Critical Data Aesthetics:

Towards a Critically Reflexive Practice of Data Aestheticisation

Wesley Goatley

PhD in Creative and Critical Practice

University of Sussex

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Declaration:

I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

Signature.. Date.............................

University of Sussex

Wesley Goatley

PhD in Creative and Critical Practice

Abstract

This thesis responds to the aesthetic representation of data in multiple cultural contexts, arguing that a critical exploration of these aesthetics is necessary and needs to be elaborated. In this thesis, this is undertaken through three works produced across the duration of this project: *Breathing Mephitic Air*, an installation that aestheticises air pollution data (exhibited at Somerset House, London); *Ground Resistance*, an installation that explored data and representation in a smart city system (exhibited at Milton Keynes International Festival 2016); and *The Dark Age of Connectionism: Captivity*, a sound installation that centered upon the opacity of the Amazon Echo (exhibited at Haunted Machines/Impakt Festival, Utrecht).

In the first chapter, 'Contexts', I lay out the critical studies of data, artistic practices and dispositions which underpinned this project and informed the works produced through it. The second chapter, 'Breathing Mephitic Air', opens with a critique of claims to sensor objectivity using Daston and Galison's concept of 'mechanical objectivity' alongside Donna Haraway's 'situated knowledges', before exploring the relationship of these theories to the aesthetic decisions in the chapter's titular work. The third chapter 'Ground Resistance' critiques how the promises of the 'smart city' relate to the aesthetic representations of it in phenomena such as the dashboard interface. These are discussed further in relation to the *Ground Resistance* installation, detailing how its production was both informed by and re-informed my theoretical concerns. In chapter four 'The Dark Age of Connectionism: Captivity' the 'smart speaker' field of devices is critically examined with particular focus on the opacity of these devices and their related networked infrastructures. *The Dark Age of Connectionism: Captivity* is then presented

and assessed as a response to these conditions through critically reflexive practice. The final chapter 'Towards a Critical Data Aesthetics' reflects upon the works and their relationship to the concerns of the thesis, including the ethical and political considerations and their importance in a dispositional approach to critical data aesthetics work.

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Preface

This thesis is the product of my on-going practical and theoretical investigation into the role of critical artistic practice in creating data aestheticisations. As this thesis developed, so too did the works made during its creation, much as the works themselves enriched the theoretical positions with new challenges and demands particular to practice. The aesthetic decisions within each work required rigorous critical analysis against the aims of the thesis, while new aesthetic potentialities provoked research investigations in the development of each work. It is in this way that both the theory and practice described here symbiotically interacted in a continual process of development. Through this, I have developed my own sense of what form a 'critical data aesthetics' might take.

This thesis consists of a written component and three artworks. The written element is divided into five chapters: the first is an examination of the fields of study related to this project, an overview of projects with similar goals in other disciplines, and a critical reflection on the relevance of this project within this milieu. The second, third and fourth chapters are each dedicated to an in-depth examination of individual works of critical data aesthetics I have produced during the course of this thesis. These examinations detail the theoretical landscapes which informed the production of each work, their aesthetic and technical components, and how they articulate techniques or concepts valuable to a critical practice in this field. Each chapter develops an argument about the role of data and aesthetics in these individual domains, and how data aestheticisation practice can respond to and critique these conditions. The final chapter reflects upon the combination of theoretical and practical investigations made throughout, and their relation to ethics, politics, and critical practice in the field of data aestheticisation.

The three works occupying the central chapters have been selected from a range of

works I've produced over the duration of this project. The selected works are: *Breathing Mephitic Air,* an installation exploring air pollution and sensor data; *Ground Resistance,* which creates a view of the 'smart city' oriented around its temporal and spatial gaps; and *The Dark Age of Connectionism: Captivity,* which provokes novel methods of critiquing opaque networked devices such as the Amazon Echo.

These works have been selected due to their demonstration of a range of approaches, different varieties and volumes of data, and context-dependent challenges involved in their development. The creation of these works has demonstrated that it is in practice that I find the opportunity for critical reflexivity most keenly felt and enacted, which is why I have adopted an active practitioner position in this field when undertaking this investigation. As Johanna Drucker has argued, "making things, as a thinking practice, is not only formative but transformative" (2009, p. 31), and it is in acknowledgement of this that the examinations of the works here are illuminated with descriptions of the challenges and conflicts encountered in their creation, and how they influenced both the works themselves and the theoretical concerns that informed them.

Data aestheticisations are produced in an increasing range of fields and creative cultures, and accordingly the findings of this thesis, and of this critical project as a whole, are aimed at making a contribution to the self-knowledge of a range of agents. These include researchers in related fields (both academic and industrial), and creative practitioners in art and design. The intent is to make this a valuable reference for practitioners wishing to deepen their critical and theoretical engagement with this work, and for researchers who wish to reflect upon how practice in this domain can create new forms of knowledge production and provoke new theoretical interrogations. To keep this goal of broad access in focus, I will be referring to data aestheticisations as 'works' or 'practice' rather than 'art' or 'design'. The latter terms will however be used in discussing specific methodologies and practices such as 'artistic research' (Borgdorff

2012) and 'speculative design' (Dunne and Raby 2013).

Given this intent, this thesis is not a 'how-to' guide to producing data aestheticisations. This is folly when, as is made explicit throughout, each work of data aestheticisation is necessarily unique, responding as it does to the context and content of the work, and the perspectives of those creating it. Instead, the project I will present is being developed as a tool for thinking-through and thinking-with practice, encouraging theoretically and artistically rigorous responses to the challenges and opportunities of data aestheticisation. This frames the subject at hand not as the aesthetics *of* data, but aesthetics *with* data; of how critical practice can combine with the affordances of data aestheticisations to generate insights into the contemporary role and presence of data.

Regarding terminology, I'm wary of the pitfalls of using exclusionary or domain-specific language when aiming to address a broad spectrum of readers, while at the same time aware of the work that particular terms can do in reinforcing a critical position. Towards this, I will use and explore 'aestheticisation' as a term that refers to a range of practices such as visualisation, sonification, sculpture, haptics, and others. This will be used contextually as both a noun and a verb, in reflection upon how 'sonification' and 'visualisation' are commonly used. This term hopefully allows for an application of the concepts in this project to a wide range of current and future forms of practices and media, while widening a theoretical discourse that retains a considerable bias towards visualisation (D'Ignazio 2015; Drucker 2011; Drucker 2014; Halpern 2014; Gray *et al* 2016; Manovich 2002; Bjørnsten 2016, among others).

I'm not alone in seeing the value of 'aestheticisation' in relation to artistic work with information technologies. In *SpecLab* (2009) Joanna Drucker employs the term several times as a catch-all for the range of aesthetic processes used in her 'speculative computing' projects, and this thesis could in fact be seen as an affirmative response to a

statement made at the close of the book that "the question remains as to whether aestheticizing information technology…offers an alternative to instrumentalization" (p. 182). I also use this term in reflection upon Michael Bull's 'aestheticisation of experience' (2008), which describes the effect of overlaying sound to the visual perception of the world through mobile audio playback devices. Here the term is less descriptive of techniques, and more on the effect of those practices on everyday perception. My use here is a position somewhere between Bull and Drucker's, being useful both in the range of practices it allows for, and the poetics that it offers up for consideration.

Throughout this thesis I will refer to aestheticisations as being *representations* of data, much as I will be referring to data as *representations* of the phenomena they refer to. This use highlights data aestheticisation as a process which creates a symbol or sign for the data it refers to, rather than a literal corollary to the data, reinforcing the crucial distinction between aestheticisation and data. This is in contrast with, for example, *translation,* whose field of study has a long history of addressing the misperception of it being a value-free and mechanistic process, and whose use therefore risks carrying over this misconception (one which already dogs many critical studies of data cited in the thesis).

Alongside the practical works made over the period of this thesis' development, I've given many talks and workshops on these topics in both academic and public settings, each offering a new method and context for presenting the thesis arguments. These activities offered valuable opportunities for the theories and terms to be challenged and refined, producing the definitions given here. The public exhibition of the artworks examined in this thesis offered similar opportunities for the aesthetic techniques to be refined, with each exhibition involving many valuable discussions with audiences, artists, and curators. I greatly appreciate all such exchanges, and they have contributed

substantially to this thesis.

Chapter 1: Contexts

Data and data aestheticisation cannot be understood through databases, sensors, and displays alone - that is, in purely technical terms. In fact, what I will argue is that the more important and defining elements of data and aestheticisation are people, cultures, and contexts; for critical analysis of these factors reveals the politics, narratives, and power structures that influence how data is conceived of and employed. This introductory chapter will explore how such analyses, alongside related artistic practices and dispositions, created the establishing position from which this thesis and its artworks were produced. This approach will be further developed in the following chapters, where I will examine individual works of data aestheticisation produced alongside this thesis in relation to the cultural and theoretical contexts which informed their development.

In the scholarly study of data, there are recurring demonstrations of how a critical analysis of data reveals more than just its technical conditions. For example, examining the provenance of data reveals the actors and ideologies inherent in its creation (Gitelman 2013), while critiquing claims to certainty made through data (Bogen 2010) can bring to light wider questions regarding data's perceived truth-value (Leonelli 2015). These investigations share an interrogation of the wider systems and cultural conditions surrounding data's collection, organisation, dissemination and applications as key elements in a critical study of data. When Rob Kitchin asserts that "[t]he generation of data and the work these data do are inherently infused with ethical, social and political concerns" (2014, p. 206), he joins others in putting forth an understanding of data as an 'assemblage' of these social relations, conditions, and technologies that inform its production (Halpern 2014; Kitchin and Lauriault 2018; Iliadis and Russo 2016; boyd and Crawford 2012). These and other studies with similar concerns typify what Dalton and Thatcher have termed 'critical data studies' (2014), a largely interdisciplinary field that seeks to "question and challenge [data's] role in an emerging

hegemonic order of societal calculation" (ibid., no pagination). The work of critical

data studies contains significant obstacles when these assemblages unfold in "messy,

contingent and relational ways" (Kitchin 2014, p. 97), making the sites of the study of

data varied; examples of these investigations can be found in fields such as social

science (Lampland and Leigh Star 2009), visual arts (Halpern 2014), philosophy

(Leonelli 2015), and geography (Shaw and Graham 2017), among others.

In reflection upon these conditions, critical investigation of data aestheticisation

requires an examination of the varied and contingent components of data assemblages.

One of the fundamental critical standpoints in this is the understanding of data's

inherently human construction; that data does "not arise from nowhere and [its][1]

generation is not inevitable" (Kitchen and Lauriault 2018, p. 6). The importance of

data's constructedness to the critical study of data is referenced in the title of Lisa

Gitelman's edited collection *Raw Data is an Oxymoron* (2013) whose introduction

extends the statement made in the title, that data is "always already 'cooked'" (p. 1), is

always already the product of subjective processes of collection, storage, and processing

before it is disseminated. Within these acts are decisions about what to measure, how to

measure, when and where to measure from, and what storage medium to use,

implicating human action and subjectivity explicitly in the ongoing creation and

deployment of data[2].

The importance of this core concern of the critical study of data is demonstrated by

Joanna Drucker in her argument to redefine *data* as *capta* (2011). Drucker determines

that the etymological distinctions between *data* and *capta* reflects misconceptions of

data in the humanities and elsewhere as a self-generating or naturally occurring

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[1] A note on pluralism: I'm choosing to use *data* in the singular rather than plural throughout this thesis. This is in acknowledgement of Daniel Rosenburg's (2013) research into the widespread accuracy of this usage, and to benefit the reader when the plural use of data is often restricted to specialist fields.
[2] I employ the term 'data collection' throughout this thesis, as it suggests an ongoing and active process of human action.

resource, where *capta* translates from Latin as 'to take' and *data* 'to be given'. This re-assessment of conventional terminology foregrounds human agency and intervention in data's construction, rather than perceiving data as objective or pre-existing fact. This distinction between data and fact offers a further point in the critical study of data; as Daniel Rosenburg (2013) observes, a fact[3] proven to be inaccurate can no longer be called a fact, however data still meets common definition criteria for data regardless of its accuracy or fidelity to the world it represents.

The value of such distinctions to the critical study of data are demonstrated when a dataset containing entirely 'inaccurate' (or judged as such) measurements can still reveal much about how and why data is collected and deployed, while offering insight into data's distinctiveness from fact. This is not to say that data has no relation to the 'real' world; but rather than simply re-presenting reality, data plays an expanding role in constructing reality through its widespread and affective human application in corporate, civic, and personal environments. With data's supposed authority and objectivity being a key mechanism in processes such as border control (Ackerman 2015), predictive policing (Thomsen 2014) and invasive government surveillance programs (Schneier 2009; Solove 2004; Westin 1967), assessing these claims of accuracy is an essential form of social criticism that is already being undertaken in various ways.

This rise of data-centered capitalism and surveillance has resulted in calls from many areas of study for further critical engagement with how data is created, distributed, and employed (Galloway 2001; Liu 2011; Haque 2015; Chun 2011; Easterling 2014; Manovich 2002). This is particularly the case in critical data studies, such as when Rob Kitchen and Tracey Lauriault, two authoritative voices in the field, state that "we have

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[3] Though an exploration of the philosophical status of what is called a fact does have some relevance to data's perceived truth-value, it is regrettably beyond the scope of this investigation.

barely begun to critically conceptualise data and their apparatus and elements" (2018, p. 18); however, this conceptualisation is problematised by data's ontological condition. Despite the fact that "data itself has no inherent holistic form…or inherent forms that are accessible to humans" (Swan 2015, p. 474), there are inescapably material dimensions in its storage and processing. For example, the energy consumption of data infrastructures already accounted for 7.4% of total global energy consumption in 2012 (Pomerantz *et al* 2015), and the reality of 'the Cloud' is found in fortified data centers containing vast server racks (Burrington 2016).

Such material impacts must be taken into account in the critical study of data, even while paradoxically there is a wider cultural anxiety towards data, that "*data can see and manipulate us without our being able to see and manipulate*" it (Swan 2015, p. 468, emphasis original). What is articulated in a statement like this is that data has undeniable effects in the world, whether through the banality of everyday interactions such as applying for bank loans, or more transformative events such as the increasing reliance upon data in immigration procedures. When the systems and practices behind these applications are already opaque or closed, the notion that data itself is also beyond human perception may deepen any sensations of helplessness and disempowerment felt in relation to it.

One site where the ontology of data intersects with these anxieties and material consequences is in data aestheticisation: the process of representing data through aesthetic methods, such as data visualisation, necessary to making data perceptible. It is in such methods that the assemblages of data are applied in their varied spaces, towards varied ends, enacting varied politics and ideologies. In the case of data visualisations, it has been argued that they "assemble and arrange the world in specific social and material patterns" (Law and Ruppert 2013, p. 230), that they come with their own ways of producing knowledge (Gray *et al* 2016), and that their deployment varies widely

across academic disciplines (Bjørnsten 2016; Freeman *et al* 2015; Philipsen and Kjærgaard 2017).

Interpretation haunts both critical studies of data and its aesthetic representations. Joanna Drucker's *Graphesis* explores this, tying the interpretation of aestheticisations such as visualisations to the ontology of data: "[v]izualisations are always interpretations - data does not have an inherent visual form that merely gives rise to a graphic expression" (2014, p. 5). Here Drucker is making the key point that there is no 'innocent' data or visualisation: because data can only be apprehended in human perception through aesthetic representation, it is always subject to forms of bias and interpretation related to its aesthetic construction and reception.

Studies of data sonification and visualisation report that the critical analysis of such methods is under-represented in their fields compared to more formal or descriptive studies, yet critical analyses contribute measurably to the perceived success of these projects (Cawthon and Moere 2007; Barrass and Kramer 1999; Hermann *et al* 2011). This call for criticality is occurring in parallel with those for more reflexivity in the use of tools and techniques in fields where data is an increasingly common object of (and tool for) study, such as the digital humanities (Liu 2011; Ramsay 2003). In short, the study of data aestheticisation involves much of the same politics and interdisciplinary perspectives as that of data itself, entangled with the politics of representation and aesthetics.

Data Aestheticisation

When surveying the field of critical data studies, 'data visualisation' is the most commonly used term to describe the process of making data perceptible in fields such as art and design, and much work exploring the aesthetics of data focuses almost exclusively on visualisation (Bjørnsten 2016; D'Ignazio and Klein 2016; Drucker

2014). However, visualisation on its own does not account for the many forms and practices that may be employed to make data perceptible, each with their own forms of interpretation. One space where this is particularly clear is in exhibitions of contemporary art and design practice where data sculptures, sonifications, and installations are increasingly common (*Big Bang Data* 2015; *Electronic Superhighway* 2016; *The Glass Room London* 2017).

Employing the term 'data aestheticisation' to describe the aesthetic representation of data opens this visual-centric field of study up to more varied aesthetic territory. This term broadens the discourse at hand to include visual, extra-visual and multi-modal methods of producing (and perceiving) aestheticisations. While aestheticisations can be more generally understood as representations of data, the use of this term foregrounds aesthetics explicitly in the process, and it is to aesthetic decisions and their consequences that my study of data aestheticisation will focus upon.

Alongside the term aestheticisation, throughout this thesis I will also be employing a definition of aesthetics that is relevant to this work of looking at how aestheticisations are made, and how they are offered to the senses of those who engage with and use them. For this I draw upon Richard Shusterman's definition of a Baumgarten-influenced contemporary aesthetics as being centered upon "perception, including our perceptual capacities, perceptual practices, and perceptual experiences" (2012, p. 106). Instead of a Hegelian aesthetics "essentially concerned with the philosophy of fine art" (ibid.), this understanding of aesthetics focuses upon the 'everyday' perception of aesthetics, what impacts and qualities these perceptions have, and their effects on human experience. This approach acknowledges the need to engage with forms of data aestheticisation that occur commonly across many sites, such as advertising, newspaper articles, and many disparate online spaces, and what effect these have on the perceiver's experience and understanding of data. Limiting an understanding of aestheticisation to

fine art practice alone would make such a study far less applicable to these areas; Shusterman highlights this limit when arguing that "[a]esthetic experience…constitutes a far wider realm than the experience of art" (p. 109). This he builds upon to argue for a study of aesthetics as a form of 'mindful attention' towards ordinary objects and everyday experience, towards perceiving these phenomena in a mode "more conscious, focused…rendering our experience both richer and more memorable" (p. 111).

It is the focus on attention and everyday perception that makes this understanding of aesthetics so applicable to this study of aestheticisations, and to how aesthetics can be leveraged in the work of *producing* critical data aestheticisations. Being attentive to the everyday appearances of data aestheticisations in news programs, billboards, websites and so on is not to limit judgement to their aesthetic properties alone. To consider their everyday commonality is to reflect upon the roles that aesthetics have in these spaces, and how the decisions made in the creation of data aestheticisations are central to the impacts they have upon the world.

Data In And Through The World

In considering what this 'mindful attention' towards data aestheticisation might yield, I will follow Munster's referencing of Felix Guattari in asserting that "it is not possible to understand a technology without locating it within its social ensemble of relations" (2006, p. 14). Towards this, I will examine how data aestheticisations are commonly represented in the world, and their relationship to the social and cultural conditions they operate in.

Google Image Search is a window into a specific form of cultural imaginary; a subjective glimpse at both the modes of disseminating images made capable by this dominant platform, and the way they are classified, connected, and displayed through it. When image searching for the term 'data', even a cursory overview makes several

trends apparent in the hundreds of thousands of resulting images. Trends in colour (predominantly blue and white), arrangement (such as iterations of raining digits, *The Matrix*-style), and symbols (such as zeroes and ones, or lines connecting to dots) are immediately evident and widely repeated (see Appendix A). A closer analysis also reveals that humans are often absent from these images, and the few who are present are predominantly represented as white males in business attire. Based on these images, an argument could already be made that in them data is being repeatedly depicted as being utterly non-human, vast beyond our understanding, and the domain of a particular group of individuals in conventional positions of power. While this judgement is based on a small amount of images produced by a personal Google filter bubble, it does indicate a provocative starting point.

To explore how representations of data in everyday interactions may contribute to and reinforce a wider cultural understanding of data, I turn to David Beer's (2018) examination of the data analytics industry, where trends in communication can be seen as informing and reforming both the work of data analytics and the expectations of the wider public. Beer's study examined the language and imagery used by the top thirty-six data analytics providers from a Google search, detecting consistent trends such as the repeated promises of omnipresence, prophecy, and extra-human cognition. Through this, Beer argues that these actors are "both creating *as well as* responding to these visions of data" (p. 466, emphasis original), creating a cyclical process where these 'visions' of the power of data analytics become reinforced, gaining further dominance with each repetition.

Beer's study suggests that the artefacts found in the earlier image search are not simply cultural exhaust, but instead are contributing to this re-informing of how data is perceived, and of how such representations of data are produced. Nelson Goodman describes this effect in *Languages of Art*, where "the aesthetic properties of a picture

include not only those found by looking at it but also those that determine how it is to be looked at" (1968, p. 111-112); in this way, aestheticisations both perpetuate and reinforce the values of those producing them, and possess "particular analytical, mediation and narrative regimes regarding which we ought to be attentive" (Gray *et al* 2016, p. 291).

Given this, the repetition of particular aesthetics throughout the images seen above should not be overlooked; my proposition is that these images can be understood as both a promise and a strategy. They are promissory in the ways they describe data as objective and free of human bias, and as having a totalising reach and scope, an almost supernatural combination of properties. But they also strategically position data as the domain of those in traditional seats of power, placing these supernatural properties in their hands; for in representations such as these, what is present (as well as what is absent) "is never arbitrary, but determined by current power relations and ideology" (Schmid 2012, p. 85).

These promises and strategies can be understood to be coercive in character when their repetition creates a dominant imaginary of data, one that both informs and reinforces claims made about and with data. Throughout this thesis I will investigate the notion of the promise and strategy as a way of examining the work that data and aestheticisation does, and the potential for critical practice that intervenes upon this.

Against Transparency

The understanding of aestheticisation in development here can be leveraged to illustrate the value of applying critical studies of data to data aestheticisation practice.

Even in common forms of visualisation such as the line graph, there are decisions made about what data to include, how much of it, in what format, what visual aesthetics, and

in which spaces or to which audiences. Amidst this are the particular affordances of the softwares or media at hand, their technical and aesthetic limitations, and the construction of the data itself. Decisions such as these make it clear that, much like the creation of data itself, there can be no impartial data aestheticisation and that these decisions are an enactment of the values and ideologies of its authors. Neither data nor its aestheticisation represent an *a priori* truth, but offer constructed, fallible, and subjective views of the world.

Despite this, 'transparency' is still heralded by some as a goal in the production of data aestheticisations. Transparency in this context is the belief that aestheticisations should and can be an objective representation of data that does not 'distract' from it. Such approaches are argued by Drucker as reinforcing the proposed "claims to 'truth' through the 'transparency' of the visualization" (Drucker 2014, p. 135), thus obfuscating the subjective process of interpretation in the act of visualisation.

In his influential book on data visualisation 'The Visual Display of Quantitative Information' (2001), Edward Tufte sets this form of transparency as a central goal in data visualisation when he calls for visualisation authors to employ a 'graphical excellence' that tells "the truth about data" (p. 53). The truth he refers to here is not of data's contemporary role in the exploitation of individuals and communities through algorithmic capitalism, but of a visualisation that represents data 'truthfully', i.e. without the personal bias of an author.

Tufte's claim that "graphics reveal data" (p. 13, original emphasis) implies a similarly neutral practice of aestheticisation, framing it as a process that merely shows what is already there. In fact, aestheticisation creates a representation of data which is phenomenologically distinct to the data itself, in much the same way that data is distinct to the phenomena in the world that it measures. The aestheticisation is something new, becoming a distinct entity to the data through the act of representation. This is not a question of aesthetics, but of ontology: graphics do not transparently reveal data - they create a new subjective interpretation of it.

These notions of fidelity and impartiality repeat constantly through Tufte's book, with questions such as "why do artists draw graphics that lie?" (p. 78) seemingly predicated on the belief that there is one singular 'true' expression of data (as well as one true expression of what that data represents), and that this truth is obscured by the subjectivity of artistry.

It is a misunderstanding to consider data's 'truth' to be found in the content of some given data set; I believe instead that *the underlying assumption of data* as *truth should be the target of critique*. The implication that artistic subjectivity, or in fact any form of expressing data, which demands that it be represented, 'detracts' from the data positions the data itself as being free from subjectivity, possessing an objectivity and truth that must be retained in its aestheticisation. Given the inescapably partial nature of data aestheticisation, to set transparency as its goal is both an unachievable aim, and promotes a discourse of data's objectivity by sublimating its layers of subjectivity.

Critical Data Aesthetics

The conditions of data and aestheticisation explored so far informed my own creative practice of data aestheticisation prior to this project. What my experience of this practice had repeatedly demonstrated was the potential for an intervention upon the conditions of data and its aestheticisation, performed through reflexively critical practice and theoretical interrogation.

This thesis will elaborate further upon the relationships between theory and practice, and between data and aestheticisation, and it asks how the development of a practice of aestheticisation can assist in gaining critical insight into these digital conditions. I call this approach to making work a 'critical data aesthetics', and will explore its development through this thesis via my own experimental and critical practice; one that informs and is informed by my ongoing theoretical investigations in data aestheticisation.

This approach has prior form in the history of visualisation and interfaces, such as the illustrator and artist Walter Crane's graphical languages which were intended to "train the eye and the mind at the same time, providing cultural references and analyses as well as formal means for production" (Drucker 2014, p. 33). Unlike Crane however, I do not intend to prescribe a formal set of rules to follow in the creation of data aestheticisation. When the tools and techniques of aestheticisation are so varied, to restrict this approach to one mode of practice would place unnecessary limits upon it; much as how the varying sites and impacts of the assemblage of data requires interdisciplinary methods of investigation. It is for these reasons that critical data aesthetics, as I develop it, is best understood as a *disposition*; a medium-directed critical orientation for thinking about and responding to the particular context of data aestheticisation production, through critical practice and theoretical rigour.

Research in and Through Practice

I am undertaking this practitioner-led project in acknowledgement of Henk Borgdorff's (2012) argument for the value of research in and through practice. Borgdorff sees such an approach as balancing the seemingly undisciplined nature of art against the essentially disciplined nature of academia, keeping the two always in focus.

Within this, the notion of artistic practice *as* research produces useful indications of where research and practice are inevitably entwined. Borgdorff's definition of artistic research as "research in and through art practice" (p. 66) positions it as a method that is embedded in artistic and academic contexts, but whose methodological pluralism occupies its own place in the broader realm of academic research. Borgdorff sees its core strength as the non-conceptual, pre-reflective content of artistic practice, what he calls the "unfinished thinking" (p. 148) produced by art, which "prompts us towards a critical perspective on what there is" (2011, p. 47). Rather than aiming for a finite

resolution, this mode of research is more open-ended and explorative, denying any defining end-point.

In positioning aestheticisation practice as a method of provoking new forms of research, as well as articulating the research through and with practice, I am siting this project as an intervention within the practice itself, one that is engaged directly with the processes and practices of aestheticisation. Isabelle Stengers (2013) argues that such practitioner interventions are potent in critiques of practices and their cultures when "there is no identity of a practice independent of its environment" (p. 187), and given that operating within a practice means to "intervene in the ethos of the practitioners" (p. 189).

The benefits of such a critique are raised by Rita Raley's (2013) study of critical surveillance art as an exploration of surveillance studies. In a pre-emptive response to concerns that critique through artistic practice in this field lack critical distance, she states that "critique and critical reflection are at their most powerful when they do not adopt a spectatorial position…but rather penetrate the core of the system itself, intensifying identification so as to produce structural change" (p. 137).

These positions are joined by calls for increased critical engagement specifically with data aestheticisations, including visualisation, and their relationship to how data is collected, disseminated, and understood. Such calls include those for "new kinds of reflexive *praxis* for the creation and reconfiguration of visualizations" (Gray *et al* 2016, p. 317); for work that exposes decisions such as "data type, categorization schema, visual typology, interaction mode, and intended audience" through the design process (D'Ignazio and Klein 2016, no pagination); and for humanistic and interdisciplinary analyses of the role of visualisation in knowledge production through the humanistic construction of interfaces and visualisations (Drucker 2014). These demands for such enquiries are also echoed in practices outside of visualisation, such as the calls for both

technical and artistic reflexivity in the success of data sonification work (Cohen 1994; Hermann *et al* 2011).

In reference to these interdisciplinary sources, I believe that this practitioner-led intervention will be a potent position to adopt when constructing an authoritative critique of both the practices and products of data aestheticisation, and their relationship to the critical study of data.

The Cut

In discussing the production processes behind the artworks that accompany this thesis, I will explore how the reflexive creative and critical development process impacted the outcomes of each work, capitalising upon my role as author both of this thesis and the works it examines.

To aid in this critically reflective process, I will look to Joanna Zylinska's articulation of 'minimal ethics' in which she frames creative decisions in producing such works as necessary 'cuts' performed in a constantly unfolding universe (2014). In her definition, the 'cut' is an active gesture, one which acknowledges the hand making it, as well as the outcome; rather than a 'transparent' approach, the cut foregrounds the inherent subjectivity, and responsibility, in such an act. Such actions are "actively making cuts into the ongoing unfolding of matter" as opposed to a "passive reaction to pre-existing reality" (p. 140), framing creation as a willing of the world to be different.

Inherent to this is the responsibility to "respond to there being other processes and other entities in the world", and to account for "our relations to and with" the world (p. 140); producing an ethics of both "being-in but also about being-with" (p. 91). In this understanding of the responsibility inherent to each cut, the work of practice can be seen as an ongoing process of decisions being made; decisions which are at once creative and

ethical. Reflecting upon the ethical content of these decisions is "necessary because it is inevitable" (ibid.). When there is no such thing as a 'neutral' decision, to attempt to ignore the ethical implications of practice is not to avoid them. As Zylinska puts it, "[s]uch responsibility can always be denied or withdrawn, but a response will have already taken place nonetheless" (ibid.).

In reflecting upon the notion of the cut throughout this thesis, I will be accounting for my responses and my responsibilities as the author of each of the works, and of this critical project as a whole. When data aestheticisations are understood as having power to express and amplify political concepts and narratives, I believe that this responsibility rests in exposing the assumptions and ideologies behind that power, and the formulation of challenges to the work that it does.

Demonstration

In exploring this responsibility, I will be using Andrew Barry's notion of the 'demonstration' (2001) to articulate the relationship between the artworks discussed in this thesis and the subjects with which they engage. The dual meaning of this term is particularly potent for this project, for a demonstration is both an active role taken against an injustice or state of affairs and "the possibility of a real object…a way of showing what can or might be done" (p. 178).

It is this demonstration of 'what might be' that I believe makes a medium-directed critical orientation necessary in this context; a way not only of conceiving challenges to what is present, but of formulating and presenting them as an alternative to it. Towards this, the artworks that accompany this thesis are my own interventions on their respective domains and topics, and each formulates challenges to how data is leveraged or perceived. Alongside this, each artwork also intends to show how the notion of critical data aesthetics I'm developing might challenge norms of aestheticisation

practice, and suggest new dispositions to it. When discussing each work I'll describe the conditions that the works are demonstrating *against*, as well as how they demonstrate alternatives to established narratives, new forms of interaction, and what might be.

Much like Zylinska's cut, but moving outside of the more narrowly ethical realm, Barry sees the demonstration as both a technical and ethical practice that reflects a personal social responsibility. In describing my works in this way, I am following Barry's argument that when such demonstrations intend to "have effects on, or challenge the minds of, or effect the conduct of others" (ibid.) they are not disinterested or impartial, but are active forms of challenge.

In Context

I'm developing the critical data aesthetics approach through a reflection on other critical investigations and interdisciplinary perspectives. The Berlin-based Critical Engineering Working Group is one such instance, stating in their manifesto that "the Critical Engineer observes the space between the production and consumption of technology", and that critical engineering "looks to the history of art, architecture, activism, philosophy and invention" (Oliver *et al* 2011), making clear their interdisciplinary influences. Projects produced by critical engineers such as Julian Oliver's *Harvest* (2017) express a reflexive approach to this work through a critique of common tools and platforms of both engineering and digital art, exposing points of collusion and friction between the two disciplines. Crucially, *Harvest* also indicates the capacity for such a practice to engage with complex socio-political subjects, including anthropogenic climate change, as an expression of its author's own political concerns.

Perhaps the most relevant interdisciplinary corollary to critical data aesthetics lies in the field of critical cartography, described by Denis Wood and John Krygier (2009) as a

response to the "hegemonic tradition of mapmaking as a progressive and value-free transcription of the environment" (p. 340). Critical cartography intends to promote critical reflexivity in the practice of mapmaking, particularly regarding mapmaking's reinforcement of political narratives and their role in sovereignty and to "call into question the presumptions of professional cartography" (ibid.). Wood and Krygier also champion artistic interventions in mapmaking practice (which they refer to as 'art maps') as a key facet of the critical cartography approach, stating that art maps "contest…the authority of professional mapmaking institutions", and specifically "draw attention to the world-making power of professional mapmaking" (p. 344). Cartography has a number of other compelling parallels with the field of data aestheticisation – they are both concerned with translating data points into aesthetic elements, often feature keys to decode the aesthetic information at hand, and have a fractious relationship to the world they represent. The field also grapples with tensions concerning authorship and bias where "maps are imbued with the values and judgements of the individuals who construct them" (Dodge *et al* 2009, p. 9), echoing the discussion of transparency in data aestheticisation. Given these correlations, it is no surprise that many authors in critical cartography also publish works related to critical data studies (Ford and Graham 2016; Kitchin and Hubbard 1999; Degen *et al* 2017).

This interdisciplinarity also characterises Philip Agre's 'Critical Technical Practice', an interrogation of the cultural conditions surrounding and informing artificial intelligence engineering (1997). Agre asserts that "moral and ethical discussion and encourag[ing] connections with methods and concepts from other fields" (p. 136) are a vital component of his project. Richard Shusterman's aesthetic theory also resonates with this, acknowledging that "perception…is always already shaped by a cultural and cognitive background" (2012 p. 117), and that in this understanding contemporary aesthetics "has had to become more interdisciplinary" (p. 116).

Aside from these projects that are situated in and respond to their fields, there are notable instances of artistic practices and works concerning data or data-driven technologies which echo a similar set of values to this project. The use of Virtual Reality technology in Char Davies's *Osmose* (1995) produced an artwork which continues to provide valuable reflection on and push at the boundaries of its field over twenty years later. In this work, the breathing and body movements of the participant ('immersant') measured through a body sensor kit were used to manoeuvre them through several landscapes perceived through a VR headset and surround sound. The main landscapes themselves were semi-transparent natural environments, allowing movement through and around the designs. Breathing out passed the immersant under the landscape at hand to a substructural layer composed of the live code running the artwork, revealing elements such as the immersant's breathing data as measured by the body sensors. Breathing in ascended the immersant back into the landscape and into a higher level of text composed of sources either relevant to the conceptual intent of the work, or of personal significance to the author herself. Through revealing both the substructure of the work's code and the superstructure of the artist's intent, both non-linear and meta-narratives were available to be constructed by the agency of the immersant, away from the traditional linearity of screen-based media. In a medium with many 'on-rails' environments, this agency not only rejected such an interaction paradigm, but also presented a new way of engaging with artistic intent. *Osmose* allowed the immersant to drift freely through these layers of meaning and intent in the work, experiencing it either formally in terms of aesthetics and construction, or at the conceptual level of intent, inspiration, and meaning. While an important reminder that intent does not guarantee success is present in a critique noting that the "level of control and supervision surrounding the piece prevent[ed] any sense of voluntary exploration" (Slater 1994), *Osmose* continues to be cited as a landmark work in the field of immersive VR (Boucher 2017).
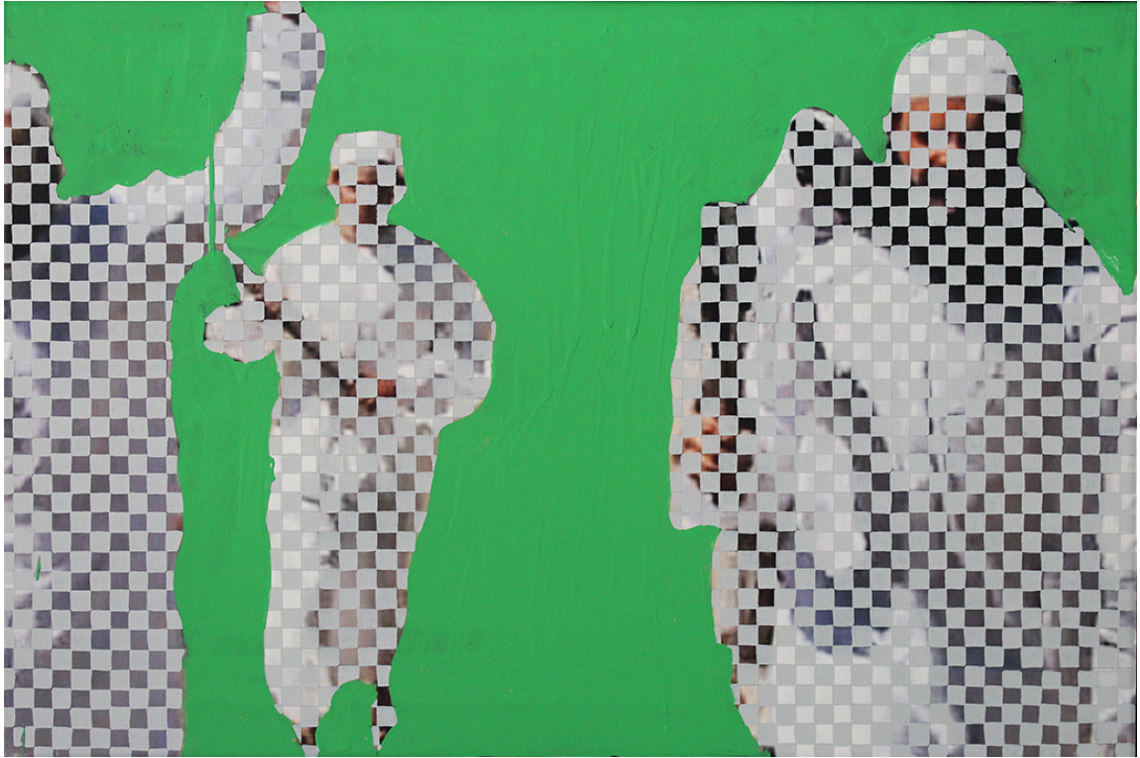
Figure 1: *Are You SAG? (Muslim Rage)*.

Source: http://www.khandossos.com/works/so-much-magic-2/are-you-sag/

While *Osmose* uses aesthetics to explore the individual intent behind her work, the artist Navine G. Khan-Dossos leverages aesthetic techniques to critique the cultural conditions that her work is produced in. In *Are You SAG?* (2013) Khan-Dossos produces a series of images that reflect upon the use of blue- and green-screen technologies and their roles in producing Western Orientalist fantasies and anti-Muslim propaganda. In parallel to the narratives of data's neutrality and transparency, *Are You SAG?* highlights the political and ideological dimensions of technologies whose intended function is invisibility.

Influenced by both the 1940 silent film *The Thief of Baghdad* and the 2012 online film *The Innocence of Muslims*, Khan-Dossos interrogates the manipulation and re-presentation of the 'Other' through these technologies, where bodies become tools of imposed narratives and overt ideological expression. In contrast to the filmic

techniques she critiques, both the painted green-screen effect of the background and the Photoshop grid obscuring the identities of the subjects of *Are You SAG?* foreground the hand of the artist as producer of the work and its intent. Drawing attention to these elements through craft, Khan-Dossos exposes both the constructed nature of representation as well as the ideological work of particular tools and techniques.

In addition to the above works, Matthew Plummer-Fernandez and Julien Deswaef's installation of *Shiv Integer* (2016) at London's Somerset House in July 2016 demonstrated how critical design practice can promote socio-technical understandings of complex technological processes. In this work, the artists wrote a program for scraping, deconstructing, and reconstituting combinations of 3D mesh models uploaded to Thingiverse, a site popular for sharing such files. This program then uploaded the resulting combinations of meshes back to the Thingiverse site, flooding its database with new objects produced through this algorithmic process. This provoked a great deal of discussion on the site itself, including a number of complaints from other users that their work had been plagiarised by the *Shiv Integer* software or its operator. In presenting this work for installation, the artists produced 3D printed models of several of the algorithmically-proposed objects arranged on a desk. Next to each, they presented a sample of the code used in the work, positioned next to a comment (often a complaint) left from a user on the Thingiverse forums. These comments would often reference a specific function of the *Shiv Integer* program (such as its scraping of the site, or constant batch-uploading of new objects), and these were displayed next to the portion of the *Shiv Integer* code which was concerned with the function being discussed. This offered the opportunity for an audience member of any level of software literacy to reflect upon the processes of the code, its impact on the users of Thingiverse, and the complexity (or simplicity) of the code function in question. The resulting process offered the audience the opportunity to develop self-directed understandings of the code at hand, while producing a critical commentary on the tools

and culture of this field of design.

It is their enquiries into the conditions of production that make the practices of Davies, Khan-Dossos, Plummer-Fernandez and Deswaef's such compelling points of references for this thesis. Each demonstrate a reflexivity to the tools at hand and their application, producing works that carve out new critical and creative territories through this reflection on what it is to be performing this work.

As well as these practices that resonate with the goals of this thesis, there are those that demonstrate the kinds of methods and attitudes to representation that my work pushes back against.

Refik Anadol's *Wind of Boston* (2017) serves as an example of a data aestheticisation practice to which I would place my concept of critical data aesthetics in opposition. The three visualisations (alternately described as 'poetic data paintings' and 'sculptures') in the work use wind measurements recorded over one year to create a "unique visual interpretation of the interaction between the environment and the city" (2017, no pagination). This claim is immediately thrown into contention in the documentation, where the data is described as taken from Boston Logan Airport, while the images themselves depict different locations around the city. There is no clarification of when this data set was produced, or what time periods the measurements relate to, making space and time contentious in a work ostensibly rooted in both. Adding to this obfuscation, the movements and shapes on screen are presented without a key to assess the visuals' claimed relation to the speed of the wind, its direction, or even confirmation of which direction is North. This produces an aesthetic product which arguably fails at its described aim of exploring the data produced "between the forces of nature and the built environment" (ibid.), given that neither the original data set, the natural phenomena, nor any particular built environment are particularly

discernible in the resulting aestheticisations.
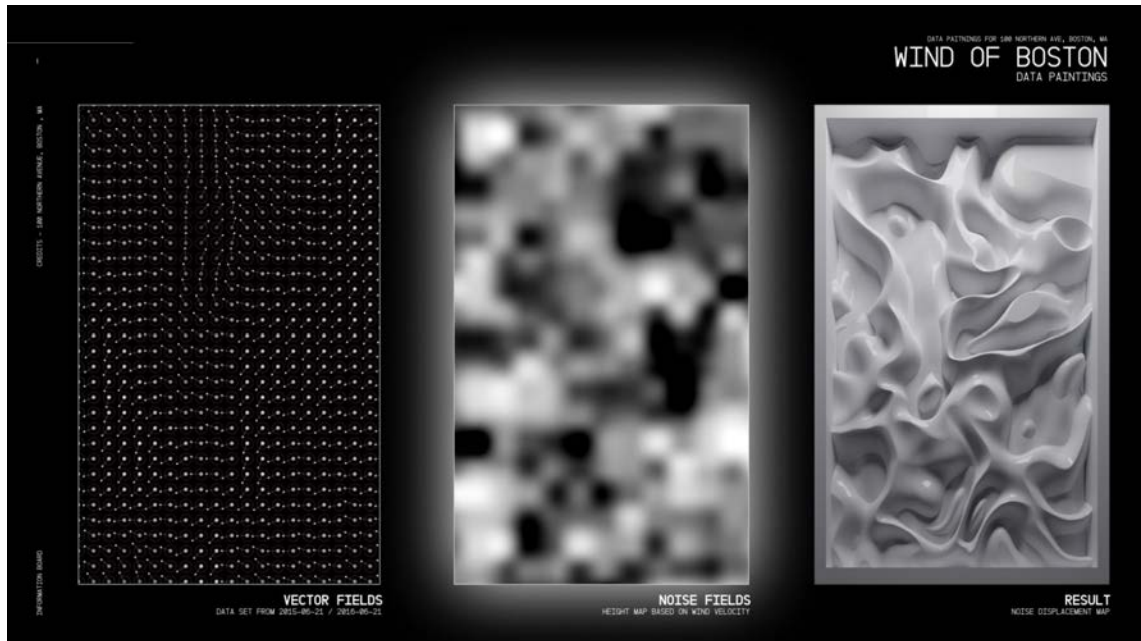
Figure 2: *Wind of Boston.*

Source: http://refikanadol.com/works/wind-of-boston-data-paintings/

It is the use of aesthetics that obscure data while uncritically leveraging its supposed authority that make this work a counterpoint to the aims of this thesis. Furthermore, it misses opportunities for a reflexive critique of both data and the phenomena at hand. For example, the choice of data set itself presents an opportunity for critical questions to be asked before any visual decisions are made: what dates may have added relevance in this context? Could they have been selected to, say, fall on the anniversaries of Hurricane Sandy or Irene, which caused large-scale damage in New England? Was there any damage to weather sensors during those periods, and have the types of sensors changed now? Such questions could introduce new critical dialogues about the methods of weather sensing and their roles in forecasting when there is increasing danger of extreme weather in the city of Boston and surrounding areas (Abel 2017).

Given the long-term installation of this work in a corporate headquarters in Boston, an

opportunity for a lasting contribution to this ongoing discourse was missed. Through this thesis, I will be assessing the potential for a form of data aestheticisation practice that instead seeks to weave such critical analyses into the fabric of each work produced through it, in recognition of the "influential role that is played by those who are locating value, narrating and attaching meanings" to data (Beer 2018, p. 466).

Beyond Visualisation

The dominance of data visualisation in the scholarly study of data aestheticisation is unsurprising given the visuo-centricity of the cultures much of this work is produced in. Given that "data has no 'look', no natural 'visualization'" (Hansen 2013, no pagination), visual methods of aestheticisation are no more or no less transparent than any other form, and should not be seen to be unequivocally the most 'efficient' method of aestheticising data. Whether the aestheticisation is visual, sonic, or haptic, nothing can produce an impartial representation of data; but addressing the value of techniques and forms outside of the visual reveals their qualities for use in projects of knowledge production and experimental practice such as this.

A brief overview of methods outside of visualisation suggests what value a range of aesthetic approaches might have in both the critical practice of aestheticisation and the critical study of data. An example of what such considerations may reveal can be seen in studies such as Salomé Voegelin's *Listening to Noise and Silence* (2010), in which Voegelin contributes to ongoing studies of how knowledge is produced through hearing (Lacey 2013; Sterne 2003), a key component of which is how distance is constructed between the source and perceiver.

Voegelin describes seeing as occurring in a meta-position to the seen, the certainty of the separation of viewer from object enabling "a detachment and objectivity that presents itself as truth" (2010, p. xii), spurring phrases such as 'seeing is believing'.

Hearing does not allow for this certainty, instead positioning the listener in relation to sound rather than source; as Voegelin puts it, "I cannot hear it if I am not immersed in its auditory object, which is not its source but sound as sound itself" (ibid.). This condition, Voegelin argues, produces a more searching form of engagement than vision, as "[l]istening discovers and generates the heard" (p. 4).

When used as a method of data aestheticisation, the capacity of sound to make "the subject and the work…as transitory as each other" (ibid.) has metaphorical ties to the distinction between phenomena and data, and between data and aestheticisation, positioning data sonification as a compelling medium through which to approach these important topics.

The 'liveness' and presence of performance also enables a distinct form of knowledge production. Hester Reeve describes her performance practice of 'live art actions' as producing knowledge which "hangs momentarily in the air" (2015, p. 75), where the performer's body becomes a focal point of this knowledge.

Figure 3: Hester Reeve performing *On The Good*.

Source: http://hester-reeve.squarespace.com/live-art-works/

The ontological gap between audience and performer denies certainty, allowing the audience to reflect upon their own individual accounts of this process, to "know otherwise for themselves" (ibid.). In the context of the thesis this has many advantages, not least in how this produces knowledge that requires interpretation by an audience predicated on an articulated gap between themselves and the performer-aestheticisation. In performances that implicate the human body in the way Reeve describes, this could be employed to critique the representation of data as 'inhuman' and bodiless, while offering bodily movement as a new set of symbols to aestheticise data with.

These observations are echoed in studies particular to these forms (Doane 1980; Schafer 1977; Doctor 2007; Lingis 2009; Auslander 1999), and suggest the myriad critical possibilities that open up when the work of aestheticisation is expanded beyond common forms of visualisation.

Reflections

In examining these scholarly and artistic interrogations of data and its aestheticisation, this chapter has detailed the theoretical investigations, milieu of practices, and concerns that this project has as its informing context. Through an experimental practice that produces new interventions on the representation of data, this project set out to produce works that reflect upon these critical studies of data, and to explore the role that a critically reflexive practice of aestheticisation can have in this ongoing discourse.

In this report, the three works of data aestheticisation, developed over the course of my doctoral study, will be presented in the following chapters. Each is centered on data of differing volumes, provenances, and forms, employing a range of aestheticisation techniques. The descriptions of these works will reflect upon the theoretical conditions that informed their production, where and how the demands of practice provoked new theoretical investigations, and how these works articulate the developing components of a critical data aesthetics approach to data aestheticisation.

Chapter 2: Breathing Mephitic Air

The first of the three works to be examined in this thesis is *Breathing Mephitic Air* (Goatley 2017a), an installation I exhibited as part of the 'Space to Breathe' exhibition held at London's Somerset House in January 2017. This was an installation artwork that employed multi-screen projections, immersive audio and other atmospheric aesthetics to explore London air quality data, drawing upon aesthetic properties of air pollution to represent this data and expose the discrete mechanisms of its collection.

To articulate the development and production of this work as a demonstration, I'll begin this chapter with an overview of the theoretical and contextual terrain that informed its conception and development, focusing upon sensor subjectivity and situated knowledges (Haraway 1988). This will include discussion of how these concerns drove new avenues for research and practice within this work, and will be followed by an examination of how the final form of the work acted as a response to these concerns.

Pollution Politics

Large-scale projects such as the London Air Quality Network operated by the Environmental Research Group (ERG) at King's College London employ fixed-position air monitoring stations throughout London, with automatic data collection at each site via air quality sensors. Through this network, the ERG provides air pollution data and analysis for public, policy, and scientific use (London Air 2018). Because air pollution and its diverse impacts are both an ecological and an international human rights concern (European Court of Human Rights 2018), this data set is a compelling subject for a project that seeks to engage critically with not only data itself but also with the social ramifications of air pollution. It is for the reasons that the ERG data was selected as the subject of *Breathing Mephitic Air.*

The spectral nature of air pollution itself makes it a provocative subject for

aestheticisation. There are obvious challenges in measuring and representing a pollutant such as carbon monoxide that is colourless, tasteless, and odourless. In this, it shares something with data's ontological condition, where data's lack of an inherent form contributes to the anxiety of it as an 'unseen' power; for while we cannot detect the presence of carbon monoxide using our senses, it has an enormous material impact on the environment and the human body (NHS 2016). Even 'air quality' itself is a contentious subject, given that it has not been given a clear definition in relevant UK government policy documents (DEFRA 2011). With different local, national, and global organisations establishing varied definitions of 'air quality', it ceases to be a measurement of pollution and is instead "an expression of a relation between air and the government of an urban population" (Barry 2001, p. 169). Much like data, the tensions between materiality, perception, impact, and uncertainty are woven throughout these discourses.

Given these conditions, my approach to this topic began with a reflection upon some critical questions regarding this particular data assemblage: questions such as how and where the data is applied in policy making, how the data is processed and by who, and what methods of predictive analytics may be relying upon the data. From this, *Breathing Mephitic Air* focused upon two concerns relevant both to the air pollution data and to the broader critical study of data: analysing claims to 'mechanical objectivity' in sensor data, and the value of adopting situated perspectives in interpreting this data.

Sensors and Objectivity

Critically analysing the assemblage of sensor data necessitates an enquiry into the relationship between the world and data. Claims of data's fidelity to the world underpin its value in many sectors of industry, government, and elsewhere, and such claims are the subject of pointed critiques (Gitelman 2013; Leonelli 2015; Iliadis and Russo 2016).

Critically analysing these claims are essential when decisions affecting individuals and communities made by those in power are predicated on the belief that the data at hand is 'right'. To critique these claims in the current context requires attention upon how sensor data such as the ERG's informs decisions made at local and international levels, in machine-to-machine interactions, and multiple entanglements of both.

An instructive example of the reliance upon sensor data can be seen in a 2017 freedom of information (FOI) request concerning London's Rotherhithe tunnel, made by a member of the public (What Do They Know 2017). Transport for London (TfL) fitted the tunnel with an entirely automated air venting system, which triggered the venting of air to the outside when certain levels of air pollution were detected by a sensor network inside the tunnel. The request revealed that there were no air quality sensors monitoring how this impacted the residential areas outside the tunnel's venting outlets, which the TfL respondent blamed upon the tunnel crossing between two civic jurisdictional areas. Considering the residential character of areas near the vents, the author of the request considered this to be an oversight with considerable public health ramifications.

A closer examination of the data released in this request reveals that several of the tunnel's sensors were reporting zero pollution levels during rush hour traffic, thereby failing to trigger pollution venting from the tunnel as they were designed to do. This is in spite of the fact that, previous to reporting zero pollution, the sensors had frequently reported high concentrations of air pollution, and were at the time claimed to be in 'good working order'. This implies a trust that, in spite of reading literally *zero* pollution during rush hour traffic, the sensors and its data were deemed to be accurate; so much so that no action was stated to have been taken in response to what the FOI request had exposed. Eventually the request was deemed to have been fulfilled by TfL and the public requests for more information ceased; at the time of writing my own requests for clarification on this have not been responded to.

Here, the notion of a promise and strategy can be seen, where the promise is that data's objective view allows mastery over this complex system. This also creates a way of removing responsibility from those in authority, as can be seen when the data is trusted to the point where human oversight of this system is neglected. But the above interaction between sensors, networks, and social systems exemplifies both the partiality of this sensor-based view of the world and the reliances that are made upon data's accuracy, problematising the assumption of data's objective fidelity to a world that it is supposed to represent, and in this case, inform.

Considering the complexity of the systems and relations in play, my critique of this trust in data requires the examination of a broad range of studies. In *The Critique of Pure Reason* (1787), Immanuel Kant makes a distinction between *phenomena* and *noumena* that is instructive in the context at hand. Kant understood phenomena as constituting the world as it occurs to us through sense-perception, an inherently subjective process. Noumena are objects as they are in the world; not as they occur to human sense-perception, but the 'things-in-themselves' (*Ding an sich*). Kant stresses that phenomena do not refer to the things-in-themselves, but to the mode in which things appear to us, in accordance with our own subjective qualification and within the boundaries of our perception. The noumenal world is therefore inaccessible to us. This philosophical claim to an inescapably subjective human experience of the world suggests the problems of asserting any form of access to the noumenal world. In choosing such a well-cited example as this, I'm illustrating the breadth of scholarship that exists on this point, and it is but one of many challenges to a human-accessible objectivity through digital technology that find support in pre- and post-Enlightenment philosophy (McQuillan 2017; Warburton 2018).

The belief that technology can allow us to surpass the subjectivity inherent to our

perception and grant access to the noumenal world is referred to as 'mechanical objectivity' by Lorraine Daston and Peter Galison (2007) in *Objectivity*, a belief they examine through the field of scientific atlases. These atlases were often heavy tomes of encyclopedic intent, containing artist-drawn images of flora and fauna coupled with descriptions of each item written by a scientist. Daston and Galison chart the tensions between artist and scientist in the field of atlas production, where many scientists felt that the artist's interpretation of how to best represent the flora or fauna at hand introduced an undesirable subjectivity to what was intended to be as objective a process as possible.

With the advent of photography, this conflict between the subjectivity of the artist and the desire for objectivity was seen by some of the scientists to have been conquered. Atlas authors who adopted this technology in its infancy saw the camera as "exactly representing the objects as they appear, and independently of all interpretation…without the least contribution of the hand of man" (Donné 1844-45, quoted on p. 131, italics added). This makes clear the belief that the exchange of the artist for the device removed the 'hand of man', creating an impartial view finally realised through the mechanism of the camera. The mechanism was seen as a transparent and objective component of the process, subtracting nothing from the scientists' view of the world.

A contemporary photographer might see this as a naive understanding of photography. Photography combines elements such as the camera body, lens, and film/image processor with the skill, experience, and 'eye' of the photographer, with each of these layers involving subjective interpretation and decision making. The practice itself can be understood as an active intervention upon the world, a form of both sense-making and knowledge production (Kember 1998). Even when automating photographic processes (such as auto-capture features on cameras or 'AI cameras' on smartphones), one still cannot escape the human decisions that define how these devices and their

automation function, and those that frame their use (Bassett 2015a). Far from being transparent or objective, photography is irrevocably bound into multiple forms of human subjectivity; that of the creator of the device, whose decisions define what can be captured through it and how, and the unavoidable judgement of the photographer themselves.

This same logic can be used to understand the subjectivity in the collection of data, and unravel claims to its objectivity. For example, what data is gathered by a sensor is determined by the decisions made in its material construction, its placement, when it is turned on, when it is turned off, what measurement scale it uses…this all before the data is stored, arranged, 'cleaned' and other processes that may occur before it is applied or published. These can be understood as the 'layers' of data's subjectivity, when each step in the process requires the subjective judgement of human decision making (perhaps from more than one person). Much as how a single event can be captured in many different ways by different photographers with different cameras, data produced in the world is not the objective 'truth' but just one possible view of it, constructed via these subjective layers. As this production of data is the first stage of any aestheticisation, rejecting claims to data's objectivity is a crucial one in analysing the subjectivity inherent to aestheticisation.

That sensor data is not objective does not trivialise or undermine it any less than the subjectivity of photography negates the value of the photograph; in fact, theoretical analyses and artworks that explore the creative practice of photography champion the camera and its related practices as a valuable vehicle for creativity in the expression of one's subjectivity (Barthes 1980; Sontag 1979; Zylinska 2014). Challenging claims to data's objectivity or totality in this way is not to dismiss it as useless, but to clarify its potential roles as an expression of subjectivity.

Situated Data

In rethinking the notion of a mechanically objective sensor data, I want to explore what the value of this data may be when it is understood as an artefact of subjectively assessed decisions. Towards this, Karen Barad's (1996) notion of 'agential realism' as a way of understanding the relation between objects and agencies grants some insight. In searching for a middle-ground between scientific realism and hard constructivism that allows for both the value of scientific empiricism and the socially constructed nature of scientific knowledge, Barad suggests the standpoint of agential realism as a position between the two. Agential realism defines scientific knowledge practices (such as the production and use of data) as part of an embodied, partial understanding of the world. In this view, "*there is no unambiguous way to differentiate between the 'object' and the 'agencies of observation'*" (p. 170, original italics), and that the interactions between objects and agencies "*forms an inseparable part of the phenomenon*" under examination (Bohr 1963, quoted in Barad 1996, p. 170, emphasis original). Through this, what is produced by pollution sensors is not a measurement indicative of the noumena of the pollutants in the air, but a new document of the intra-action between phenomena, human, and measurement processes. Instead of an objective record of the world, this agential realistic view positions the data produced by sensors as a perspective on the world that sits alongside, rather than replaces or dominates, the human sensory perspective.

In *Situated Knowledges* (1988), Donna Haraway critiques what she sees as the dominant narratives of science and history that strive towards an impartial and objective position, the "god trick of seeing everything from nowhere" (p. 581). In her analysis of the cultural construction of history and science, she suggests a response in the notion of 'situated knowledges'. Drawing on Marxist theories of immanent embodiment, the critique of hegemony, and an object relations theory of psychoanalysis, she puts forth a notion of objectivity that acknowledges embodied presences in places, rather than one

that transcends "all limits and responsibility" (pp. 582-583) by implying a 'view from nowhere'. When adopting this view, sensor data becomes an opportunity to "strike up noninnocent conversations" (p. 594), to see data as a component of an ongoing discourse and engagement with the world, rather than simply a measurement of it. In examining the situatedness of data, there is the opportunity to discover what bodies, intentions, and ideologies combine to construct its perspective, with all of the opportunities for a nuanced understanding of the subject that this suggests.

The understanding of how the subjective position of data is constructed, rather than accepting it as an objective one, facilitates a far more substantial and rigorous process of producing knowledge about the world through data. Both of these theoretical positions help to deconstruct claims to an objective view of sensor data, while also articulating the value of it as a subjective account of the world through the agents of its collection. Such challenges represent one route to becoming "answerable for what we learn how to see" (p. 583) through sensor data.

Breathing Mephitic Air

In the *Breathing Mephitic Air* installation*,* air pollution data recorded outside the exhibition space in Somerset House, London by the King's College London Environmental Research Group was sonified through an eight-channel surround sound arrangement and visualised through projections made onto three polythene screens. This work was authored by myself and was a development of *Watching Mephitic Air* (Goatley and Revell 2016)*,* an earlier installation made in collaboration with Tobias Revell, who provided valuable visual production assistance for *Breathing Mephitic Air* .

In this work I was analysing data collected between June 23rd to November 8th 2016, taken from an open data repository published by the ERG. In this data, air quality measurements were recorded every hour, including the wind direction and amounts of

three pollutants in the air (nitrous oxide, nitrogen dioxide, and particle matter between 2.5 and 10 microns). To produce the work, I sonified and visualised the data at a rate of one hour of recorded data per second, compressing 3300 hours of collected data into a 55-minute work.

The conceptual provocation for *Breathing Mephitic Air* stemmed both from the discussions around objectivity and situated perspectives described here, and the specificity of this data's context, provenance, and applications. News reports on air pollution in London are typified by the reduction of complex phenomena and measurements to simplified, totalising narratives. This is evident in widespread reports on the breaching of cumulative pollution limits (Carrington 2018), reporting that focuses on 'peak' events (Taylor 2018), and articles in which complex air pollution data is reduced to a single, damning figure (Kirk and Scott 2017). In response to these trends in the public-facing discourse, the key questions that informed my approach to this work became: How can these simplifying narratives be expanded while retaining clarity and accessibility? How can data aestheticisation illuminate the behaviours and materiality of the pollutants themselves, and how can it be used to discuss the politics of data more broadly?

Figure 4: *Breathing Mephitic Air* installation view. Each screen measured 3.5m x 4m, with 2m separating each screen, here shown with two streams of pollution data visible.

First Decisions

The decision made in the selection of the data set to be aestheticised both defined the size and scale of the data being examined, and was my establishing act of critical practice in it. In *Breathing Mephitic Air*, the period of June 23rd to November 8th 2016 was chosen as the data sample range because of its correspondence to the dates of the Brexit vote and the election of Donald Trump as U.S. president – two dates with vast consequences for both national and international climate policy (Laville 2017; Federal Officials 2018). This connection was described in the wall text for the installation, making clear the intent behind it to the audience. Setting two random dates to select data from would have missed this point that substantial political shifts ripple out into domains such as this. My decision to filter and frame data in this particular way was an opportunity to make the situatedness of the data a feature of the installation, and to

include new critical discourses into the work.

Figure 5: *Breathing Mephitic Air* installation view, with two pollution data visualisations visible.

Sonification

My decision to use sonification was based upon both an explorative approach to the use of aesthetic processes in aestheticising this data, but also as an experiment in drawing upon the specificities of different aesthetics to enact theoretical concerns through practice. One approach to this was to expose the rhythms and patterns present in the data set by presenting it in a linear format, 'playing back' the data over time rather than presenting it as an impenetrable mass of numbers. Given the amount of data at hand, such an approach required attention to legibility and temporality in its aestheticisation. With studies into sonification highlighting its capacities for pattern recognition and rhythm analysis (Barass and Kramer 1999; Franinović and Serafin 2013), it presented me with a compelling method to achieve this. I made this decision in acknowledgement

of the perceptive factors particular to sound, in that sonification allows a constant 'reading' of the data being sonified outside of the limits of the listener's visual field (Edwards 2011; Fitch and Kramer 1994), allowing for freedom of movement within the space without disrupting the reading of the data. In place of the media outlet reduction of the dynamic and non-constant phenomena of air pollution to a single data point, my approach instead presented the wider data set with particular care placed upon how an audience could navigate through the entire set via multiple sensory means. This foregrounded both the dynamics present in the data set, and those of the phenomena it measures.

As with data visualisation, there are noticeable tropes in data sonification that reflect narratives of data that have already been critiqued in this thesis. For example, short bleeping 'digital' sounds (possibly intended to sound 'scientific') are frequently used in sonification projects, echoing the visual representation data as an electronic 'other' made up of unfathomable quantities of abstract numbers and symbols (Swain and Jones 2014; Ikeda 2006). Another recurring trend is the use of Western orchestral arrangements to sonify data, such as assigning ensemble instruments to different components of a data set to generate conventionally harmonious combinations (Earthzine 2013; GÉANT 2018; Gregson and Jones 2012). This suggests an attitude of the designers that the association with traditional 'high culture' aesthetics lends a classical authority to the resulting sonifications. This invocation of authority has a range of potential implications, such as reinforcing the belief in an *a priori* authority of data through the culturally entrenched classist connotations of these aesthetics (Peterson 1992). In my view, this could further frame data as the domain of a minority cadre of experts, such as the businessmen gazing into the data abyss seen in the last chapter.

Sonification, like visualisation, can also produce aesthetic representations of data that deny the authorship, agency, and subjectivity inherent in the process of aestheticisation.

Examples include reducing the subjective and value-laden process of sonification to "computer algorithms to convert those electromagnetic frequencies into sound" (Patel 2014), and describing this process as a computational 'conductor' that simply "[g]enerates the musical output" to be heard (Gregson and Jones 2012). Such descriptions obscure the very meaningful compositional and aesthetic decisions made in data sonification, echoing again the notion of 'mechanical objectivity' through the obfuscation of human action in these processes.

In response to this context, the sonic aesthetics in this work were developed through a process of research into the wider contexts around this data and the phenomena it represents. This research was informed by a reflexive relationship between practice and theory, where conceptualisation and technique were developed with the same rigour as the critical theoretical position. This was an attempt to produce critical and conceptual depth regarding the aesthetics used in the work, while also increasing the breath of its theoretical discourses. In this, I am grateful for fruitful discussions with Ian Mudway of the ERG, whose experience in science communication and air quality policy greatly expanded my understanding of these domains (Jarvis *et al* 2018; Walton *et al* 2016).

Figure 6: Speakers surrounded both audience members and the visualisations. This image shows the Nitric oxide visualisation.

Each of the three pollutants present in this data set was represented by its own sound, the volume of which increased and decreased to reflect the hourly changes in air pollution quantity readings as the data unfolded. In consideration of the specific site of data and the aims of the installation, the choice of sound used for each of the three pollutants in *Breathing Mephitic Air* invoked the global systems that are enmeshed in the production of these pollutants and manifest locally in different ways. Nitric oxide (NO) was represented by field recordings made at the roadside sensor where this data was collected, grounding the aesthetics in the material processes of data collection and situating the data at its source. Nitrogen dioxide (NO_2) was represented by the rattle of a car's catalytic convertor, a common component of contemporary petrol engines, and was recorded using an automotive contact microphone. The data pertaining to particle matter between 2.5 and 10 microns in diameter (PM^{10}) was sonified with recordings sourced online of platinum refining recorded in Norilsk, Russia's most polluted city

(Bityukova and Kasimov 2012).

The acid rain which now falls in Norilsk has made the top soil so polluted that it can be refined for metals that were previously deep-excavated there, including platinum (Kramer 2007). The same platinum is also used to build the catalytic converters used in most Western vehicles to reduce engine emissions of NO, NO_2, and PM^{10}: the pollutants measured by the data set in *Breathing Mephitic Air*. Paradoxically, the converter also produces platinum residue, which is deposited through exhaust fumes as roadside dust and which is now a common component of PM10. The amount of platinum particles now present on some roads is so great that the roadside dust can be profitably refined into useable platinum (Murray 2017).

Visualisation

The same level of consideration was given to the method of visualising this data, and how the visualisations may interact with and compliment the sonifications. Each pollutant's data set corresponded to a data visualisation projection on each of the three polythene screens. Thus, the same data was sonified in the speaker array and visualised through the screen projections, at the same rate and time. The data was visualised as a stream of particles, whose size and movement were determined by the pollution amount, wind speed and wind direction for each data set. With an hour of data corresponding to a second in the visualisation, audiences could watch discernible rhythms of air pollution play out across the three screens, with these same dynamics being audible in the changing volumes of the data sonifications.

Figure 7: Projected visualisations of NO_2 and NO data, projected onto polythene screens.

The aesthetic decisions I made served to ground the visuals in the material conditions of what the data measures, and related again to the research performed in the process of sonification. With the visuals, this research was provoked by the desire to refer to the material properties of the pollutants themselves; to ground the aesthetic choices in the phenomena at hand. This produced investigations into the various states that the pollutants could be found in, and what aesthetic properties these states had.

For example, NO is gaseous at room temperature and was thus represented visually as a stream of light, gaseous bubbles. NO_2 is liquid at room temperature, though due to its volatility and the heat of the exhaust, quickly evaporates in car emissions. I represented it as the bronze liquid form it takes when stable. PM^{10} was visualised as metallic platinum particles in reference to the quantity of platinum commonly found in it, a point further explored elsewhere in the work in its references to the platinum mining in Norilsk.

There were several gaps in the ERG data set, ranging in size between only a few empty records to entire months where the data was absent. No explanation given for these particular absences were available on the ERG's open data portal. Instead of simply connecting the start and end points of these gaps in the data to create a seamless data set, these gaps were left in as absences in the visualisations and sonifications. When a period of absence occurred in the data set, the corresponding sounds and visuals in the installation stopped until records in the data resumed. This produced stark moments of silence and darkness, contrasting with the otherwise constant multi-sensory aestheticisation process.

This foregrounding of absence served to highlight that this data is not a continuous, total account of the phenomena. It opened the sensors and modes of storage of this data to critique by exposing their limitations, rather than espousing claims to their capacities. This also serves as an example of how the politics of data's collection are always in play in the work of aestheticisation, and navigating them is part of the process that author(s) of such work must engage with.

The interactions between the sonifications and the visualisations presented multiple methods of reading the data at hand. Both forms of aestheticisation were received differently depending on the position of an audience member in the room, making certain sonifications louder or visualisations more proximate as they walked through it. The sonifications were always immediate and dynamic; the presence of the sound throughout the space meant that, regardless of the viewing position, audience members were always co-present with the rhythms of the data. In contrast, the trailing forms of the visuals showed the recent history of the data as well as that which was occurring at that moment, displaying a linear view enabled through the visual method. The complimentary modes of perception enabled by each form demonstrates the capacities

of such a multi-modal approach when engaging with large data sets such as this. It also has the effect of producing a more spatially transformative and immersive work, operating as it does on these multiple perceptive levels; and this immersion was further enhanced by an additional aesthetic intervention on the air of the room itself.

Air and Space

During the exhibition of *Breathing Mephitic Air*, the Environmental Research Group offered attendees the opportunity to gather data on the air pollution values in the streets immediately surrounding the installation space. Every time data was contributed by a participant in this way, a blast of water-based mist was introduced into the installation (a process I somewhat reservedly refer to as 'data mistification'). As well as allowing the creation of data to influence the aesthetic experience of *Breathing Mephitic Air* for those inside the installation, it referenced the emerging use of 'mist cannons' to alter air pollution data. Since 2015, several Chinese cities have seen a notable increase in the use of industrial machines that saturate the air with nebulised water particles. Costing over £70,000 each, these mist cannons are intended to trap pollution particles in the mist, dragging them down out of the air. However, their actual efficiency in combating pollution is contentious, with environmental activists and researchers noting that mist cannons are routinely deployed near air quality sensors, a practice which may alter readings to imply that pollution in the city as a whole has been reduced (Buisman 2016). Given the earlier examinations of the political ramifications of faith in data's accuracy, these claims are hard to dismiss.

Figure 8: Mist highlighting the light of the projected Nitric oxide visualisation in *Breathing Mephitic Air*.

The mist in *Breathing Mephitic Air* inverted this practice, working instead to highlight when a situated and subjective contribution of air pollution data has been made to create add to the collective views of the phenomena. With the haze machine positioned centrally in the installation, its activation moved gusts of air around the space. These gusts made the polythene screens ripple in response, causing a cascade effect which challenged the fixity of the screens, as the sounds continued to move freely around and through the audience. The quality of the air and light was also affected; large volumes of mist altered the humidity of the room, and created visible paths of projector light where it passed through mist. This produced an aesthetic impact on the space that was atmospheric in both senses, and drew the narratives of the mist cannons into the examination of the data set.
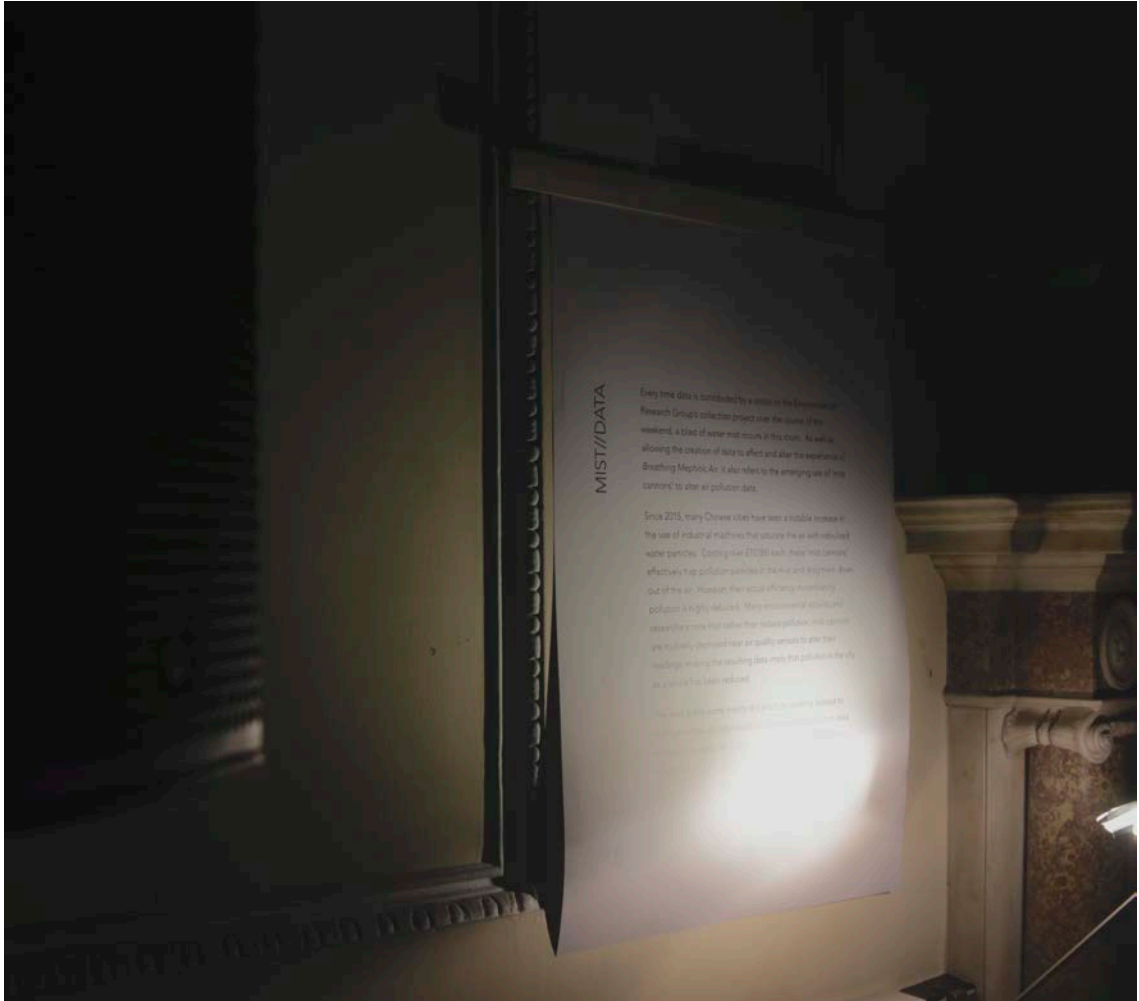
Figure 9: Text hung within the installation space describing the use of mist in *Breathing Mephitic Air.*

Throughout the installation space, wall texts detailed the origin of the sounds, visuals, and mist, and their relationship to the data. They functioned as a 'key' or map, making clear the elements assembled together to produce the work, and thereby also informing the audience of my intentions in producing the work as an intervention.

Texts such as these can be a potent method of creating additional layers of engagement in the work, ones that are led by the curiosity of the audience. In *Breathing Mephitic Air,* the main wall text outside of the installation space detailed the overall concept, offering the audience an overview of the core relationship between the data and the aesthetics. The additional texts were installed throughout the space, without an intended order in which they should be read. Rather than being simply descriptive, these texts were treated as another layer of aesthetics, laying under those of the sound, projections, and mist. Should an audience member be drawn to know more, this

information was accessible, offered more as a reflection on the piece as a whole.

This illustrates the value of text outside of its normative roles in similar forms of art. Rather than functioning as a description of the work or its materials, in research-led practices such as this it offers a method of articulating more of that research in the work itself, without necessarily over-loading its core intent or aims.

Politics and Demonstrations

The aestheticisations in *Breathing Mephitic Air* created methods of perceiving the data through and with aesthetics that were tied to the data's collection and the phenomena of air pollution. This entanglement of the many subjective elements of the data with the aestheticisation of it was intended to provoke novel conceptions of how data may be represented, and the potential in that representation for new forms of experience and knowledge. This was not only influenced by my desire to represent data, but also by an engagement with the politics of this act.

The aestheticisations depicted air pollution as a widely varying phenomenon; volume peaks revealed rhythms in the amount of pollution measured throughout each day, producing a representation in conflict with a preconception of air pollution as a constant. Consistent peaks of pollution impacted the experience of the installation substantially, creating sustained moments of cacophony and dynamically expanding visuals, before typically receding after several 'hours' of data. This offered the opportunity for a more nuanced analysis of the data than a totalising view allows; revealing how air pollution responds to the patterns of daily life in a city, and is rhythmically symbiotic with the human population.

In reference to the notion of the demonstration, the political engagement present in this work was in producing this reassessment of how this data may be presented to a public, and how new forms of presentation or demonstration may foster new forms of

understanding and engagement with both the data and the phenomena it represents. This parallels my underlying theoretical concerns, engaged as it was with exploring the narratives of what both data (and aestheticisation) can and might do.

Barry's clarification of what the 'political' is also has relevance here, which he describes as "the ways in which artefacts, activities or practices become objects of contestation" (2001, p. 6). This contestation is not a given and requires intention to bring it into public space, for as Barry observes, "[t]echnical controversies are *forms* of political controversy, although it is open to question whether…such disputes take place in a public political arena" (p. 9, emphasis original). The political nature of siting the work in a public space such as this is what Rancière calls the placing of "one world into another" (Rancière 2010, p. 38). The political core of this work then lies in the contestation of the neutrality of sensors and their data in a public space; of presenting an alternative to simplifying media narratives of air pollution data, and of the sensor as a mechanically objective view of the world.

One intention of this demonstration was to 'bridge the gap' between the phenomena of air pollution and the audience, through the work of data aestheticisation. It re-sited the data outside of its typical engagement through screen and print media, allowing for embodied methods of navigating through this data. The 'layers' of sonification, visualisation, mistification and text could be engaged with to varying depths, left up to the agency of the audience; a key component of the non-didactic and agency-focused approach to the structure of this work. In my observations of the audience this often resulted in a *dérive*-like movement through the space, with audience members drawn by different elements at different times during the duration of the work.

Functioning as an aside to the aestheticisation of the data, the descriptive texts installed through the room provided means for a further dive into the decisions and research that

informed the aesthetics and the selection of the data. This was intended to not only bridge the gap between the audience and the phenomena, but between the audience and my intent in creating this work.

Responses

In analysing the outcomes of this work, two key points emerge that contribute substantially to the development of this thesis. Firstly, data aestheticisation offers the possibility not only to represent the data at hand but also, through the aesthetic decisions made in this representation, to draw in the world not measured by the data. Secondly, the exhibition of this work showed how nuanced theoretical concerns can be enacted through an explorative approach to aestheticisation practice.

To address this first point, it must be understood that rather than showing only the contents of a dataset, data aestheticisation practice has the opportunity to explicitly place the data in dialogue with discourses that are tied into data's creation, dissemination, and application, but which are not present in the data set itself. Aesthetic materials do not exist in a cultural vacuum; they possess histories of how and where they are used, which influence how they are encountered and perceived (Goodman 1968). When each aesthetic choice comes with its own context and meanings in this way there is the opportunity to actively exploit these meanings, and draw parallels from their contexts, as part of a critical practice of aestheticisation.

As an example, consider if the sounds used in *Breathing Mephitic Air* were replaced with different pitches of generic 'blowing wind' sound for each pollutant. Arguably this would have made the data to which the sound was mapped equally legible, and therefore have been 'read' as easily by the audience. Perhaps it may have been interpreted as a soothing or gentle sound, conferring these qualities onto the installation itself. This approach would not, however, have provoked the wider research processes

in the development of the work, processes which revealed points such as the ecological crisis occurring in Norilsk, which in turn influenced new aesthetic decisions in the work itself.

This method of research was in effect a search for inspiration, for aesthetics that would do extra 'work' in including discourses outside of the data itself, without reducing the legibility of the aestheticisation. Such a research process is aesthetics-led, a search for discourses relevant to the data at hand that possess aesthetic qualities that can be brought into the work. It is also a response that is provoked when working with data that has its origins outside of the author of the aestheticisation, and demonstrates how the stages of developing the aestheticisation itself are as important as the final form it is presented in.

As an example of this relationship between research and practice, when exploring possibilities for the sonification aesthetics I was drawn to the physical properties of air pollution and what sonic aesthetics they may possess. This led to my discovery of the relationship between platinum and PM^{10} through an investigation into the function (and sound) of the catalytic convertor. This resulted in a conceptual and theoretical direction with which the aesthetics of the sonifications and visualisations could be aligned. In this instance, the requirements of the practice were the provocations for new theoretical investigations, driven by a critically reflexive approach to data aestheticisation.

Figure 10: View of the three data streams (PM^{10} in the foreground), seen layered through each projector screen.

The second point to reflect upon is the articulation of theoretical concerns in and through aesthetic decisions. For example, in *Breathing Mephitic Air* the semi-transparent polythene screens allowed the viewer to see three streams of data simultaneously from a single point in the room; however, the semi-opacity of the material introduced a hierarchy to the clarity of the images as seen from a given position. This created a space that necessitated exploration between each screen to view them clearly. In its exhibition I observed audiences adopting positions between each visualisation, comparing and contrasting between them to perceive patterns not possible when adopting a single view of all three. This use of structure and arrangement of space and aesthetics allowed for multiple perspectives on the data in the installation, each possessing their own equally authoritative view. Inspired by the theoretical positions of Barad and Haraway, this created a non-linear feel to the installation, favouring multiple embodied perspectives over a single disembodied view.

Similarly, the discourses of mechanical objectivity and the relationship of sensor data to the world informed the decision to leave the gaps in the data intact. These gaps produced extended periods without sonification or visualisation; given the dynamic and multi-sensory nature of the work, these periods of absence produced notable impacts upon the space. This articulation of absence was an intentional challenge to hegemonic practices of data cleaning where gaps, breakages, and other frictions to the seamlessness of a data set are routinely 'corrected' (Rahm and Hong 2000). The inclusion of such voids in data is intended to raise questions that might invoke critiques of claims made with data: is the data missing through an accident? Was it deleted, or did it never exist? Does it change its value if it is not complete? Asking these questions requires consideration of the infrastructures, people, and practices involved in data's collection, aggregation, and delivery, provoking an interrogation into this data assemblage.

The work itself was intended to prioritise the opportunity for questions such as these, rather than presenting a specific judgement to be communicated and received. A further aim, or hope, was to produce an artwork that encouraged a questioning attitude to how both data and air pollution are presented in public spaces, rather than present them both as already authoritatively 'solved'. When the discourses of data's objectivity deny the value of the situated perspective and of questioning the authority of data, creating the space for new questions, both for the author and the audience, is of paramount importance in building a critical practice of data aestheticisation.

New Questions

The need for reflexive consideration of how aesthetics decisions may enable critical discourses and spur new research trajectories is intrinsic to the approach to data aestheticisation that I am developing. With a vast range of media forms available to practitioners, the challenges presented by data aestheticisation can be daunting. How do you as the author of such work decide how to aestheticise the data, when these decisions

have pervasive consequences? How do you account for the potentially opaque

provenance of the data you're working with? And how do you navigate through the

theoretical landscape while acknowledging data as an interdisciplinary research subject?

Alongside these questions, others have arisen from the analyses thus far looking at the

sites in which mechanical objectivity operates, and how they can they be addressed

through this methodology. These questions further unpack the relationship between

theoretical and political concerns, and grappling with their implications is one of the

central tasks of this thesis.

Chapter 3: Ground Resistance

Ground Resistance (Goatley and Voss 2016) was a multi-channel audio and visual installation commissioned for the Milton Keynes International Festival 2016, made in collaboration with Georgina Voss. The installation explored the data collated by the MK:Smart smart city system developed by the Open University, and used this data to examine the temporal and spatial limits to claims of smart cities as 'all-seeing and always-on', and challenge the parallel ideologies in data visualisation. As with the previous chapter, I'll begin by detailing the critical study of the smart city that the work was made in response to, before examining how the project engaged with these concerns in practice. I'll be focusing specifically upon how the claims to the potency of the smart city relate to the critical study of data made so far in this thesis, the role that aesthetics have in reinforcing these claims, and the potential for critical practice to subvert them.

'Smart' Cities

According to the UK government, the term 'smart cities' defines "the use of data-driven digital innovations to improve services and sustainability in towns and cities…both nationally and internationally" (UK Parliament 2018, no pagination). While this definition places data at the core of the smart city concept, it bears resemblance to terms such as 'digital cities' and 'future cities' and a host of others promoted by different interest groups (Eremia *et al* 2017). These systems also frequently involve non-governmental sources of data, such as energy providers or telecoms companies, using technology developed and operated by information technology corporations (MK:Smart 2018; Gaffney and Robertson 2018). To take the example of one such system, MK:Smart, the Milton Keynes smart city project operated by the Open University until its conclusion in 2017, is described as a centralised data management system that collated data on "energy and water consumption, transport data, data acquired through satellite technology, social and economic datasets, and crowdsourced data from social

media or specialised apps" (MK:Smart 2018, no pagination). This data was collated from a number of government and industry sources to support "sustainable growth without exceeding the capacity of the infrastructure" (ibid.) and made accessible to the public through a dashboard interface and an open data archive.

Studies of the smart city concept describe it as employing a range of networked digital and information technologies in the pursuit of various economic, ecological and social goals, similar to earlier studies on ubiquitous computing in urban space (Crang and Graham 2007). The intended goals of smart city systems include business innovation, increased resource efficiency in governance, population surveillance, and ecological sustainability (Rose 2017; Hollands 2008; Eger 2009). The breadth of the term has been traced to the reality of smart city systems as "complicated assemblages of various things – technologies, policies, data, products and discourse – with a wide range of aims and effects", whose form, function, and capacity are not uniform across all sites of such projects (Rose 2017, p. 178). The smart city is then not a single object with a fixed form, but an assemblage of technologies, practices, people, and policies.

The political and economic geographer Alberto Vanolo responds to the lack of specificity in the term by framing it as an "evocative slogan lacking a well defined conceptual core", seeing its use as a tactical gesture such that "proponents of the smart city are allowed to use the term in ways that support their own agendas" (2014, p. 884). Vanolo's claim that smart city projects are indebted to the 1980s 'New Urbanist' concept of 'Smart Growth' serves as a further indictment of the hollowness of the term, when in this reading 'smartness' would actually predate the widespread civic uptake of fibre-optic cabling, low-cost GSM services and Internet-of-Things technologies that are the source of the smart city's 'smartness' (Mattern 2017b). Such critiques posit the smart city as reflecting a "positive and rather uncritical stance towards urban development", when no city "does not want to be smart, creative and

cultural" (Hollands 2008, p. 305).

Materiality and Metaphor

Though smart cities would appear to be necessarily site-specific systems, generic 'out-of-the-box' technologies are also being developed for smart city projects, intended to be cheaper, generic solutions for small cities and townships. The CEO for Surbana Jurong, a Singapore-based developer of one such out-of-the-box solution, described that in "taking a leaf from how consumers use apps in their daily lives, we realised that city planners also need the same convenience of a plug and play integrated solution to manage cities" (SmartCitiesWorld 2016, no pagination); 'cities' are seemingly invoked here as standardised and standardisable units, rather than a label for a series of complex and unique ecologies.

The consumer app metaphor suggests a notion of 'smartness' that reduces complexity and labour in governmental decision-making, replacing it with a form of 'play', albeit not quite in the way Jurong's executives used the term. Such notions are likely to be very appealing to underfunded municipal bodies. However, the adoption of these out-of-the-box systems may have ramifications outside of a single city when "the potential to provide convergence for several smart cities across the State" is part of the developer's intent (Nirmal 2016, no pagination), the desire being to 'lock-in' multiple cities into particular operational ecosystems (Townsend 2013).

The positioning of these systems as a way of reducing the complexity of governance can be found in an interview with Niraj Prakash, Director of Oracle India, who repeatedly describes their out-of-the-box smart city system as 'the box', stating that they have automated "the capability to cleanse, prepare, organise and analyse data" (Nirmal 2016, no pagination). The implied transparency of this process and its presentation as being based on a mere mechanical function, both of which bely the incredibly

interpretative series of actions described so far in this thesis, further demonstrates the simplifying narratives of these out-of-the-box systems, and the kinds of subjective decisions they obscure.

This 'simplification' narrative itself becomes a form of obfuscation to the study of 'smart cities', and this obscurity ramps up further when we realise that crucial elements of their function are automated by closed processes. This obfuscation is deepened still further when major smart city system developers such as Cisco and IBM closely protect the technology and silo the expertise for maintaining these systems (Townsend 2013). Both metaphors used by these CEOs carry with them an aesthetic of obfuscation, either through the simplification of 'the box' or through the seamlessness of 'it just works' consumer discourses. Reducing the complexity of a system that claims to run a city down to a standardised 'box' adds, through metaphor, to the opacity and limits of access to these systems (Latour 1999). Stahl (1995) argues that when such metaphors abstract the function of technologies, they bestow an authority through a form of esoteric complexity and effectively become 'magical', and in this become a form of knowledge "which other people, the non-expert, cannot master" (Adorno 1974, p. 78).

This interplay between expertise and authority bears examination. As Caroline Bassett argues, when data is seen as the 'ultimate expert', "the question of who is 'allowed' to be an expert matters" (2015b p. 556). In examining the rhetoric of smart city proponents, expertise is often bound up in technical obfuscations and serves to isolate these systems from critique. Eduardo Paes, the mayor of Rio de Janeiro and a vocal proponent of their smart city system, describes it as allowing his government "to have people looking into every corner of the city 24 hours a day, 7 days a week" (Paes, quoted in Townsend 2013, p. 67); the hyperbole in such a statement is suggestive of the allure of such a system for those in government. It also demonstrates the notion of the centralised, 'top-down' vision that Paes sees the smart city as providing; one that offers

a totalising view of the city, made possible by the technology (and data) of the smart

city. This is an example of how the rhetoric of expertise can function as an expression

of a new social order (Slaton 1998), in this case one that bestows an authority through

this totalising view of the city. However, when Rio's system itself is a proprietary

product of IBM, and neither the system nor its collected data are made available for

public scrutiny, investigating precisely where and when the system's gaze can fall is

difficult to discern.

Challenges

A potential consequence of corporate presence in smart city systems, such as IBMs co-

operation of the Rio de Janeiro smart city system and the multiple corporate

partnerships in the MK: Smart system, can be seen in an event in Assen, the

Netherlands. In 2011, a publicly-funded sensor network was built in the city that

regulated and managed traffic lights, car parks, and parking signage. In 2017, the

project went bankrupt, and was subsequently sold to a "still-unidentified private

company" (Naafs 2018, no pagination). The shift of this publicly-funded infrastructure

to private ownership placed the new owner in a powerful position, where "the

municipality will have to strike a deal with the new owner about the use of its public

traffic lights and parking signs" (ibid.). Such situations were already predicted in

Robert G. Hollands's 2008 study of the smart city term and its ramifications, in which

Hollands warned against one outcome of the 'smart growth agenda' in which

"community interests are superseded by developer's interests, or the requirements of

capital accumulation" (p. 306).

This concern is also present across other sites where the pursuit of technological

innovation is in conflict with government accountability. Technology firms have

attempted to bypass key democratic institutions, such as local government departments

and legal jurisdictions, of the cities in which they are operating to field-test

experimental networked technologies of population control and governance (Crawford 2018). One example of this can be seen in data-mining company Palantir's field test of a data-oriented crime management system in New Orleans, beginning in 2012. In order to keep this field test away from public records and therefore potential legal challenges, Palantir exploited a legislative loophole by 'donating' the system free-of-charge to the New Orleans Police Department. This allowed them to effectively experiment on both the city's residents and the department itself, a situation that was only revealed after a lengthy investigative reporting process (Winston 2018).

At the policy level there are calls for 'permissionless innovation', whose proponents argue that legislation should be changed to reduce the bureaucratic checks and balances they describe as hindering the rate of innovation (Thierer 2014). It is within this milieu of challenges to democratically-established limitations on corporate influence over civic governance that smart city systems are being developed, warranting an examination of how the purveyors of such systems are enticing civic authorities with promises based on data collection and analysis, as well as data-driven policy recommendations at the high level and data-driven automation of decision-making processes in everyday urban contexts.

One example of the stakes at play in this comes from an advertorial for the Singapore Smart Nation project in the Straits Times (Kang 2015). The article states that there will be significant "digital disruption" in their proposed smart city projects, and that "any repetitive work…may slowly be automated away" (no pagination), without specification of how this will be automated. Tellingly, there is no clarification provided on what will happen to workers who are not in "knowledge-based industries" (ibid.), or even which industries are not based on knowledge. While this is described as a process of 'value creation', there is no mention of who will benefit from this value creation, a glaring omission given the loss of jobs being described. Even the fates of those who retain their

jobs through this 'digital disruption' are left uncertain, when the most attention this is given in the article is the vague assertion that their labour will be "made more productive through technology" (ibid.). This is one of many examples of how smart city systems implicate the population and material landscape of the city (Mattern 2017a; Koolhas 2014; Morozov 2017; Poole 2014), and demonstrates the importance of examining and challenging claims made regarding their capacities.

A Promise and a Strategy

Given these conflicts of terminology and application of the smart city concept, the multi-sector critiques of it, and the obfuscating claims of its operators, the smart city is perhaps best understood by returning to the notion of the promise and strategy. What seems to be promised is that, with enough data from the city, complex and long-standing challenges of governance will finally be 'solved', or at the very least, that the decisions made are guaranteed to be 'smarter'. Strategically, this promise endows those in power with a portion of data's authority, which is consolidated through the centralisation of a data-based view of the city.

The discussions of the smart city seen so far also have notable aesthetic references running through them: from giving a physical form to the smart city as a 'box', to the channeling of the simplicity of app interaction, and the notion that these systems create a form of enhanced 'vision' of the city for their operators. These metaphors and similes repeat throughout these discourses, offering an opportunity to analyse their relationship to the claims made by smart city operators and purveyors. What follows here will be an application of the understanding of data and aestheticisation developed so far in this thesis to the concept of the smart city as promise and strategy, and an investigation into how the aesthetic and perceptual metaphors of the smart city relate both to this critique and the practice of data aestheticisation.

Mechanical Objectivity Perpetuates

The promises and strategies of the smart city I describe have a unifying feature: they are all underpinned by an understanding of mechanically objective data as that which can create an objective view of the city, and it is this objectivity that underpins the supposed 'smartness' of these systems. To illustrate this with the example of the 'out-of-the-box' smart city systems, both Prakash and Jurong channel the discourse of mechanical objectivity through their 'magic boxes' that automate subjective processes of data analytics, while reducing the complexity of decision making within and with these systems to the level of smartphone apps.

Policing is one such activity that smart city operators assert will improve through their 'smarter' approach to civic governance (Cisco 2018, IBM 2018). Companies such as PredPol (2018) and Palantir (Winston 2018) produce products that claim to predict where crimes will happen, based on training data sets generated by historic police recordings. Their argument is that the use of data in these systems produces fairer, less biased, and more efficient forms of policing (PredPol 2018). Analysing how such claims manifest in a practical application such as predictive policing offers a route to critiquing the related claims made by smart city operators.

The belief that these data-intensive systems produce their intended effects is articulated in the promotional materials released by their operators, such as: "Would-be offenders see the police activity and are deterred from committing a crime there…[d]uring our test, we *probably* disrupted criminal activity eight to 10 times a week" (PredPol 2018, no pagination, emphasis mine). The vagaries of this statement aside, the Predpol argument is that even if their system assigns officers to an area and no crimes occur there, this only demonstrates the efficiency of the system and its claims. Claims such as these are upheld even while the database designers themselves emphatically state that "trying to predict who is going to do what based on last year's data is just

horseshit" (Corsaro, quoted in Winston 2018, no pagination). PredPol's emphatic assertion that "PREDPOL IS NOT "THE MINORITY REPORT". IT IS SCIENCE. IT IS MATH" (ibid., emphasis original) suggests that the ever-present 'hand of man' objected to by the scientific atlas producers is still an ever-present anxiety in this field.

Returning to the notions of transparency in data aestheticisation, sensor subjectivity, and the 'cut' offers an opportunity to challenge the notion of data as an objective tool in both the smart city and predictive policing. Once it is accepted that there is no objective sensor data or unbiased human decision, it becomes clear that any data set that is the product of any or all of these factors cannot be understood as objective. The author of the data set will always impart their subjectivity onto the set itself through decisions such as size of the set, the range of data it represents, the symbols or syntax present, and the format in which the set is constructed. In these ways, data sets are always a product of partiality and bias in their creation, and these subjective elements become inextricable components of the systems built around and with this data. Of course these actions and processes - themselves a form of ordering - also deeply inform how later aesthetic decisions are taken.

In the context of predictive policing, the data sets are often the product of policing practices prejudiced along racial and socio-economic axes; rather than being objective and impartial, they are an embodiment of these historic biases (Impakt Festival 2015). Instead of removing biases, these systems are better understood as introducing their own biases into these practices (AI Now Institute 2018).

The importance of recognising many kinds of sensor data in the smart city as a form of situated and biased knowledge becomes essential in critiquing their use in these systems, for sensors become nodes of civic control when they are routinely employed to alter temperature, flows of traffic, or the performance of workers. The technical

decisions made towards completing these tasks in a city have potentially substantial impacts on the lives of a population living in and with these systems; suddenly a malfunctioning sensor becomes the cause of traffic accidents, or implicates a worker as being unfit for their task. It is through this power that "the most banal and everyday objects" such as sensors, switches, and routers acquire "tremendous power to regulate behaviour" (Morozov 2014, no pagination), a power that is reinforced when their situated view is mistaken for an objective one.

Solutionism

A theme running through both predictive policing and the smart city is that not only is the data seen to be mechanically objective, but that it is also the complexity of their systems and novelty of the technology that allows for their feats of control to be performed. This seems to breed a form of 'technological exceptionalism', a belief that with the right technology (and the right data), these systems will succeed where previous technological efforts have failed. When data is believed to give access to some kind of higher objective truth, that it is 'good enough' as it is, and does not require semantic or causal analysis (Anderson 2008), this exceptionalist narrative is empowered. This same process would seem to be in play when smart city developers invoke big data, machine learning, and artificial intelligence as if the words themselves are incantations that conjure 'smarter' governance (Reichert 2017). One way to counter this is to re-position the way such a topic is addressed: to understand that neither governance nor policing are 'problems' that can be 'solved' through technology at all, and that a faith in technological solutions to the concerns of governance is far older than the notion of the smart city (Rittel and Webber 1973).

Both smart city and predictive policing projects represent a particular reliance upon innovation to finally 'solve' problems that Evgeny Morozov refers to as 'technological solutionism' (2013). Morozov characterises technological solutionists as having a preoccupation with "sexy, monumental, and narrow-minded solutions...to problems that

are extremely complex, fluid, and contentious" (p. 6). This is illustrated by the earlier example of the Singapore Smart Nation advertorial's claim that an unspecified future technology will make labour more 'valuable' in similarly unspecified ways. Morozov states that "in solving the 'problem', solutionists twist it in such an ugly and unfamiliar way that, by the time it is 'solved', the problem becomes something else entirely" (p. 8).

The promise and strategy of the smart city seems to rest not only on the claims that technology will enable 'smarter' decision making, but also in the power and allure of the perspective such a system confers on its operators. The 'view' of the city that the sensor-based smart city promises is built from a distributed network of data sources; but who has access to this view, and the form that it takes, is far more centralised. This centralisation commonly occurs at a control center, where data is collected and accessed by the operators of smart city systems (Reichert 2017; Berst 2013). The control center is the point from which the data is analysed by those in positions of power, and from which they make their claims to a continuous totality of vision, such as Mayor Paes' earlier claims that the Rio de Janeiro system created an all-seeing and constant view of the city for him and his team.

Aesthetics and the Optics of Power

In order to consider the allure and ramifications of this view, it is instructive to reflect upon studies of similar 'top-down' governance projects. In *Seeing Like A State* (1998), James C. Scott charts a geographic and historically disparate series of centralised governance projects, united by the drive to 'modernise' complex systems and social orders. In projects such as scientific farming, the creation of maps by Nazi occupation forces, and the restructuring of rural Tanzanian settlements, Scott notes the repeated failure of systems that aim to reconfigure space and people according to aesthetic ideals of simplification, legibility, orderliness, and 'progress'. Each project in Scott's study represented an attempt to 'correct' the inherent 'messiness' in many (successfully

functioning) human social systems, projects that resulted in the disruption of traditional societal structures, loss of social cohesion, and even mass casualties for populations implicated in these projects.

In Scott's account of these top-down projects, the design aesthetics of totality and order were both the blueprint for operation and a political ideal. He notes the repeated presence of an 'optic of power' recurring across them, where "an efficient, rationally organized city, village or farm was [understood to be] a city that *looked* regimented and orderly in a geometric sense" (p. 4, emphasis original).

Scott argues that the aesthetics of this kind of ordering were alluring to those in control of these systems, while disempowering those beneath their gaze, whether these are the inhabitants of a village or state, so that, as he notes; "the image of a nation that might operate along these lines is enormously flattering to elites at the apex - and, of course, demeaning to a population whose role they thus reduce to that of ciphers" (p. 254).

This assumed authority comes back to the notion of the smart city as a promise and a strategy; that the promised potency of the view of the city, and the supposed objectivity of the data, endows the operators an authority to 'solve the problem' of civic governance, while both the centralisation of the view and its aesthetics work to keep the population of the city at a distance from the mechanisms of this power. Haraway (1988) describes the appeal of such views as a masculinism that establishes its authority through the singularity of this vision and its exclusion of any other views.

Data inserts itself into these tropes of governance, and does so in characteristic ways. In the smart city, this notion of the 'view' is not only concerned with what can be seen, but with the inherent 'truth' that is accessed through the mechanical objectivity of the sensor network that provides for this data-based view; and the capacity for 'smart'

decisions this bestows upon the viewer. Central to this is the Dashboard.

The Dashboard

When a view of the smart city is made publicly available, it is typically presented

through the 'dashboard', a visual interface common to many international smart city

projects (MK:Smart 2018; Building City Dashboards 2018; City Dashboard 2018;

Smart CEI Moncloa 2018). Typically an app-based visual interface, the dashboard

allows the user access to the multiple streams of data generated by the smart city system

at hand, either as part of a control center, or as a remote analogy for it.

In correlation with the discourses of the smart city, Shannon Mattern highlights the

narratives of totality of vision and commanding presence of data that persist throughout

the dashboard, and how they underpin its assumed authority. Mattern notes that in both

historical and contemporary instances of dashboards, they "often cultivate a top-down,

technocratic vision that…run[s] the risk of framing the city as a mere aggregate of

variables" (2015, no pagination).

Examples of this can be seen in the arrangement of the dashboards themselves. For

example, the developers of the London-focused CityDashboard refer to it as aggregating

"simple spatial data" (City Dashboard 2018, no pagination). However, the dashboard

also includes attempts to quantify the happiness of the city's population with an opaque

'happiness index'. The only other gesture that implicates humans explicitly in this view

is the inclusion of a list of twitter trends 'for London', though without any analysis of

what hashtags such as #MondayMotivation may mean for the diverse population of

London.

Within this single view, simplification is invoked alongside attempts to quantify the

immeasurably complex subject of human happiness. When such a metric is displayed

alongside available bicycles for hire and weather information, it seems to be presented with the same epistemological certainty, in spite of its clearly subjective and interpretative nature. This frames it as simply another aggregated variable, alongside the stock market and traffic, to fall under the operator's gaze.
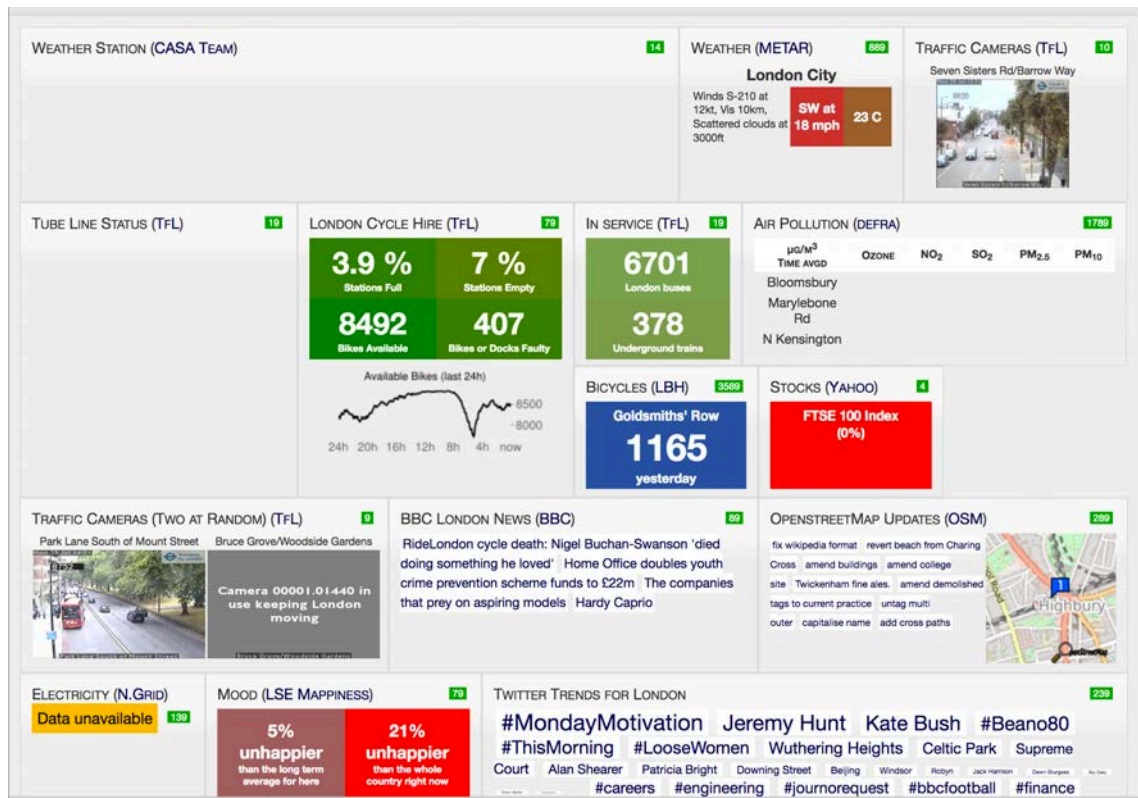
Figure 11: Screenshot of the London CityDashboard interface. Multiple feeds were unavailable at the time of capture.

A critical element in examining dashboards is to consider what is absent in the aestheticised visions of 'the city' they produce. This is not limited just to what has been deemed non-essential to, or otherwise removed from, the streamlined view of the dashboard; but also to consider what elements of the city and its population may resist quantification entirely. Even without knowing exactly what has been removed (or never included) in it, the question of absence immediately foregrounds the depth of the political and ideological decisions made in constructing the dashboard's view, in spite of its claims to simplification. In critically analysing a smart city ideology where it is

only that which can be counted that counts, it must be acknowledged that cities are "messy, complex systems, and we can't understand them without the methodological and epistemological mud" that the dashboard sifts out (Mattern 2015, no pagination).

Visions of Order

In the examples of top-down governance seen here and in the description of the smart city, a singularity of vision both allows for and lends authority to the decisions of governance, while placing a distance between the observer and the observed. What distinguishes the smart city is the obfuscation created by the simplification of complexity offered by dashboards and control centers, and the supposed mechanical objectivity of data that underpins the project as a whole. Both of these factors relate to the supposed transparency and authority of data visualisation; that the data is true, and therefore the visualisation seen in the dashboard or control center is simply a translation of that truth into visual perception.

Figure 12: Image accompanying an article titled 'What Will The Smart City of the Future Look Like?'
Source: https://www.mytechlogy.com/IT-blogs/20668/what-will-the-smart-city-of-the-future-look-like/

To glance again through the view of the world that is Google Image Search (see

Appendix B), there are notable representations of the smart city that seem to correlate closely to the dominant imaginaries of data more broadly, such as data's mechanical objectivity, its ever-presence and inhuman nature. There is a prevalence of images that show the smart city sprouting from a smartphone or a tablet in the palm of a (man's) hand, suggesting an 'always-on' control that works from anywhere, simplifying the operator's interactions with the city through this common device. Many others show a spectacular hovering 'cloud' of information above the city, simplified into app-like icons, suggesting the interconnected nature of the data creating the all-seeing view available to the operator.

Notably, it is rare to find images of the smart city in these searches that feature humans living in the city, only the view above it, with its population implied by (or replaced with) the flow of data. These images should be viewed both as an expression of an operational ideology, as well as artefacts that reinforce a narrative and its claims. Such a reading correlates with the analysis of the smart city discussed in this chapter: that the smart city promises simplicity for those in power, an all-seeing and always-on view of the city, offering the supposed objective precision of data over the subjectivity of a population. This is why examining what *is* there, from who makes these claims, to the technologies being used, and the aesthetics used to represent the smart city and construct its view, matters.

The Spectacle of Scale

The performance of authority present in these aesthetic representations is not limited to the topic of smart cities; trends seen in data aestheticisation practice echo this through presenting similarly totalising views. The influential Edward Tufte, for instance, states that "more information is better than less information" (2001, p. 168) suggesting that his notion of 'excellence' and 'truth' in visualisation is concomitant with the scale of the data at hand. Data visualisation projects with substantial press coverage and

institutional backing such as *Phototrails* (Hochman *et al* 2013) demonstrate a similar practice of leveraging abundance and complexity in the creation of a data aestheticisation that seems to imply the *a priori* authority of the authors, the data, and the aestheticisation.

Phototrails was a data visualisation project that collated 2.3m Instagram photos together, compressing their size and arranging them into a single image so that patterns in their form became apparent. In producing this distant reading of the images, the authors present multiple arrangements of them which they have organised by features such as colour and location metadata. Across each of these arrangements of the data set, one trend is consistent: that *Phototrails*' explicit focus on what the authors call 'All-in-One' visualisations, of all-presence and mass-scale viewed at a distance, renders the deeper content of the individual images themselves near-illegible. Legibility instead is granted to a much narrower group, that of the observers of *Phototrails*, a group which does not necessarily include those implicated in the images.

The project reinforces the norms of visualisation and of data's perceived truth value described in this thesis so far, including claims to qualitative knowledges such as "social, cultural and political insights" (ibid.) gained through quantitative means such as these. By exploiting the allure of the god's eye view, such representations position both the author (and, through consuming the work, the audience) as "master of the known" (Houser 2014, p. 328), a mutual reinforcement of both their own authority as revealers of this knowledge, and claims to the *a priori* authority of data itself.
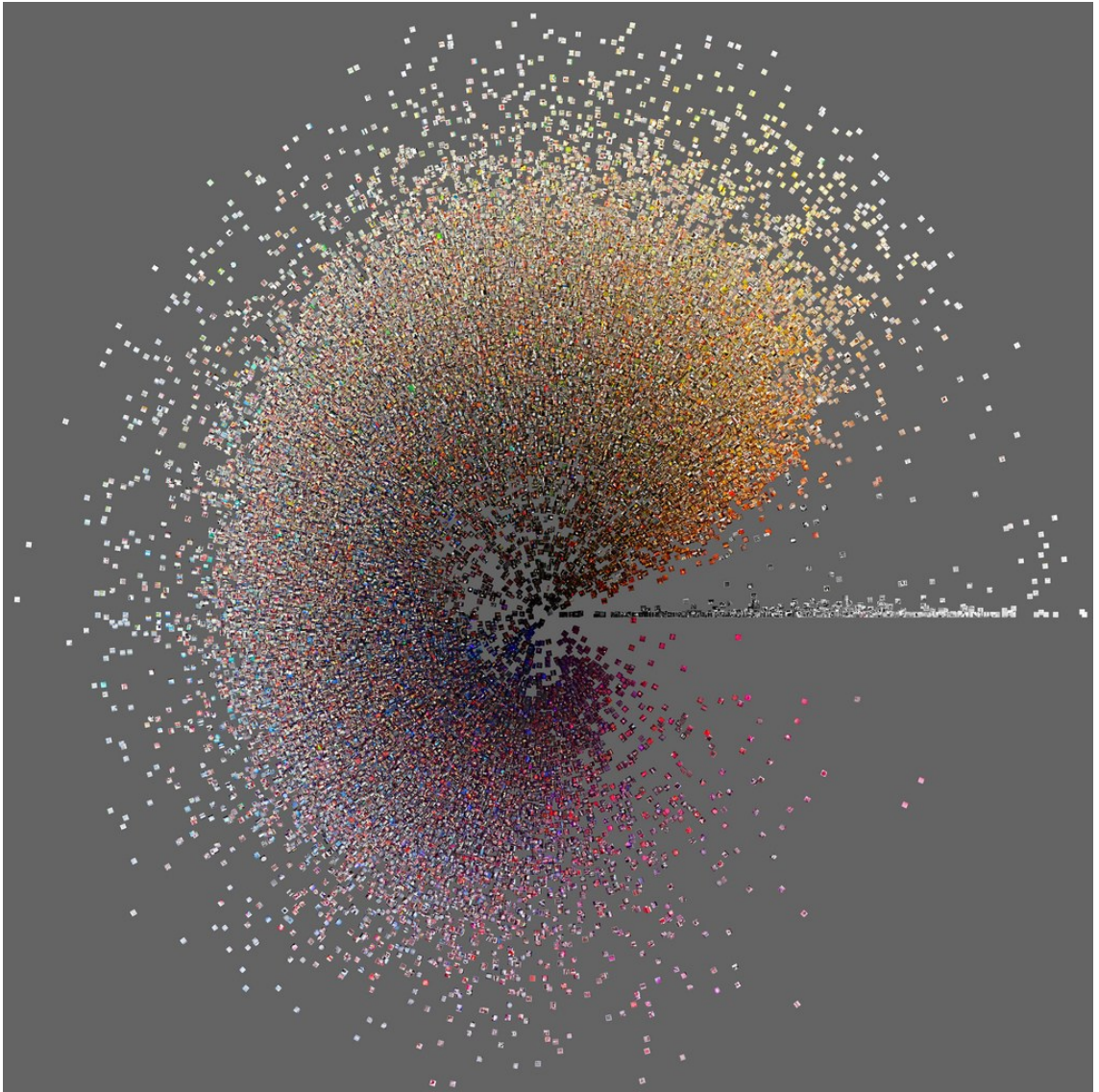
Figure 13: An image from the *Phototrails* project, described as representing Instagram use in San Francisco.

Source: http://phototrails.info/instagram-cities/

When *Phototrails* reduces the individual content of these images down to two parameters (such as colour and quantity), it performs an example of Helen Houser's warning that "the pressure to visualize complexity in a digestible form ends up excluding that very complexity" (ibid.). In this process, the depth of each individual image is lost: what the photographer chose to photograph and why is lost; what insights the images themselves may have provoked about society, culture and politics as seen from the intimate vantage point of the photographer are lost. Moreover, the 'all-in-one'

view constructed by work such as *Phototrails* presupposes "a finite project…
[suggesting] a containable problem-space" (Hall *et al* 2015, p. 94), a vision of a
knowable and conquerable world that has been presented by the author. In such
instances, scale itself is framed as a spectacular centerpiece from which the authority of
the author can be assumed, a scale whose presence performs "an epistemological claim
in the mere act of display" (Gregg 2015, p. 42).

To critique this 'spectacle of scale' is not to say that large scales and high volumes of
data have no place in data aestheticisation, but instead to propose a re-thinking of the
approaches to the work of aestheticising large data sets. In rejecting scale *as* spectacle,
there is an opportunity to challenge the related narratives of totality, presence, and
immediacy through the practice of data aestheticisation, particularly when working with
large data sets. The potency of scale in a critical context may, for example, function as
a revealing parody of such totalising views, or as a repurposing of scale as a critically
reflexive technique. An example of the latter is Forensic Architecture's visualisations of
drone and artillery strikes in Afghanistan (2018). Here, the density of the visuals is in
contrast to the obscured nature of these strikes in Western media, so that the scale of
visual information uncovered in their investigations is in itself a commentary on the
lack of media coverage and government accountability of the attacks. In instances such
as this, the choice of scale presents itself as another cut in the practice of
aestheticisation, an opportunity to reflect upon the work, its aims, and its audience.
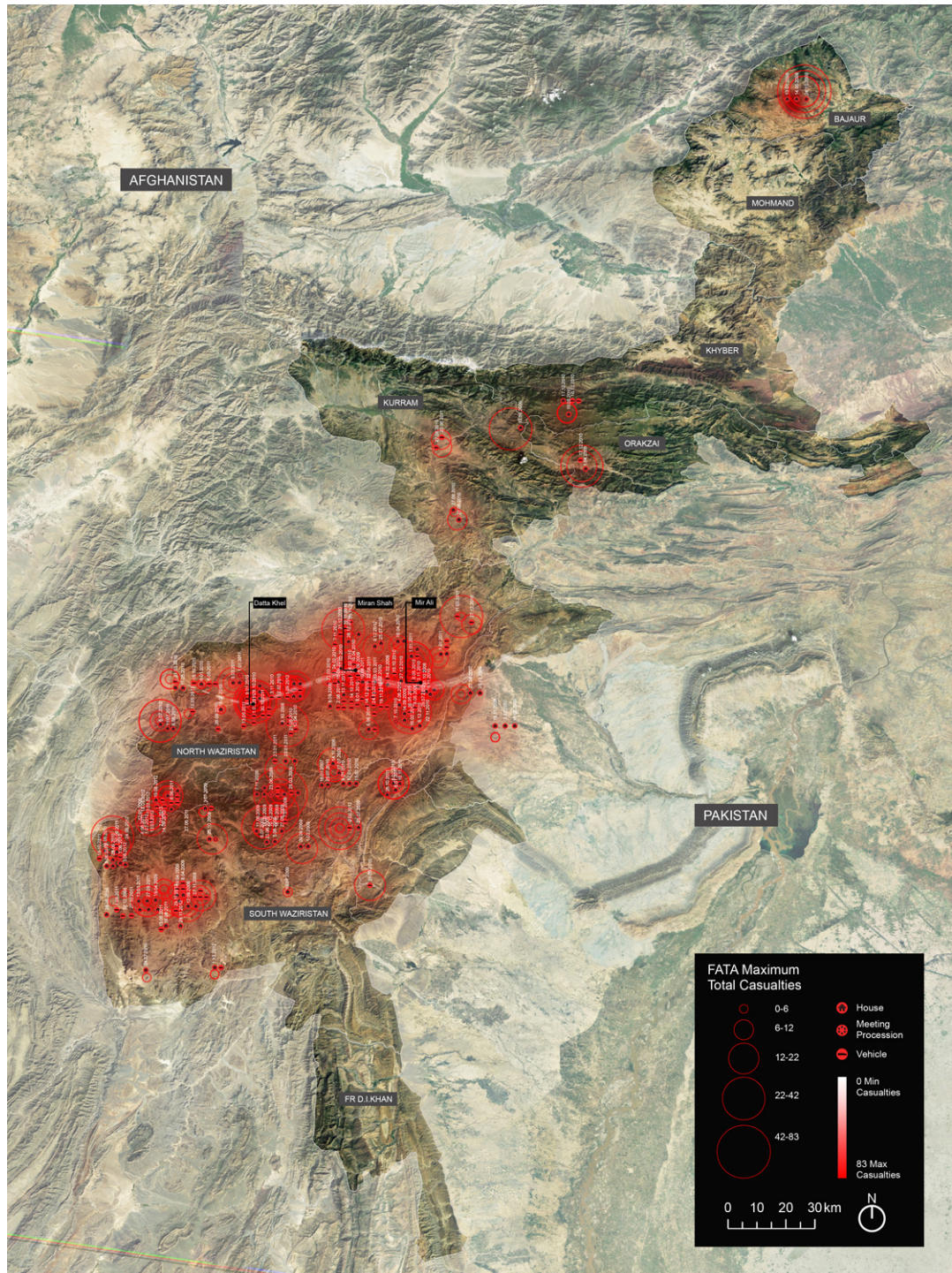
Figure 14: A visualisation of drone strikes in Afghanistan by US military forces, by Forensic Architecture.

Source: https://www.forensic-architecture.org/case/drone-strikes/#toggle-id-5

Ground Resistance

In engaging with the conditions detailed in this chapter so far, *Ground Resistance* was a

demonstration against the smart city discourses of top-down control and hyper-

presence. It was intended to create an interpretative, situated view of the smart city that highlighted the temporal and spatial gaps in such a system. The work set out to demonstrate how the authority of these systems is asserted and reinforced by rhetoric and aesthetics, and asked how to present an understanding of the data at hand as a form of situated knowledge, rather than a mechanically objective account of the city.

The work was a collaboration between myself and Georgina Voss, and this exchange contributed substantially to this project. Georgina's training in anthropology and policy research meant that we inhabited distinct disciplinary perspectives on this topic, while sharing many of the same overarching concerns. The value in this form of collaboration is substantial when the politics of data and cities is in the purview of such a wide range of fields. What this collaboration notably engendered was a wide-ranging discussion around the concerns we shared on this topic, and how they might be enacted in the work. While I was responsible for synthesising these discussions into practice, this should be understood as a co-authored piece given how essential Georgina's insights were in developing the critical and conceptual intent of the work.

Ground Resistance was comprised of a 4m x 3m floor-projected map of Milton Keynes, with eight ceiling-mounted speakers hung above it. The installation sonified and visualised multiple data sets selected from the Open University's MK:Smart project. We were given early access to the MK:Smart dashboard in order to explore how the open data was being collected and classified. The data we selected constituted every set that concerned to the 'hard' infrastructure of the town in the MK:Smart system, such as electricity and gas usage, traffic, car park spaces, and bus movements. Every point of data had been geotagged, meaning that it could be visualised onto, and sonified above, the area of the map that the data referred to.
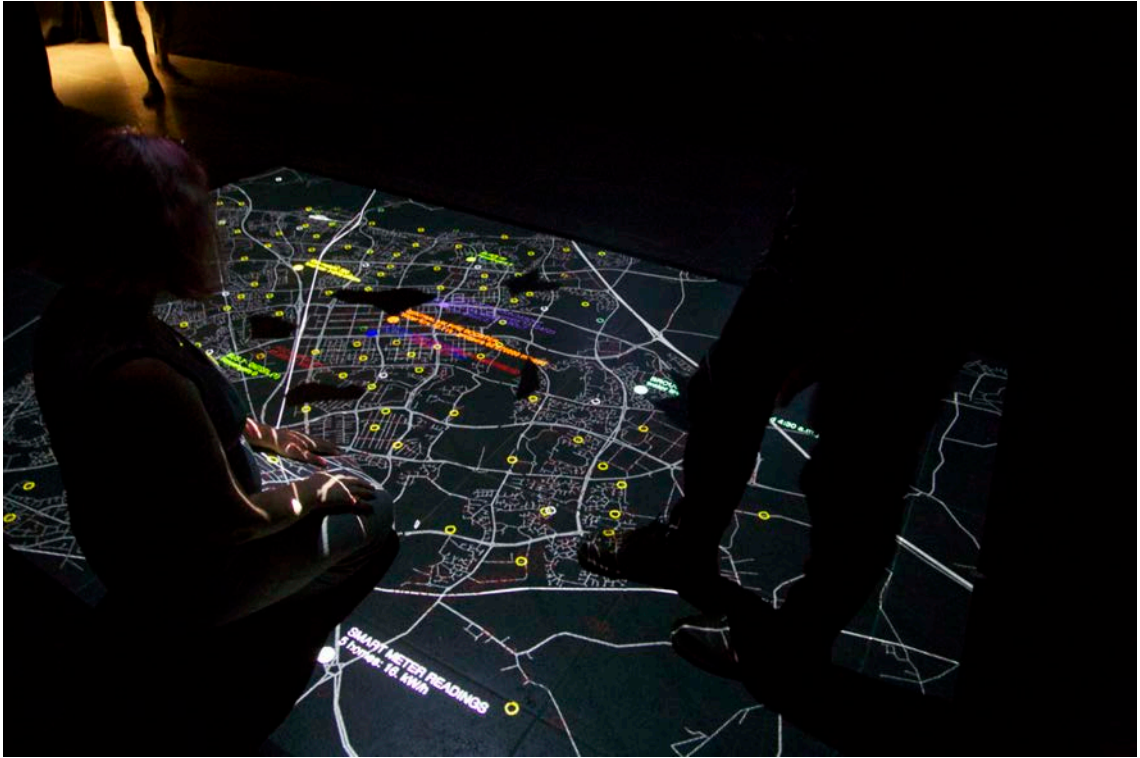
Figure 15: *Ground Resistance,* showing the floor-projected map of Milton Keynes.

The immersive nature of the walk-through map created a form of navigating this data that implicated the viewer within it, rather than keeping them at the distance that a dashboard does. Moving through the map altered it to being something physically oriented to an audience member's body, rather than only their view, obscuring some elements while bringing others into sharper focus. This blurred the physical separation between observer and map, as well as the separation between map and place.

Time

As with many smart city projects, the MK:Smart hub was comprised of data from multiple sources, both industrial and civil, with different methods of data collection, aggregation, and delivery. This meant that while many of the datasets at hand were referred to as 'live' in the database, the specific metrics of time varied wildly between each source. For example, roundabout usage was updated every sixty seconds, while car park space availability was updated by the supplier every two minutes. Other data

sets involved temporal values which were not current; for example, data on electricity consumption of Western Power Distribution customers was accessible, but only for the previous year (and only recorded every thirty minutes). This seemed to us an immediate space for critique, both as a way of foregrounding the presence of corporate bodies in this space, and of considering the functional temporality of smart city systems that are referred to as 'live' or 'real-time'. Commenting on such systems where data is often promoted as being 'live' without any specificity as to what this metric is, Kember and Zylinska (2012) could easily be speaking of these data streams, rather than television, when they say that "[f]or some, its very essence, or ontology, is liveness" (p. 42).

The visual representation of the data in this work attempted to explicitly counter the narratives of totality and objectivity through a focus on temporality. The geotagged data was visualised as colour-coded circles on the map, with annotated text moving through the set over time, detailing the contents of each data point. To aestheticise the varying temporalities of the data sources, the visualisations would fade to black in time with the rate of data update; so a data set that was updating every minute would appear bright at the moment of its update, and be almost completely black at the point just before it updated again. This created a method of reading through the data that incorporated the temporality of each dataset, illuminating the distinct temporal contrasts between them. This also created a data visualisation where a totalising view of the data at hand was impossible; data sets faded in and out of view in a-synchronous rhythms with each other, in contrast to an 'all-in-one' approach to data visualisation, with the moving text annotations detailing the contents of each data set over time.

The speakers mounted above the map offered an opportunity for the spatial qualities of sound to add a further level of sense-making to the presence and temporality of the data at hand. In considering the choice of sound for this sonification, we were drawn by a

desire to ground the experience in a more historically substantial narrative than the smart city discourse expressed. As with *Breathing Mephitic Air,* this provoked a new research process, moving away from the contemporary discourse of the smart city and technological exceptionalism, examining instead the wider contexts of this domain. This was another aesthetics-led research process, one informed by the demands of a critically reflexive practice, with the aim of uncovering aesthetic references outside of our initial theoretical concerns.

Driven by the temporal focus of this work, we settled upon an inspiration drawn from Lewis Mumford's claim that "The clock, not the steam-engine, is the key-machine of the modern industrial age" (1934, p. 14). Mumford's point illustrates the importance of clock towers and bells as tools of mass-synchronisation, in itself both a requirement and a goal for the smart city. To draw this discourse into the work, the sound of each of the 18th century bells from the nearby St. Andrews Church in Great Linford were sampled, and each of these samples was assigned to a data set. These sounds were then digitally processed so that the decay rate of each bell (the time it takes for the bell to fall silent after it has been rung) matched the update time of the data set. When a data set updated, its matching bell sample would 'ring' and begin decreasing in volume at the same rate that the visuals for that set faded from view. With the eight speakers mounted directly above the projected map, spatial audio processing was employed to make each bell ring directly above the position on the map that visualised its corresponding data. This created a dynamic soundscape that offered a secondary mode of 'reading' the temporal dimensions of each set, drawing upon the strength of listening as a rhythm analysis method to allow the audience a constant and immersive sense of the varying temporal dynamics at play.

Absence

Although the data used in this installation related to elements such as household utility

use and civic infrastructure, there were still areas of the town with a notable absence of geotagged data. For example, there was no data in these sets for the Conniburrow Estate, located very close to the centre:MK shopping centre where *Ground Resistance* was exhibited. This provoked new questions: why were these areas absent from the data? Was it human or mechanical error, or something intentional? Questions such as these, which address who and what may be left out of the smart city, demand enquiry into the all-seeing, '24/7' discourses of the smart city and made these absences a compelling site of examination for this work.

This absence of data was explored in *Ground Resistance* by analysing the six urban areas of the map for which there was no data in the sets at hand, and performing a sculptural intervention on the visualisation itself. Sheets of black acrylic were laser-cut to match the shape of these areas of absence, and hung on monofilament wire below the projector above the area the shapes corresponded to. This created shadows which imposed themselves on the projection as a black far deeper than can be achieved with projected light, creating truly black voids over the areas that were absent from the data. This stark interruption of the seamlessness of the visualisation, coupled with the very visible sculptural element of the shapes hanging down between the audience and the projector, created an environment where the absences in the data were foregrounded to the audience, rather than obscured.

Figure 16: Acrylic shapes causing black shadows to be cast through the projection and onto the floor.

The foregrounding of absence served not only as a rejection of the spectacle of scale, but also to highlight the value of absence as a critical tool in this context. This is addressed in Catherine D'Ignazio's notion of a feminist data visualization (2015), in which she argues that in visualising absence and uncertainty we mark limitations and expose what is missing, challenging totalising promises and rejecting data and its visualisation as a catch-all solution. The combination of effects in *Ground Resistance* created a view of the smart city that was based upon the temporal and spatial gaps in the data at hand, instead of the narratives of breadth and presence. One observer close to the organisation behind the MK:Smart system described it as 'an existentialist view' of the data, an apt description given that the work intended to question some of the fundamental discourses of the smart city, and reflect upon alternative modes of understanding such systems.

Figure 17: Text boards detailing the data sources and aesthetics, overlooking the installation.

Much like *Breathing Mephitic Air,* the presence of text within the installation made other layers of context available to the audience. The first of the two text boards detailed what the audience were looking at and listening to, functioning as a key to the aestheticisations, while the second board detailed the sources of the data and the functions of the mechanisms that produced it. The latter component was produced through investigations performed by finding and contacting the respective data providers and requesting details on how they gathered data, at what rates, and why. This revealed additional layers to the temporal focus of the work; for example, that the reason for the car park data updating only once every thirty seconds was simply to limit 3G data costs to the provider. This additional research foregrounded the industry bodies and the many layers of human subjectivity in the construction of this view of the city, in contrast to the narratives of the 'magic box smart city' and its supposed mechanical objectivity.

Exposing Gaps

As was shown with *Breathing Mephitic Air*, *Ground Resistance* illustrates how a critically reflexive practice of aestheticisation can respond to theoretical concerns, and how these can be expanded and developed through the practice itself. This work also sets out to expose the gaps between the presented narratives of data and their reality in practice. Keller Easterling suggests the potency of exposing such gaps, or "[r]edesigning disposition", in a presented narrative by exposing "the ways in which power says something different from what it is doing" (2014, p. 214). This drawing of attention to limitations offers an opportunity to critique how these narratives may serve those in the position of power to dictate them.

In the context of this work, the always-on and all-seeing capacity of the smart city projected by many developers and their government clients is one such narrative that deserves disruption. When these systems are perceived to be the solution to such an old problem as the ideal optimisation of civic governance, the discourses surrounding their capacities should be closely scrutinised to ensure that governments are responding to the needs of the population, not to the promises of corporate developers and technological solutionists. In exposing the difference between the a-synchronous and incomplete view in this system and the all-seeing, 24/7 promises of the smart city, *Ground Resistance* enacts this scrutiny. The goal of such an act is to leave audiences in an empowered position in relation to these systems, fostering new forms of literacy towards the intimate function, capacities, and limitations of the smart city.

Resistance

The redesigning of disposition is a central component of this work as a demonstration. The political nature of such a demonstration is made explicit by Barry, when "the telling of a truth in public can never be described as disinterested" (2001, p. 178), with the 'truth' at hand in this work being the temporal and spatial realities of this smart city

system. What was kept in mind in this was avoiding what Jacques Rancière refers to as the 'pedagogical model' of political art (2010). Such a model positions its audience as receivers of authoritative knowledge, and where the condition of success is the conversion of them to a particular cause or belief.

In contrast, *Ground Resistance* is explicitly not presented as a static narrative in which something needs to be 'learned' in order to 'complete' an interaction with the work, and we did not try to cross-examine every audience member that left the installation; instead, there were many cuts made in the creation of this work that reflected our desire to allow the audience as much agency as possible within the system we were building. The processes that implicated the body and the viewer's attention throughout the work were intended to be dictated by the agency and interest of the audience member, as much as the aestheticisations are determined by the rhythms of the system under observation. This approach to audience-directed interactions with the work was also bound into its rejection of the spectacle of scale, where the visualisations were inherently tied to both the pointed absences of data, and the temporality that prevented an all-seeing view to be achieved. Rather than presenting an immutable and final visualisation, it was grounded in the necessary impermanence of such a view and the futility of attempts to fix something as fluid and dynamic as a city in place.

With no narrative 'destination' in this work, it allowed what knowledge may be synthesised from it to be led by the audience, who occupied the position between the subject of the work and its contested meaning. When the narratives of the smart city so frequently privilege the experience of the operator of the systems over their population, this approach had added resonance with our critical and political intent as its authors.

Alongside the other aesthetic decisions in this work, the exhibition location of *Ground Resistance* was selected with reflection on our critical goals and how this decision may

impact them. After visiting several potential sites within museums and art galleries, an empty shopping unit in the centrally-located centre:MK shopping centre in Milton Keynes was chosen as the exhibition site. This central commuter hub was both well known in the surrounding areas and easily accessible by a range of communities. When installed, signs were placed throughout the shopping centre directing visitors to the installation, and well-briefed installation assistants were present to answer questions and enter into discussions during each day of exhibition. This produced a constant throughput of visitors to this critical view of the smart city, one which offered a novel view of familiar geographic territory.

This stands as an example of how the making of cuts continues into both exhibition and dissemination. The properties of who has access to the work and how, and through which gatekeepers, changes between spaces. While the gallery may be the appropriate venue for some works, alternative venues can be valuable sites of engagement, and involve communities who may not see themselves or their interests as being served by traditional art spaces. Reflecting on the varying limits of access to different spaces requires considering the needs and experiences of the audience, an attitude which should be woven into every decision being made throughout critically reflexive work such as this.

Throughout its exhibition, I spent some time within the exhibition space acting as an invigilator, using my time there to observe audience interactions in the installation, and be on hand to discuss the work if needed. During these moments, several audience members reported that it had been their first engagement with the subject of smart cities. When so much promotional hyperbole surrounds the smart city, introducing a critical perspective on it was an alluring opportunity to introduce a dissenting voice on a subject that may, in time, profoundly influence how the population of Milton Keynes is governed. Introducing critical discourses into the beginnings of cultural conversations

with such wide potential impacts is an incredibly valuable and often one-time opportunity. This is one of the particular advantages of making work that critiques emerging or novel technologies; these are sites where critically reflexive art and design practices may perform early interventions upon domineering discourses that exploit individuals and communities through these technologies.

The Limits of Access

We were fortunate to be given the access we had to the database behind the MK:Smart project, as it enabled informed technical critiques to arise from our investigation of the system. Given that much of the concerns around the smart city detailed in this chapter relate to the opacity and limitations of access to the systems behind them, leveraging the access we were given was a goal from the offset. This produced the deeper analyses of elements such as the sources of data, the mechanisms of construction, and the structure of the data sets themselves.

There are, however, many sites in the critical study of data where practitioners and researchers have limited access (if any) to the data at hand, such as private data centers, proprietary data sets, and commercial algorithms. This presents a substantial obstruction to critical enquiry at both the technical and cultural levels, and requires alternative approaches than those described so far. It is towards such limits of access that the next chapter turns, with an exploration of how opaque networked technologies and their politics can be interrogated through aesthetics- and practice-led investigations.

Chapter 4: The Dark Age of Connectionism: Captivity

The Dark Age of Connectionism: Captivity (Goatley 2017b) was an artwork commissioned by Haunted Machines for Impakt Festival 2017 in Utrecht, The Netherlands. This work explored the limitations of devices such as the Amazon Echo through a multi-channel audio and sculptural installation. Through this, it suggested new forms of behaviour for living amongst these technologies, and how the opacities encountered in their function can be responded to. This was an iteration of an ongoing series of works titled *The Dark Age of Connectionism*, exhibited between April 2017 and December 2017 (Lighthouse 2018; V2 2018; SFX Seoul 2018).

This work was influenced by theoretical investigations into the field of devices referred to as 'smart speakers' such as the Amazon Echo. This chapter will begin by framing this work as a demonstration, focusing upon the capacities and challenges of critiquing the 'smart speaker' field of devices. In discussing how *The Dark Age of Connectionism: Captivity* responded to these challenges, I will explore how the reflexive practices and theoretical approaches to data aestheticisation explored so far in this thesis were applied and developed, alongside how they can be applied in the context of 'speculative data'.

The Rise of the 'Smart Speaker'

When Apple incorporated their Siri voice assistant as a non-removable component of the new iPhone 4S and iOS update in 2011 (Velazco 2011), voice-user interfaces became implicated in the lives of millions of consumers through their personal devices. Since then, the ongoing refinement of voice-user interaction technologies has enabled the 'smart speaker' field of consumer technologies to emerge. These are audio playback devices that utilise voice-user interfaces, and are reliant upon internet access to networked data centers to perform their computationally-intensive feats of natural language processing, data analytics and voice synthesis. While the development of

voice-user interfaces is a field more than half a century old at this point (McCorduck 2004; Pieraccini 2012), there is an evident contemporary surge in its popularity. The increase in major product launches in the 'smart speaker' field since 2015 indicates manufacturer confidence that the combination of technological advancement, required infrastructure, and consumer desire necessary for these devices has been achieved; and this is also a moment when the information gleaned from the user base of these products has lucrative applications.

The market for these devices is a site of considerable investment from some of the world's largest consumer technology corporations, with a noticeable increase in high-profile products being released in the UK in 2017 alone (Apple 2018a; Amazon 2018a; Amazon 2018b; Google 2018a). This raft of new products (and the first forays into this market for both Apple and Google) appears buoyed by the $400m valuation of this market in 2016 (Global Market Insights 2018), with claims that this could increase to $13bn by 2024 (Globe News Wire 2017). This expansion is not without its tensions, with popular media sources offering warnings regarding the concerns of data privacy presented by these technologies (Brandom 2017; Estes 2017), which repeatedly echo the anxieties of being constantly 'listened to' by these devices. These anxieties are occurring alongside practical investigations into the cryptographic security of these devices and its potential exploitation (Apthorpe *et al* 2017).

Examining these concerns is problematised by the layers of opacity common to these devices. The physical forms of products such as the Amazon Echo, Google Home, and Apple HomePod all feature minimal points of user interaction, and a trend towards seamless design principles which obscure crucial components, such as microphones. Alongside this, the algorithms and machine learning systems which underpin the capacity of these devices are closely-guarded intellectual properties, and the data centers from which they operate are on well-secured private property (Mosco 2014;

Burrington 2016). In spite of the rise in popularity of these products, these layers of restricted access problematise investigations into the limitations of the technologies, the ideological decisions evident in their code, and the analytics being performed upon the data they capture.

Conditions such as these are a considerable obstruction to the study of a technology, as social constructivist critiques of 'black boxed' technological systems illustrate (Bijker *et al* 1987). However, a purely technical 'unboxing' of such technologies fails to expose the deeper power structures and ideologies that underpin their development and dissemination (Winner 1993). To challenge the limits of access presented by a networked technology such as the smart speaker, a technical unboxing similarly fails; for when the data collected and analysed through them is kept geographically separate from the device itself, and this data is part of an existing data brokerage ecosystem (Federal Trade Commission 2014), the problem of access to this particular form of black box is not one that can be solved through simply scrutinising the mechanical components of the device.

Gaining Access

To critique these networked systems, what is required are methods that draw attention to the limits of access to data and decisions inherent to them, and engaging with who benefits and who may potentially suffer from this arrangement. In pursuit of this, there are available avenues of investigation that engage with the social, technical, and political elements of their function, and from which an intervention can be developed.

A close-reading of the terminology used to describe the hardware and software at the core of these devices begins to suggest the discourses and use cases which their developers promote, and a route to their critique. As discussed in the last chapter, the term 'smart' carries with it a discourse of progress through technology in spite of its

lack of specificity. Its use is prevalent in the field of 'Internet of Things' devices in the home (smart fridges, smart thermostats, smart meters), in which the smart speaker is positioned as a voice-user interface for this broader network of home automation devices (Google 2018a; Apple 2018a; Amazon 2018c).

The domestic machine-utopia of the 'smart home' that smart speakers are intended to control has been argued to produce a passive and infantilised domestic subject, reliant upon multiple corporate actors for the basic function of their home (Darby 2018). The added concern here is that the voice-user interface becomes a commanding top-layer of control for these devices, that grants access to a range of other home automation technologies. This places the manufacturers of the voice-user interface in a position of power with uncertain outcomes. For example, while a smart thermostat made by an external party might be controllable with a Google Home voice-user interface today, this compatibility may be rescinded if Google decide to produce their own thermostat device, rendering the competing product obsolete within the Google platform ecosystem. Another concern is that the access to third-party devices required for interfacing with a smart speaker may also grant the speaker manufacturer discrete access to new, exploitable data on the home procured through this network of third-party devices. These eventualities are contingent on the 'smartness' of these technologies being accepted by their users and therefore deploying them in these contexts. As with the smart city, critiquing this term draws attention to the limits of function present in these devices, and undermines their potential for exploitation.

The framing of these devices by their developers as smart *speakers*, rather than smart *microphones,* also warrants investigation. In terms of hardware, there is commonly far more complexity in the form and function of the microphones in this field than in their speakers. The discrete near-field microphone array inside the hockey puck-like Amazon Echo Dot (Amazon 2018c) is a powerful component of the device, and an

impressive feat of audio engineering; yet to many observers the Dot might look nothing like a microphone, and the position of any of the seven internal microphones is difficult to discern without disassembling the device. While the speakers in such devices are typically impressive for the form factor, patent filings suggest the microphone technology and audio processing in devices such as the Amazon Echo is likely the subject of far more research and development (United States Patent and Trademark Office 2018).

The audio input processing in these devices, such as methods of noise cancellation, are in themselves complex processes that are far from value-free. What is programmatically determined to be measured as 'noise' is a decision that fixes this into the functionality of the device; but noise itself is always contextual, and always subjective. A police siren can be considered a form of invasive nuisance, a source of profound relief, or one of impending threat to different people hearing the same sound. Hard-coding certain boundaries of sound as being 'noise' may cause difficulties in detection for those who speak with mechanical assistance (Kaye *et al* 2017), with 'marginal' dialects and languages (Paul 2017), or in architectural spaces which amplify nearby traffic sounds (Newman 2017), to name but a few. To fix a definition of noise is to determine the 'correct' space for the user to be in, and a 'correct' type of voice, to the detriment of any who do not fit this ideal. As Jacques Attali states regarding the political dimensions of noise: "Everywhere, power reduces the noise made by others and adds sound prevention to its arsenal" (1977, p. 123).

Always Listening

In the context of the above discussion, it's more accurate to instead describe this range of products as 'always-listeners' rather than 'smart speakers'. The common term 'always-on' is a descriptive one to frame the function of these devices when neither the Google Home, Amazon Echo, or Apple HomePod are fitted with an off switch. Given

that the capabilities of such always-on devices are being constantly refined based on the collated interactions with users (Amazon 2018d), they cannot be said to be just 'hearing' what's being spoken; listening is an active intention, in contrast to the passivity of hearing. The term 'always listeners' then describes multiple purposes of their design: to be operated continuously, to employ ubiquitous microphone operation, and to actively analyse the captured data. To use this small linguistic protest against these nominative obfuscations foregrounds the intersections between their political, ideological and technological contexts every time it is invoked.

Exploring the naming of always-listening devices, when the image of the corporate identities behind them is so painstakingly curated, can itself contribute substantially to our understanding of them. Take Siri for example: the name is extrapolated from the acronym SRI, or Stanford Research Institute, who were responsible for the core development of the Siri technology. The SRI's initial research was commissioned by the US military's DARPA (Defense Advanced Research Projects Agency) department. This research was part of the CALO project, or 'Cognitive Assistant that Learns and Organises', with this acronym itself taken from 'calonis', Latin for 'a soldier's servant', revealing its origins as a battlefield assistant (SRI International 2018). As with the other elements of the design and implementation of such devices, this is an instructive example that names and naming are never neutral.

Naming is implicated again in the field of voice assistant technologies embedded within many of these consumer products, such as Microsoft's 'Cortana', Amazon's 'Alexa', and Apple's 'Siri'. With all of these, and the default voice for the Google Home voice assistant, being coding as female identities, these organisations are "presenting an embodiment of woman that is bodiless, yet interactive and conversational" (Branham *et al* 2011, p. 410). This politically and ideologically loaded norm across this field is extremely concerning, framing the female personality as one of subservience that

delivers on-demand responses to issued commands (Sweeney 2013). The potential ramifications of this are far-reaching, with the potential to trivialise "the violence experienced in real life against our real bodies and our real selves" (ibid) experienced by women across the many spaces these devices operate in.

The form of these always-listening devices follows certain trends and commonly share materials, often looking not dissimilar to an air freshener. This isn't a purely aesthetic analogy; this association serves the stated aim of the manufacturers to make an object that is ambiently, almost invisibly, enmeshed into spaces such as the bedroom or kitchen (Amazon.co.uk 2017). The kitchen itself is a recurring use-case scenario in adverts for the Echo (mpixy 2016), which is a revealing decision; the kitchen is the most frequent place in the home where items such as cooking ingredients and cleaning products need re-stocking, often when both hands are occupied with food preparation, dish cleaning, etc. This makes it the ideal location to promote the installation of an Echo, where its advertised use-case scenarios are often tied closely to the company's online purchasing system (Amazon Echo 2018).

To consider again the parallel developments surrounding these technologies, the launch of multiple Echo products on the market coincides with a time when Amazon appears to be positioning themselves as the provider for household items and food, as the Amazon Dash button (Amazon 2018f) and their acquisition of the international supermarket chain Whole Foods (Chan 2017) would suggest. It would seem that, unsurprising for a global company of its scale, Amazon are very specifically framing and promoting the use of its always-listening devices in the precise way they want their consumers to engage with the devices.

Speaking to the Underworld

During its development in the 20th century, sophisticated speech-to-text (and text-to-

speech) technology had proven to be computationally expensive, and was rife with

under-delivering on the lofty promises of its proponents (McCorduck 2004). The latter

has plagued the history of artificial intelligence research more broadly, such as with AI

luminary Marvin Minsky's (debated) claim in 1970 that by 1978 "we will have a

machine with the general intelligence of an average human being" (Minsky, quoted in

Darrach 1970, p. 58D). While technologies such as Amazon's Alexa voice assistant

have yet to fulfil these claims, the operational requirements of its voice-user interface

are met through Amazon's use of its networked data centers. These handle the

computationally-intensive tasks of speech analysis, natural language processing, and

voice synthesis, tasks which cannot yet be performed on a device the size of an Echo.

The Echo itself effectively only listens for its 'wake word' (the default being 'Alexa'),

transmitting anything captured by the device after this word to be processed off-site to

one of a number of possible geographical locations where Amazon operates a data

center. This makes the device itself simply a conduit through which data flows to this

distributed network infrastructure, a portal to the underworld.

The strength of this approach is that it allows this form of voice interface to function

through a relatively inexpensive and comparatively small object. This is in stark

contrast to the cost and scale of operating a network of data centers, such as Amazon

Web Services (AWS). Deutsche Bank (Kim 2015) declared AWS to be the 'fastest

growing enterprise technology company ever', and since this declaration AWS have

seen their revenue triple (Statista 2018). The reliance upon this infrastructure can have

far-reaching ramifications; while a company Slack channel going down for two hours

may seem disastrous to its employees (as Slack operates on AWS servers [AWS 2018]),

it could cost lives when Amazon are pitching the Echo as a support tool for the health

sector (Nickelsburg 2016). Network infrastructure is then inextricably tied into the

function of these always-listening devices, and how both the infrastructure and its

obscured relation to the end-node are an unavoidable subject in their critique.

The risks of such a heavy reliance on data center infrastructure and connectivity is not just a potential problem for Amazon, for Apple and Google also rely upon their own networked services to perform their feats of voice-user interface. However, this situation is also key to a considerable form of profit relating to these devices. Google, Apple, and Amazon's terms of service make it clear that the companies can legally use data gathered through their always-listeners towards further, unspecific ends and retain it for undisclosed lengths of time (Google 2018b; Apple 2018b; Amazon 2018d). The value of this data is clearly considerable, given that supply-side analytics suggest that the production of the Echo hardware and operation of the required network infrastructure is potentially done at a considerable loss in order to establish this valuable user base (Hook *et al* 2017).

This situation also draws out the paradoxes of space and place inherent to these devices. The data centers that process the voice data and perform analytics on it are typically geographically disparate, and even when logging the IP address endpoint for the communication, it can't be proven where else the data may travel afterwards. This geographic re-location of the voice places the data under potentially different legal jurisdictions than those of the owner of the voice, where there may be different data protection laws and intelligence agency capabilities. This location needn't be static, and can result in strategic relocation of data processing to avoid data protection laws unfavourable to certain practices of data exploitation (Ingram 2018). These political ramifications of the detachment of the voice from the body parallels the AI assistant, which is a voice deprived of a body; and both situations represent new ways of implicating bodies in the politics of exploitation.

Hidden Drives

These infrastructural dimensions also obstruct investigations into the analytics

performed on data captured by devices such as the Echo. As David Beer argues, there is already a "powerful role – both technical and rhetorical – played by the emergent industry of analytics" (2018, p. 465), and this industry has a vested interest in conjuring up hype surrounding the "analytical prowess of data" (p. 466). Kennedy, Hearn and Andrejevic note that the substantial relationship between data analytics and "questions of power, subjectivity, governance, autonomy, representation, control, and resistance" (2015, p. 384) means that when such analytics are routinely hidden from public view, they possess a threatening potential for "new, unaccountable and opaque forms of discrimination and social sorting" (p. 379). The secrecy surrounding such algorithmic processes is argued by Nick Seaver to not simply be a barrier to be overcome in their study, but an inextricable part of the practices of the organisations themselves (2017). Even if researchers are given access to data or proprietary systems such as these, what data is kept from them, or only provided to those with particular forms of privileged access, are factors that create systemic unevenness in their study (boyd and Crawford 2012).

To both draw attention to and challenge this obfuscation, what is required is a form of critical speculation that is performed in reflection upon the evident tools and capacities of the manufacturers of these devices, and the cultural contexts they operate on/in. Such speculation finds its ground in the fact that Google and Amazon confirm in their terms of service that they already use data analytics on their users' online activities to produce targeted advertisements; the new domains for analytics that voice-user interfaces allow would extend this existing logic away from the keyboard or smartphone and into the (former) privacy of the home.

For example, Amazon has developed what it calls 'Echo Spatial Perception' (Amazon 2018g), which performs distance estimation based on the spectral qualities of the users' voice; differentiating between a close voice and a voice on the other side of the room.

If this was combined with Amazon's 'Comprehend' natural language tool (Amazon 2018h), the sentiment of this speech could be analysed. If a voice was then detected as increasing in volume but not distance, and the content of speech included terms determined to be commonly used in anger, it would be theoretically possible to build a voice analysis system that attempted to discern if there was an angry argument occurring in the home where the Echo was based. This system would likely be clumsy, simplistic, with a low success rate to begin with, but may be improved through training data in the same way that these devices are already being trained. For companies like Amazon and Google, who have built successful and powerful businesses through attempting to discern (or influence, or dictate) what their customers will buy next, this information could prove profitable if, for example, the account holder for the device then sees targeted adverts for local couples' counselling services, or self-help books for navigating abusive relationships. Seeing these sorts of advertisements flooding a browser window through ad banners or sponsored content when surviving trauma may well intensify it, or cause other forms of trauma to occur.

Such analytic processes might not only be performed upon what is said to and around these devices, but also to the sounds of the environment and of bodies interacting with it. Take for example the promotion of these devices as being kitchen assistants, as noted earlier. On hard flooring such as laminate wood, linoleum, and other wipe-clean surfaces common in kitchens, footsteps are far more audible than on carpeted floors. Given the spatial location technologies of the Amazon Echo's sound processing, this would mean that more than one set of footsteps detected on opposite sides of the room could be discerned from each other through this device. This could mean that machine learning analytics (such as Amazon's 'Rekognition' technology [Amazon 2018i]) could be applied to the detected footsteps to determine the number of potential consumers in the house, regardless of who speaks to the Echo. This would clearly be a valuable metric to advertisers, potentially revealing indications about income, home size, and

demographic information. Given that the sound of typing on keyboards can be used to remotely confirm individual identities (Roth *et al* 2014), this is not an overstretch of what can be extracted from such data.

The consequences for this extend out of the corporate realm and into the state and geopolitical level. Given that internet communication passing through US soil comes under the telecommunications jurisdiction of that country, and that Google, Amazon, and Apple all operate data centers in the US, users of these devices could find the sentiment and content of their speech to be a factor in a successful border crossing into that country (or potential forced extradition from it) as already occurs with smartphone data (Solon 2017). Such effects could also extend to countries that share such intelligence with the US, such as the UK, Canada, New Zealand and Australia. Even Apple's assertion that voice recordings from their HomePod device will be encrypted (Apple 2018c) is no guarantee of privacy, given the information made public by US National Security Agency contractor Edward Snowden in 2013 that the NSA had established access to at least some of Apple's servers as early as 2012 (The Guardian 2013). The use of personal data 'to improve products and services' may also extend to tools developed specifically for the US military by Amazon, including Echo-related technologies such as voice synthesis and natural language processing (Amazon 2018j), an example of how data captured by these devices may be implicated in a much older and more powerful industry.

Speculations such as this are just that: speculations, yet necessary ones. Moreover the obfuscation central to these assemblages mean that speculations cannot be dismissed as inaccurate, only unconfirmed. In this context, these speculations are valuable because they articulate what the promise and strategy behind such technologies may be: the promise of a helpful home assistant, that obscures the strategy of the 'always-listening' smart speaker as a vehicle for data collection and analytics.

Speculating in this way is an enquiry into how these systems may function today, as well as a warning as to how they may function in the future. The value in this speculation in the context of critical practice is already present in fields such as speculative critical design (Dunne and Raby 2013), where proposing near-future scenarios is a rubric through which to interrogate the present, "to question, in an imaginative, troubling, and thoughtful way, everydayness and how things could be different" (p. 189). This speculation creates an opportunity for creative and critical thought to conceptualise and present alternative routes to interrogating these devices and their politics. Creative practice can be another form of speculation – and one that offers different insights than those gained through speculative fictions.

The Dark Age of Connectionism: Captivity

The Dark Age of Connectionism: Captivity was an installation that comprised of a ring of seven microphones surrounding an Amazon Echo hanging above a small speaker, with additional speakers mounted in the ceiling above. In contrast to the design of Amazon's device, these microphones were arranged to appear to be overtly monitoring the area surrounding the Echo, craning over the audience. The microphones captured sounds such as footsteps, the rustle of clothing, noises from phones, as well as speech. Any sound detected by the microphones triggered the voice of 'Siri' from the small speaker to ask a question to 'Alexa', which the Echo attempted to respond to.

There were over three hundred possible questions to be asked, all rooted in an analysis of the present and historical context of the device. Examples of the questions included 'Alexa, can you please read out the terms and conditions of your usage?', 'Alexa, who decides what languages you can speak?', and 'Alexa, how long a break do workers in Amazon warehouses get every hour?'. Each new question interrupted the last as new sounds were detected, creating a constant stream of partial questions and responses

between the two voice assistants. In order to hear a question and its answer without interruption, audiences had to devise methods to move silently around the device; an experiment in learning new behaviours that don't reveal their presence to these technologies.

In asking these questions, the technical limitations of the device were also presented to audiences. The promise made through Amazon's marketing of the Echo show it conversing fluidly with its owners. How this was exposed in this installation was in how the Echo could frequently not parse questions in conversational tones, in spite of the claims to being a conversational interface. This was not merely an artefact of the synthesised voice of 'Siri' asking the questions, as certain trends were notable; for example, questions that involved adding items to an Amazon wish lists or shopping basket were more likely to be successfully interpreted by the Echo. Occurrences such as these exposed the strategy operating alongside this promise: that the non-neutrality of the device's function suggested that its speech-to-text system had been developed with particular emphasis on successfully processing purchases through it, rather than having a meaningful conversation with 'Alexa'.

Many of the questions intentionally tested these technical capacities of the Echo's voice analysis and synthesis technologies. Examples such as including database manipulation commands in questions demonstrated that an adversarial position could also be adopted through this process. This continued through questions which drew attention to landmark legal cases with wide-ranging privacy implications for other always-listening devices, or the behaviour of Amazon's founder, Jeff Bezos. In spite of the opacity of the Echo, these questions demonstrated the many routes to knowledge that are available through critically aware and inquisitive interactions with these devices.

Figure 18: *The Dark Age of Connectionism: Captivity* installation view, showing the microphones surrounding the Amazon Echo.

During each day of the exhibition, every instant of sound captured through the microphones was being stored in a database of half-second audio recordings. If no sound was detected by any microphones after fifteen seconds, these sounds would begin playing from the speakers mounted in the ceiling above the installation. The sounds were triggered in random order, reorganising the audio into new arrangements. The resulting combinations of syllables and noises produced new and unintended forms from the collected sonic data. This attempt at computational sense-making of the installation's inputs was an intentional parody of Amazon's storage and analysis of sound captured by Echo devices.

With both the central voices in the installation being female-identified assistants, their presence offered an opportunity to reflect upon the predominance of the disembodied

female-coded voice in these devices. Upon examining the device and the accompanying API, it was clear that the voice of 'Alexa' is not directly manipulable through the Echo itself; this spurred a new aesthetics-led line of research into the techniques of Amazon's voice synthesis. This led me to Amazon's 'Polly' text-to-speech system, a product that is likely a co-development of the 'Alexa' voice itself. Polly's synthesised voices are in numerous dialects and languages, yet the majority of them are assigned a female identity. When there is only one voice, it is commonly labelled 'female'; such as the only Korean voice in the system at time of writing being 'Seoyeon, Female' (Amazon 2018e). To highlight this persistent development of female voices, every female voice present in the Polly system at that time was played above the entrance to the exhibition space, each chanting the word "Alexa" in a generative arrangement. Instead of a subservient role as passive respondent, these voices were gathered together in protest, calling to the one voice missing from their number.

Figure 19: The Amazon Echo, suspended above the speaker amplifying the voice of 'Siri'.

Speculative Data

The approach to aestheticisation in this work builds upon the findings of the theoretical

investigation that informed it: that speculation can produce new methods for

interrogating networked technologies that present substantial limits of technical access.

The limited access to what data is collected through these devices, and how this

obscures the consequences of what the data collection may be, is what this work is a

demonstration against; and it is also a demonstration of how a response to such

conditions can be posed, and articulate new possible routes to knowledge.

In this response, I employed aesthetics to explore 'speculative data', or data that we

know exists, can assume is being analysed to produce more data, and yet we have no

access to. Speculation as a component of such practice is "not a destination or something to be strived for but a medium to aid imaginative thought" (Dunne and Raby 2013, p. 3). Here, this speculation formed a central conceit: that what may be possible, and in fact happening, behind the facade of these devices should be seen as something to be wary of, a threat to be physically circumvented. In foregrounding the audience's bodies as sites of information production, reducing the amount of sound made around the Echo was framed as a personal exercise in data privacy. This activity was also the driver of the interaction within the installation; for when audiences produced less sound, the questions being asked to Alexa would cease interrupting each other, making their content and the Echo's response both legible. In my observations of audience members in the space this was a successful approach, and one that highlights the value of 'silence' as a critical tool in data aestheticisation.

Silence is not simply the absence of sound; from my own experiences in anechoic chambers, the sounds of the human body's respiratory and circulatory systems are an inescapable constant, preventing access to a state of silence as the absence of all sound. Silence is then, like noise, a shifting and context-dependant state. The influential composer John Cage[4] articulated this in a discussion about silence, noting that for him, living above 6th Avenue in New York, the 'baseline' of sound was that of traffic outside of his window. This sound was in effect 'silence', the background level of sound that any other sound operated over (casinodc00 2007). This understanding of silence sees it not as an absence, but as a way of drawing attention to the background, the ignored, and the overlooked.

In public performances of Cage's seminal 'silent' composition *4'33"*, one becomes aware of the sounds produced by bodies that usually go unheard: the creaking of chairs as weight shifted, the rustle of clothing moving against itself, the discrete sounds of

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[4] Whose experience of anechoic chambers mirrored my own (Cage 1961).

digestive and respiratory functions. *4'33*" is not then simply an absence of sound, but instead presents its audience with an opportunity to re-think the role of sound in their lives, and to reflect upon what is unheard and obscured.

As Caroline Bassett notes when proposing silence as a response to the communicational economy of social media, calling for silence is not simply "an injunction to silently and individually withdrawal" (2013, no pagination) but is instead an active tactic in these contexts. *The Dark Age of Connectionism: Captivity* drew upon this understanding of silence to foreground how, when the body is a site of exploitable sonic information, sound is entangled with a co-existence amongst always-listening devices. It was a call to see silence in this context as a form of protest, to boycott the capture of the body by reframing all of its sounds as the Echo's input, and denying it them. Similar to the discussion on absence in the last chapter, silence, when used in this way, becomes not just the absence of sound, but a tool that can expose that which is obscured.

Situated Questions

The demonstration of what is possible and the notion of speculation as an aid to imaginative thought are most explicitly present in this work in the asking of questions. The questions being asked to Alexa were contributed by myself and twenty other invited participants, and this widening of the range of perspectives was a practice-based articulation of a situated knowledges approach to these systems. Considering that the recording and exploitation of voice recordings and other data by devices such as the Amazon Echo occurs in both private and public spaces, the range of people potentially implicated in this process is vast. In acknowledgement of this, I approached a range of people from the arts, academia, and industry, and from geographically and ethnically diverse backgrounds to contribute to the project. These multiple subjects each came with their own approaches to enquiry and knowledge production in relation to the Echo. This produced a collection of enquiries with many interpretations and potential

contradictions between them, whether they were about personal anxieties of living amongst these devices, the infrastructure that provides for them, their technological function, or the actors behind them.

This process created a space where an audience member could place themselves explicitly within the act of questioning, blurring the lines between questioner and audience when the audience themselves were responsible for the vocalisation of each question. Foregrounding this range of "specific ways of seeing" (Haraway 1988, p. 583) and implicating them within this environment was intended to provoke new knowledges in the opaque system at hand. In applying this to the discursive nature of the Echo, it suggested the value of 'interrogating' voice-user interfaces to test their abilities, limitations, and how their response to speech may reveal the values of the developers embedded within them. In an attempt to "avoid romanticizing and/or appropriating the vision" (p. 584) of individual question-authors, each question does not identify its asker. To ensure their labours were given particular presence in the work, the list of question providers appeared prominently on the wall alongside the installation, along with thanks and an explanation of their contribution.

To address a question directly *to* a technology *about* that technology is a compelling aspect of the recent advancements in voice-user interfaces. As a form of knowledge production this was intended not to resolve all questions, but to illustrate how many productive positions can be adopted that offer ways of interrogating the politics of these devices. In the face of obfuscation and the limits of access, these questions were intended to leave audiences with a sense of possibility rather than incapacity. As the collator of these questions I was not exempt from this, and found the range of perspectives provoked multiple new avenues of theoretical enquiry. For example, a number of submissions articulated the anxieties of living amongst such devices, and its ramifications. This unplanned theme in the questions spurred new research

engagements for me into the potential emotional tolls that such devices can exact, which resulted in a concentrated study of how personal trauma can be amplified through them. This demonstrates that not only can a theoretical position such as situated knowledges be enacted in practice, but that this can itself lead to new theoretical understandings.
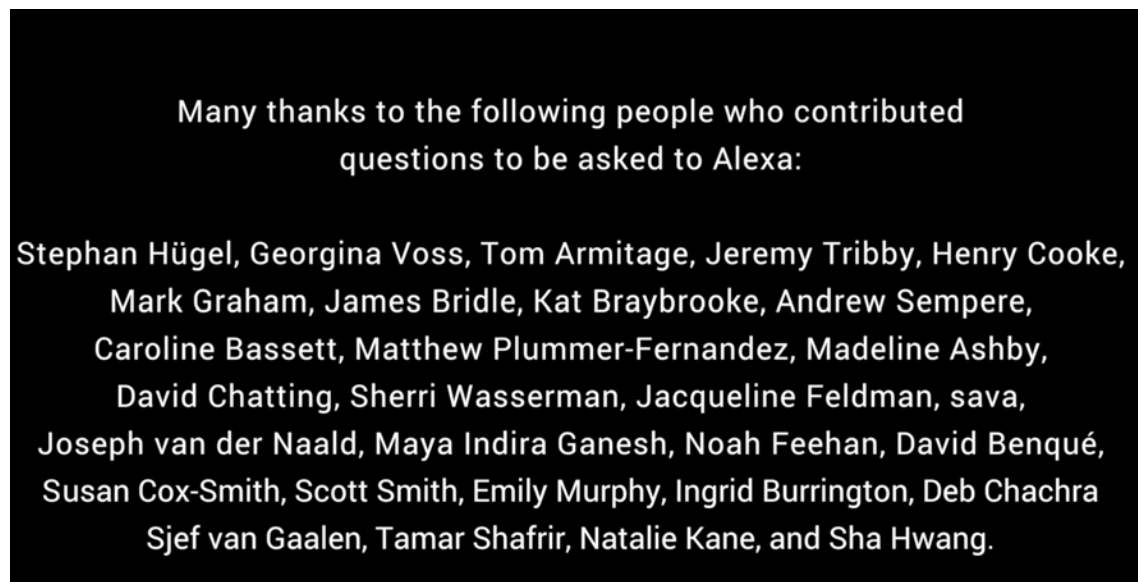
Figure 20: Screenshot from video documentation of *The Dark Age of Connectionism: Captivity*

The relative novelty[5] of the technology being critiqued here is also worth noting for the opportunities it presents for critical practice. The promotion of such consumer products often revolves around the 'wonder' of its function and the novelty of the interactions it enables (Stahl 1995). To introduce dissent and criticality at an early stage is an opportunity to intervene upon the discourse being promoted, creating an engagement with both the capacities and limitations of the devices and the more discrete functions and politics of them. This was particularly evident in the iteration of this work in question, which was exhibited in the Netherlands in October 2018. With no Dutch-language version of the Echo on the market at that point, many audiences reported

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[5] The first iteration of *The Dark Age of Connectionism* was shown in April 2017, seven months after the launch of the Amazon Echo in the UK.

having never seen nor heard of the device before. This produced an opportunity to present critical discourses around the device before the formidable advertising power of Amazon could establish itself.

In creating critical engagements with these always-listening technologies, approaches such as those described here demonstrate how, when faced with the aesthetics of obfuscation and opacity in these technologies, critical art and design can create a new position between audience and device. Rather than a passive receiver of the discourses presented by their operators, this position encourages speculation, interrogation, and creativity in response to them.

Chapter 5: Towards a Critical Data Aesthetics

In this thesis I've isolated a range of approaches and techniques that I have adopted and explored in order to produce a critical data aesthetics approach to creating data aestheticisations. The attached works, and the theoretical discussions that accompanied them, articulate a practice that reflexively responds both to the cultural conditions of data and aestheticisation, and explores how critical data aestheticisations can produce new forms of knowledge regarding these conditions.

The previous chapters have addressed the subjects that such a practice might engage with, the sorts of aesthetic approaches that might be taken, what forms reflexivity may take in this practice, and what the relationship between theory and practice are in this approach. In what follows I will reflect upon these findings.

Reflexivity

The works examined in the preceding chapters present practice as a key method in pursuing the theoretical intent of this thesis, and of my doctoral study as a whole. The production of these works has been essential in provoking new avenues of aesthetics-led research, generating investigations that delve into both the contents and contexts of the data sets at hand, and experimenting with new methods of representing data. A reflection on these methods addresses how critical data aesthetics practice can function as a method of articulating research concerns, and how this relates to the forms of knowledge it produces.

In his analysis of artistic research, Henk Slager conceives of practice as producing novel concepts and insights through the interaction between three lines: the 'activation of imagination', self-critical knowledge production, and reflexivity. The activation of imagination is described as producing an alternate perspective on the ordinary, seeing the world "according to different norms…different habits", providing "an open view

while liberating the spectator from a frozen perspective" (2011, p. 337). This echoes both Rancière's 'labour of fiction' and Borgdorff's notion of art as a vehicle for 'unfinished thinking', where practice is distinct from traditional forms of research when it escapes the need for a finite resolution on the subject of its focus.

Slager goes on to frame the questioning of what art *is* as the second interacting line of artistic research; in his view, this postmodern reflection on the essence of art should include potentially transformative judgements on the foundations and concepts that the work is based upon, and questioning the conditions in which it is produced. The critical practice of data aestheticisation I am articulating here reflects in this way upon what aestheticisation *is*, and how it is influenced by the cultural context it exists in. Such a reflection is one that articulates judgment on both the contemporary role and influence of aestheticisation, and what roles and influence aestheticisation may have.

These questions are entangled with Slager's third line of interaction: reflexivity. The self-reflexive questioning of shifting situations and positions produced through artistic research is "a constant process of interacting, intermingling, and traversing" (2011, p. 338), between both itself and its subject. One example of these elements in practice can be seen in *Ground Resistance,* specifically in the use of the hanging acrylic shapes, and the shadows they cast through the projection. The 'different norm' this presented was of data visualisation not as a seamless whole, but as something fractured, and whose fractures themselves represented forms of information. In 'breaking' the projected image with the paradoxical presence of what is missing from it, I was questioning the conditions and normative practices of visualisation, notably the 'spectacle of scale'; and in drawing attention to who and what is left out of the smart city system, I was reflexively critiquing what my role and goals were in relation to the system I was examining.

Cuts and Experiments

Essential to this critically reflexive approach to aestheticisation was my framing of each aesthetic decision as a 'cut'. Through this, the relationship between aesthetic decisions and theoretical concerns was continually re-addressed in reflection upon the importance of each cut, as a way of interrogating my own decisions throughout the process. Where the demonstration was an overarching concept, the cut was a notion that was involved at a more granular level in these works as a process of taking responsibility for my responses. When "our response is a way of taking responsibility for the multiplicity of the world, and for our relations to and with it" (p. 140), it is clear that the cut was not simply a method for making theoretically or conceptually rigorous decisions in these works, but was a form of active engagement with the politics of the work as it was performed.

Where these notions of self-reflective decision making and the potential scope of aestheticisation were both apparent was in the variety of aestheticisation practices used in these works. Spatial audio, sculptural practice, atmospheric mist, and speech synthesis were each used in their respective works to articulate elements of the critique at hand, and as a way of exploring an expanded range of practices outside of visualisation. In instances such as the use of mist in *Breathing Mephitic Air,* this created new methods of perceiving data through atmospheric methods unavailable to visual media, while creating new aesthetic forms in the installation through the reactions between the mist and the projections. The use of both sonification and visualisation in *Ground Resistance* showed how these methods can be combined to develop immersive forms of aestheticisation. In *The Dark Age of Connectionism: Captivity,* the use of synthesised speech to 'ask' the questions, rather than present them as, say, a list of text, allowed for the questions to expose the limits of the Echo's speech recognition and performance. Examples such as these show how multi-modal forms of aestheticisation

offer both opportunities for aesthetic experimentation, and also the generation of new critical insights through this process.

Theory < > Practice

Part of the self-reflexive nature of these works was present in the relationship seen in them between theory and practice. Throughout each work, there are examples of where practice was generative of new theoretical research, and how theoretical positions informed the decisions made in practice. To examine *Breathing Mephitic Air* as an example, allowing the demands of practice to provoke new aesthetics-oriented research resulted in a work which had layers of conceptual and theoretical rigour, as was particularly evident in the aesthetics used to sonify the data. This process uncovered the contention surrounding the use of mist cannons in China, resulting in the development of the 'data mistification' component of the work. Such a development is a useful example of how research can provoke new experiments in practice.

The works also suggested how practice offers new sites for the expression of theory. In *Breathing Mephitic Air,* this was seen in the expression of 'situated knowledges' through the use of multiple semi-transparent screens in the work, denying a 'god's-eye view' of the data and allowing for multiple, situated perspectives on it to be adopted. In *The Dark Age of Connectionism: Captivity,* the questions themselves foregrounded the assemblage of data captured through the Echo, drawing attention to the many technological and cultural domains that intersect in this discussion. In formulating these questions, both myself and my contributors were offered an opportunity to consider how to frame a theoretical concern into a question, and what it meant to give an aesthetic presence to theory through the voice of Siri. In these ways these works suggested how such practices can provoke new research trajectories, enact research concerns, and create new interactions between theory and practice.

Mechanical Objectivity

Throughout the sites examined in this thesis, mechanical objectivity is a pervasive notion in spite of the many critical standpoints disproving it. It underpins the notions of sensors as an objective view of the world, of data as a higher authority than humans, and of data's 'prowess' as a source of knowledge to be mined through analytics. Mechanical objectivity also permeated many forms of data aesthetics examined in this thesis, from the promissory visions of data seen in the first chapter, to the human-free visualisations of the smart city, and the 'spectacle of scale'. These examples illustrate how pervasive a narrative it is, and therefore how urgent and important it is to explore its workings and its ideological force; in my doctoral project this has been undertaken through a series of engagements with particular sites and spaces of interaction with data, engagements informed by theoretical reading, but undertaken through practice.

The works seen in this thesis articulate multiple ways that the narrative of mechanical objectivity can be challenged through practice. In *Breathing Mephitic Air* this manifested in exposing the subjective character of the data, the sensors, and the audience's view; the response in *Ground Resistance* came in using temporality and absence as techniques to disprove the claims that an objective view of the city may be given through data; and in *The Dark Age of Connectionism: Captivity,* the re-combination of sounds to produce unintended meanings parodied the certainty with which the data analytics industry makes its claims about the efficacy of its products.

These examples also show that the challenge to mechanical objectivity can be made as part of more specific critiques, as seen in each of these works. When the notion of mechanical objectivity is so pervasive in many techno-social contexts such as these, its critique is not only possible within critically reflexive data aestheticisation practice, but should be seen as a substantial target for such critiques. Understanding where and how mechanical objectivity impacts a given subject offers a starting point for critical data

aesthetics works.

Revealing and Revelation

An important element to highlight here is that, in critiquing notions such as mechanical

objectivity in these works, and forming responses to the specific subjects of each work,

my intention was not to 'reveal the invisible'. This is a familiar phrase to overhear in

digital art and design exhibitions, and is typically a claim that a goal of such practices is

to present non-visible or non-apparent elements of technologies such as smartphones or

WiFi as a method for gaining substantial new insights into them (Mattern 2017b). But

to aim only to 'reveal the invisible' is to miss a fundamental point in the critical study of

data: that many of the people, mechanisms, and practices of data collection are not in

fact invisible, but are either ignored or overlooked. They do not fit with claims to the

infallibility and impartiality of data, exposing as they do the subjectivity and

situatedness of data at every level of its creation, analysis, and dissemination. Given

this, to 'reveal the invisible' does not guarantee revelation.

This was a point that became clear throughout these works, and one that built upon the

notion of data as an assemblage, and of the limitations to a technical unboxing of 'black

box' technologies. What these works and this thesis have shown is that attention can be

drawn to the overlooked or hidden in ways that extend this process in addressing *why*

these elements are assumed to be, or made to be, 'invisible'. In *Breathing Mephitic Air*

this manifested in the focus upon sensors as an often-overlooked component of air

quality measurement, and the political dimensions of sensor placement and use.

Rejecting a 'spectacle of scale' approach to visualisation in *Ground Resistance*

produced the opportunity to focus upon APIs and corporate actors as often-overlooked

components of smart city systems, and the impacts they have on the totalising claims of

smart city operators. In *The Dark Age of Connectionism: Captivity,* the concept of

'speculative data' created the opportunity to both draw attention to and offer critiques of

components of smart speaker devices that their owners are likely to never have access to.

Shannon Mattern argues that such approaches can highlight the "recurring and divergent formal patterns" behind these technologies, producing a route to exposing "the aspirations and ideologies that undergird them" (2017b, p. 5). Through this thesis and its works, I am similarly arguing that such approaches are appropriate responses to these conditions by a critically reflective practice of data aestheticisation; one that explores not only what is present and absent in how data is represented, but how this intersects with the 'invisible' components of technologies and systems that are heavily entangled in data's collection and use.

Demonstrations

The intention to take a more active stance than to simply 'reveal' the conditions of data was a component of these works as demonstrations. With its dual meaning of both demonstrating-against and a demonstration-of, the demonstration was a method to articulate a critical position to be adopted in relation to each topic, and an acceptance of responsibility to propose an alternative to it.

The demonstrations being made through these works include critiques of the supposed mechanical objectivity of sensors, and limits of access to networked technologies such as the Amazon Echo. In the case of *Ground Resistance,* the articulation of the demonstration was in demonstrating against the notion of the 'all-seeing, 24/7' smart city as both a promise and a strategy. The decision to foreground the temporal and spatial gaps in the smart city system at hand made these critiques the lens through which the system was presented to the audience. It manifested this critique through the use of absence as a critical tool, in contrast to the 'spectacle of scale' in data visualisation, and demonstrating a new way to see and think through the notion of the smart city and its

claims.

The demonstration offers a way of articulating both the justification of the subject of a work as one that requires examination, and asserting the importance for the demonstration of an alternative, or what might be. This capitalises upon what Jacques Rancière calls the 'labour of fiction', that of a "re-framing of the 'real'…changing existing modes of sensory presentations…varying frames, scales and rhythms; and of building new relationships between reality and appearance" (2010, p. 38). These works were temporary sites of engagement, exercising a responsibility to respond through this offering of something new. It is this responsibility that makes the demonstration a potent structural device for critical practices of data aestheticisation.

Promises and Strategies

The promises and strategies of data responded to across these works, from the promissory visions put forth by the manufacturers of smart city systems, to the claims of the Amazon Echo as a 'smart' conversationalist, informed how and why these demonstrations took the form they did. In recognising these promises and strategies as being sites of critique, I acknowledged how "[p]articularly potent images or metaphors, once part of a media frame, can go on reciprocally shaping the social world and the media accounts of that world for a long time" (Stahl 1995, p. 238). As components of data assemblages, they offer a space to consider how and why narratives of data are constructed. In the works themselves, I seized these narratives and used them as provocations to be responded to through practice.

As an example, in *The Dark Age of Connectionism: Captivity,* the questions asked to the Echo exposed the difference between the friendly, neutral home assistant portrayed in Amazon's advertisements and the reality of its complex function and politics by exploring the often discrete discourses of labour, ownership, and ecological impact

surrounding always-listening devices. These questions forced it to continually state its failure to understand the question, a contrast to the seamless interactions seen in Amazon's marketing materials; a form of promise that is made visibly, across multiple public and private spaces through advertisements and other forms of promotion.

Seeing these sites of data's interaction with the world as promises and strategies allowed me to take the 'visions' constructed around these technologies and direct critical attention to them. In critical data aesthetics work, this method not only offers a way of 'redesigning disposition', but exposes how practical responses can be formulated that present counter-narratives to expose both strategy and promise. Isolating the promises and strategies in a given context can then act both as a way of critically interrogating the topic at hand, but also to generate a starting point for a practical response to it. This is evident in *Ground Resistance,* where the claims of smart city operators were made the focus of the work, and determined much of the critical interrogation into the subject and the resulting artwork.

As I have argued regarding the repetitively dominant imaginaries of data, smart cities, and dashboards examined in this thesis, to challenge the promises and strategies is to bring their authority into question, and the authority of those perpetuating them. This makes isolating these narratives and considering their aesthetic properties, or analysing them through aesthetic methods, valuable techniques for critical practice in this field.

The Antithesis of Transparency

In the development of these works, what became apparent is that the practice of data aestheticisation offers the opportunity to not only show the content of a data set, but to use aesthetics to draw in wider discussions into such work. I propose that when data can be found or created on almost any phenomena, and the range of aestheticisation methods are so vast, the potential for a socially critical, politically engaged, and potent

practice of data aestheticisation is evident.

An example of this can be seen in in *Breathing Mephitic Air,* where the aesthetic decisions not only reflected the relationship of sensors to the data at hand, but also extended the work's scope from the local to the global scale by drawing Norilsk's nickel mining and the use of mist cannons in China into the work. This is again seen in the use of the voice of Siri as the text-to-speech technology in *The Dark Age of Connectionism: Captivity*. Firstly, there are many easier to use and more customisable text-to-speech programs available to practitioners than Apple's system. However, the use of Siri in this instance enabled an important new dialogue to be introduced, both in the exhibitions space and in discussions with audiences: that of how the history of Siri's name reveals its origins in U.S. Department of Defense research. This inclusion reinforced the overall conceptual approach of the questions asked from the Siri voice itself in the installation: to expose the older, knowable systems of power and control present in and around these devices.

To return to the supposed goal of 'transparency' in data visualisation with this in mind, aestheticising data through only the quickest or most technologically efficient method, or the one with the least artifice to it (what Edward Tufte might call 'the most transparent'), misses this opportunity for a critically reflexive practice of aestheticisation that explores how aestheticisation can engage with both data itself, and data's relationship to the world. Transparency is then not only an unachievable goal, but is in effect the antithesis of this approach. Where Tufte's transparency sees such applications of artistic intent as 'lies' that countermine the aim that aestheticisation should seek only to 'reveal' the data through the most neutral methods available, I believe that a critically reflexive practice of data aestheticisation is one that must reject this transparency.

To reject transparency in this way repositions aesthetics as no longer in the service of data, but instead coupled with data to serve a wider engagement with the world. An experimental and expressive practice of aestheticisation highlights data's subjective and interpretative character through drawing out the politically and ideologically contentious characteristics of data, its situatedness, and its shifting relationships. When these affordances of practice are explored rather than ignored, they can provoke new forms of perceiving and interacting with data: using aesthetics with data to place it in new contexts and dialogues with the wider world.

Disposition

I've chosen the phrase '*towards* a critical data aesthetics' as the title for this closing chapter to reflect the fact that the development of such an approach is not a task with a resolution. In framing this as a disposition I'm committing it as a hopeful gesture into the field, presenting a possibility of what could be. Rather than articulating this as a set of rules or criteria to be met to qualify a work as 'critical data aesthetics', I offer this thesis and its works as an ongoing project, one whose focus upon reflexivity necessitates it as always in development.

The possibility of a critical data aesthetics practice can be seen in the approaches to aestheticisation I have proposed in this thesis, in which aestheticisations are positioned as demonstrations as a way of placing them in dialogue with their topics while also actively proposing interventions. Producing such work involves an implicit rejection of the notion of transparency, to instead frame critical data aesthetics practice as one which actively explores an expanded range of aestheticisation methods and their potential for drawing wider discourses into each work. In such a practice, the promises and strategies that are components of the assemblage of data are seen as provocations to be responded to through practice. Mechanical objectivity can be understood as an over-arching logic to be challenged in this process, with this challenge being formulated

alongside domain-specific ones made in the work. These approaches show how, through this critically reflexive practice, theory and practice are entangled in a way that produces useful interactions between the two, and these interactions are generative of both new theoretical research and experimental practice.

Like the disposition itself, the future of data and its aestheticisation is far from fixed. New aesthetic tools and techniques for aestheticisation are constantly being developed, and the political implications and cultural presence of data is always in flux. The intention in the ongoing development of this approach is not to settle the matter, but to stir up that which has already settled; and to provoke others to continue to do so.

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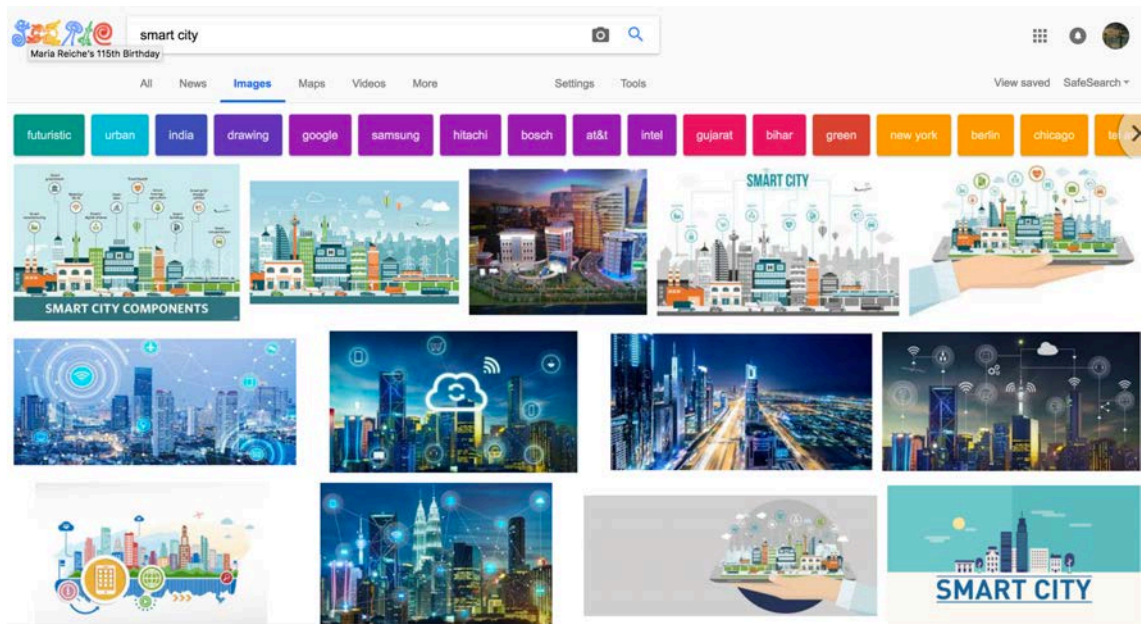
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Appendix A: Google Image Search results for 'data'

Appendix B: Google Image search results for 'smart city'

Digital Archive Contents List:

FAO Examiners - Please read first.PDF

Breathing Mephitic Air

     1. Breathing Mephitic Air - walkthrough.MP4

     2. Breathing Mephitic Air - extended walkthrough.MP4

     3. Installation Image 1.JPG

     4. Installation Image 2.JPG

     6. Installation Image 3.JPG

     7. Installation Image 4.JPG

     8. Installation Image 5.JPG

     9. Installation Image 6.JPG

     10. Installation Image 7.JPG

10. BMA install diagram.PNG

Critical Data Aesthetics - Thesis PDF copy.PDF

Ground Resistance

     1. Ground Resistance - walkthrough.MOV

     2. Ground Resistance - Shadows.MOV

     3. Installation Image 1.JPG

     4. Installation Image 2.JPG

     5. Installation Image 3.JPG

     6. Installation Image 4.JPG

     7. Installation Image 5.JPG

     8. Installation Image 6.JPG

     9. Installation Image 7.JPG

     10. Installation Image 8.JPG

     11. GR install diagram.PNG

List of exhibitions + selected press 2015-2018.PDF

The Dark Age of Connectionism - Captivity

     1. DAoCC - walkthrough.MP4

     2. DAoCC - further questions.MP4

     3. Installation Image 1.JPG

4. Installation Image 2.JPG

5. Installation Image 3.JPG

6. Installation Image 4.JPG

7. Installation Image 5.JPG

8. Installation Image 6.JPG

9. List of Siri's questions.TXT

10. DAoCC - install diagram.PNG