite production; sonified wall installation of galena, iron pyrites, and crystalline products; from evening public opening, CW, Berlin, 2012.

artificial fulgurites than was possible in the Suffolk Pyschogeophysics Summit; and attempts at odic (life force) imaging of various leachate and contaminated water frozen crystals.[81]

At the end of the lab a series of presentations and experiments constituted a prelude to the exhibition opening. Various demonstrations followed on from three brief commentaries made by participants including the author that introduced the open laboratory and exhibition to the audience: live experiments included an earth battery made with a bucket of earth, lead and copper electrodes, with the slow addition of sulphuric acid to increase voltage and register on an uncalibrated measurement via a diffracted laser beam; another artificial fulgurite construction made by discharging high voltage arcs across collections of crushed integrated circuits, powdered silicon, and sand; attempts at producing another synthetic geological formation by detonating thermite embedded in a mound of computer junk and mineral ores;[82] the sonification of a wall array of crystallization residues; and three improvised noise performance using arrays of reconstituted ores, crystals, and c-

Fig. 51. Thermite detonated over junk computers and mineral ores, CW, Berlin, 2012.

Fig. 52. Exhibition detail of open lab remains, CW Berlin, 2012.

81 ie. the injection of contaminated cpu leachate/saturated chemical solutions into film container pinhole cameras loaded with pieces of photographic paper, their subsequent freezing and exposure using a photographic enlarger.

82 Thermite is a mixture of aluminium powder and iron oxide, once ignited it can burn at up to 3000°C; see: http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:techniques#synthetic_geologies accessed January 28th, 2013. Attempts were made in the lab to try and derive sufficient quantities of the metal powders from the rocks and computer junk – however on this occasion they failed to ignite, so commercial products were mixed and used instead.

waste.[83]

The following exhibition, lasting two weeks, presented the remains of all demonstrations and experiments, lab equipment, and lab products, all left as-found in the five rooms, with each room annotated with a brief label to indicate the kinds of activities took place there (for example, "high heat activity area"; "chemistry area").[84]

83 The electrolytic earth battery experiment was by Martin Howse; the thermite reaction of minerals and computers and the artificial fulgurite production were by the author; the sonified wall was a collaboration between Anna Vo (http://annavo.bandcamp.com/) and Ryan Jordan; performances were by Martin Kuentz (http://www.tunedcity.net/?page_id=126), Hye Jo Jun (http://hyejoojun.tumblr.com/), and Joon Kim. All accessed January 28th, 2012.

84 The Crystal World project was also the main subject of Jussi Parikka's presentation on a panel with Inke Arns, Wolfgang Ernst, and Siegfried Zielinski, moderated by Timothy Druckrey at Transmediale 2012, Berlin.Transcript: http://jussiparikka.net/2012/02/07/exhumation-as-artistic-methodology/; video: http://www.transmediale.de/content/presentation-jussi-parikka-search-method Both accessed October 30th, 2012.

The project was well received by a large audience (daily visitors to the lab and those who came to the opening event) and by several reviewers both during and after the festival, including from bln.fm, an online radio magazine, http://www.bln.fm/2012/02/kristalle-computer-und-das-chaos/; and white hot magazine, an online arts journal http://whitehotmagazine.com/articles/open-laboratory-kunstraum-kreuzberg-bethanien/2474 Both accessed October 30th, 2012. There was also a subsequent one hour radio show on Berlin's free art radio station, reboot.fm, The Crystal World Substrat Radio, broadcast on February 26th, 2012, http://reboot.fm/2012/02/26/substrat-radio-7-the-crystal-world/ accessed October 30th, 2012.

The lab and exhibition were documented by many participants, festival staffers, and independents: much of this material was collated and selected for online display on a dedicated website for the project, http://crystalworld.org.uk/, and included a post-description page, http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:post-description Last modified 29th October, 2012, and some large digital *sui generis* images of this Berlin iteration, http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:selected_large_images Last modified March 26th, 2012. Other online documentation include an image archive, http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:image_archive Last modified April 4th, 2012, and a video archive, http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:ctm12:video_archive Last modified February 21st, 2012.

The project website also received a large number of visits: between January 1st and November 1st, 2012, the project site has received a total of 21,676 unique visits, according to the implemented real-time logfile analyzer *Awstats* (http://awstats.sourceforge.net/).

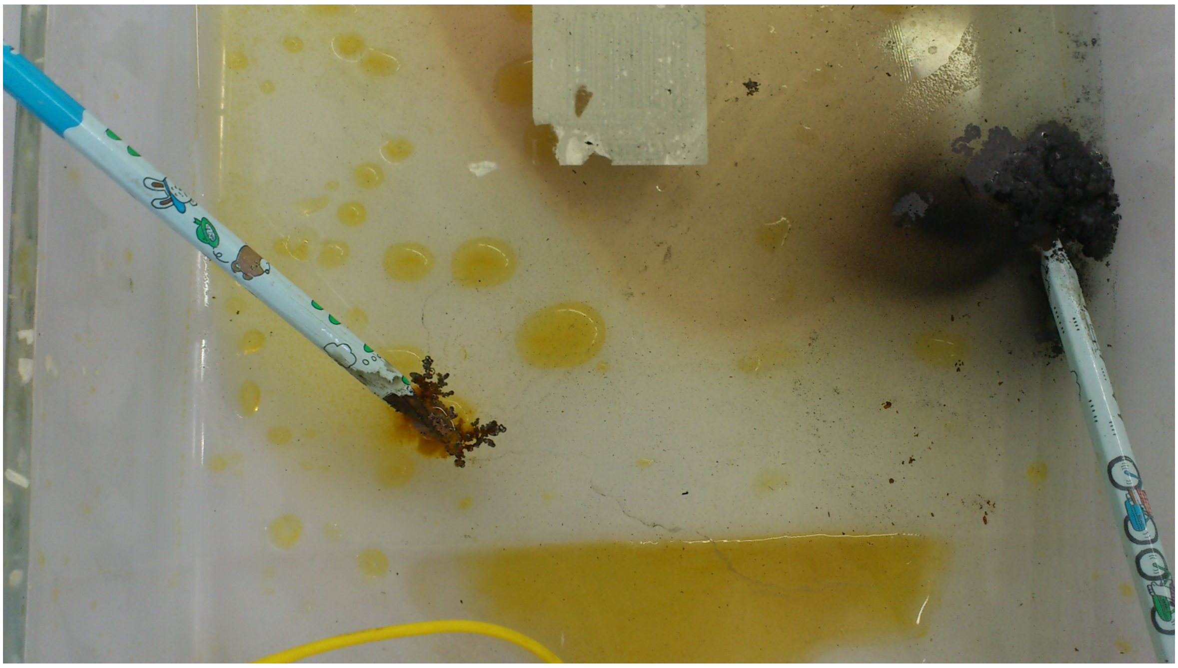


Fig. 53. The Crystal World, London: detail from exhibition installation, September 2012.

The Crystal World v.02

In the spring of 2012 The Crystal World project was awarded financial support for its London iteration, including a Permacultures Residency by SPACE, London.[85] The project was proposed by the author as a five day open laboratory with public access, a public salon event, an exhibition opening event, and a one month exhibition installation, all to be held at a new SPACE venue, The White Building in Hackney Wick, and immediately adjacent to the 2012 London Olympics main stadium.[86]

Pre-laboratory Formulation:

The project literature included a publicity and open call online pages for the laboratory, both shared across the project and SPACE websites.[87] A diverse selection of collaborators were selected by the project organisers[88] from the large quantity of respondents to the call,

85 http://spacestudios.org.uk/whats-on/events/the-crystal-world-open-laboratory, http://spacestudios.org.uk/whats-on/events/the-crystal-world-open-laboratory-exhibition-, and http://www.spacestudios.org.uk/whats-on/permacultures/permacultures-18-the-crystal-world All accessed November 1st, 2012.

86 http://thewhitebuilding.org.uk/ accessed November 1st, 2012.

87 Jonathan Kemp http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:space:publicity (last modified September 25th, 2012); http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:space:opencall Last modified June 25th, 2012.

88 Jonathan Kemp, Martin Howse, and Ryan Jordan.

and a variety of pre-lab materials were made available including The Crystal World Reader v.01, along with Techniques, Equipment, and Investigations collaborative wiki pages.[89]

The open laboratory of the selected twelve participants[90] took place between the 17th and 21st July, culminating in a final evening of public demonstrations and performances. A two week construction period for the exhibition then followed with a public opening event on August 3rd 2012. The exhibition was open five hours a day/three days a week until September 1st 2012.[91]

The London iteration of the project was embedded in its location. Given the Ballardian prompt of The White Hotel, a strange and illusionary respite from the crystalline jungle,

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89 The Crystal World Reader v.01; Techniques: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:techniques Last modified July 9th, 2012; Equipment: http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:equipment Last modified July 14th, 2012; http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:investigations Last modified July 13th 2012.

90 A list of the twelve participating artists with website links can be found at the foot of http://crystalworld.org.uk/wiki/doku.php?id=the_crystal_world:space:postdescription accessed November 1st, 2012. They included new media artist, fine artists, sound artists, a writer, and two artists working with crystal healing.

91 An online review of the exhibition was commissioned by Mute, a London based online magazine "dedicated to exploring culture and politics after the net": Matthew Fuller, *The Garden of Earthly Delights*, http://www.metamute.org/editorial/articles/garden-earthly-delights; and another review was commissioned by Furtherfield, a London based centre for the exploration of digital cultures: Rob Myers, *The Crystal World: Algorithms, Inhuman Speed and Complexity* http://www.furtherfield.org/features/crystal-world-algorithms-inhuman-speed-and-complexity This review was also circulated on Rhizome, an long established international resource "dedicated to the creation, presentation, preservation, and critique of emerging artistic practices that engage technology". http://rhizome.org/discuss/view/207703/

A further article was also commissioned by Mute: Martin Howse and Jonathan Kemp, *The Crystal World*, http://www.metamute.org/editorial/articles/crystal-world All accessed November 12th, 2012.

The lab and exhibition were documented with still and video cameras by most of the participants and several independents: much of this material was collated and selected for the project website, as an online image archive http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:space:image_archive Last modified September 28th, 2012, and for a post-description page, http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:space:postdescription Last modified November 6th, 2012. An impressionistic video documentary of the exhibition was also produced by the author: http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world_v.02:video Last modified March 31st, 2013.

The project was well received by a large audience including daily visitors to the lab and those who came to the salon, opening event, and visited the month long exhibition: audience figures for the exhibition, including the opening, were 411 over effectively 90 hours (18 days x 5 hours/day). No figures were collated for lab visitors nor the salon event audience.

Various participants have blogged about their experiences, including Kat Borges http://chamama-katiushka.blogspot.co.uk/2012/07/alchemy-of-hearts-crystal-world-lab.html; Graham Dunning http://grahamdunningcrystalworld.wordpress.com; and Lorah Pierre, http://lorahpierre.tumblr.com All accessed November 12th, 2012. A performance from the salon event is also archived here: http://archive.org/details/RyanJordanAndLukeMoss-LiveFromTheCrystalWorldSalon and reviewed here: http://www.actsofsilence.com/album-review/so-what-did-you-do-yesterday/ Both accessed November 12th, 2012.

The White Building's eccentric juxtaposition next to the Olympic bejewelling of the Hackney Wick Bow hinterland allowed for an elaborate disinterment of computational machinery over elements of a transformed substrate of Hackney mud, the Grand Union Canal, and the remnants of Hackney Wick's Victorian industrialism.

Laboratory Description:

Various participants collaborated in high voltage experiments that continued over the five days. Plasma arcs, colossal electrostatic discharges, were created using a 5,000 volt 3-5 amp D.I.Y. transformer made from two microwave oven transformers. These were drawn across more fulgurite mixes of Hackney silt and mud, silicon, magnetite, and along trails of silver nitrate, recovered from junk computers, over scrap wood and London clay bricks, burning them with Lichtenberg-like tree figures.

In high heat experiments, crucibles recessed in alumina “bubble” pizza oven bricks were painted with a silicon carbide and sodium silicate susceptor mix.[92] Silicon powder (produced from quartz sand heated with magnesium powder, then dumped into hydrochloric acid) was mixed with a flux of boron oxide, poured into the D.I.Y. crucible and insulated with another brick and ceramic wool, before packing and smelting in a microwave oven for more than forty-five minutes at maximum power until, at over 1410°C, silicon flakes formed.[93] Other participants produced pig iron from haematite and smelted at around 1200°C, while other smelts of quartz, integrated circuits, hard drive platters, and ferrite rings, made in the microwave ovens or a digital furnace, were used for

92 A susceptor is a material used for its ability to absorb electromagnetic energy and convert it to heat. The author researched this method with regard to microwave energy in email conversations with a private and institutional correspondents in the USA and The Netherlands. To the author's knowledge silicon, with a melting point of 1410°C, has not been melted using such a DIY method. A longer ambition by the author is to make a diy dirty silicon chip.

93 Silicon, although the eighth most abundant element in the world, does not exist in a naturally pure form: part of the author's conception was that silicon, in being deposited in this pure form as part of the next geological layer (the anthropocene) manifests capital's pathology of extraction, use, and (re)deposition in the earth, which wilfuly invites the investigation into how to decrystallize, decode and re-encode such pathologies propagated over nature and the psyche.

further experimentation. Either poured directly onto steel plate or into simple moulds, the reconstituted materials were further used in electro-crystallizations and sonifications, part of the “mine-in-a-pot” experiments, or as components for the earth computer (see below).

Experiments powered by recycled computer power supplies played 5 and 12 volts across electrolyte soups of sulphates, acids, canal water, and Hackney Wick mud to provoke crystalline accretions and etched depletions over various computer derived electrodes including copper, zinc, and lead, or other materials including graphite pencils, cassette tapes, shellac records, and Olympic souvenirs.

Other experiments furthered the precipitation of saturated and super-saturated solutions (potassium nitrate, potassium carbonate, potassium sulphate, copper sulphate, rochelle salts, alum phosphate, and ferrous sulphate) through evaporation (sometimes accelerated by adding pyrex containing solutions into pans of simmering water). These were produced for further excitation including exploring the piezo effects of rochelle crystals with hard drive actuators, or crystallized directly onto various supports including paper, textiles, bone, hard drives, cassette tapes, other crystals and minerals.

Audible signals were produced using a metal ores and loosely based on the Axon Hillock circuit, a circuit that captures the basic principle of operation of biological neurons. Cats whiskers of copper wire were placed in contact with various minerals including raw chalcopyrites, a copper iron sulphide; iron pyrites; and limonite, an iron ore; and signal variations included doping the ores with various sulphate solutions, or using computer fans to rotate the minerals[94]. Other audible processes included the hard drive turn-tabling of disc-pours of shellac and integrated circuits under copper cats whiskers.

94 For notes on the Axon Hillock see Ryan Jordan's Channelling Interference workshop resource page, http://ryanjordan.nnnnn.org.uk/doku.php?id=workshop_resource accessed November 6th, 2012.

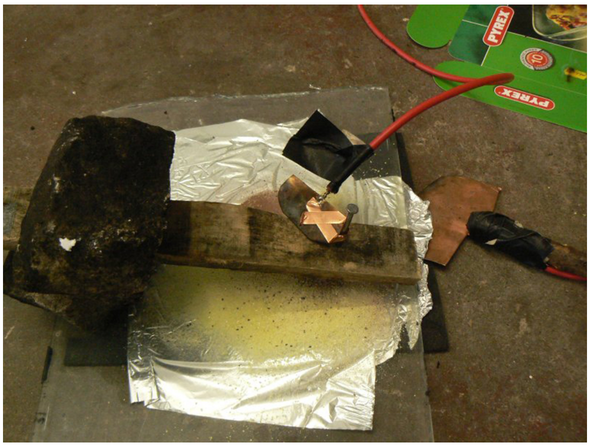

Fig. 54. Experiment to expose high voltage discharge over paper using silver nitrate, CW, London, 2012.

Fig. 55. Sending high voltage discharges across various treated substrates, CW, London, 2012.

Fig. 56, 57, & 58. Smelting silicon powder mixed with boron oxide at over 1410°C in a treated pizza oven brick, ceramic insulation, microwave oven, to produce silicon flakes. CW, London, 2012.

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Fig. 59. Furnace smelt product made from hard drive ceramic platters for the earth computer project, CW, London, 2012.

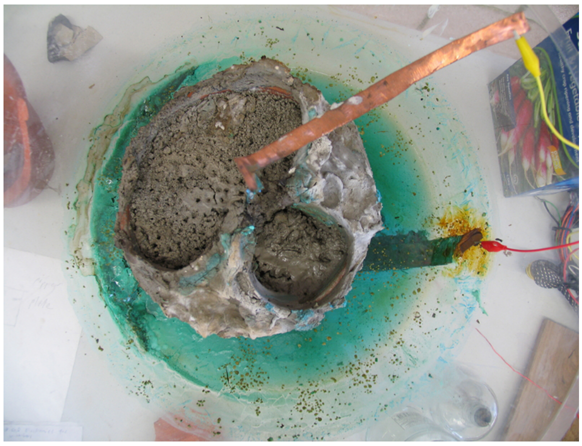

Fig. 60. Computer psu powered electrolytic clay and canal silt mud soup experiment, CW, London, 2012.


Fig. 60 & 61. Experiments in the precipitation of saturated and super-saturated solutions directly on various substrates. CW, London, 2012.

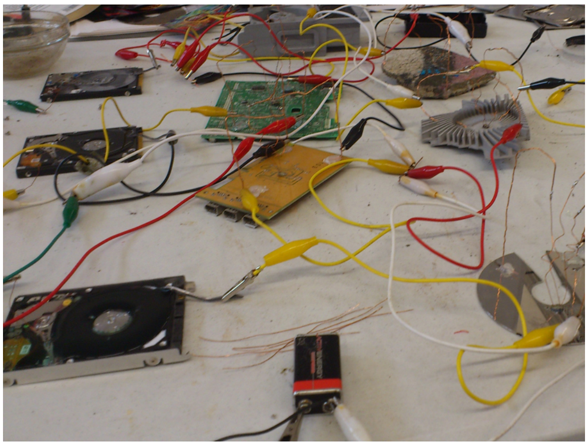


Fig. 63 & 64. Ores, crystals and solutes in arrays as audible signal generators including bastardized Adams Crystal Amplifiers and crude Axon Hillock circuits capturing the basic principle of operation of biological neuron. CW, London, 2012.

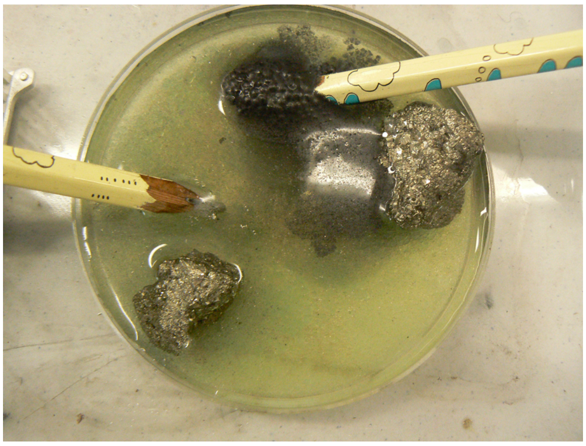

Fig. 65. Provoking crystalline accretions and etched depletions over various computer derived electrodes, CW, London, 2012.

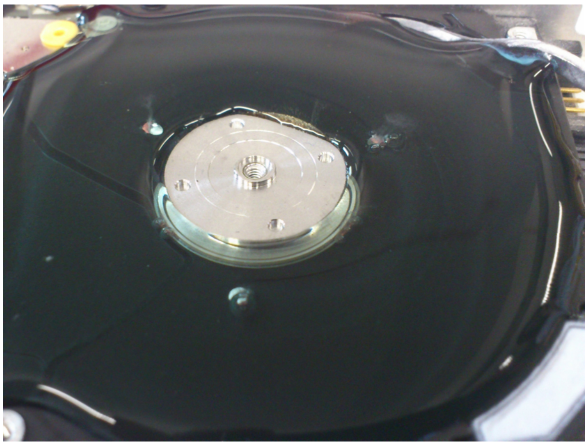

Fig. 66. Hard drive turn-tabling of shellac disc pour, CW, London, 2012.

Exhibition:

Amid the remains of the laboratory's apparatus and its products, over twelve days a Hackney Wick Construction was designed and installed:[95] two containers filled with Grand Union Canal water, one mixed with blue copper sulphate, the other colourless sulphuric acid, supplied small pumps and a sprawl of clear tubes with a month-long liquid feed, leakily recycled first over a pile of selected rock ores suspended on a steel grid then trickled over a heap of junk computer parts on another grid before collecting back in the palletted tubs. Such a cycle of feeds variously doped the construction with sites of precipitation and dissolution, nutrient-poor crypto-vegetations, and intemperate performances of the Axon-Hillock score (see below).

The same sulphate and acid laden canal water was side-fed to six split polythene containers in a sub- bath before percolating for recycling back to the mother tank's feed cycle. Combinations of select components and acidic solutions were left to etch, accrete, clump and discolour: iron pyrites over a heap of old server memory; a yield of oyster mushrooms over a soak of straw and mycelium; assorted gold and copper floated filagrees over green, dirty yellow and sky-blue solutions; a matted blackened oxide overblowing an aluminium electrode, others of graphite pencils rusting and dendritic in their leachate. Nearby another electrolytic bathing, of a G5 motherboard and housing in sulphuric acid, slowly recrystallized its leached base metals within other oyster mushrooms.

Two versions of two signal generator circuits were constructed and inserted into the installation computer junk. Using chalcopyrite, a copper iron sulphide mineral, as a semiconductor, the first was the Axon Hillock circuit with tubes of mineral solutions

95 The exhibition was designed and installed by the three organising artists, Jonathan Kemp, Martin Howse and Ryan Jordan, with input by various lab participants. A “leaky fountain” idea by the author was translated by all three into the central and sub-bath structures, and the author and Howse for the contents of that sub-bath; further installations included Howse's earth computer project; Jordan's Axon Hillock project, and the author's “mine in a pot'”experiment.

(potassium nitrate, sodium, and citric acid) replacing wire connections. The second was a bastard version of a 1933 Adams Crystal Amplifier[96] which used three cats whiskers to contact with the chalcopyrite. The completed circuits were arrayed on and connected to the c-waste via the tubes to then act as audible signal interrupts to the flow of sound from the piping of liquids down and around the installation.

Tables used in the laboratory framed the sides of the room, left arrayed with minerals, computer parts, slag, experimental products, glass ware, microwave ovens, a furnace, crystallizations, moulds, melts, bricks, diagrams, bits of tape. On the floor scorched stone and wood lay alongside an electrocuted sausage of Hackney mud; nearby delicate crystalline drawings were on one wall, and a paper tube of crystals, the result of solute capillary action, punctuated another corner. On an additional table a scattering of reference books to the project were made available.

On another side of the room raw minerals, either dissolved or as solid plates were placed within a porous ceramic/glass structure to be buried within the earth at a location close to Hackney Wick. Described as an "earth computer" over time, it is anticipated that both underground electric currents (telluric flows) and minerals/rainwater leaching through the soil could re-form these base components (some extracted from computer waste) into a functioning earth computer; a machine without wires, without components and without abstractions, operating in the earth and proposing a negative ecology.[97] Within the exhibition an earth computer simulation was attempted, replacing the potential flow of telluric currents with energy from a crude copper dipole antenna. The simulation embeds a ceramic container within mud/earth dredged from the nearby canal. Silver nitrate (0.1N solution) was used as an electrolyte with recovered/recast copper (from CPU heatsinks - as

96 http://web.archive.org/web/20100105122933/http://www.aethmogen.com/wri/radams/tenigma1/07ada/01txt.shtml accessed November 6th, 2012.

97 See: The Crystal World Exhibition opening night publicity where the the earth computer project is described. http://crystal.xxn.org.uk/wiki/doku.php?id=the_crystal_world:space:opening Last modified August 1st, 2012.



Fig. 66, 67 & 68. Exhibition construction included using Intermediate Bulk Containers, c-waste, rocks, Grand Union Canal water, acid, steel mesh, pumps, and acrylic piping, CW, London, 2012.

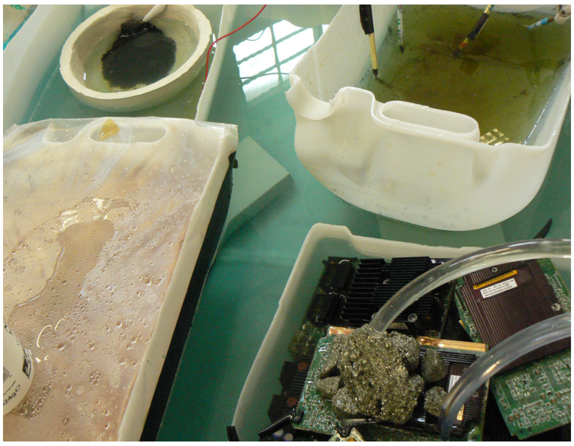


Fig. 68 & 69. Exhibition details: side bath of different electrolytes, reconfigured computer minerals, and mycelium galena straw mix; remains of various high voltage experiments, CW, London, 2012.

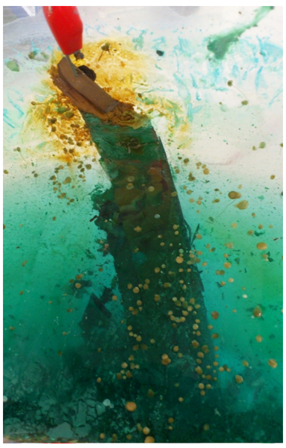
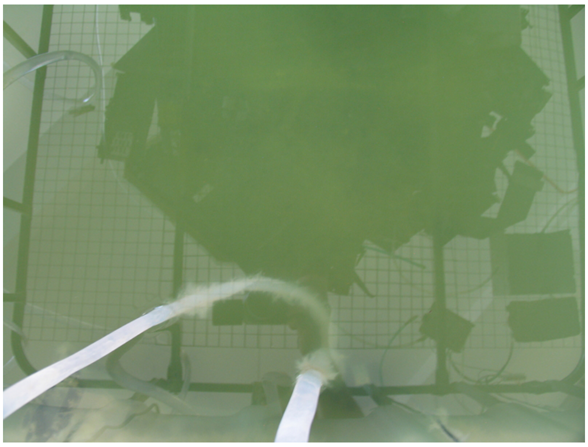
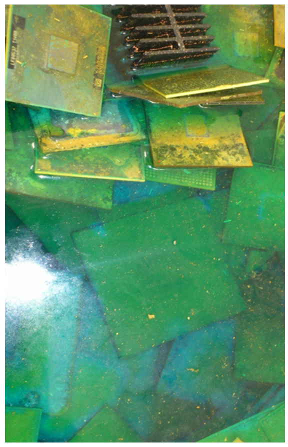

Fig. 70, 71 & 72. Details of precipitation, dissolution, and crypto-vegetation from piping of Grand Union Canal water and acid mix over rock ores and c-waste, CW, London, 2012.

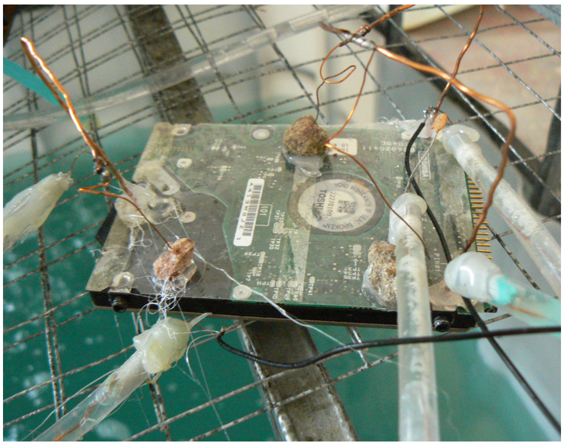

Fig. 70. Multiple Axon Hillock audio generating circuits with copper and iron ores with nitrate and acidic solute connectors, CW, London, 2012.

Fig. 71 & 72. Earth computer simulation: ceramics, glass, canal mud, silver nitrate, recovered copper, zinc, ferrite, copper antenna, CW, London, 2012.

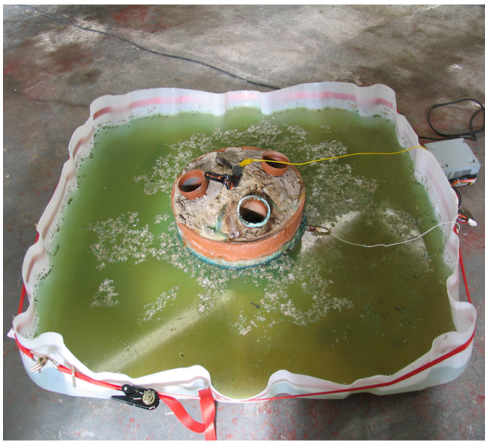

Fig. 73, 74 & 75. “Mine in a pot” electrolytic experiment in semi-conducting lode formation with silicon wafers, computer manufacturing and recycling chemicals, Hackney silt, Rendlesham UFO sand, S-Material clay, powdered silicon, CW, London, 2012.

Fig. 76. The Crystal World exhibition installation view, CW, London, 2012.

part of CPU material and as extra heatsink), recast ferrite (from power filters) and zinc.

Earth mineral electro-crystallizations were further examined in an updated version of early nineteenth-century experimenter Andrew Crosse's "the mine in a garden pot".[98] Placed within a container of Grand Union canal water, contemporary solutions used in processor manufacture and recycling (Aqua Regia, nitric silver chloride, potassium carbonate) were slowly leaked out via their sub-pots filled with gold plated edge connectors and crushed ICs, into a potted island mud of Hackney Wick silt, pipeclay,[99] Rendlesham UFO sand, and powdered silicon, charged between electrode of a copper banding (+) around the porous pot, and silicon wafers (-) stuck into the mud, to provoke transverse deformations of semi-conducting lode formations from within its depths.

Discussion:

The research practice has staged several different human-material-apparatus configurations in a variety of settings, from the pragmatic and procedural workshop environments of Decrystallization and Recrystallization, to the more openly speculative open laboratory iterations of The Crystal World.

These experimental situations have been characterized by the attempt at executing processes in part based on inexact transcriptions from the natural sciences, and a lack of interest in the arrays of inductive and deductive protocols, that is, those predefined procedural design methods that typify such a normative science (whether natural or computer), to answer the question“how best to recover x from y”. What has been argued is that the practice has sought to help make explicit the many kinds of media and their differing intra-actions that criss cross such configurations that some formalisations, as in

98 “Experiment called The Mine in a Garden Pot” in Crosse, A., Crosse, C., *Memorials, Scientific and Literary of Andrew Crosse, The Electrician*, (London: Longman, 1857): 240-3. NB. At the time of writing, this experiment is being continued at the project studio in East London, and will run for a year.

99 What the author actually used was S-Material, a relatively expensive clay that artist Grayson Perry uses, and the nearest white clay equivalent to pipeclay, which was once ubiquitous and very cheap.

new media art, can obscure.

The use of the conceit of the "crystal" throughout the research practice can now be further illuminated in relation to the notion here of normative and protocol-based access to the material through a consideration of one of its instruments, that of measurement. Where inductive and deductive protocols are established as standardizations in the natural sciences for the replication of results irrespective of laboratory (but not equipment, conditions, analysis, and interpretation), they place considerable demands on the nature of their measuring instruments,[100] as they demand the unambiguous correlation of something about the object under investigation with a corresponding some thing of some other system that serves as the measuring device, and that is, in its own materiality, already measured (à la Feynman). Thus computer science has increased the number of ways of calculating, measuring and representing the world, with many of those ways being algorithmic interventions and distinctions made between and with the viewing subject and the object viewed. As computational measuring instruments they are dependent on their routines (both universal and non-universal) being correlated with the properties of their physical substrates so that a systematic programmability (re. protocols) can operate successfully in the two ways minimally demanded: implementing *a* replicable model of computation (eg. that which can measure *x* against *y*), and implementing a particular problem solving function (eg. how to measure these *x's* against *y*).

If measurement, and thus programmability, cannot be determined independently of its substrates - because they are always intra-acting and bound up in each other – then the only way they can be determinate is through the execution of an agential (here human) cut through the specific and unidirectional correlation of logic states to certain levels of

100 This is true for both the mundane and the more spectacular practices of science, including, at the time of writing, December 2012, the very recent measurements of neutrino's travelling faster than the speed of light. Postscript*:* it was subsequently stated that they did not.

behavioural tolerances of the varying material substrates in computers. In other words, to make calculable the dynamic properties of materials, such that they can be dependable for any symbolic/semantic functional system (cf. the discussion of Feynman in Chapter One: Computational Materialism), can result in an apparent ontological determinacy because of such anthropocentric intentionality (“crystallization”).

With Barad in mind, the projects' intra-actions, as sketched out in the preceding descriptions, attempted to undermine some classic macroscopic interventions employed in the inscription of the computational over its material substrates (for example, provoking mushroom and earth bound “semi-conductors”), albeit in a quasi-vitalist disavowal of quantification, measurement, and versioning in its apparatus (cf. Jane Bennett's influential articulation of a vibrant matter).[101] The “doing' or 'being” of intra-action within the experimental configurations of the research practice suggests that a greater and less resolute distribution of agential and performative indeterminacies are always at work at any level of formalisation (including those of new media art). This reinforces the suggestion in this chapter that any theory or practice which is thus predicated around the constraints of particular abstractions, for example, and as in the case of much new media art, at the levels of code and software, hardware, or interface, is necessarily instrumentalist as it will always trade off some things for others.

One caveat to this practice is that, however much its un-analysed *material* uncertainties are acknowledged, and however ideological they appear (with regard to Bennett's concept of polities),[102] it has not been executed as a claim to be 'representing' ontologically

101 In *Vibrant Matter* Bennett suggests that there is a “vital materiality” in the ad hoc and variable distribution of agency, (which I take in the sense of Barad's “agential realism”) active across all kinds of entities in the world including, in this project, metal oxides, acids, heat, people, public space, insurance, and new media art, and in which there is no overcoding of matter by something untethered from this material world (the traditional sense of immanence and universality).

102 That is, the formalism of any post-humanist ventriloquy as recognized by Jane Bennett, in that it is always a human giving voice to other “vibrant” things, in a kind of performative contradiction. No human assemblage can realistically “horizontalize” the world completely so her vital materialism's real-politik is one based on “a polity with more channels of communication between members”.

indeterminate states where there is “no determinate fact of the matter concerning the property in question,” nor only to introduce uncertainty as just an epistemic matter, a lack of knowledge.[103]

Finally, and in concluding this chapter, the argument so far developed and supported by the research practice suggests, with regard to Jussi Parrika's call repeated in the Introduction to this chapter, that any putative “new apparatus theory” of new media art needs not only to attempt some very particularised accounts of its subjects, but also to abjure any appeals to any one particular level of abstraction. It is when these accounts make the methodological cut from the affective horizon of elegant theory to extend their constitutive inclusion to things like mud, mines, metallurgy and minerals, that they then make this move into a more performative relation to indeterminacy.[104]

> “Is it not, after all, a self·conscious, language·wielding human who is articulating this philosophy of vibrant matter?" It is not so easy to resist, deflect, or redirect this criticism. One can point out how dominant notions of human subjectivity and agency are belied by the tangles and aporias into which they enter when the topics are explored in philosophical detail. One can invoke bacteria colonies in human elbows to show how human subjects are themselves nonhuman, alien, outside, vital materiality … The voice of reason or habit is, however, unlikely to be mollified by such tactics and will again grasp for that special something that makes *human* participation in assemblages radically *different*. (Original italics)

Bennett, *Vibrant Matter*, 120 – 121.

103 Barad, *Meeting the Universe*. 265.

104 But, with Bennett in mind, still as some kind of post humanist formalisation.

Chapter Three: Methodological Diffractions, Perverse Confluences

Introduction:

My aim in this chapter is to examine some of the methodologies that have influenced the formation of The Crystal World project. It is not my intention to stamp the project as a representation of a theory of something, nor to suggest it represents only a particular state of affairs, nor attempt its chronological or positivistic ordering. Instead the approach in this chapter will be to write around certain themes and problems that frame The Crystal World, so as to speculate on how these problems can be approached in ways that might help further develop the project whilst, in turn, recursively vitalising some of these themes. This approach will also emphasise the discontinuity in representing the materiality of the project within any operative diagrammatic.

Thus, underpinning this chapter is the commitment to approaching new media art as variable and complex apparatus of materials, epistemic effects, interfaces, protocols, and abstractions, rather than only as presenting a particular plane of aesthetic response or fufilling a particular mandate.[1] As indicated in Chapter One: Computational Materiality, considering media in this way, as being composed of complex agencies and effects, does appear to produce its own subject, in that it contributes to its own materialization so that as a cause it no longer precedes any effect. However, in so doing, it also does also appear to the author to be consistent with the drive of the research away from epistemological norms and towards more fine grained analyses of new media art.

The chapter sketches a history, implicit to the project, of co-operative social production

1 That is, where a strong epistemic sense of "p presupposes q" is forwarded about proposition p, and this plays a key role in going on to assert q in a way that possesses some sort of discursive credibility (that is, credible within some epistemic set). A claim of entailment like this is indistinguishable from possible false claims of q on the basis of p, which calls into the question the mandate of some of the examples I have in mind in the context of new media theory, which can also be tried, for example, under the fallibility of *pars pro toto*, (that if a has x, then the whole system A has x): In both Sean Cubbitt's 1998 *Digital Aesthetics*, and Lev Manovich's 2001 *The Language of New Media*, film theory is invoked as the source for their descriptions of new media and its non-linear hybridisation of space and time as offering new languages of expression. Similarly, Jussi Parikka's *Insect Media*, readdresses studies in ethology to reprise the network as being inseparable from both biology and technology. The Crystal World research has, in part, been driven by the strong sense that the lacunae in such literature about the materiality in new media art theory results in somehow lower epistemic standards, while conversely, acknowledging the impossibly high level of justification such projects otherwise require.

(knowledge commoning) in relation to new media art practice, beginning with free software and open hardware initiatives, and elaborates some of the political and epistemic determinations that subsequently attempt to re-map such collaborative practices, techniques and ensembles as acts of critical practice. In so doing, the chapter also raises some problems where such practice has been charged as a means to reinvigorate politics, by questioning whether such co-operative modalities of agency can ever significantly re-determine the interests that drive capital.

Finally, in the light of all this, the chapter moves to diffract The Crystal World research through a tradition of autophagic "refusal".

Whose cooking?

If the structures of computational programming were for a long time overlooked as an artistic material and significant cultural elements of the computational have been wilfully neglected in many new media studies, then just as such production underwrites any new media art, it can also be seen as the site where artists can modify and create their own tools in a way that "greatly enhances the freedom to technically implement artistic ideas".[2]

Core ideas about freedom and co-operation in relation to software production are not new. Where Donald Knuth made the analogy between programming computers and following a recipe in cooking,[3] Richard Stallman further pointed out that cooking recipes have always been shared and circulated *gratis*.[4] Stallman goes on to write that the early days of software development at Massachusetts Institute of Technology (MIT) were marked by a similar sharing of work in an open and collaborative community long before he became involved at MITs Artificial Intelligence Lab in 1971.[5] Throughout the 1960's and 70's users

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2 Aymeric Mansoux and Marloes de Valk, "Preface" in *FLOSS + Art*, eds. Aymeric Mansoux and Marloes de Valk, (Poitiers: Goto10/Mute, 2008), 9.
3 See Chapter Two: Executing a new media materialism, footnote 7.
4 Richard Stallman, "The GNU Operating System and the Free Software Movement", in *Open Sources: Voices from the Open Source Revolution*, (Sebastopol, C.A.: O'Reilly, 1999). http://oreilly.com/openbook/opensources/book/stallman.html accessed March 12th, 2012.
5 Ibid. 31.

frequently modified, improved and debugged the software themselves,[6] especially if it was to be run on different hardware to that on which it had been developed. But, according to Stallman, this all changed from the early 1980's through a combination of the depopulation of the AI lab to private spin-off companies such as Lisp Machines Inc. and Symbolics, and a subsequent software copyrighting and licensing agreement by MIT being reversed by Symbolics leading to competing non-shared and non-free operating systems complete with non-disclosure agreements.[7]

After the end of such open collaborations and the demise of the MIT hacker community, Stallman, in 1983, initiated the GNU's Not Unix! (GNU) project to develop an operating system based entirely on free software.[8]

Given that the project somehow arose from his reactions to the change in culture apparent in the Symbolics story[9] and that the overarching goal of the project was declared to be to

6 cf. the original meaning of being a “hacker”.

7 For a classic account of the birth of hacking that includes an account of the schisms referred to here, see: Stephen Levy, *Hackers: Heroes of the Computer* Revolution, (New York: Doubleday, 1984).
Later, the idea of open collaboration/hacking was famously attacked eg. by Bill Gates in his 1976 *An Open Letter to Hobbyists*, where he likened the hacker idea of sharing to stealing.
http://www.blinkenlights.com/classiccmp/gateswhine.html accessed March 13th, 2012.
More generally, a popular and earlier mythology about the birth of the Unix operating system at the AT&T Lab:

> that it was law, in the form of the 1956 antitrust 'decree' (actually an agreement between AT&T and the U.S Government) that created an environment in which management decided to simply give away the Unix time sharing computer system to anyone who wanted it. It was, the story goes, given away in a manner similar to the way that today, it is said that Linux is freely given away. In this popular story it is law that created a time and space where 'freedom' and sharing was the norm within AT&T. .. It was law that not only created the environment of freedom but when law changed it caused a different space to arise, one where sharing and freedom gave way to corporate greed. This change was the 1982 AT&T divestiture agreement. This change saw the company change track from being a national provider to become one of the global oligarchs of international telecommunications.

Martin Hardie fulminates that any such founding father story that cleanly demarcates production into legal periods of free or non free, open and closed, or proprietary and non-proprietary, is bedevilled in the real detail as it is more the processes of the law and patenting and money that ultimately underwrite FLOSS production, whatever freedoms are declared.
Martin Hardie, *Time Machines and the Constitution of the Globe*, (European Ways of Law, Oñati, 2005).
http://auskadi.com/files/timemachines.pdf accessed April 17th, 2012.

8 Stallman founded the project in 1983 using the recursive acronym *GNU's Not Unix!*, before going on to found the Free Software Foundation in 1985 to fund free software activities.
http://www.gnu.org/ accessed March 13th, 2012.
GNU's design is Unix-like but is free software and contains no Unix code. A GNU kernel has still not been implemented at the time of writing, however in 1991 Linus Torvalds provided the Linux kernel so as to make the first free operating system.

9 Or more prosaically that Stallman could not access the (closed) software for a Xerox laser printer at MITs AI Lab. See: Richard Stallman, *Free Software: Freedom and Cooperation*, 2001.

free users from any proprietary lock-downs, in 1989 Stallman devised a “copyleft”[10] license for its distribution that would prevent GNU software from being turned into proprietary software - the GNU General Public License (GPL) enshrines four freedoms and essential access to software source code, with the requirement that all derivative works preserve the same freedoms. Those freedoms are:

- The freedom to run the program, for any purpose (freedom 0).
- The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so you can help your neighbor (freedom 2).
- The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.[11]

Thus the GNU/Linux project defines free software as embodying a political idea of freedom underscored by a strong belief in the undifferentiated rights and freedoms of individuals to create and produce, distribute and collectivise their labours free from its accumulation and capitalisation by others (the “proletarianization of the programmer”, as Simon Yuill characterizes it).[12] As a commons, the free software movement has developed a resource where technology is seen as a self-governed common project, and where

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http://www.gnu.org/events/rms-nyu-2001-transcript.txt accessed March 13th, 2012.

10 The copyleft principle is designed ensure that the licensee is bound by the licence in protecting the freedom of the licensee rather than just the author. An early example of the word being used is here: http://en.wikipedia.org/wiki/File:Copyleft_All_Wrongs_Reserved.png, which was made, in part as a riposte to Gates' attack on hackers of the same year, 1976.

11 See http://www.gnu.org/philosophy/free-sw.html accessed March 13th, 2012.

12 Yuill gave a presentation, “Forking free software” at the Makeart 2009 FLOSS art festival in Potiers, France and he makes this point about Stallman and some of the motives behind the GNU/GPL initiative in a following discussion session archived here: http://makeart.goto10.org/2009/?page=video&lang=en accessed February 5th, 2013.

accessibility is embedded in the relational modalities and community building processes that are free for all to use – and arguably therein resides both free software's political potential and limitation.

While the impact of the project has been influential (eg. on peer-to-peer (p2p) philosophies), exponential,[13] and exhibits a versatility and maturity in the range of its software reflected in its domination of both the server[14] and film industries,[15] there is the not unexpected irony that, given its aims and its military origins,[16] GNU/Linux licensed products have been taken up by some of the very kinds of organisations that lock users into such restrictive copyrights about their content and end-products (eg. the military and the entertainment industries).

For new media artists, free software is seen to present an opportunity to escape the classic top down approach of the end-product form of media art through a continuous and collaborative engagement in what can be characterized as an open form of artistic research.

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13 That is, a claim solely based on the number of distributions of the operating system built on top of the Linux kernel, see: http://distrowatch.com/search.php?status=Active accessed March 13th, 2012. There are 319 active distributions available at the time of writing - this compares to Aymeric Mansoux's remarks that there were only three in 1995 and 354 in May 2008, when he and de Valk were writing their preface to *FLOSS + Art*. Mansoux and de Valk, *FLOSS + Art*, 8.

14 In 2008 Steve Balmer, Microsoft CEO, said that: "Forty percent of servers run Windows, 60 percent run Linux … How are we doing? Forty is less than 60, so I don't like it. ... We have some work to do." http://www.pcworld.com/businesscenter/article/151568/ballmer_still_searching_for_an_answer_to_google.html accessed March 13th, 2012.

15 eg. In 2003 Disney was one of the last big film companies to move over to Linux: http://www.nytimes.com/2002/06/18/technology/18LINU.html?pagewanted=all accessed March 13th, 2012.

16 MIT's student run Tech Model Railroad Club (TMRC) is cited as the foundational centre of hacker culture and from the 1950's its members were active in designing and building a semi-automatic control system for the clubs model railways which was based on complexes of relay operated switching systems originally used in telephony. The TMRC had close links with the AI Lab at MIT and MIT's Project MAC, initiated in 1963 and under which the AI Lab was at first incorporated, also enjoyed a tradition of modifying hardware, in its case mainframe computers (eg.IBMs 7094). See Steven Levy, *Hackers: Heroes of the Computer Revolution.* Project MAC was the then US Government's Advanced Research Projects Agency (ARPA) sponsored program researching Machine-Aided Cognition, expressing the broad objective of the AI research program; and Multiple-Access Computer, a major timesharing systems development endeavour, under the guidance of the tripartite leadership of Robert Fano, J.C.R Licklider and Marvin Minsky (the latter head of the AI Lab). See: Stefanie Chiou, Craig Music, Kara Sprague, and Rebekah Wahba *A Marriage of Convenience: The Founding of the MIT Artificial Intelligence Laboratory*, (Cambridge, Mass.: MIT AI Lab, 2001), 13-14. The Advanced Research Projects Agency (ARPA) was created in 1958 to meet the need for "a high-level defense organization to formulate and execute R&D projects that would expand the frontiers of technology beyond the immediate and specific requirements of the Military Services and their laboratories". Its successor, the Defense Advanced Research Projects Agency (DARPA), was fundamental in the development of the internet. http://www.darpa.mil/About/History/History.aspx accessed March 19th, 2012.

If the film industry generally eschews any potential politicisation of its means of production, that is, what Walter Benjamin regarded as film's necessarily collective conditions of production and reception, then artists who embrace free software with its open licenses, by default politicise notions of ownership through the sharing, attribution, and modification of their content, while at the same time asserting an autonomy over their productive means in some ways akin to those early collaborative explorations in computing.[17]

Furthermore, Mansoux and de Valk note, because such content can be freely distributed through, for example, online repositories, it allows not only the free use to others to do anything with it, but ensures a degree of its continued preservation through the loss of proprietary dependencies. It also makes clear that software is not just a technical component of new media art, rather "it *is* the artwork and its code provides another reading of it. This often forgotten layer of interpretation should be open to others, to study and understand..."[18]

Another often forgotten layer, the hardware, was readily disinterred in those early days of computing; from the first prong of military backed hardware modifications run out at MIT from the late Fifties into the 1960's, to a second prong of homebrewed computing devices in the Seventies,[19] varying shades of do-it-yourself (D.I.Y) and do-it-with-others (D.I.W.O)

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17 In his 1936 essay Benjamin also viewed film technology as providing the 'democratizing' character of reproducibility's destruction of the artwork's aura. Walter Benjamin, *The Work of Art in the Age of Technical Reproduction* http://www.marxists.org/reference/subject/philosophy/works/ge/benjamin.htm accessed November 21st, 2011.

18 Mansoux and de Valk, *FLOSS + Art,* 10.

19 Homebrewing is the design and building of computers, from the ground up from the sub-board level, sometimes from kits. Most early microcomputers were available for construction with levels of commercial component support varying by cost, or as published designs only, usually with a range of options in construction. Leading examples of prefabricated kits included Micro Instrumentation and Telemetry Systems' 1975 Altair 8800, a diy kit microcomputer, and MOS Technology's unadorned 1976 KIM-1 microprocessor, both made available through various popular electronics magazines. The most famous group of homebrewers was the Homebrew Computer Club in Silicon Valley where the idea of the personal computer was born and from whose ranks sprung many contributers to the development of the computer including Adam Osborne and Lee Felsenstein, later of Osbourne Computers, and the now better known Apple Computer founders, Steve Wozniak and Steve Jobs.
See: Steven Levy, *Hackers: Heroes of the Computer Revolution*; Hugo Cornwall *Hackers Handbook III*, (London: Century Hutchinson, 1988).

approaches to hardware autonomy pressed towards opening up the computer-to-everyone until refluxed into what largely then became Silicon Valley's patent-based engineering of the knowledge economy.[20]

Contemporary iterations of an open hardware ethic establish both physical and networked events, hacklabs (or hackerspaces), and workshops worldwide, publicly organized through internet relay chats (IRCs), mailing lists, and wikis.[21] As such, project details and documentation, which can include live IRC discussions (and archived transcripts), images, descriptions, drawings, BOMs (bills of materials, ie. parts list), schematics, and step-by-step instructions, are made available to all under variations of existing copyleft licences, so that any design can be implemented, developed and used freely.

Thus if, as Matthew Fuller argues, free software developers form "a socio-technical pact between users of certain forms of license, language, and environment" which favours a looping of "open-source internalism" around a "culture of experts",[22] then the open hardware movement is immediately more heterogeneous in its constituency and outward looking in its scope. The physicality of a hacklab, moreover, points back to the general need for the pooling of resources and labour in a commons of both ideas and bodies.

The diversity of open hardware projects, from DIY lock picking[23] to "open soft drinks" by

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20 See: Walter Powell and Kaisa Snellman, "The Knowledge Economy", *Annual Review of Sociology*, Vol. 30, (2004): 199–220 for definitions and discussion of "the knowledge economy" and its relation to the computer industry and labour productivity

> Numerous social scientists have documented the transition underway in advanced industrial nations from an economy based on natural resources and physical inputs to one based on intellectual assets. We document this transition with *patent data* that show marked growth in the stocks of knowledge, and show that this expansion is tied to the development of new industries, such as information and computer technology and biotechnology. (p. 215) (my italics).

21 The current wave of hacklabs seems to have started in January 2001 with the inceptions of the Borman STL lab in Maryland Heights, USA and PoetryLab in Palazzolo Acreide, Italy, quickly followed by a spate of labs opening a few months later in Germany, Serbia and Spain. Source http://hackerspaces.org/wiki/Timeline. For links to a range of worldwide hacklabs see: eg. http://www.hacklabs.org/?q=en and http://hackerspaces.org/wiki/ Both accessed March 14th, 2012.

22 "Open Source" in this context does not especially refer to the Open Source movement - see footnote 28 below - but to the collaborative principles of free software in general. Fuller's argument is contingent on free software illiteracy: Matthew Fuller, *Behind the Blip: Software as Culture*, 24-26.

23 A tradition going back to the days of the Manhattan Project (1942-46) where Richard Feynman "used to amuse himself by breaking into safes containing secret documents". Paul Graham, *Hackers and Painters*, (Sebastopol, CA.: O'Reilly, 2004), 50.

way of DIWO biohacking or the measuring, monitoring, and sharing of real-time radiation data with "humanitarian open source hardware",[24] can be seen as both variously challenging orthodoxies in commerce and governance and actively inserting non-expert citizens into, for example, emergent technologies and disaster responses.

However, as in the early days of computing, such citizen science and engineering projects can equally be purposed around military and entrepreneurial behaviours through the implicit recognition of their value in connecting culture, science, capital and society in ways that traditional policy would never assume.[25]

Both these turns are nothing new: as already mentioned, the original MIT-led computing projects were extensively funded by the then United States Department of Defence's Advanced Research Projects Agency (ARPA), and many of its original hackers and homebrewers went on to found various patent-led companies. With regard to contemporary networked cultures, Tiziana Terranova long ago suggested that such a "participation

24 The examples cited are from current members projects on the London Hackspace wiki, http://wiki.london.hackspace.org.uk/view/London_Hackspace, except for the last which is a project developed in response to the March 2011 Fukishima earthquake and nuclear disaster called Safecast, a global sensor network started in Japan after 03/11 by members of Tokyo Hackerspace: http://blog.safecast.org http://www.tokyohackerspace.org/en/blog/measuring-radioactivity-in-matsudo All accessed March 14th, 2012.

25 And the recognition of citizen science and its importance is explicitly acknowledged at the highest level – for example, in the 2010 report by a US Presidential Commission into synthetic biology and the question of how much new regulation was required, positively promoted citizen science projects as tools to empower notions of social democracy and citizenship. Under a section the "Fostering Grassroots Collaborations ", the commissions report states:

> As noted, democratic deliberation is based on ongoing interaction among citizens on topics of common interest. For an emerging technology such as synthetic biology, many of these dialogues will be among scientists or other interested citizens and policy makers or regulators. Such interactions are vital to a democracy, but they are not sufficient. Exchanges among individuals and groups of citizens are also important. In particular, grassroots collaborations have been established around synthetic biology. Groups such as DIYbio are loosely organized networks of self-described "citizen scientists" coming together because of a common interest in the tools, methods, and applications of synthetic biology, rather than shared professional affiliations or policy responsibilities. In this way, the "do-it-yourself " community embodies a "do- it-together" ethos.
>
> These kinds of collaborations are commendable; they strengthen notions of citizenship and community at the core of a democracy. They demonstrate that science and its oversight do not belong exclusively to experts, highly trained professionals, or government officials. Science is a shared resource, affecting and belonging to all citizens.

New Directions: The Ethics of Synthetic Biology and Emerging Technologies, (Washington, D.C.: Presidential Commission for the Study of Bioethical Issues, 2010), 159 – 160. http://www.bioethics.gov/documents/synthetic-biology/PCSBI-Synthetic-Biology-Report-12.16.10.pdf accessed March 14th, 2012.

economy" is marked by the tensions between the "free labor" of cooperation that defines collaboration and its appropriation by the "outernet" of capital [26] (this in the context of the idea that "There is no longer an outside").[27] Capitalism has a proven ability to change its social structures, and initiatives from within the "participation economy" like Open Source Software and Creative Commons aim at its further redevelopment and social re-structuring within itself.[28]

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26 Tiziana Terranova, "Free Labor: Producing Culture for the Digital Economy", *Electronic Book Review*, http://www.electronicbookreview.com/thread/technocapitalism/voluntary, last updated 07-26-2005. In this way, she disagrees with Richard Barbrook's optimism towards how collaborative projects can overcome capital from the inside - which is also the position taken by Michel Bauwens and Project Oekenux in their discussions around collaborative/commons-based economic and political practices. cf. Richard Barbrook, "The High-Tech Gift Economy," http://www.imaginaryfutures.net/2007/04/19/the-hi-tech-gift-economy-by-richard-barbrook/ Both accessed March 21st, 2012.

27 "There is no longer an outside" drives the pessimism in Terranova's critique. One source for this could well be Michael Hardt and Antonio Negri's claim in *Empire*, Cambridge, MA: Harvard University Press, 2000, that, since the fall of the Berlin Wall, there is no longer an outside to capitalism, and that any struggle must be installed from within. It is from within this claustophobia that Terranova cannot see the escape as seen by participatory-network evangelists. Perhaps Negri, writing in 2009, seems to see escape as possible precisely only from the inside. It is in such terms that he writes:

> Firstly, it is of interest to note that there is no longer an 'outside' in this context, and that struggle (not only struggle, but the substance of subjects in struggle) is now totally 'inside'; there is no longer any semblance or reflection of 'use-value'. We are completely immersed in the world of 'exchange-value' and its brutal and ferocious reality.

Antonio Negri, "Communism: some thoughts on the concept and practice", http://www.generation-online.org/p/fp_negri21.htm accessed December 7th, 2012.

Deleuze and Guatarri use the idea of the "apparatus of capture" to suggest that while capital relentlessly subsumes other life-forms, 'real' creativity comes from something other, which is only then secondarily captured and put to work by capital. The untamed potential creativity of Marx's "living labour" shares, some of the qualities of the general intellect (social knowledge), before, according to Paolo Virno, it is objectified, and these qualities, of being reflexive, affective, cooperative, communicative and creative, can produce self-organisation antagonistic to capital. Virno contends that every act of this creativity breaks with the regulation of convention, re-writing the grammar of the system, abrogating rules to, in effect, redefine future generative possibilities. Its broker is not the State but the life-form that creates an exception-from-below. These exceptions can proliferate not through revolution but, he contends, through "engaged withdrawal" from a capitalism that removes the means for living other than by wage labour, and in a search for new strategies with which the general intellect can, apparently, subtract its creativity from any embedding in productive labour, which 'has given life to a sort of paradoxical "communism of capital"'. Hardt and Negri specifically argue that the struggle is about the primacy of living labour from within a (global) subsumption. Living labour is the creativity which capital seeks to objectify yet, as it is of the multitude, there is always the potential to produce something that pre-exists capture by capital and so might liberate itself, even when pushed further out by late capital's reification of the general intellect, for example, through contemporary technologies (eg. biotech, social media, etc.) The problem with this thesis, however, is that it could equally be seen as a logic empty of meaning as it faces the familiar problem of scaling compounded by both evading capture, and satisfying the need to eat, both at the same time.

cf. Chapter Thirteen "Apparatus of Capture", Gilles Deleuze and Felix Guatarri, *A Thousand Plateaus*, 424-473.

Paolo Virno. *A Grammar of the Multitude*, (2004) http://www.generation-online.org/c/fcmultitude3.htm accessed February 11th, 2013.

28 Open Source Software is a project initiated by Eric Raymond and others in 1998. In opposition to Stallman, Raymond advocated that the term free software should be replaced by open source software (OSS) as it is less ambiguous and more comfortable for the corporate world so that "there's now a chance

So where, for example, Yochai Benkler or Michel Bauwens suggest that there is an *in potentia* within capital for cultivating rival forms of production based around what they call “commons based peer production” (or just “social production”), their arguments consistently fail to surmount the structural similarities with late capitalism.[29] In late capitalism, social production invokes a highly normative term and technology that functions in analogy with the management of feedback signals observable in other spheres like data mining, statistical evaluation, or economic assessment. In many ways social production appears as a new operating system for late capitalism.[30]

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we can make serious gains in the mainstream business world without compromising our ideals and commitment to technical excellence”.
Eric Raymond, *Goodbye, "free software"; hello, "open source"*, http://www.catb.org/~esr/open-source.html accessed March 16th, 2012.
Creative Commons was established in 2001 by Hal Abelson, Lawrence Lessig and Eric Eldred as a vehicle for a new form of copyright licensing for a digital age: “Creative Commons develops, supports, and stewards legal and technical infrastructure that maximizes digital creativity, sharing, and innovation” and “creates a balance between the reality of the Internet and the reality of copyright laws”. CC licenses variously allow creators to choose some rights to reserve and which to waive for the benefit of recipients or other creators. http://creativecommons.org/about accessed March 19th, 2012. Florian Cramer argues that the name “Creative Commons” doesn't create a commons at all, as with its “some rights reserved” attribution available across its licenses it takes licensing back to the default restrictions of copyright. Florian Cramer “The Creative Common Misunderstanding”, in *FLOSS + Art*, eds. Aymeric Mansoux and Marloes de Valk, *FLOSS* + Art, 128-137

29 Yochai Benkler, *The Wealth of Networks*, Yale University Press : New Haven, 2006, in which Benkler sets out a familiar liberal agenda:

> Individuals are using their newly expanded practical freedom to act and cooperate with others in ways that *improve the practiced experience of democracy, justice and development*, a critical culture, and community”. p. 20 (my italics).

Michel Bauwens is co-founder of the P2P Foundation, an organisation dedicated to studying “the impact of Peer to Peer technology and thought on society” and attempting to build the model of p2p production within capitalism to eventually supplant it.
http://p2pfoundation.net/ accessed March 14th, 2012.
Bauwens believes that although peer production is used to benefit capital with its free inputs of social cooperation which create a surplus of value that capital can monetize and accumulate, it also has within itself elements that are anti-, non- and post-capitalist.

> Peer production is based on the abundance logic of digital reproduction, and what is abundant lies outside the market mechanism. It is based on free contributions that lie outside of the labour-capital relationship. It creates a commons that is outside commodification and is based on sharing practices that contradict the neoliberal and neoclassical view of human anthropology. Peer production creates use value directly, which can only be partially monetized in its periphery, contradicting the basic mechanism of capitalism, which is production for exchange value.
> So, just as serfdom and capitalism before it, it is a new hyperproductive modality of value creation that has the potential of breaking through the limits of capitalism, and can be the seed form of a new civilisational order.

http://www.furtherfield.org/interviews/interview-michel-bauwens-founder-foundation-p2p-alternatives accessed March 24th, 2012.

30 With arguably the ”soft control by crypto-hierarchies” always at work in any 'open' organisation, especially when the need for scaling becomes apparent, see: Jamie King, *The Packet Gang*, Mute 2004 http://www.metamute.org/editorial/articles/packet-gang accessed April 3rd, 2012.

For Benkler, social production is centred on the circulation of an abundance of information via peer-to-peer (p2p) technologies that enable loosely coupled large numbers of people to be collaboratively involved in non-reciprocal and non-rivalrous ways in "system[s] of production, distribution, and consumption of information goods characterized by decentralized individual action carried out through widely distributed, nonmarket (sic) means that do not depend on market strategies".[31]

Yet, as collaboration lies at the heart of any social form (including science and the humanities), and the pooling of resources and self-organization are common across both business (where capital determines participation) and free software/open hardware production, the capitalisation of (end-) user participation in the production cycle can always be ensured because of capital's innate capacity for kludging.[32]

Thus it is arguable that where the labour invested in producing free software is given publicly (at best given in the spirit of the commons ie. common value/property), then, as the efforts and end-products of its co-operative and collaborative production can be readily appropriated and framed by capital, it is only ever an expression of a new form of labour rather than a rival to capital itself.[33] Neoliberal society is ultimately based on private

31 Benkler. *The Wealth of Networks.* 3.

32 That is, to work around by making a quick and dirty fix or solution - for example, and echoing the ARPA/MIT relationship behind Project MAC (footnote 16 above), a recent and notably divisive example of the appropriation of collaboration as a form of crowd sourcing (where large numbers of potential solutions or information is obtained relatively inexpensively) for almost undoubtedly closed source products is the US Defense Advanced Research Projects Agency (DARPA) Manufacturing Experimentation and Outreach (MENTOR) program, developed with MAKE and Otherlab, two for-profit organizations involved in DIWO design and engineering. MAKE has a very broad based appeal and "the MAKE audience continues to be a growing culture and community that believes in bettering ourselves, our environment, our educational system—our entire world", while calling itself the "Maker Movement"; Otherlab is a more straightforward self-proclained technology frontiersman-like R&D company. MENTOR is aimed at introducing new and open source design tools and collaborative practices of making, to high school students based around the "Adaptive Vehicle Make (AVM) program". Sources:,, http://www.darpa.mil/Our_Work/TTO/Programs/AVM/AVM_High_School_Outreach_%28MENTOR%29.aspx, http://makezine.com/, http://projects.otherlab.com https://www.fbo.gov/indexs=opportunity&mode=form&id=a36a608239098b6a6a095778bc8a3f19&tab=core&_cview=1, http://makezine.com/2012/01/19/darpa-mentor-award-to-bring-making-to-education/ All accessed March 16th, 2012.

33 This is both an old and familiar, but also the source of a continuing and ever present debate within eg. Project Oekonux, a forum for discussing the study of the economic and political forms of free software eg. the current (at the time of writing, March-April 2012) exchanges on one of its mailing lists between members of the P2P Foundation, including Michel Bauwens, and those others, its discontents. See the Jox list archive page linked from: http://www.oekonux.org/journal/list/index.html accessed April 21st, 2012.

commodity production and exchange, so any (proto) rival form ultimately operates in a manner subsumed under capital's organizational form.[34]

Maurizio Lazzarato's mid-1990's concept of “immaterial labour”,[35] is (only) useful here as a way of discussing such subsumption: immaterial labour represents the time and skills used in work and leisure “that produces the informational and cultural content” to facilitate late capitalism's shifting of the “mass intellectual” into the “subjective” production of cultural and digital products (cf. Paolo Virno’s account of “the general intellect”).[36] Lazzarato argued on this basis that late capitalism recognizes a potential new autonomy in labour but seeks to annex any of its potency within its own processes, especially those that “promote continual innovation” and to break the distinction between supply and demand so that “products in turn become powerful producers of needs, images, and tastes”.[37] This spawning and shaping of an abundance of subjective processes, especially through “cybernetics and computer control”, is “first and foremost a social relation..[that] produces not only commodities, but also the capital relation”.[38]

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34 I am especially thinking of Bitcoin, the celebrated p2p digital currency variously hoarded by speculators of all types: see eg. The Wine and Cheese Appreciation Society of Greater London and Scott Lenney, “Bitcoin – finally, fair money?” *Mute*, http://www.metamute.org/editorial/articles/bitcoin-%E2%80%93-finally-fair-money Last modified February 21st, 2012; James Surowiecki, “Cryptocurrency”, *Technology Review*: 106 (2011). http://www.technologyreview.com/computing/38392/ Last modified August 23rd, 2011. Both accessed March 20th,2012.

35 … the concept of *immaterial labour,* which is defined as the labour that produces the informational and cultural content of the commodity. The concept of immaterial labour refers to *two different aspects* of labour. On the one hand, as regards the "informational content" of the commodity, it refers directly to the changes taking place in workers' labour processes in big companies in the industrial and tertiary sectors, where the skills involved in direct labour are increasingly skills involving cybernetics and computer control (and horizontal and vertical communication). On the other hand, as regards the activity that produces the "cultural content" of the commodity, immaterial labour involves a series of activities that are not normally recognized as "work" – in other words, the kinds of activities involved in defining and fixing cultural and artistic standards, fashions, tastes, consumer norms, and, more strategically, public opinion.

Maurizio Lazzarato “Immaterial Labour”, trans. Paul Colilli & Ed Emory, in Paolo Virno & Michael Hardt, eds., *Radical Thought in Italy*, (Minneapolis: University of Minnesota Press, 1996), 132. Lazzarrato soon abandoned the concept suggesting that the difference between the immaterial and material was a “theoretical complication we were never able to resolve” - from a 2010 interview quoted in, Anthony Iles and MarinaVishmidt, “Work, Work Your Thoughts, and Therein See a Siege”, in *Communization and its Discontents: Contestation, Critique, and Contemporary Struggles*, ed. Benjamin Noys, (New York: Autonomedia, 2012), 138.

36 Paolo Virno, *General Intellect*, 2001, http://www.generation-online.org/p/fpvirno10.htm accessed November 16th, 2012.

37 Maurizio Lazzarato, *Immaterial Labour.* 137.

38 Maurizio Lazzarato, *Immaterial Labour.* 142.

If collaborative modes of production can be accused of being a form of capitalist commoning, where capital preys on "decentralized individual action" as free input, then production *vis a vis* the free software movement, strives like Sisyphus for the peer production of a political commons where free is not free-as-in-expropriated labour. This is because it is exactly limited to a commons made in the abundancy of the digital, where there are virtually no reproduction costs, and so where the use-value produced cannot readily produce exchange-value, and thus a return in the form of money or a wage to satisfy much, if at all, beyond the need to eat, let alone a common stock of p2p hardware.

It is the owners of the much scarcer material means of production, its material inputs (eg. computers and where they are housed), and who sit outside such a commons that continue to capture any wealth created by it.[39]

The scaling up of a rivalling to capitalism's commodity, value, resources (how abundant), and use systems is the classic problem facing any anti-capitalist initiative, as any such form exists in the context of networks of mixed allocations and exchange mechanisms including varieties of civic or authoritarian hierarchical decision-making, market mechanisms, and communal mechanisms, including forms of gift economies. And if the network represents a key organisational principle for understanding contemporary politics and economy (ie. the network-based production of the post-Fordist era) then it appears that all efforts in "social production" are subsumed (the need to eat again) within these modalities under a predominant capital intent on reproducing itself.

Furthermore, it is readily apparent that it is the assemblage of values that is at the core of any action, rather than the collaborative mode of organization alone: just as the Occupy

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39 Dmytri Kleiner calls for a new modality, that of a materials based "common-stock "where a network of peers apply their labour to a common stock for mutual and individual benefit" so that if there are "ways of independently sharing a common-stock of material assets and thereby expand the scope of the commons to include material as well as immaterial goods, then direct producers who employ these assets in their production can retain a greater portion of their product." http://p2pfoundation.net/Dmytri_Kleiner%27s_Critique_of_Peer_Production_Ideology accessed November 30th, 2012. This echoes the Latin American tradition of "minga", where work and holdings are shared to benefit the whole community.

Movement continues to refine and develop such organizing processes in their own non-hierarchical, networked approaches to coordination, so too does the Far Right, who's activism also now takes place in so-called decentralized, peer-to-peer organizational structures.[40]

Fork Off

To recapitulate, Richard Stallman and the Free Software Foundation's emphasis on the GNU/GPL license as a mechanism designed to protect freedom for all users of software (and to prevent others making that software into a proprietary product) was not made just as an end in itself ie. as a legal nuancing of extant copyrights as protection against acquisitive capital. Rather, GNU/GPL avowedly attempts the autonomous constitution of the free software movement's social values in a collaborative commons critically analysed through the lens of intellectual property, labour and production and where labour is not the free-as-in-expropriated labour.[41]

Creativity is here seen as synonymous with autonomy and freedom. But creativity is also

40 Occupy has also been centred around a more or less dystopic vision of no-future rather than entirely trusting in a better new world. Nick Dyer-Witheford writes in 2012 that "the outrage at capital's inequity and excess is unmistakable, but so too are the difficulties in and struggles over platform and demands" and are being remaindered as largely symbolic through the occupation of parks and squares which "... are sites of public assembly, but not sites of production..." see: Nick Dyer-Witheford, "Net, square, everywhere?", *Radical Philosophy* http://www.radicalphilosophy.com/commentary/net-square-everywhere accessed April 24th, 2012. For organizational comparisons between Occupy, some Far Right groups, and p2p social production models, compare: Statement of Tea Party grassroots organization:http://www.teapartypatriots.org/about; Statement of Autonomy by the occupy London movement: http://occupylsx.org/?page_id=3349; and Alexis Madrigal, "A Guide to the Occupy Wall Street API, Or Why the Nerdiest Way to Think About OWS Is So Useful", 2011. http://www.theatlantic.com/technology/archive/2011/11/a-guide-to-the-occupy-wall-street-api-or-why-the-nerdiest-way-to-think-about-ows-is-so-useful/248562/; and Michel Bauwens, "'Occupy' as a business model: The emerging open-source civilisation", 2012 http://www.aljazeera.com/indepth/opinion/2012/03/2012361233474499.html All accessed March 21st, 2012. The Right in both Europe and the US embrace p2p network structures of organization/distribution - for example see the 2009 posting on networking of the anti-Islamic *Gates of Vienna* community blogspot, http://gatesofvienna.blogspot.co.uk/2009/06/building-distributed-counterjihad.html. Others have been influenced by the earlier work of the US right wing extremist Louis Beam who, in the 1980's, founded an "Aryan Nations Liberty Net", and, since the early 1990's, has written extensively about the organizing resistance in cell-like structures of "Leaderless Resistance". http://www.publiceye.org/hate/online_85/Aryanbbs.html, http://www.louisbeam.com/leaderless.htm All accessed March 23rd, 2012.

41 This is to be compared with the legalistic endgame promoted by Creative Commons in its redaction of 'free' culture to the reinforcement of property rights in capitalist commoning - for Terranova, however, such a charge does apply to the free software movement. Terranova, "Free Labor: Producing Culture for the Digital Economy".

molar to neo-liberal expressions, which are generally assumed by many social producers (including Benkler, the OSS and CC movements)[42] to be the unsurpassable horizon of our times (built, as they are, around tautologies of creativity as self fulfilment and choice). Matteo Pasquinelli cites Italian economist Enzo Rullani in pointing out that just as capital still presides over patent monopolies and intellectual property rights, it is now also diffusive, that is, where the free multiplication and reproduction of subjective forms is seen as a necessary vitalism within late capital, simultaneously, as "immaterial commodities (that populate any spectacular, symbolic, affective, cognitive space) [they] seem to suffer from a strong entropic decay of meaning".[43]

Another problem for proponents of the commons is how (the should is unquestioned) such a new societal base can execute an all-inclusivity that does not end up flip-flopping into exclusivity under capital? In examples from free software's proto-modes of commons production, where there have been problems around, for example, in continued agreement on core values, some projects have simply forked off from each other in, at best, the spirit of consensual solution.[44] And where such forks (and branches) can be consolidated and

42 Eric Raymond has written seminal papers on Linux as being created through the harnessing of egos powered into common-value crowd sourced project governed by "principles of shared understanding" (a notion borrowed from Kropotkin), including the 2000 articles *The Cathedral and the Bazaar* and *Homesteading the Noosphere.* http://www.catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/, http://catb.org/esr/writings/homesteading/homesteading/ Both accessed March 20, 2012.

43 Matteo Pasquinelli, *The Ideology of Free Culture and the Grammar of Sabotage*, 2008, http://www.generation-online.org/c/fc_rent4.pdf accessed July 2nd, 2012.

44 For a comprehensive article detailing forking in free software development, see Benjamin Mako Hill's 2005 *To Fork or Not To Fork: Lessons From Ubuntu and Debian* http://mako.cc/writing/to_fork_or_not_to_fork.html accessed February 3rd, 2013, where forking is defined as:

> The act of taking the code for a free software project and bifurcating it to create a new project is called "forking." There have been a number of famous forks in free software history. One of the most famous was the schism that led to the parallel development of two versions of the Emacs text editor: GNU Emacs and XEmacs. This schism persists to this day.

Other well known examples include the KDE and GNOME desktop projects and the issue of GNU/GPL licensing, and the more recent OpenOffice/Libre Office split over the same core values. Forking has thus been seen as a bad thing to happen in free software groups and communities, as it can be politically divisive and lead to work redundancy/wastefulness. These definitions are somewhat historic and now unclear - where contemporary development is executed over massive distributed version control systems, forking can look like branching, bifurcation, or parallel tree branching, (all with possible shared or derivative code). Otherwise forking has tended to be used less rigorously as being polar around the political, organization, and technical fallout between projects.

grown locally and successfully, to an outsider this might appear as ultimately exclusive (à la Fuller's "open-source internalism") and destructive because of the continuing propagation of divisions.

The task for any anti-capital commoning is how to outgrow its beginnings, that is, how it is to "organically" enhance its own reproduction, inclusiveness and autonomy from non-abundant, rival resources so as to dominate capital (given the idealism of its claims as a new base for society)? [45]

Theorists like Bauwens and Benkler suggest that peer-to-peer production is a mode of production which is inherently ecological and political as it radicalises values, subjectivities, practices and goals in its participant communities, something with which Phoebe Moore concurs, before adding that:

> the creative and networked industries provide the components for creating post-capitalist relationships, or if that is somewhat optimistic, at least a challenge to capitalist relationships. Explicit methods of immaterial and material production and emerging P2P ecologies are built on tenets that defy capitalism and allow subjectivities that blossom outside of the dominant models that are fraught with competition and rivalries.[46]

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45 Michel Bauwens recently claimed that:

> we can see, within evolving capitalism, the crystallization and emergence of new value practices and institutional logics, which, while being integrated in the mainstream system, also create new class conditions in which substantial elements are in favour of peer producers, and allow us to seek leverage points to make p2p into a real mode of production, eventually, given the convergence of social movements and new value practices.

The discussion here is in part based on recent Jox list emails (see footnote 34). The quotation is from one of Michel Bauwens emails to the list, March 20, 2012: Full discussion archive linked from: http://www.oekonux.org/journal/list/index.html

46 Phoebe Moore, "Subjectivity in the Ecologies of P2P Production", *The Fibreculture Journal*, 17: 2011 http://seventeen.fibreculturejournal.org/fcj-119-peer-to-peer-production-a-revolutionary-or-neoliberal-mode-of-subjectivation/ accessed March 26, 2012.

Following on from Louis Althusser's conception of the individual as always being subjected to ideological framing, Michel Foucault's later iterations of subjectivation grant individuals the capacity to produce themselves as ethical subjects in power-relationships, abetted through, following Deleuze and Guatarri's expansion of the concept in a *A Thousand Plateaus* (ibid.), environmental-machinic inputs and restrictions. Under this later reading capitalism is taken as a machine of subjectivation as capital acts as a

> point of subjectivation that constitutes all human beings as subjects; but some, the 'capitalists', are subjects of enunciation that form the private subjectivity of capital, while

These productive ecologies are thus described as being a politically oriented way of understanding the various scales and layers through which p2p productions are articulated, including "politics", "capitalism" and "nature". In this way, such processing cannot be detached from subjectivation and its affordances, that is, an epistemological repositioning of subjectivity through experiences that refuse capitalist appellation (and therefore lead to renewed interpellation). Somewhere therein lies, it is argued, the answer of how to realise their potential for organic growth and succession.

This is problematic. Describing such production as ecological admits the grounding of its *in potentia* to a certain scale and genre, acknowledging the limitations of its capacity to bootstrap itself beyond its host's (late capitalism's) modes and means of production. Furthermore, and as already discussed, to call p2p a mode of production arguably obfuscates how it is both very slight and very dependent on these other dominant modes of production – as it exists today, it may appear to function well for certain so-called immaterial tasks (i.e. usually taken to mean some kind of symbolic processing like software development), but is still reliant on many market mechanisms for its social reproduction, and once it moves to physical production, that dependence is even bigger.[47]

Thus in the notion of the "immaterial", private property is implicitly taken as a stable

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others, the 'proletarians', are subjects of the statement, subjected to the technical machines in which constant capital is effectuated.

Gilles Deleuze and Felix Guatarri, *A Thousand Plateaus*, 457.

It is unclear how Moore's optimism about p2p's so-called "post-capitalist" behaviours can effectively counter the neoliberal machine of subjectivation when it appears to this author that many of the behaviours assimilated under capitalism are versioned in such models, thereby effectively locking in the psycho-pathologies of capital.

47 The move from such p2p 'symbolic processing production' to material production is fraught with such dependencies. In personal communication with the author, Anthony Iles, co-editor of Mute, an online and print journal concerned with "dedicated to exploring culture and politics after the net", and co-organiser of the PostMediaLab http://www.postmedialab.org, a collaboration between Mute and Leuphana University, Germany, has communicated that, "Michel Bauwens examples of projects that embody transition to another social relation he calls 'peer production' are all technologies or services based on existing commodities and in the example of the car, made for sale and embodying private property relations in exactly the same way. In a non-capitalist society, why would one 'need' ones 'own' car? Certainly such amusements might be possible, but the idea that the our needs would coincide with those permitted under capitalism shows a complete lack of imagination, and more dangerously amounts to a perpetuation of things more or less exactly as they are - I fear peer production=peer exploitation, arguably more efficient capitalist productionn (sic), but not a way out of capitalism". Anthony Iles, email message to author, April 16th, 2012.

mechanism controlling the material realm, but taken as a form of ownership not extended to the “immaterial”. The obvious problem of separating say, immaterial labour from material labour, is that the former necessarily relies upon the latter. It is not possible to share code online without physical hardware and network cabling, meaning that there is an enormous industrial apparatus underpinning the “immaterial”, from mining of minerals used in conductors through satellites in space to those who labour in the very material processes of their production, maintenance, and disposal. Thus bracketing out something as being only immaterial hides, for example, those environmental and human costs from view.

As such, and while p2p production always remains open to external capitalisation, it manifests a lack of capacity to organize labour and resources necessary for larger scale infrastructures. This problematic is perhaps best acknowledged in how such theorists have not produced a vision of how a p2p society would work over and above the various aspirational and metaphorical models sketched in the *imaginarium* of expanding and making sustainable existing peer production processes to one day become the core of a new social functioning.[48] Such a vision is akin to the complexities of laying down a blueprint of how to build Cockaigne, while the otherwise inconvenient truths coming from within existing p2p praxis about any “blossoming of subjectivities” is (un)fortunately left obscured.

If as a critique, such argument might seem anexact and less than rigorous,[49] then so too is the use of “network” by proponents of “openness” and p2p, where it is historicised *pars*

48 For example, on the Project Oekonux wiki Stefan Meretz writes about the “Germ Form”, which is also incorporated on the P2P Foundation website. http://keimform.de/2011/pattern-10-germ-form/, http://p2pfoundation.net/Germ_Form Both accessed March 23rd, 2012.

49 That the argument above is neither an exact reduction to, nor an inexact summary of, a very apparent problem for proponents of commoning/social production. The expression is used by Deleuze, and appropriated from Edmund Husserl, who wrote (in *Ideas and the Origin of Geometry*) of a new geometry that is neither inexact - not unmeasurable and unrepeatable - nor exact - reducible and repeatable - but was instead "anexact yet rigorous," meaning measurable yet irreducible. See Gilles Deleuze and Felix Guatarri, *A Thousand Plateaus*, 367.

pro toto as the contemporary and organisational complexer of modulated and modulating behaviours.[50] As such, scaling and sustainability cannot be invoked in such a model given that failure is the experiential conditioning of all fragile networked commons-values accumulated over time and through "good" ambitions (the apparent defining motivation of social production). The problem is that the political autonomy of action experienced in these loose networks goes against the grain of governance on which any audit culture relies (such as the ambitious "The P2P Foundation" operating within dominant capital), *viz.* to become sustainable, networks need to organize themselves which itself signals a point of departure from any temporised autonomism in their foundational logic (hierarchy versus autonomy).[51] Furthermore, there is a hierarchy of networks whose incommensurabilities themselves are scalar in that their domains are local as distinct from transnational or global.

These antagonisms are installed at the heart of p2p as any scaling from horizontal modes cannot escape such a *real politik* of governance. The hierarchy-autonomy issue is embedded in the contemporary notions of the network because at the heart of it there is asymmetry in its geo-politics that is intertwined in the social, the cultural and the technical: autonomist actions will always be situated within a hierarchy of allocation, in the case of free software, through language, relational protocols (the functional layering of TCP/IP), domain allocation (through the US-based ICANN), root name server location (mostly in

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50 For example, the P2P Foundation's modulation of network by their understanding of peer-to-peer:

> The following essay describes the emergence, or expansion, of a specific type of relational dynamic, which I call peer to peer. It's a form of human network-based organization which rests upon the free participation of equipotent partners, engaged in the production of common resources, without recourse to monetary compensation as key motivating factor, and not organized according to hierarchical methods of command and control. It creates a Commons, rather than a market or a state, and relies on social relations to allocate resources rather than on pricing mechanisms or managerial commands.

http://p2pfoundation.net/Our_Understanding_of_P2P accessed April 2nd, 2012.
See also Jamie King, *The Packet Gang*.

51 Taking the internet as the exemplar, networks are organised through protocols (regulations), controls that exist after decentralizaton and guide all distributed networks. See Alexander Galloway, *Protocol - How Control Exists After Decentralization*, (Cambridge, Mass.: MIT Press, 2004).

the US), or software/hardware sources (patented or open/free).[52] Thus while there are putative modes of production which can make business profits appear vulnerable to the vagaries of the swarming of a networked labour, rarely is this power (of the masses) able to focus exclusively on common-value projects with any concomitant political subjectivation, that is, realising the political potential immanent in such practices.[53]

If one problem for p2p social production lies in the tension between the ambition to become the dominant mode of production, and an inability to scale itself, then another comes from within the cybernetic definition of ecology which it inhabits. This is a philosophized ecology where things in relation have a purpose, living things are privileged over inorganic matter, long range positive feedback phenomena are rare, and negative feedback regulation (*viz.* production and culture) is necessarily dominant.[54] It is also the attempt at the valuing of an anti-capital productivity, with some nod towards a theory of power.[55] But the problem of how p2p networks convert any of its social capital into

52 Martin Hardie's analysis of FLOSS, time and patents in *Time Machines and the Constitution of the Globe*, pinpoints a hierarchy of allocation in the genealogy of Unix; a real politik further revealed by, at the time of writing (September 2012), the UK Government proposals for a new law to allow police and security services to have "on demand" access to online traffic in real time, via private companies, to monitor emails and social media messaging services.

53 eg. Contrast the asymmetries between autonomist “Occupy” and “Edufactory” causes with the growth and significant upscaling of those businesses that masquerade behind the communitarian rhetoric and techniques of the informal economy, and who are more likely to erode that economy than enhance it. Examples include the 2012 US-centric “social media trends” of “Kickstarter”, which crowdsources project funding for some kind of return; “Quirky”, a crowd approval site that ranks the 'best' product ideas and then helps them get produced and sold while the "inventor" takes a cut; and “Airbnb”, which helps people turn extra space into hotel rooms providing both the 'owner' and traveller an opportunity to make and save money (with the company avoiding any responsibility for what's on offer). http://www.occupytogether.org, http://www.edu-factory.org/wp, http://kickstarter.com, http://www.quirky.com/, http://www.airbnb.co.uk/. All accessed March 31st, 2012.

54 That cybernetics influences p2p modelling is emphasised here: http://blog.p2pfoundation.net/cybernetics-for-resource-based-economics/2009/09/20 accessed March 26th, 2012.

55 Indeed Jeff Vail's Deleuzian - rhizomatic *Theory of Power* is favourably referenced (although with an appended critique) by the P2P Foundation for its “examination of rhizomatic vs. hierarchical power, and how to get from the latter to the former”. http://p2pfoundation.net/Theory_of_Power
Vail argues that “the same concept of power-relationships that defines sub-atomic structure also seems to define the larger world we live in - ecologies, societies, and economies. It acts like opening a watch to reveal the works inside”, and where

> Rhizome acts as a web-like structure of connected but independent nodes, borrowing its name from the structures of bamboo and other grasses..........Rhizome structure has no inherent instability, but it will quickly reorder into hierarchy if we do not address the institutions within our society that serve to perpetrate hierarchy

http://www.jeffvail.net/2005/03/theory-of-power-online.html Both accessed April 10th, 2012.
This versioning of Deleuze would see him detailing a roadmap for an accelerating, self-perfecting form of late-capitalism, one of endlessly refined productivity.

concrete sustainable outcomes free of subsumption by the host ecology is largely unaddressed, with the impression given that it is this host that legitimizes any specific and measurable gains within its own political, economic and industrial spheres in which p2p commoning ventures.

As discussed in the previous section, the major obstacle to a commons or social production is its dependency on private property in the material realm of resources (requiring at least, in order of an increasing scarcity, a network of eg. cables, hardware, ISPs, dns, and then the buildings to house it, land to build it on etc).[56] And where the threat to p2p production appears to be the threat of privatising of the "immaterial" (content ownership on social media, increasing moves to software patents, etc), this is merely the consequence of the existing late-capitalist system that is one of exclusivity because of private property. It is because of this that Terranova argues that the p2p/Free software movements are involved in capitalist commonism in so far as both implicitly or explicitly assume that existing economic powers cannot sustain themselves without a minimal degree of commonalty with other modes of production.[57] This might also be because the

56 Radical attempts at breaking this material hegemony are currently centred on notions of what can be called no-net Internet, where new forms of "nomadic infrastructure" are envisaged. Examples include, the Electronic Countermeasures project which "explores the design and manufacture of a flock of interactive autonomous drones that form their own place specific, temporary, local, WIFI community", http://vimeo.com/36267881; Danja Vasiliev's pirate *Netless* project, "a digital network that is using city public transport as its information carrier. permission-less, distributed and friend-2-friend" fashioned as an independent communication system based on city transport maps. http://k0a1a.net/netless/; and, to a lesser extent, Telekommunistens Octo Intertubular Pneumatic Packet Distribution System, a satirical network that plays with conceptions of immaterial/materiality. http://telekommunisten.net/octo/. All accessed November 20th, 2012.

57 As such, Michel Bauwens of the P2P Foundation embraces the scenario thus:

> Even under capitalism, with commodification very dominant and all-encompassing, it is not totalitarian, in fact, it could not exist without the non-market economy. So in fact, multiple modes have co-existed with the market, from nearly the dawn of time, until today. This does not make the market mechanism unproblematic … the real question is what mode is dominant, how do they co-exist and how can the negatives of certain modalities be avoided and diminished ... [there are] dramatically painful historical record of social attempts to abolish hybridity by fiat and everytime, market mechanisms where re-introduced either from above (Lenin's NEP), or from below (cigarettes as money in prisons); on the other hand, many intentional production communities have successfully abolished money transactions internally. Let's learn from real experiences, and see how we really can get to a more p2p, or even a p2p-dominant world. We only differ in that I do not wish for a p2p-only world, but think a continued diversity of reciprocal and non-reciprocal relationships is a good thing.

Jox mailing list, March 30, 2012. Full discussion archive linked from: http://www.oekonux.org/journal/list/index.html accessed April 4th, 2012.

morphogenetic paradigm invoked is exactly the opposite of being precarious,[58] that is, as a probabilistic (scientific) preclusion of precarity, it attempts to establish the patterns and structures of internal units from those of the larger syntactical structure as a whole, so that change is always seen as an internal product of this arrangement and not as something catastrophically external or contingent. Thus, arguably p2p situates its own self-replication, scaling and reproduction within a host ecology whereby any of its positive, deviation-amplifying but *short range* feedback is inevitably appropriated, integrated, and modulated.[59] This stands in sharp contrast to other strategies of resistance,[60] such as the Italian Workerist *operaismo's* notion of the refusal to work, to which I will return to below.[61]

Ergo argot orgnet

In order to make such a “shift from the short-termism of tactical media to strategic development of trans-scalar sustainability”[62] another purview emphasises the galvanisation of a network's loose mutualities through the potential for the emergence of what has been coined as “orgnets”,[63] networks that conspire for the possibility of “the production of

58 ie. Morphogenesis relates to studies of the development of the morphology and structure of an organism, including processes of redundancy and differentiation in living systems over time. For comparison:

> P2P processes are not structureless, but are characterized by dynamic and changing structures which adapt themselves to phase changes. It rules are not derived from an external authority, as in hierarchical systems, but generated from within.

http://p2pfoundation.net/Defining_P2P_as_the_relational_dynamic_of_distributed_networks accessed April 1st, 2012.

59 With the 'commons' facing the final endgame in Garrett Hardin's gloomy 1968 prognosis, *The Tragedy of the Commons*, also described in Gregor Claude's 2002, *Goatherds in Pinstripes* http://www.sciencemag.org/content/162/3859/1243.full http://www.metamute.org/editorial/articles/goatherds-pinstripes Both accessed April 4th, 2012.

60 ie. as connected to power and social change.

61 See Mario Tronti, “The Strategy of the Refusal” in *Operai e Capitale* ("Workers and Capital"), 1965, http://libcom.org/library/strategy-refusal-mario-tronti accessed July 7th, 2012.

62 The phrase is from a list of orgnet concepts published in 2007: http://orgnets.net/projects/ci_laboratory/concepts accessed February 12th, 2012.

63 Many characterizations of networks, whether as social production/commoning, or, as here, 'orgnets' owe much to Deleuze and Guatarri's legacy of concepts such as “transversal” and “rhizome” in *A Thousand Plateaus*, Ibid. The conceptual framework of “orgnet” was first offered in 2005 by Geert Lovink and Ned Rossiter in *Dawn of the Organised Networks,* as a proposal for overcoming the problem of hierarchy versus autonomy in devising scaled and sustainable anti-capital production. See http://five.fibreculturejournal.org/fcj-029-dawn-of-the-organised-networks/ and expanded for the project, *Organized networks - mobile research labs, Beijing 2007 + 2008* http://orgnets.net/. Both accessed April 17th, 2012. Various attempts to federate groups into organised networks are active at the time of writing: http://lorea.org, is one such project set up by a small group of predominantly Spanish hackers, new media

transversal connections that move across a range of social, geocultural and institutional settings".[64] These are described as being radically different from the logic of capital's networks which are "predicated on vertical integration and representative tenets of liberal democracy". So when questions arise as to what strategies of resistance are possible, especially where knowledge production becomes capitals dominant mode of production, eschewals of any representative models are made in favour of the greater resistance seen as immanent in the deep mutuality offered in these "new institutional forms that emerge within the social-technical culture of networks".[65]

In contrast to p2p's supposed organics, this is all a bit, well, precarious, as networks are obviously fragile and their mutuality contingent.[66] To engage with new models of decision making that avoid those of representation demands something sustainable. And here again

artists, and activists, to "create secure social cybernetic systems, in which a network of humans will become simultaneously represented on a virtual shared world". Their "n-1" online platform, designed with the aim of providing a service and infrastructure for applications that reflect the needs of groups and social movements, was used to help co-ordinate the http://labsurlab.org new media art-activist network (see footnote 76 below) before being implemented across some of the dozens of 2012 Occupy-like anti-capital "acampadas" ("campings") that took place throughout Spain and beyond. Both accessed December 4th, 2012.

64 And

> whose social-technical dynamics are immanent to the culture of networks. Orgnets are partly conditioned by the crisis and, in many instances, failure of primary institutions of modernity (unions, firms, universities, the state) to address contemporary social, political and economic problems in a post-broadcast era of digital culture and society. They are characterized by practices of openness, sharing and project-based forms of activity. Networks become organized as a response to the challenges of governance and sustainability experienced in online environments prone to weak social ties and ephemeral relations between participants.

Geert Lovink and Ned Rossiter, *Urgent Aphorisms: Notes on Organized Networks for the Connected Multitudes*, 2010 http://nedrossiter.org/?p=136 accessed April 10th, 2012.

65 The first research vector from "Concepts, Methods, Research Vectors", *organized networks - mobile research labs, beijing 2007 + 2008* website. http://orgnets.net/projects/ci_laboratory/concepts accessed December 4th, 2012.

66 Adrian Mackenzie points out how standard sociological definitions of networks by sociologists such as Manuel Castells, in *The Rise of the Network Society* (Oxford: Blackwell, 1996), emphasise how "a network is a set of interconnected nodes" and is "the new social morphology of our societies", stressing how relations come before substance, identity, or essence. Citing media theorists Anna Munster and Geert Lovink (from 2005), Mackenzie puts the idea into question as "the figure of the network struggles to contain an always-already abstracted dispersion", cannot easily "afford unmitigated flow between distinct nodes", and in reality is "unpredictable, often poor, harsh, and not exactly 'rich' expressions of the social". He goes on to suggest that it is this paucity in expression of the social, the social richness of the "more than information" (the expression is Steven Shaviro's), that any network formalism fails to describe and remainders it as a political fantasy.

Adrian Mackenzie, *Wirelessness: Radical Empiricism in Network Cultures*, (Cambridge, Mass.: MIT Press, 2010) p. 9.

Anna Munster and Geert Lovink, "Theses on distributed aesthetics: Or, what a network is not". *FibreCulture*, 7 (2005) http://seven.fibreculturejournal.org/fcj-040-theses-on-distributed-aesthetics-or-what-a-network-is-not/ accessed February 5th, 2013 .

the shibboleth of the "network" appears problematic. The appeal of networks, their mutuality, is also frequently their malaise as the sought after deepening of mutualities is conditional on the continuing interest and acceptance of core common-values (the forking problem referred to above), which might well include the drive for upscaling the network to a more substantive and sustainable collectivised organization, an orgnet. As such, and where this institutional logic is internal to the socio-technical conditions of that networks emergence and existence, it, along with the "greater" orgnet, will either be reconstituted or destroyed by the contingency and frailty of this process of transformation (from local network to greater orgnet).

It is not clear how such "new institutional forms" can accrue real outcomes or production beyond the vagaries of organised protest and informational platforms. Similarly, when linking into more traditional institutions (universities, unions etc), it is difficult to see whether such networks have realized specific or quantifiable gains beyond only corroborating late-capitalism's preferred mode of short-termism.[67] Being charged with being immanent "enhancement engines" that "can inspire new expressions, new socialities, new technics"[68] doesn't really bootstrap networks that far beyond the aspirational, regardless of how, for example, the Occupy and Acampada protest movements were mobilised.

Any upscaling presents a form of the institutional dilemma, that growth demands that resources need to be spent in order to manage other group resources. Even if resources are derived from other common-value networks of alternative exchange mechanisms, then, arguably, not only are the same problems of sustainability faced, but also those antagonisms of being chained in as productive surrogates of capital. This is somehow the

67 An interesting study of a common-value network and its semi-representation by a union is accounted for in Richard Saundry, Mark Stuart and Valerie Antcliff, "Social Capital and Union Revitalization: A Study of Worker Networks in the UK Audio-Visual Industries", *British Journal of Industrial Relations*, Early View (Online Version of Record published before inclusion in an issue), 2011. http://onlinelibrary.wiley.com/doi/10.1111/j.1467-8543.2011.00850.x/abstract accessed April 17th, 2012.

68 Geert Lovink and Ned Rossiter, *Urgent Aphorisms*, 2010. Ibid.

material “perverse confluence”[69] always faced by an anti-capitalism with ambitions for scaling (apparent in the variants so far examined) that always prefigure the endgame of increasing the “greater good”.[70]

Congruently, where Hannah Arendt sees the immanence of freedom and creativity reified when people come together to act in a public space,[71] then the occupy movements of 2011/2012 similarly seek prefiguration through spatial commoning. However, where it isn't clear from such commoning how or what resources will be allocated, it also becomes inescapably clear that for building any anti-capitalist network there is, as noted earlier, something more material at stake: a challenge to the whole structure of property with, for example, the need to appropriate or build and run the means of production for network communication itself.

So far this chapter has dwelt on sketching out some of the influential and oft-cited free software and commons-based mechanisms that surround some new media practice and which, to a degree, frames the ontogenesis of this research: the next section discusses how some of these themes and problems have been absorbed within particular kinds of practice found in new media art labs, before contrasting some of their elements with the current research practice.

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69 Evelina Dagnino, a Brazilian political scientist, coined the phrase “ perverse confluence” in relation to the concept of “active citizenship”. She pointed to how in the last three decades in Brazil opposing political interests - social movements, the state, and neoliberalism - all use the notion as though they have the same vision of democracy and inclusion. In reality social movements use it to build inclusion across race, class, gender, sexuality etc; the state uses it in a legal way to control who counts, has access, and decides; and neoliberalism equates it with active consumers who can expand markets. Thus these diametrically opposed agendas employ the same political terminology in an example of what she calls “perverse confluence”. Evelina Dagnino “Citizenship: a perverse confluence” in *Deconstructing Development Discourse: Buzzwords and Fuzzwords*, edited by Andrea Cornwall and Deborah Eade, (Oxford: Oxfam, 2010), 101-110.

70 Jeremy Bentham's Utilitarianism can be roughly defined as being that an action is good if it creates the greatest happiness for the greatest number. Bentham conceives of an algorithmically based calculus for judging whether an action is good or not. However, the calculus can only work in a commensurable and closed system, that is, in a state of being self-defined and isolated from environmental influence as in, for example, a dictionary, which is a closed system in that it defines each word in terms of other words, all of which can also be found in the same dictionary. Any disagreement about the commensurability of common-values means that any Bentham-like calculus is theoretically impossible.

71 See the subsections “The Greek Solution” and “Power and the Space of Appearance” in Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958), 192-206.

Lab Oratory

Just as hack labs and tactical media emerged in the nineties from the social centres of the seventies and eighties in Italy, Spain, and the Netherlands; so, at the turn of the millenium, critical and commons-based “media labs”[72] were established in attempts to socially replicate and reproduce technological knowledge, often through examination of some of the means of production of networks and communication.[73]

Through their instantiation the nurturing ludic of a “recursive public”, first attributed to free software, is being played out[74] across interdisciplinary organizations, collectives, institutions,[75] and spaces. Convened around new media art and technology, they work in the spirit of “open culture”[76] to offer “critical approaches towards the use, implementation, logic, social embedding of media, tools, the established structures of knowledge

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72 Here I use the term as a catch-all for those spaces that stand outside those that are exclusively institutional, patent-based and business-style R&D media labs such as MITs Media Lab http://www.media.mit.edu/ or the X-Media Lab group http://www.xmedialab.com/. Both accessed April 7th, 2012. The former was probably the first use of the term, derived at some point from 1985 when Nicholas Negreponte's MIT “Media Laboratory”was founded, and to which Stewart Brand was invited to attend in January 1986 alongside people like Alan Kay and Marvin Minsky.
Stewart Brand, *The Media Lab: Inventing the future at M.I.T.,* (Penguin: London, 1987).

73 For example, NICE was founded in November 1999 during the Baltic Sea Media Space meeting as a networked resource:

> The Network Interface for Cultural Exchange in the field of new media that facilitates information exchange and collaboration between the media centres and labs in the region of the Baltic Sea and North- East Europe, and integrates these activities into wider European media cultural contexts.

with its aims focussed:

> To establish, support and develop new media centres and media labs.
> To discuss and develop models and principles for new media centres (media labs) and virtual networks outside.
> To collaborate in projects like joint servers, exhibitions, events, common research.
> To share and exchange information and resources.
> To develop common financing and funding strategies.
> To conceptualise new media culture.
> To work towards new cultural policies.

http://nice.x-i.net/network/index.html accessed December 30th, 2012.

74 Where a broad and constantly modulating contingent software commons is said to emerge from the building, sharing, development and usage of its publicly shared code and products. Chris Kelty, *Two Bits, the cultural significance of free software,* (2008) http://twobits.net accessed April 2nd, 2012.

75 For example, LabsurLab1 in 2011 was partly hosted and supported by the Museo de Arte Moderno of Medellín, Colombia.

76 A non-definitive and somewhat outdated list of media-labs can be accessed here: http://monoskop.org/Category:Media_art_labs last modified April 5th, 2012. There are innumerable active hacker, biohacking and new media artist groups who engage in projects exploring technology; heterogeneous initiatives that the author has knowledge of include __micro_research in Berlin (2007-9) http://1010.co.uk/org/xxxxx_micro_research.html; Nuvem in rural Brazil http://nuvem.tk/; el puente_lab in Colombia http://www.elpuentelab.org/concept.htm. All accessed December 5th, 2012.

production”.[77]

An oft declared commons-based culturing is motivated by the use of free software and copyleft licenses to help “locate resources, to map them and to rethink and evaluate allocation and redistribution” for the “production of intellect” that breaks with “passivity” and explores “curiosity”, so as to emancipate people from the domination of prematurely naturalized (that is, ideological) objects and behaviours.

Thus spaces are often charged with activating experimentation in socialized learning and multi-directional collaboration techniques, and mandate technical skill sharing where experts collaborate with amateurs who become collaborators, but where participation can be strong or weak. Furthermore, their new media (art) productions are considered as devices that help reorientate “away from the governance of institutional politics, towards a praxis of urban tinkering, DIY and experimentation with the 'technical, legal, practical, and conceptual means' of the city” and beyond.[78]

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77 This and the following quotations are taken from a collaborative draft text, "Laboratories of the in-between", as a statement of intent for a project for 2009-2011 between five European media labs, written for the *Future of the Lab*, eds. Clare Butcher and Angela Plohman, (Eindhoven: Baltan Laboratories, 2010) http://www.labtolab.org/~labtolab/wiki/index.php/Baltan_future_of_the_lab_publication#Subjects_or_problems_we_intend_to_address_together (accessed March 28, 2012).
Often similar expressions of intent can be found on the LabSurLab website, an orgnet of Latin American media labs created as a federation of “hacklabs, hackerspaces, medialabs and any type of biopolitical laboratories and collectives operating from and for [South] America, trying to create their own spaces of action and representation starting from experimentation. labSurlab is a conglomeration of *labs. Official, marginal, institutional or independent ones from: Argentina, Brazil, Belgium, Colombia, USA, Spain, France, Mexico, Perú, Venezuela.” http://labsurlab.org/ Also see the draft of the LabsurLab Collective Report where there is concurrence around ideas that:

> Laboratories break with the divisions between the expert knowledge and everyday knowledge. One of the current debates of the laboratories of digital culture focuses on the consolidation of proposals for direct social action, participatory citizenship, the strengthening of digital competencies, creative visualization of information; all working in much the same way as in the sense of legitimizing commons sharing or p2p practices. (My translation).

http://objavi.booki.cc/books/cooperaciones-en-2012.12.04-12.14.10.odt Both accessed November 12th, 2012.

78 Laura Fernandez, Marcos Garcia and Peter Westenberg, *Public, proximity, commons and complex. Some thoughts about neighborhood-labs*, LABtoLAB website, 2011. LABtoLAB is a network of media labs set up by five European organizations that are active in the field of new media. The quotation is from Chris Kelty, Ibid. http://www.pingbase.net/wordpressfr/wp-content/uploads/2011/06/some-thoughts-about-neighborhood-labs.pdf accessed April 2nd, 2012.
From early 2000's variants of “locative media” workshops and events exploring concepts of the city have included galvanic skin response (GSR) “emotion- mapping” of cities, for example, http://biomapping.net; DIYindoor farming prototyping http://fo.am/growyourown/, and the “radical cartography and geopolitics” of the commons and occupied territories http://hackitectura.net All accessed December 4th, 2012.

In operating at the intersections of digital technologies and social and political life[79] failure is acknowledged as an implicit condition of such a shared-know-how/know-how-to-share model, with the model's success perhaps predicated by its mushrooming replication in a game of pre-figurative politics to realise a half envisaged and ill-determined new world generated with some rigour in its (notational) means.[80]

The networking and replication of lab spaces thus involves a slow prototyping where it is acknowledged that there is an inherent awkwardness in marrying the "laboratory-world and a strongly emancipated terminology"[81] as the lab "exists as a sort of proto- or para-institution"[82] in which some of its attempts will be unsuccessful or useless.[83]

Reprising the drives of earlier technologies toward social and cultural transformations[84]

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79 ie. one version of what "new media art" is.

80 By "notational" I have in mind Simon Yuill's *All Problems of Notation Will Be Solved By the Masses*, in which he subverts Cornelius Cardew's maxim in the statement that "the problems of notation should not be solved by the masses, but rather the notations of production must be made constantly problematic" as otherwise they fall easily into the hands of late capital, and if anything

> is to realise a free-as-in-libre labour rather than free-as-in-unpaid-expropriated labour this can only happen in the foregrounding and realising freedoms of production, rather than the 'bourgeois freedoms of circulation promoted by Creative Commons and remix culture

Simon Yuill, "All Problems of Notation Will Be Solved By the Masses", in Aymeric Mansoux and Marloes de Valk, *FLOSS + Art.*Ibid. 64-90

An example of such an approach is suggested in the work of http://fo.am/ with reference to *Open-ended processes, open space technologies and open laboratories* by Maja Kuzmanovic and Nik Gaffney, http://lib.fo.am/openspace_and_openlabs Last modified August 27th, 2008.

Also see the slightly less rigourous *Grow your own media lab* comic trip style publication by James Wallbank (Access Space, Sheffield, 2008) http://access-space.org/lib/exe/fetch.php?media=publications:gyoml_01.5_150.pdf accessed March 28th, 2012.

81 Catherine Lenoble. "The ability to share what is being created", *PiNG : digital culture and resources* website, 2011. http://www.pingbase.net/wordpressfr/wp-content/uploads/2011/06/the-ability-to-share-what-is-being-created.pdf accessed March 29th, 2012.

82 Note: not as anti- or alt- institutions - this difference becomes clearer later in this section. On the desired characteristics of media labs according to Nik Gaffney of http://fo.am/, Brussels, see *The Future of the Lab*, http://lib.fo.am/future_of_the_lab Last modified June 8th, 2010.

83 On the mandate to fail see eg. Florian Schneider, quoted by E.A Shanken in, "The History and Future of the Lab: Collaborative Research at the Intersections of Art, Science, and Technology", 2012

> Collaborations are the black holes of knowledge regimes. They willingly produce nothingness, opulence and ill-behaviour. And it is their vacuity that is their strength (...). It is in this vacuous black holes, that the labs of the future must boldly plunge, enabling the unforeseen to emerge in its opulent nothingness.

http://artexetra.files.wordpress.com/2009/02/shanken_history_future_lab_proof.pdf accessed March 28th, 2012.

84 See discussion in *Contextual Review: Computational Materiality*, pp. 9-10 around Friedrich Kittler's analysis that the material basis of technology must take place before any other meanings can be given and that "discourse analysis ignores the fact that the factual condition is no simple methodological example but is in each case a techno-historical event" Friedrich Kittler, *Gramophone, Film, Typewriter.* Ibid. 229.

labs adumbrate the epistemologies of subjectivation and egalitarianism through building localised infrastructures based around open education, self-learning and self-institutioning, which primarily reveal, as Geoff Cox suggests elsewhere, the antagonisms to be found in the relations of production in contemporary digital and networked cultures.[85]

As critically informed spaces, media-labs not only appear to devise homeopathic-like outings of some of these antagonisms, but attempt to segue putative new socialities with the drive to move beyond the inherent ephemerality of networks. Thus, how to cooperate at a distance, sustain active lines of research, and disseminate knowledge, are primary concerns,[86] that are often addressed through excursions into the abstractions and structures of “free” networking[87] in public events that propogate techniques of content generation and diy social media, combined with, for example, the ambition to build networks of free

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85 Cox writes in relation to software art:

> Like the drudgery of work in general, the production of software is taken to be a negative condition under capitalism. Therefore a number of oppositional tactics are proposed, such as the refusal to work (non-executable code) or by working in a negative mode or unruly manner (dirty or messy code) outside the orthodoxy of passive working (analogous to proprietary models of clean and pure code). The argument is that software art holds the potential to make apparent contradictions within the relations of production, as well as be programmed to act in a disruptive manner itself, by calling upon its dialectical properties. This way of working rejects determinism associated with software, for something far more speculative (and ‘artistic’ even).

Geoff Cox, *Antithesis: The Dialectics of Software Art,* (Arhus: DARC (Digital Aesthetics Research Centre, Aarhus University 2010): 13-14. For a comprehensive survey of such critical software art up until 2006 see Ibid. 144-161. Expanding this software art 'tradition' from the work of Jodi (http://wwwwwwwww.jodi.org/) and Eva and Franco Mattes (http://0100101110101101.org), and into the network and beyond, new works include Moddr_ 's *Web 2.0 suicide machine,* http://suicidemachine.org/; and UBERMORGEN, Paolo Cirio and Alessiandro Luduovicio's *Amazon Noir,* http://www.amazon-noir.com/ All accessed March 19th, 2012.

86 Which can also include conservative exhortations such as those of Susana Serrano, a Madrid based “cultural researcher, specialist in artistic practices that make social and creative use of new technologies”, and associated with that city's Prado Museum's media lab, MediaLab-Prado (http://medialab-prado.es/person/susana_serrano). She recently suggested that if media lab projects are to be sustained, then labs should seek legitimacy and thereby support from institutions and commerce to show how they have “value”. She also claims that labs can help “recover the citizenship power in decision-making regarding public policies (real democracy), trying to improve the management of common resources precisely by integrating these new practices and knowledge sharing.” (My translation). http://susanaserrano.cc/2012/04/28/labsurlab-2-respondiendo-al-cuestionario/ Both accessed December 5th, 2012.

87 A free network is a network which is built and managed collaboratively by its own users and presents the minimum characteristics of: 1) ensuring decentralization, preventing the monopolization of resources, coercion or oppression. 2) respecting the neutrality of the network. 3) guaranteeing public and free access. 4) being a distributed network; with growth possible from anywhere. 5) exchanges and interconnections are made on equal terms. 6) that the creation of other interconnected and interoperable free networks is promoted. Based on and translated by the author from the manifesto of free networks at http://redeslibres.altermundi.net/Manifiesto accessed December 4th, 2012.

servers.[88] Similarly, issues around the recycling of redundant technology have long been a focus, with various projects resourcing discarded machinery on which to implement free software/open hardware strategies in attempts to ground and reproduce the (hoped for) newly subjectivated general intellect.[89]

However, where these experiments are aimed at the pre-figuration of new political agencies, lab practitioners might be tempted to philosophize subjectivity in accordance with their brand of epistemological realism (representationalism), tempered by, for example, their given social dynamics and their access to the material-economic, all of which play a constitutive role in the production of their subjects and meaning.[90] Given the familiar difficulty of subsumption, such thinking can arguably be skewed by a lack of excavation into the real material agencies and ecologies that underlie and give continuity to media labs otherwise molecular projects of technological reappropriation. More

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88 This list of activities was included in the LabsurLab summit in 2011. Alejo Duque, one of the 2011 organisers, is positive about how the summit introduced diverse groups to ideas about technological appropriation and self sufficiency, but also hints at the peril of exclusivity:

> basically a meting (sic) place to recognize each other, from there the exchange comes naturally since we (allow me it) have already shown some tendency to work on networks of collaboration. For my part as organizer and agitator it's been fundamental to open space for all those small groups that even risk their life making videos or hip-hop... for them it was very valauble (sic) to have the chance to speak out at the same level of people coming from abroad.. in a colony as colombia (sic). Some strong vector pushes from the side of development.. this is very close to lorea.cc (http://lorea.cc) and the server seeds they plant …from a federated network of servers (Nodos Autonomos Colaborativos) … too much hacker attitude stops my interest.. i (sic) see it a bit as a self built ghetto.

Alejo Duque, email message to author, December 4th, 2012. Workshops executed in the 2011 LabsurLab included a familiar range of subjects including federated web sharing, streaming, 3D printing, "Digital interactive open source tools", circuit bending, solar circuits, and video cartography.

89 There are numerous projects centred around the theme of appropriating and up/re-cycling discarded technology: examples include the early Lowtech computer refurbishing project set up by the Sheffield (UK) arts group Redundant Technology Initiative in 1997, still running from their centre, Access Space http://www.lowtech.org/, http://access-space.org/doku.php?id=getinvolved:recycle; the interrogative Un/Loquer, BIOS project in Medellín, Colombia http://unloquer.org/bios/; and, with a different approach, the recent congress *Interactivos?'12 Ljubljana: Obsolete Technologies of the Future*, which took place in September 2012, http://wiki.ljudmila.org/Obsolete_Technologies_of_the_Future All accessed December 4th, 2012.

90 Where abstractions, linguistic representations, are matched to persisting material engagements, whilst perhaps bracketing out the significance of other practices. See Barad, *Meeting the Universe Halfway.* Ibid. 53.

> Examples like this make it clear that representationalism is a practice of bracketing out the significance of practices; that is, representationalism marks a failure to take account of the practices through which representations are produced. Images or representations are not snapshots or depictions of what awaits us but rather condensations or traces of multiple practices of engagement.

forgivingly, ultimately this kind of lacuna is a question about the control of resources: capital has interpolated the world's resources to such an extent that it appears impossible to acquire anything without interacting with its regimes of value extraction, so, not surprisingly, lab-like groupings try to work within the context of this subsumption, however paradoxical this might be.[91]

Thus the para-institution of the media lab appears to this author to be more like an office where the rhetoric of the lab can provide a means for the understanding and fostering of diverse processes.[92] By this I mean that as an material-economic strategy under subsumption, this notion of the media lab is now the more useful.[93] Arguably, where

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91 cf. the idea of a "communism of capital" outlined by Virno and others, where neo-liberal business models are, as mentioned earlier in this chapter, born out of the digital networks with the collaborative commons at the centre of their mode of production, legalised with their "creative commons".
Stewart Martin's diagnosis of "artistic capitalism" is also apposite as art, he argues, now appears as a socio-economic *symptom*:

> The dissolution of art into life not only presents new content for commodification, but a new form of it in so far as art or culture has become a key medium through which commodification has been extended to what previously seemed beyond the economy. The creeping subsumption of life under capital may thus be understood as a cultural or artistic capitalism.

Stewart Martin, "Artistic communism – a sketch" in *Third Text*, 23,4, (2009): 481-494.
Arguably a certain subjectivication, or symptom, is apparent in the co-production by this doxa of art and commerce in the virulent rash in the production of hang-out spaces, for example, in Hackney and Clapton, London, from 2010 onwards..

92 This description is also suggested by Felipe Fonseca, the founder and articulator of, among others, MetaReciclagem, an emergent Brazilian network related to the deconstruction of information technologies (http://rede.metareciclagem.org, 2002); Bricolabs, an international network of experimental labs (http://bricolabs.net, 2006); MutGamb, an internet based collaborative editorial group (http://mutgamb.org, 2007); Lixo Eletrônico, a collaborative information resource on e-waste in Brazil (http://lixoeletronico.org, 2008); and Rede//Labs, an open platform for research and development between new media labs both internationally and within Brazil (http://redelabs.org, 2010). All accessed January 5h, 2013. Felipe Fonseca, email message to the author, December 22nd, 2012.
Similar sentiments are hinted at by Mindaugas Gapševičius, artist and collaborative initiator of international cultural/educational projects related to networks and digital culture including o-o Institutio Media http://www.o-o.lt/ and the Migrating Art Academies http://www.migaa.eu/ Both accessed January 5h, 2013. Mindaugas Gapševičius, email message to author, January 5th, 2013.
For some this has transmuted into questions of organisation after the network:

> to reassess how the idea of the 'self-organising network' has reshaped politics and notions of agency in different models and domains of collective agency. How does the network paradigm beyond its technological sense coincide with economic, social and epistemological shifts which effect patterns of organisation and our ideas of good or efficacious social organisation? What forms of emergent organisation are moving beyond the notion of the network, as it has become a commonplace by now? It will also be asked whether we can rethink autonomous activity, subjects or agencies in a climate of multiple global crises, economistic ideologies and a generalization of austerity? Especially appreciated are re-evalutions of alternative, autonomous or autodidact institutions and practices within the context of the net and its many knowledge sharing potentials with a view to prospective forms of organization.

http://www.postmedialab.org/3-fellowships-organisation-after-networks accessed January 7th, 2013.

93 Nik Gaffney, a founding member of FoAM (http://fo.am/people/nik/) writes that at FoAM they have been trying to "understand this balance ourselves" and that

contemporary practioners use such para-instituitional arrangements for the sake of it without any concomitant belief in the subjectivication model nor in its growth-through-replication (both of which seem like idealist inflations), often with projects that are readily subsumable, then such office-like para-institutions can also provide breathing spaces, in part created by their managerial "psychoasthenia", for other opportunities to fork into misrule.[94]

Lords of Misrule

The varying commons-based activities thus far noted, it is suggested, are generally decoupled from considering their own material constitution and production - for example, while new media labs might give themselves a mandate to reveal the antagonisms of cultural production in particular technologies, somewhere else in the chain of production (and not in any "bazaar-like" sense)[95] there are specific material conditions to "the present state of things" to consider.[96] It is only after such investigation that any such proponents of anti-capitalism can, perhaps, then consider their activities as engines of new subjectivities without an assumption of already existing causes.

Instead of trying to "organize the unorganizable"[97] in attempts to kickstart processes that somehow address the problematic of freedom (which is often predicated on some kind of idealism around anti-copyright or involve a systems ecology such as "permaculture"),[98]

> perhaps for us the para-{x} has been to focus attention toward 'process' rather than 'product' with enough structure to keep some continuity, but importantly refleciton (sic) on the process, annotation, documentation, etc+.

Nik Gaffney, email message to author, February 7th, 2013.

94 This paragraph is, in part, based on a discussion with Anthony Iles. Anthony Iles, email message to author, January 4th, 2013.

95 For example, the Raymondesque techno-philia of http://openmaterials.org/about/ accessed April 12th, 2012.

96
> Communism is for us not a state of affairs which is to be established, an ideal to which reality [will] have to adjust itself. We call communism the real movement which abolishes the present state of things. The conditions of this movement result from the premises now in existence.

Karl Marx and Friedrich Engels, *The German Ideology*, trans. Tim Delaney and Bob Schwartz , Marx/Engels Internet Archive (marxists.org) 2000 , http://www.marxists.org/archive/marx/works/download/Marx_The_German_Ideology.pdf accessed April 17th, 2012.

97 The eponymous title of Florian Schneiders 2002 documentary http://wastun.org/v2v/Organizing_the_Unorganizable accessed April 19th, 2012.

98 With the assumption that these serve as catalysts for political action or participation, by somehow

other commons-based productions can be seen as forking into more contingent, local, autonomous, and summarily (auto-) destructive tactics.[99] These approaches do not address the politics of voluntarism and the idealism of subjectivication, nor tinker with life-forms in such a way that perpetuates the blockage of what could be; rather they attempt a direct assault on the corralling of imagination by the conditions of the present, of the "no outside". As such, they can be seen to point towards the fabulated conceptual horizon of Mario Tronti,[100] whose 1970's call for the refusal of work particularised the capacity of workers to reveal how capitalism obscures its own precarity, that is, its own internal generation of crisis, risk, and uncertainty.[101] Where this collective refusal is a particularised

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revealing capitalism's "hidden" contradictions. More short term neoliberal assumptions about direct social engagement are prevalent under the notion of "democratizing culture" in the various forms of "relational art", "participatory art", and "community art" brought about by, among others, UNESCO, state and regional governments, NGOs, the market, advertisers, cultural managers, and the cultural and creative industries. Parallel activity in 2012 saw both the Berlin Biennale for Contemporary Art and dOCUMENTA (13) extend curatorial invitations to Occupy, signalling a less than contradistinctive concern with the productive modes of a specific historical moment.

99 Gustav Metzger's spirited auto-destructive labour of the negative (neither art work nor labour) has been an influence on previous collaborations with Martin Howse. For a selection of Metzger's auto-destructive art texts and manifestos from 1959-1964, see http://www.english.ucsb.edu/faculty/ayliu/unlocked/metzger/selections.html Last modified April 11th, 2004.

100 Mario Tronti, *The Strategy of the Refusal*, Ibid.

> it is a way of saying "No" at a particular point in the process and a refusal of the concrete labour which is being' offered; it is a momentary.' blockage of the work-process and it appears as a recurring threat which derives its content from the process of value creation.

In recognition of this capacity and in relation to orgnets, Ned Rossiter speculates on the need to encourage the potentiality of this refusal "in ways that produce subjectivities that can open a better life". http://orgnets.net/node/490 accessed April 17th, 2012. Contrast this with Herman Melville's Bartleby the Scrivener and the absolute (rather than determinable) refusal in his "I prefer not to", as famously discussed in Giles Deleuze, "Bartleby; Or, The Formula", Essays Critical and Clinical, trans. Daniel W. Smith and Michael A. Greco, Minneapolis: University of Minnesota Press, 1997): 68-90.

101 Capital's own precarity can be elaborated via recent discussions around automatism - how late capital always provides the makings of its own crisis, for example, that as technology-driven productivity rises and drives greater output (following the constant call for growth), labour diminishes and unemployment increases as does a generalised misery, and that this can harbinger the seeds for capitalisms downfall. More precisely, automatism can be described as automatic processes geared towards furthering the basis of capital accumulation. Its logic threatens capital through reliance on the computational with the material upgrading of "the present state of things" towards an instantaneousness of its transmissions to manage value through information control.

> The fastest trading chip executes a transaction in 740 nanoseconds (or 0.00074 milliseconds) while human reaction time to a visual stimulus is around 190 milliseconds. In 1945, US stock was held on average for four years; this dropped to 8 months in 2000, 2 months in 2008, and 22 seconds in 2011.

Alberto Toscano, "Gaming the Plumbing: High-Frequency Trading and the Spaces of Capital", *Mute*, (2013), http://www.metamute.org/editorial/articles/gaming-plumbing-high-frequency-trading-and-spaces-capital This automatism simultaneously threatens that basis by provoking the runaway of capital through, for example, the disaggregating effects of high frequency trades, activated in milliseconds, which threaten concept, other "momentary blockages" of localised practice might hint at their own destructive or entropic methodologies as attempts to rupture capital's interpellation and escape their use as resource.[102]

A versioning of The Crystal World (CW) diffracted the project as an attempt to escape the enclosure of the bio-geologic by capital influences the pre-lab literature and descriptions of the lab processes and products. Therein, they are described as being destabilizing to the reification and habituation of contemporary economic apparatus, including cybernetics - regulation theory. Conventionally, Taylorist practices separate the cycles of computer manufacture, use and recycling, by outsourcing them across innumerable suppliers and manufacturers, from minerals to casings, all brought together under some principle of efficient cost-effectiveness.[103] As such, CW, in a mimicry of such separations, was said to evade the reprisal and recuperation of the computational at all stages and critically play with something of the auto-destructiveness and entropy through the methods used across the project. If late capitalism manifests risk and uncertainty in the antagonisms inherent in executing a logic of autonomisation, then, in a minor way, some of the methods executed in the project were also autophagic in that their interrogation of computational materials at

the bases of accumulation, expansion and reproduction (eg. the high speed "flash crash" of May 2010 where the second largest fall was recorded on the Dow Jones Industrial Average, recovering again within twenty minutes). Also see, Inigo Wilkins and Bogdan Dragos, "Destructive Destruction? An Ecological Study of High Frequency Trading", *Mute,* (2013), http://www.metamute.org/editorial/articles/destructive-destruction-ecological-study-high-frequency-trading Both accessed January 22nd, 2013.

102 Here I'm offering practices that circumvent valorization under categories like creativity or the informational, *pace* Christian Marazzi and Paolo Virno, (and Antonio Negri and Michael Hardt).

103 Responses that the author received when asking for details of any quantitative analyses of the minerals used to manufacture domestic computers including cpus, to various computer and semi-conductor manufacturers replied almost universally that they did not know that kind of thing because of outsourcing manufacture to third parties, including "wafers, packaging, and assembly", with the added proviso and that even if they did it would be restricted "under non-disclosure" agreements. C.J. Holthaus, VIA Technologies, email message to the author, January 3rd, 2012. Similar replies were received from US processor manufacturers Intel and National Semiconductors. Other potential data holders approached included the US Geological Survey (after consultation of the US Geological Survey 2001 Factsheet, *Obsolete Computers, "Gold Mine," or High-Tech Trash? Resource Recovery from Recycling*); and the working group on minerals and earth minerals from Psi-k, (a European-wide association of researchers in the field of computational material science). Dr. John Cohn a Fellow at IBM Systems and Technology Group generously supplied slides from his work that elaborates the increase in the use of periodic elements in processor manufacture, concluding that by 2005 some fifty four different elements were being used. Dr John Cohn, email messages to the author, December 22nd, 2011.

times completely eviscerated this adjectival descriptor.

Under the rubric of diffraction, a chasing up and down along an axis of determinacy-indeterminacy is systemic to the project, with The Crystal World v.01 and v.02 especially foregrounding various performative exclusivities so entailed in its pursuit of the material. However, these foregrounded fragments also appear as perverse confluences to a backdrop of the refusal to persist too long with any one apparatus. In one sense, perhaps the idea of refusal was inverted, as if to ask the impossible question of how the world might be before inscription?

This refusal also predicates that other forms of engagement can present entirely novel intra-actions of the material and social in ways that appear indifferent to ideological representations, with a self-actualization that cannot be easily identified.[104] Whether any such novel configurations are guided by self-immunized refusal and negation (Bartleby-esque), or from a precarity that leads to catastrophe, they summon darker forces that remain unparsed into capitalism's positivism of subjects or objects.

Although this appears like the quid pro quo of a Marxist aesthetic, where art must some-how, if and perhaps from within, remain separate from capitalist life; such a wildness in the imaginarium (lacking in many commons-based visions) does not have to be aimed exclusively towards communization, but also to a self-actualization and reconfiguration in "a cognitarian insurrection of sort" (sic),[105] where such breaching can work as a mechanism to problematise any grounding of experimental outputs as just being about conceptual

104 Gregory Sholette's *Dark Matter: Art and Politics in the Age of Enterprise Culture* (London: Pluto Press, 2010) propounds the thesis of the rise of "a shadowy social productivity" made through amateur, informal, autonomous, activist, non-institutional, and self-organized practices, in an insurrection against "enterprise culture", although, as he comments, all need not be necessarily progressive.

105 The expression is Franco 'Bifo' Berardi's, from his March 2012 online article, "Reassessing recomposition: 40 years after the publication of Anti-Oedipus", *Through Europe*, http://th-rough.eu/writers/bifo-eng/reassessing-recomposition-40-years-after-publication-anti-oedipus accessed December 2nd, 2012. I use it loosely here as I think it is problematic in that it is an incantation (appellation) of a limited "form of life" used to reprise social subjectivication in a doctrinal mis-en-scene of diagnosis/therapy for the body politic, via the "cramped subject" (the expression is Deleuze and Guatarri's). In Berardi's hands, it appears to me as the fetishisation/augmented reproduction of the division of mental and manual labour under capital, and from which he seems to suggest politics is made through its breach of the constraints of governance.

production, concrete engagement, tactical intervention, or geopolitical commentary.

Summary: What computer?

The research has provided a practical methodology for interrogating the materials of computation and, concomitantly, suggested further the kinds of relations to that materiality with which NMA theorists and others can engage. This methodology was presented in the practice through an initial regimen of stranded techniques and enquiries from which several events were bootstrapped in a series of expanded collaborative practices.

The study did not set out to undermine the possibility of knowledge-making (as a principle of uncertainty) nor to set methodological constraints predicated on exclusivity, rather, the methodology enacted throughout the project entertained what might be called a theatre of complementarity, where the attempt was made to treat things as not being given as in some so-called natural or pure state (as subjects and objects), but rather as being inseparable from the apparatuses and enactments that configure them, that is, co-constitute them (and only determinable when under this or that set of intra-acting conditions). So in one sense, the project asked what the world might look like if we could operate in the absence of any pre-existing meaning.

Thus some of the theoretical concerns of the project have not just been about epistemology, but ontology too, as measurement is taken by the project to be active in material-conceptual production in the sense of providing the apparatus for the (performative) conditions that produce phenomena and meaning (see also the final discussion in Chapter Two**:** Executing a new media materialism). Meaning is made possible through specific material practices that enable and constrain what can be said, subject to a dependency on their particular agential intra-activity to persist. Materiality and meaning are thus both indeterminable outside these particular and persistent intra-actions.

So, unlike a project concerned with epistemological uncertainty, where gaps or incompleteness in human knowledge is the concern and the *a priori* separation of how we know from what can be known is presupposed, indeterminacy here is seen as being primarily ontological with the production of certainty inseparable from the iteration of dynamic intra-actions produced through certain arrays of apparatus. This has the added consequence that any contradictory determinate value cannot exist at the same time because of its entanglement with one apparatus and not another.

As this thesis rehearses, material-conceptual enactments have been characterized by the author, following Barad, as to make cuts that make exclusions at any one moment, and which matter for epistemological, ontological and, arguably, ethical reasons.[1] To engage with the material substrates of NMA's technical media close up, and not from some far off theoretical standpoint, is, in part, to disinter the criss cross of their prompts and imperatives, as rolled out under the research, rather than to view them as only blank substrates awaiting human inscription. In chasing notions of computational materiality through different arrays of co-constitution, what materialized as phenomena in the practice has been rendered performative against the more general backdrop of refusal, that is, where all else is left, well, un-mattered and indeterminate.

Whatever the success of the CW project, it is hoped by the author that in creating discrepant experimental enactments with computation's substrates, the footprint of criteria is increased around how future NMA theory and practice might be constructed. Through the reinforcement of the suggestion in the hypothesis, that there are always multi-directional entanglements with ontological and epistemological consequences, any such work might then stop foreclosing on a versioning of computation's materiality before proclaiming some overwhelming comprehension in their accounts.

With reference to this second assumption of the hypothesis, that the bracketing out of the material from NMA has skewed the geology of its ideas and practice, it has been urged that any new account of such materiality cannot be further hypostasized around concepts such as “interface”, “network ecology”, “social production”, and the like, because, as reflective

1 cf. the discussion in Chapter Three about Jane Bennett and the polity of vocalising the non-human.

strategies, they then obviate anything being seen as a constructed intervention that is active-in-the-making of its subject.

Where any future theoretical outing could attempt to responsively detail those practices that materialize both phenomena and the possibility of meaning, one problem is that in trying to take account of the circumstances that make particular taxonomies, such work can be seen as making particular connections while at the same time enacting particular exclusions. This renders any call for a material-dynamic way to understand NMAs ontological instability (cf. Parikka), (necessarily) oxymoronic, as such an account would need to comprehensively specify all the experiential and experimental (material-discursive) agencies through which it could possibly register any meaning and mattering. If it did not then an unambiguous differentiation between the means of study and the object studied is impossible as the boundary between the two would have to be fixed and unalterable, with its means of production eviscerated.[2] As such, this makes any account hopelessly circular, as the object of study contributes to its own materialization, precluding the sense of any kind of reconfiguration or the appearance of distinct phenomena. These differences are not only epistemological, concerning different perspectives onto a phenomenon, but more ontological, in the sense that multiple ontologies appear to co-exist but can never be determined at the same time, thus making any possible access oxymoronic.

On another note, one might question to what extent the project can be said to assume some sort of “moral high ground” - taking the form of, for example, a Brechtian exposure of the conditions of the dispossessed - in the perception that it commits to an instrumentalization of art as a mode of dialectical critique? Or, insofar as such strategies can undergo transubstantiation into leisure time (The White Building as part funded by

2 Any conclusions drawn from the project catapults its author into a role of platform governance (here, the academic thesis) by making sure that everything is incorporated into his or her description in a way that gives traction to his or her own concerns and/or career. And here, the division between the artist-researcher and project participants problematizes any claims of counter-hegemonic practice, as the real life processes of others are appropriated for the research display.

Bloomberg), is an aesthetic of quotation (“the dispossessed”) in danger of becoming niche marketed? As such, the project has been presented in forms far from immune to capture and valorization by, for example, cultural managers, as it performs the release of a newer field from the circulation of more familiar new media art content (the project has variously been played out in cultural institutions with various connections to capital). Notwithstanding, if the project stems a negativity in repeating as art already accountable affordances, familiar in those layers of abstraction from the level of the circuit board upwards, then the contrasted logic of a skewed (in)visibility has been posed, with hope, as a micro-contagious condition for the opening out of another logic, or system of valorization.

Finally, the work of The Crystal World project has not been metaphoric. Instead of serving up a soup of relativity where everything material is deemed as somehow mushy, in addressing the notations of new media art's productions (cf. Chapter Three, footnote 80), a robust methodology (in both philosophical and empirical senses) has highlighted how the affects and affordances of computation's materiality should be read as both necessary and determinate within new media art, rather than being discarded under some telos of algorithmic universality (cf. the logico-mathematical universality of Turing, Feynman, and Shannon), or *pars pro toto* idealism. Where the project began in mimicking the vocabularies, methods, standards, and often contra-distinctive ways of doing inherent in theoretical and practical strands, these were détourned in specific material practices to execute their own performative engagements, both open and responsive, and denuded of any theoretical figleafs. That materiality is crucially dependent on the “how” of its enactment is manifest in how the project practices enacted many different kinds of matterings (*pace* the account of gold) with many different abstractions made possible.

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