

Exhibition as experiment: a study of science and culture at the Science Museum

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Declaration

I declare that the work presented in this thesis is my own. Where I have drawn from other sources, this has been indicated as appropriate.

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Abstract

This thesis is about experimental exhibition, as both concept and practice. It asks what happens when experiments take place in public and in what way exhibitions might be said to be inventive formats.

An exhibition about the invention of electronic music in London's Science Museum provides the empirical focus through which I explore these questions. Called *Oramics*, the exhibition is focused around a recently 'rediscovered' optical-synthesiser called the Oramics Machine, designed in the 1960s by the composer Daphne Oram. An exhibition about electronic music studios in which engineers and musicians collaborated to create new sounds, in *Oramics* we find styles of experimentation considerably unlike those of the professional sciences. Inviting us to consider the proposition that the experiment has a life beyond the laboratory, the *Oramics* exhibition is also said to be experimental in its curatorial procedures and in its formats of public display. In *Oramics* we find an exhibition that assembles together both heterogeneous styles of electronic music experiment and multiple modes of experimental practice.

The analysis of the thesis explores how, and in what ways, the *Oramics* exhibition might be understood as an experiment. I formulate and advance the proposition that we can understand the *Oramics* exhibition as an experiment in the relations between science, culture and the public. The analysis of the thesis is presented thematically and organised around three modes of experiment that are central to *Oramics*: the curatorial experiment, the electronic music experiment and experimental public display. Drawing on literatures from social studies of science, I apply the concept of the "public experiment" to the *Oramics* exhibition in order to give a materialist analysis of how relations are made between these very different modes of experiment. In concluding, I discuss some of the ways in which the *Oramics* exhibition might be said to be inventive with respect to relations between science, culture and the public.

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List of Abbreviations

ANT	Actor-network Theory
BBC	British Broadcasting Corporation
EMS	The Electronic Music Studio Ltd
MMW	The Making of the Modern World
NYT	National Youth Theatre
PES	Public Engagement in Science
PUS	Public Understanding of Science
SSK	Sociology of Scientific Knowledge
STS	Science and Technology Studies

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1. Introduction

The *Oramics* exhibition

*Oramics*¹ is an exhibition about the invention of electronic music held in a small gallery in London's Science Museum. Its displays showcase the diversity of electronic music's genre styles, amateur inventions and assortment creative practices of using machines to make music: 'home-made' electronic noise devices take centre-stage in the gallery, and hip-hop and acid-house artists are pictured alongside engineers and computer programmers. In other parts of the gallery the changing sound world is explored by anonymous "women writers"² and an 11-minute documentary about a group of musicians involved in curating the exhibition is shown in a small cinema. It's fair to say that *Oramics* is not a conventional science exhibition. Many of the displays that we find in *Oramics* wouldn't appear out of place in an art museum: idiosyncratic artefacts, playful experimentation and sub-cultural style are central to the exhibition's presentation of electronic music. *Oramics* is an exhibition of many contrasts with the displays of industrial history, technological progress and sleek 'hands-on' interactive science galleries that surround it and for which the Science Museum is best known. And yet, as I finish writing up my study of *Oramics*, I hear that this 'temporary' exhibition, originally scheduled to close in 2012, has for the second time been extended; its eclectic displays of electronic music will stay open to visitors of the Science Museum until the end of 2014. This thesis is about why an exhibition like *Oramics* is valued by a contemporary science museum: the following study asks what the displays of *Oramics* can tell us about experimental practice and the public appreciation of invention, and how exhibitions might be said to intervene in and shape relations between science and culture.

Before arriving at the gallery displays of *Oramics*, on the second floor of the Science Museum, visitors are first invited to navigate a series of exhibitions in galleries *en route*. Following the visitor from their entrance through the austere and functional front door of the Science Museum, past the receptionists who

1 The full title of the exhibition is *Oramics to Electronica: Revealing Histories of Electronic Music* but throughout this thesis I refer to it simply as *Oramics*.

2 A group simply named "women writers" are participants in the *Oramics* exhibition. The gender, written contributions of the group are discussed at length in Chapter Five.

press for donations, to the noisy main concourse filled with school children and young families we find the *Oramics* exhibition situated in a particular setting of public display. As we move through these various galleries in the Science Museum from displays of industrial revolution, to our knowledge of the universe, to contemporary interactive displays about environmental politics, arriving at the *Oramics* exhibition it might feel like we're leaving the Science Museum altogether. At this point it wouldn't be unreasonable to ask what electronic musicians can tell us about science and technology that isn't accounted for in these other exhibitions, or to contest the notion that "women writers" can tell us about processes of invention, or to propose that these displays simply provide a bit of 'light relief' from the serious concerns of the surrounding galleries. Indeed, in what follows I discuss some such objections, contestations and criticisms made of *Oramics*; an exhibition that certainly agitates the science warriors, the positivists and historicists for whom the Science Museum is a defender of truth, progressive Enlightenment and the sanctity of technical expertise against the irrational whims of the masses. Following a visitor's trail to the *Oramics* gallery, then, we are going to gain an appreciation of the very particular setting of the Science Museum in which this exhibition is staged.

The central concourse of the Science Museum where visitors enter is an exhibition space known as the *Energy Hall*; a display that demonstrates the great power of the steam revolution. Walking into the Science Museum, visitors are dwarfed by the steam engines surrounding them: the *Energy Hall* is a display in which objects tower over their visiting subjects, impressing on them the material impact and scale of the industrial revolution. At the heart of the gallery an enormous mill engine³, which has been repurposed for display, is staged in motion: its inner mechanics do not rest lifelessly but are shown in action, demonstrating the power of steam to turn the engine's enormous flywheel. Explaining how harnessing steam power revolutionised "our world"⁴, the *Hall's* displays tell visitors that the steam engine was not only the "driving force" behind 300 years of British trade and industry but is also at the foundation of their own everyday life; steam turbines, they are told, provide 75% of the electricity that is consumed in homes and at work. Electricity, the foundation for the conduct of contemporary public life, is demonstrated as a

3 The mill engine on display was built by Burnley Ironworks Company in 1903 and repurposed by the Science Museum for display.

4 The notion that the steam engine revolutionised "our world" is promoted in a sub-branch of the *Energy Hall* which focuses specifically on James Watt, called *James Watt and Our World*. This exhibition is discussed in more detail in Chapter Three.

triumph of ingenious science and technological advance. Alongside the mill engine an explainer from the Science Museum interacts with visitors describing to them the history of the steam engine and the basic principles through which it functions. The explainer reassures us that though technological development is revolutionary, the steam engine does not drive us but rather we are in control of it. The explainer tells us that steam power was just the practical application of one man's very simple ideas. A display about the steam revolutionary James Watt and his workshop sit next to the mill engine: in Watt's workshop we see the heroic scientist who works in isolation. The steam power that transformed "our world" came from the work of a lone intellect. In its explanation the 'power' of the steam engine switches from object to subject, and the visitor is invited into a Science Museum dialectic between progressive history and liberal education⁵.

Next to this impressive display of steam power, are two other features which can be encountered in virtually all contemporary science museums, and which demonstrate quite a different form of power: the museum shop, and a two floor cafe. In these parts of the Science Museum, the visitor is the sovereign consumer who has the economic power to choose between the diverse products on display. In the shop visitors are engaged not by 'explainers' but by retail staff who demonstrate the education toys and shiny gadgets on display. In the cafe, visitors can choose between lavish displays of various European cuisines, including artisanal-looking pastries and a specialised coffee counter. Though the Science Museum staff make a functional distinction between the practices of retail and the curating of exhibitions, we might wonder whether the visitor's experience of these commercial features of the Science Museum are not always so easy to separate from their experiences of the science exhibitions (MacDonald, 2002; Slater, 1997)⁶. Visitors often appear to take their time admiring the elaborate displays and explanations in both, pausing to clarify or absorb some information about the artefacts in front of them. When they 'consume', visitors' experience in the science shop and cafe is in some respects remarkably similar to their experience in the Science Museum galleries: diners in the cafe appreciate the sophistication of European style while customers of the shop try to better themselves by purchasing educational toys. Indeed, the slogan "The Science of Shopping" adorned

5 For a curatorial discussion of dialectics in the Science Museum see (Boon, 2010).

6 The relations between the consumer and other versions of the public has long been a topic of sociological interests, particularly in museum studies. A discussion of the role of the consumer in science and technology exhibitions is developed in Chapters 3 and 4 of this thesis.

above the shop's entrance is all-too-knowing in its conflation of these functionally separated logics of public display.

At the shop's entrance, visitors are reminded of why they should invest in science, via an inspirational quotation from the Greek philosopher Socrates:

“Man must rise above the Earth – to the top of the atmosphere and beyond – for only thus will he fully understand the world in which he lives”

The quotation set against a glittering background of stars, the timeless wisdom of Socrates is here enlisted in publicising the transcendental promise of science. But the capacity of science to transcend the Earth is not simply a philosophical ideal or a publicity gimmick, but is rather shown to be a practical reality in the adjacent gallery, called *Space Exploration*. In this gallery visitors navigate through a dimly lit space which is punctuated by brightly spotlit displays; in a very literal sense, the exhibition demonstrates how the human quest for universal knowledge brings light to the darkness of space. The representation of the planets and the solar system in images, models and dioramas are complemented by two real, retired space rockets that hang from the ceiling, occupying the length of the gallery. Have these rockets not only accomplished Socrates vision but also transformed 'our world' by extending it into the darkness of space? In this exhibition, visitors see how science not only allows us to 'understand' the earth but also changes it and liberates humans from the whims and vicissitudes of an earthly existence⁷.

In another gallery dealing with *Energy*, the power relation is reversed: the visitor is here not simply a spectator of industrial 'power' but is empowered to experiment with energy production themselves. On the second floor, next to the *Oramics* gallery, the interactive *Energy* exhibition engages visitors in the politics of energy provision. Unlike the industrial spectacle we found on the entrance concourse of the Museum, this *Energy* gallery is filled with sleek and shiny push-button and other 'hands on' exhibits through which unruly school children are engaged with future energy scenarios. In one interactive video game called *World Energy: You Are In Charge*, players are given the role of

⁷ Hannah Arendt (1958) famously describes the space missions as characteristic of Man's perennial attempts to escape his Earthly-nature; a course of action that Arendt characterises as the quintessence of the human condition.

Energy Minister of “Lectraland” and invited to experiment with the politics of energy provision: if the player ensures the population gets continuous power the Energy Minister is re-elected, if not the 'lights go out' and the Minister is fired from the government. This is a game in which the success of the Energy Minister depends on science and politics coming together to address the energy challenge. However, they can also fail to co-operate and if they do the blame sits squarely with politics: it is the Energy Minister, not the scientists or engineers, who is ousted from post. But does politics, the corrupter of knowledge and appropriator of technical practice, also hold the promise of delivering 'good decisions'? The game suggests that if politicians can be liberated from the short-term populism, power struggles and local issues they can deliver the 25-year energy strategy we need. The game, then, is clear: if politicians fail address the long-term technical challenge of energy production they will leave themselves and their population 'powerless', in both scientific and political senses. In this interactive *Energy* gallery's displays of political power, the visitor becomes a politician burdened with the weight of responsibility for directing technical development and the repercussions for its failures.

Arriving at the *Oramics* exhibition, the visitor has been educated about steam power machines, they have enjoyed the sophistication of European style at lunch, witnessed the objective reality of science's universal promise, and have experienced the political responsibility of technical governance. What can an exhibition of experimental electronic music offer this visitor who has so far either been deeply impressed by the objective power of science and technology or has subjectively exercised power in consumer choices and interactive participation?

One of the first things the visitor might notice is that though in *Oramics* we find many displays of experimental practice, these forms of experiment are both distinctly removed from the mainstream styles, concerns and settings of 'pure' science. Foregrounding the collaborations that took place between musicians and engineers in early electronic music studios, these electronic music experiments appear distinctly more playful, artful and amateur than the various laboratory experiments that we find on public display across the Science Museum. The *Oramics* exhibition centres on an experimental musical instrument called the Oramics Machine, a synthesiser designed in the early 1960s by the electronic music composer Daphne Oram. A 'one-off' and 'home-

made' instrument, the Oramics Machine is very noticeably amateur in its construction: the frame is assembled from repurposed metal shelving, a multitude of wires of disparate sizes and colours hang off at various places without connection or explanation, a roughly cut board hosts several unconnected switches (one of which is labelled "do not switch"), and a broom handle is jammed in one side of the Machine. The 'home-made' appearance of the Oramics Machine is further accentuated in accompanying gallery explanations that describe how Oram conceived and built the Machine with an engineer at her "Oramics" studio. On one wall of the Oramics Machine's case display, a large stencil graphic shows Daphne Oram working with the Machine, drawing shapes onto lines of 35mm film running across its body; as iconography of an inventor at work this image appears distinctly unlike many others we encounter in the Science Museum. Behind the Machine's case are a row of photos of Oram, elaborating the exhibition's heterodox iconography of invention. A particularly striking image, on which many friends I took to the exhibition commented, shows Oram from behind performing on stage for a concert hall audience: surrounded by conspicuous machines, Oram wears a long evening dress, and behind her we see an audience of men and women staring at the spectacle, quite likely puzzled by this collision of two contrasting aesthetics of femininity and technology. Other images show Oram studiously at work in the BBC Radiophonic Workshop, the famous British electronic music studio that she founded in 1958 and which she left shortly after to set up her own *Oramics* studio in the oast house in the Kent countryside. In the displays we are told about "Daphne's"⁸ early life – a computer display elaborates Oram's upbringing accompanied by an image of the composer aged seven in a white dress – in which she turned down the opportunity to study at the Royal College of Music and instead became a junior programme engineer at the BBC. We are told that Oram developed her own unique approach to composition known as "drawn-sound" in which the composer sought to control all parameters of sound through graphical techniques. But more than only a musical invention, we are shown how "drawn-sound" informed the electro-mechanical design of the Oramics Machine, we are told how Oram attempted to develop a studio in her home to realise this approach to composition and, furthermore, how Oram developed drawn-sound into a broader philosophy about the 'vibrational universe'. A display which emphasises the centrality of personal style, amateur interest, artistic practice in early electronic music experiments, this exhibition about Daphne Oram and the Oramics Machine

⁸ The gallery texts consistently use only Daphne Oram's first name, in wide contrast with the surname formalism of other gallery displays: for instance, nowhere in the Energy Hall is James Watt referred to solely as "James".

might at first seem antithetical to concerns of professional science and the laboratory experiments that we find in other exhibitions in the Science Museum.

Similar themes of experimental practice appear in the gallery's displays about two early British electronic music studios, the BBC's Radiophonic Workshop which was founded by Daphne Oram and Electronic Music Studios Ltd (EMS) founded by the Russian aristocrat Peter Zinovieff. These two studios are credited in the exhibition with producing some of the well known inventions of electronic music: the BBC Workshop produced music for radio and television and is perhaps best known for the Dr Who soundtrack, while EMS invented synthesisers used by rock-stars, notably the VCS3 synthesiser which was used by bands like Pink Floyd, Hawkwind and Kraftwerk. The case displays of these two studios features objects chosen by their former members who are named as "co-curators" of the exhibition and are quoted to describe the significance of these objects, in place of a factual museum label. The case displays are deeply personal in their presentation of these two studios. In the BBC Workshop's case an old metal lampshade painted green is hung from the roof of a case accompanied by quotation from the composer Delia Derbyshire who used the lampshade to produce music in the Workshop. Though the composer died in 2001, a quotation taken from an interview with Derbyshire describes how she used the lampshade for "natural sounds": the lampshade is here not displayed for its qualities as an industrially mass-produced artefact but because of Derbyshire's practical misuse of it in musical composition. In the EMS case, a trophy for "second place" in the 1968 Congress of the International Federation for Information Processing is on display amongst a jumble of the Studio's less well recognised inventions chosen by its former members. A quotation from the EMS computer programmer Alan Sutcliff elaborates the particular significance that the trophy holds for the members of EMS, beyond being merely a 'consolation prize', Sutcliff describes the musical composition ZASP – which involved the composition of music on one computer which was then realised on another computer – for which the trophy was awarded, which was beaten in the competition by an entry from the electronic music composer and architect Iannis Xenakis. Unlike many Science Museum exhibitions, these objects on display would seem to tell us more about the personalities, idiosyncratic practices and misuses of technology that animated these early electronic music studios than they do about technological innovation or industrial history.

Opposite the BBC Workshop and EMS cases, stand three thematically arranged cases curated by contemporary electronic musicians and titled: Make Do and Mend, Democratising Electronic Music, and Sonic Frontiers. These cases add a contemporary twist to the displays of electronic music, showcasing a variety of genre styles and sub-cultural practices alongside more recognisable machines of electronic music history. In one case, a recent *Wired* magazine featuring the pop star Bjork is on display. Publicising Bjork's latest album *Biophilia*, released as an interactive application for smart phones and which features the naturalist-broadcaster David Attenborough, the display offers at once a seemingly banal, everyday item, the magazine, while also hosting a more spectacular meeting between the cyber-culture, electro pop and nature. Also in this case, we find the 1996 composition 'Generative Music, produced on floppy disk', by Brian Eno, the pop star best known perhaps as the synth player in the art-pop group Roxy Music. Shown in a box featuring Eno's face against a black-background, the display suggests that the intellectual practices of algorithmic music are not as divorced from the practices of rock stars as computer science and music criticism have often presented them. And indeed, intellectuals are shown engaged in seemingly mundane practices: an instrument functionally named "Egg Slicer and Two Contact Microphones" is displayed alongside an open tool-box belonging to its maker, the composer and academic Hugh Davies, best known for publishing the first written anthology of electronic music. The disorganised display of multi-coloured wires and hand tools spilling out of Davies' open tool box forms a stark contrast with the austere industrially-produced egg-slicer which they have been used to modify. Mass-produced domestic technology and DIY hand-craft techniques are not divorced from one another or antithetical to the practices of academics like Davies but rather, like many of the displays in *Oramics*, seemed to get mixed up in electronic music experiments.

But, if *Oramics* is seemingly closer to an art exhibition than to science it nonetheless appears to depart somewhat from the 'high culture' we find described in Western art history books and displayed in many of Britain's art museums. An image gallery situates Daphne Oram alongside musical innovators from fields as diverse as Western art-music, electro-pop, acid house, and hip-hop. An image of Karlheinz Stockhausen, for instance, reminds us of the importance of high modernist approaches of Elektronische Musik. Stockhausen's application of serialist composing techniques, using aleatoric

and statistical processes to compose with electronic sound, is a very particular kind of art-music practice developed in the high-tech infrastructure of the famous Cologne electronic music studio at the WDR radio station. Stockhausen's brand of high modernism seems far removed from that of the acid-house producers Maurice and Hot Hands, also pictured in the gallery's images, who are best known for their single titled *This is Acid*. A sub-genre of house and techno music, acid-house is widely associated with Chicago's warehouse parties where the music developed; events that are often said to have broken down boundaries between different races and sexualities in popular music culture. The "acid" sound used by Maurice and Hot Hands was created on a cheap bass-line synthesiser, the TB-303, which is also on display in *Oramics*. Like many objects in *Oramics*, the TB-303 is famous for its misappropriation rather than the function for which it was commercially designed. Somewhere between 'high' and 'low' art we find the synthesiser pioneer Wendy Carlos, who is pictured in front of an enormous modular Moog synthesiser. Best known for the album *Switched-on Bach*, the first classical album ever to score Platinum record sales, Carlos painstakingly worked with the notoriously imprecise and monophonic analog synthesiser to reproduce Bach's contrapuntal compositions. Not only experimental in her musical practice, Carlos is also known for her transgressing of gender boundaries, previously having lived as Walter Carlos. Such a mix of different artistic and musical styles, social identities and cultural classifications offers a staging of electronic music experiments as events that draw few boundaries and instead appear to create relations between seemingly heterogeneous people and things.

One further way in which *Oramics* appears different from other exhibitions that the visitor has encountered so far in the Science Museum is that its curators appear in the gallery displays. In the gallery's cinema, a series of films are presented, one of which is described as "a documentary about how we made this exhibition". The documentary shows Science Museum curators working with a group of musicians (in which I also feature as a participant) in workshop settings, planning the displays. Also presented in the cinema are contributions of two groups who are named as "co-curators" in the displays. First, a series of monologues written by "women writers" are performed by actors that address the issues of sound and invention. Despite their anonymity, the personality of the writers is expressed in the monologues, a dramatic form used for the articulation of subjectivity and lived experience. The second film is a short 2-

minute clip of a performance called *Oramix* by a group of students from the National Youth Theatre. The clip shows a multimedia performance in which a group of students encounter the music of Daphne Oram through interaction with some sound scientists. In these various films visitors are shown not only that there are many curators of the exhibition but that what counts as curatorial practice might be highly diverse, incorporating both creative writing and performance. In relation to other exhibitions in the Science Museum in which the curator is absent, or rendered invisible, the *Oramics* display puts the curator in the gallery. The displays in the gallery, these films suggest, did not drop from the sky ready-made but resulted from experimental curatorial procedures involving highly diverse groups.

Having taken a brief tour of the *Oramics* gallery displays, the visitor might now pose questions that will be central concerns in this thesis. The visitor may want to know why in London's Science Museum we find an exhibition about the invention of electronic music in which experimental practice appears as amateur, artful and playful studio practice and in stark contrast to the serious experiments of pure laboratory science; why diversity and heterogeneity in the gallery displays are privileged over demarcationist conventions that would discriminate between innovative technology and mass-produced consumer products, or between 'high' art-music and pop; and, why we find not only the Science Museum's curators featured in the exhibition's displays but also a display about an experimental curatorial process that includes highly diverse groups? In what ways is the *Oramics* related to the exhibitions of industrial history and contemporary science displays the visitor encountered on their journey through the Museum? In the remaining sections of this introduction I will outline how these questions will be addressed through this empirical study of *Oramics* and situate them in relation to the research traditions with which I am concerned, namely: science and technology studies (STS), social theory and exhibition studies. This introductory chapter is in three parts. First, I situate the *Oramics* exhibition in relation to the problem of "culture" in the Science Museum and elaborate why in this setting we find concerns about the relations between science and culture. Second, I outline how the *Oramics* exhibition can be said to differ from other kinds of experimental exhibition in the Science Museum and introduce the concept of the "public experiment" that I will use to characterise the exhibition in the analysis of this thesis. Finally, I advance the central proposition of this thesis that we can understand the *Oramics* exhibition as an experiment in the relations between science, culture and the public, and

introduce some analytical approaches that will enable us to appreciate some of the ways in which the exhibition might be said to be inventive. The subsequent outline of the thesis structure and a breakdown of the chapters is meant to provide the reader with a brief overview of how the questions raised here are addressed and developed through this study.

The culture question in the Science Museum

In a documentary about the making of *Oramics*, shown in the gallery's cinema, the curator Tim Boon describes the novel curatorial approach to *Oramics* and introduces the problem of culture in the Science Museum:

“The Oramics exhibition is the first exhibition in the Public History Project and we're planning two others. Co-curation, participation, co-creation; [this approach is] not having the curator saying “here is the gospel come and read it” but instead bringing in people like our visitors to work on the development of the Museum's cultural offer.”

Boon describes the experimental “public history” curatorial process, involving multiple participants, as a means of developing the Science Museum's “cultural offer”. As Boon speaks, the film shows a group of people standing around the Oramics Machine peering with intrigue at its various component parts and discussing its place in electronic music history. The Oramics Machine, the film makes clear, is central to the public history curatorial experiment. The film is reinforced by gallery displays that inform visitors further about the curatorial experiment in public history. They explain that public history is about how visitors relate to the Science Museum's historical object collection. The Museum is interested in how its visitors think about these objects, the kind of historical knowledges they might have about them and the stories they might tell about the history of science and technology. The film makes clear that the *Oramics* exhibition has been curated in a very particular way that is experimental for the Science Museum both in terms of the participation of different groups in the curatorial process and in the ways in which these groups are represented as culturally literate in the *Oramics* gallery displays.

It is not controversial to highlight that certain forms of culture have often been considered antithetical to the concerns of science and technology. In the

Science Museum, one cultural form that has, for many reasons, often been excluded is 'art'. In one of my first meetings with the Museum's curators, I was told that the public's relation with the Science Museum differed from art museums insofar as the exhibitions of art museums encouraged public "appreciation" while science museum exhibitions are oriented towards technical explanation. Later, while researching the Museum's history, I found the same argument, made almost verbatim, in one of the accounts of the development of the Science Museum by one of its first directors Henry Lyons (between 1920-1933). Lyons is credited by the Museum's curators (see Morris, 2010) as the first director to have defined the Science Museum as an institution that catered for a visiting public; an institutional orientation that is often considered to define modern museums⁹. Lyons' argued that:

"The objects exhibited in a technical Museum differ fundamentally from those in an art museum since they are shown on account of their utility and not for their beauty or attractiveness... While in an art gallery it is a question of appreciating the beauties of an object, in a collection of technical and scientific exhibits the visitor must understand their purpose before he can realise their importance and be interested in them." (quoted in Follett, 1978: 100)

In Lyons' modern visitor-centred account of the Science Museum, technical objects are conceived as differing in a fundamental way from art objects. For Lyons, art objects are not interesting for their artefactual character but rather for their immediate beauty, their ability to aesthetically affect the visitor to the artistic museum. Technical objects, by contrast, are entirely anathema to the public unless their utility and function are already transparent. In Lyons' account the Science Museum distinguished itself from art museums on the basis of these fundamental differences in the objects of exhibition. Understanding and appreciation implied different modes of public engagement because any lay-person could appreciate the beauty of works displayed in art museums but in science museums the public needed a particular level of literacy in order to understand the technical objects on display.

The ease with which we can trace Lyons' view in contemporary curatorial discourse at the Science Museum testifies to the endurance of certain settlements of the relations between science and culture. An early director of the Science Museum, Lyons developed his account of the public display of science and technology at a time when the institution was known as the

⁹ The establishment of the modern museum as a public institution is discussed at length in Chapter Two.

National Museum for Science And Industry (NMSI)¹⁰ and was part of the British State: staffed by civil servants, the Museum was a government instrument for promoting the utility of applied science and for advancing the interests of British industry and commerce in the service of national political community. With its origins in *The Great Exhibition of the Works of Industry of All Nations*, at the Crystal Palace in 1851, the history of the Science Museum is bound up with the celebration of industrialism, evolutionary civilization, monarchical rule and Empire (see discussion in Bennett, 1995). In its current location on Exhibition Road, in London's tourist hotspot of 'Albertopolis', the Science Museum is often informally referred to as the 'poorer cousin' of its neighbour the Victoria and Albert Museum (V&A): the two museums separated from a common origin in the object collections of the South Kensington Museum, as its "art" (V&A) and "non-art" (Science Museum) objects¹¹. Lacking the artificer's objects of choice, history offers one explanation for why early directors like Lyons appealed to the utilitarian and functionalist virtues of the Science Museum's collections of technical objects. In the institutional history of the Science Museum, then, we find one significant articulation of the "culture" problem in the separation of art from technology; a settlement that is clearly considerably unravelled in the displays of *Oramics*.

More recently, a sociological study of the Science Museum under-taken by Sharon MacDonald (2002) in the late-1980s describe a different set of negotiations between science and culture. MacDonald's study *Behind the Scenes at the Science Museum* discusses a "cultural revolution" in which the Science Museum became an institution focused and organised around the visiting public. MacDonald's account describes the transformation of the institution from an object-centric to a public-oriented organisation that marketed displays of science to "consumer-citizens". This revolution was, MacDonald suggests, in part an effect of the neo-liberal reforms of Margaret Thatcher's government under which the Science Museum became a quasi-independent organisation, no longer under direct State control¹². One consequence of the reforms was the introduction of admission charges and the ensuing creation of a 'market' in which the Science Museum entered into competition with other leisure and tourism industries. Though the Science

10 The various histories of the Science Museum created by its workers account in minute detail the various bureaucratic committees, reports and buildings involved in the historical establishment of the Science Museum from the non-art collections of the South Kensington Museum (see for example Armitage, 1957; Follett, 1978; Greenaway, 1951).

11 The South Kensington Museum was created from the objects assembled for the *Great Exhibition*. A discussion of the cultural politics of the South Kensington Museum can be found in by Bennett (1995).

12 The Science Museum was made independent in the 1983 National Heritage Act, in which it attained the legal status as a non-departmental public body.

Museum is now formally independent of government, sociologists nonetheless have described the ways in which the Museum continues to participate in the challenges of governing in advanced technological societies. The interactive exhibition, pioneered in Britain by the Science Museum, was a format of exhibition that, as Andrew Barry (1998) has described, was developed and took on particular significances during the neo-liberal political reforms of the 1980s and 1990s. MacDonald and Barry's respective accounts offer yet more versions of the 'culture problem' in the Science Museum as the challenges that arise from the gulf between science, economy and politics. In the cultural revolution at the Science Museum in the late-1980s, to which the respective experimental exhibitions discussed by MacDonald and Barry were a response, the curating and display of science is shown to be highly instrumentalised and in service of particular politico-economic ends.

The question of the relations between science and culture are, I argue in this thesis, central to appreciating what the *Oramics* exhibition is 'doing' in the Science Museum. Although politics, economy and art have provided important focuses for approaching the question of the relations between science and culture at the Science Museum, I deliberately do not privilege them in my analysis of *Oramics*. Politics, economy and art are not absented from the analysis I present in this thesis: they are both clearly important registers for appreciating why we find, in *Oramics*, an exhibition in which the experiment is staged as hybrid musical-technical practice, a socially inclusive form of public display and facilitates the participation of lay knowledges in curating the history of science and technology. But, importantly, I argue in this thesis that *Oramics* is also doing more than simply *representing* recognised 'cultural deficits'¹³ in the public display of science and technology. Instead, I suggest that *Oramics* is an exhibition that might also be said to propose new kinds of relations between science, culture and the public. The focus of my analysis therefore centres on the question of to what extent the exhibition could itself be said to be an experimental format. Approaching the exhibition in this way, I hope to show how in the complex patchwork of knowledges, things, people, issues and settings that are assembled in *Oramics* we can distinguish some very particular experimental interventions in the relations between science, culture and the public.

¹³ The concept of a 'deficit' holds particular significance in the Science Museum where it has often been attributed to the public's understanding of science rather than to the Museum. This is discussed further in Chapter Two's treatment of the public understanding of science.

***Oramics* as an experimental exhibition**

At each entrance to the *Oramics* exhibition, the two text graphics informing visitors that what they the exhibition they are about to visit is “experimental”. What is at stake in the claim that *Oramics* can be understood as an experimental exhibition? Before beginning to elaborate what will be the central concern of this thesis, it is useful to distinguish between three ways in which we can understand the concept of experimental exhibition: (1) exhibitions that publicise experimental facts and artefacts; (2) exhibitions that are experimental methodologically; and, a third version that I advance in this thesis (3), the exhibition as an experiment. The first two of these versions of the experimental exhibition are well developed genres of the experimental exhibition. In London's Science Museum I suggest that we find these respective versions of the experimental exhibition in gallery displays of experimental instruments that materialise 'pure' science an in the interactive displays that facilitate public engagement with science. In both of these formats of experimental exhibition the experiment is principally a scientific genre and its exhibition is principally for diffusing knowledge to the public. The third version, the exhibition as experiment, could be said to have various precedents – for instance, Hans Obrist's 2007 Experimental Marathon exhibition in London (see Obrist and Eliasson, 2009) – but in this thesis I focus on those accounts we find in social studies of science that have suggested that exhibitions can be formats that might be said to be inventive as forms of material practice. I will here elaborate briefly these different versions of the experimental exhibition that we find in the Science Museum in order to make clear some of the ways in which *Oramics* can be said to differ as an experimental exhibition and introduce the concept of the “public experiment” which I suggest can help us appreciate the *Oramics* exhibition as an experimental intervention.

Gallery displays about experiments have often served as vehicles through which 'pure' science is given material form in the museum context. Displays of experimental instruments, for instance, have been central to the task of materialising 'pure' science in a gallery setting, and such displays are often accompanied and elaborated by detailed descriptions and illustrations of experimental processes through which facts are produced. In one Science Museum gallery about 18th century science, a reproduction of the painting *An Experiment on a Bird in the Air Pump* by Joseph Wright of Derby shows the

(in)famous demonstration of the creation of a vacuum by the air pump. Next to the painting one such air pump, which was collected by King George III, is displayed in a case and the fact of the vacuum is explained in the accompanying text. The text situates the air pump within the historical development of science, emphasising the significance of Britain's Royal Society, the scientific institution formed through the meetings of experimental philosophers in the 17th century. Centred around the experimental instrument, the air pump, the exhibition serves as a neutral space within which the results of an experiment can be made public; through displays of experimental instruments science is represented in public as a complete product ready to be applied. In this version, and others of this kind that we find in the Science Museum, the experimental exhibition serves the publicity of pure science.

Another version of the experimental exhibition at the Science Museum is the interactive exhibition, described above by Barry (1998). Interactive exhibitions deploy the experiment as a method for engaging the public with science: the interactive exhibition is a medium through which visitors can experience experimentation themselves, giving the public 'hands-on' experience of science. The Science Museum's flagship interactive exhibition *LaunchPad* is a gallery in which such interactive exhibits are used to promote the public understanding of basic physics principles. In this sense, and like the first version of the experimental exhibition, interactive exhibitions like *LaunchPad* can also be said to be concerned with 'pure' science. Where the display of experimental instruments, described above, the gallery simply provided the context for the materialisation of science, the interactive exhibition features few, if any, such objects. Rather, in *LaunchPad's* displays visitors' bodies become sites of on which the principals of physical science are materialised as they experiment freely, without instruction, with the exhibits; scientific knowledge is here diffused through experimental experience. The interactive exhibition can in this sense be said to mediate a particular kind of relation between science and the public in which the museum visitors is facilitated to experiment as the lay public for science. In this version of the experimental exhibition the relations between science and the public appear dynamic and responsive even though, as Barry (1998) has pointed out, in practice interactive exhibitions like *LaunchPad* are often highly prescriptive about the ways in which the public interacts with science. In this version of the experimental exhibition, the experiment is a method of display through which the exhibition of science is accomplished.

In this thesis I describe how both of these forms of experimental exhibition – the publicity of experiments and the experimental display – could be said to be present in *Oramics*: both experimental instruments and interactive exhibits feature in the *Oramics* gallery¹⁴. But I also suggest that these two versions of the experimental exhibition, even if taken together, do not adequately account for what is experimental about *Oramics*. Unlike the former two kinds of experimental exhibition, in *Oramics* the experiment is not exclusive, or even apparent, as a register belonging to science and nor is it limited to a method of gallery display. Indeed, in many senses there might be said to be only very limited traces of 'pure' science in the *Oramics* exhibition. In this thesis I describe how in *Oramics* we find that the experiment refers not only to the exhibition as a format of display but also to particular traditions of experiment, most centrally to music and curating¹⁵. Unlike the former two versions of the experimental exhibition, the multiple styles and modes of experiment that we find in *Oramics* do not straightforwardly serve to make public a 'pure' science that is already complete. Rather, *Oramics* is an exhibition in which the experiment is staged as a distinctly 'impure' category: the curatorial experiment invites lay persons to participate in constructing multiple histories of science and technology, the electronic music experiment is staged as a hybrid of musical and engineering practice.

While we can identify elements of both of these versions of experimental exhibition in *Oramics*, in this thesis I suggest we need a different concept to account for what is experimental about *Oramics*. In all of the modes of experiment I've identified above – as an experimental public display in the Science Museum, a curatorial experiment in historical knowledge and in the hybrid musical-engineering experiments in early electronic music studios – we find the relations between science, culture and the public look very different. In this thesis I propose that we can understand *Oramics* as an experiment in making relations between science, culture and the public. To advance this proposition, I suggest, we need a concept of the experiment that can account for the bringing together of very different experimental styles, practices and instruments without privileging one experimental formalism (e.g. the science experiment) over any other another. In this thesis I propose to apply a

14 For instance, the *Oramics* gallery displays tell us that the *Oramics* Machine was "co-curated" with researchers from Goldsmiths College, where the Daphne Oram Trust is based. These researchers, mostly computer scientists, have also designed an interactive application of the *Oramics* Machine which has been modified for the *Oramics* exhibition, displayed next to the Machine, on which visitors can experiment themselves with the sound making techniques developed by Daphne Oram.

15 Both music and exhibition curating are spheres in which experimentation has long been established as a practical focus (see, for instance MacDonald, 1998; Nyman, 1999)

particular concept of the experiment which has been called the “public experiment”. I will elaborate this concept in more detail in Chapter Two's literature review when I consider some of the different theories of the experimental exhibition as a medium that makes relations between science and the public.

Experimental multiplicity: a materialist and symmetrical analysis

There are two challenges to advancing the proposition that *Oramics* can be understood as an experiment in making relations between science, culture and the public. First, this proposition might appear highly abstract and it might be asked how we can give an account of such an experiment through empirical social description. Second, I have suggested we find some very different modes of experiment which do not conform to a single formalism: how, then, it might be asked can we analyse and compare such heterogeneous modes of experimental practice. In what follows I suggest some of the ways in which this attempts to address these analytical concerns about how to describe *Oramics* as an experiment that is at once empirically materialist and able to account for heterogeneous versions of experiment.

The Oramics Machine is the centre-piece of *Oramics*. It is also an object that occupies a central position in the analysis of this thesis. In the Oramics Machine we find the three modes of experiment, just described, assembled together in material form: the Oramics Machine is an experimental electronic musical instrument developed by the composer Daphne Oram, it is the focal point of the experimental display in the Science Museum, and it is the object around which the curatorial experimental in “public history” was developed. The Oramics Machine is an object that can be said to materialise relations between very different traditions of experiment. It is an object that therefore offers a useful starting point for the analysis of this thesis that seeks to understand the ways in which the *Oramics* exhibition might be said to be an experiment in the relations between science, culture and the public. And, once we begin to look closely at the Oramics Machine in this way the more dynamic and complex the exhibition seems as an empirical object. Such apparent dynamism and complexity, I suggest here, are in no way counter-productive to

the task of empirical description but rather are the very conditions that make possible an analysis of the exhibition as socio-material practice.

In an email conversation with one of the curators of *Oramics*, we discuss the role of the Oramics Machine in the curatorial “public history” experiment, the curator tells me:

“was the Oramics Machine important as an invention? Maybe not, but it is important in the sense that it says so much about the inventiveness and creative minds that were involved in electronic music in those early years. And it’s a nice counterbalance for the idea that it’s a masculine story involving knobs, dials and an emotionless process. I think museums should talk about dead-ends quirks and failures a lot more. They are part of the history of Science, Technology, Engineering and Medicine and can help us see the big stories in a different, more diverse and balanced light.”
(personal communication from a curator)

The curator is largely unconcerned that the Oramics Machine was never demonstrated as a technical or artistic innovation or even by the fact that the Machine might have been a total failure. For the curator the Oramics Machine is an object that tells us something about the diverse processes and practices of “inventiveness” in early electronic music. The Oramics Machine, the curator suggests, is an object that might enable us to think of invention in science and technology in ways that are “more diverse”, gender sensitive, and “balanced”. So, though the Oramics Machine might have been a “dead-end” or “failure” the object is actually useful for thinking about, and putting into curatorial practice, alternative approaches to the history of science and technology. The curatorial experiment in “public history” is discussed at length in Chapter Four, in which I discuss the curators' attempts to invent new procedures that can involve lay persons in curating the history of science and technology.

I have already introduced the gallery display of the Oramics Machine in the Science Museum, above, but it is here worthwhile noting that the gallery is not the only setting in which the Oramics Machine is publicised as an experimental object for the Science Museum. Much of the news media, for instance, focused on the 'discovery' of the Oramics Machine rusting in the back of a French barn, effectively destined for the dustbin of history until it was rescued by the Science Museum¹⁶. In this publicity, the Oramics Machine is an object which is

¹⁶ See for example: <http://www.independent.co.uk/arts-entertainment/music/features/science-museum-to-display-legendary-oramics-machine-2340020.html> and

unlike most of the historical artefacts in the Science Museum insofar as it is largely unknown to history. Elsewhere, a Facebook¹⁷ page for the Oramics Machine, set up by the Science Museum, was used extensively to publicise the exhibition to a diverse 'social network'. This digital publicity consisted of regular "posts" with updates linking to magazine articles, films, exhibitions and concerts involving or related to the Oramics Machine or music from Daphne Oram. The digital Facebook medium offers some very simple ways in which to put on public display some of the heterogeneous people and things that are brought into relation through the Oramics Machine: the "likes", the "friends" who comment on stories and the "timeline" of events that have occurred on the Facebook page. If we are interested in the experimental public display of the Oramics Machine then such forms of publicity cannot simply be considered instruments that promote, or extend, the Museum's gallery display. Instead, I suggest that the gallery display is one among several other formats of experimental publicity of the Oramics Machine for the Science Museum. This point is addressed further in the Chapter Five which focuses on some of the different ways in which the *Oramics* can be appreciated as an experimental public display.

In the course of this research I've encountered many very different accounts of the Oramics Machine as an experimental musical instrument in settings as diverse as sound-art exhibitions¹⁸, feminist blogs¹⁹, academic conferences²⁰ and theatre performances²¹. A particularly memorable setting was the experimental music venues Cafe Oto²² which hosted a seminar discussing the Oramics Machine and Daphne Oram's drawn sound. On a warm evening also in April 2011 I joined a queue outside Cafe Oto for the event called "The

<http://www.djmag.com/news/detail/3037> and <http://eandt.theiet.org/magazine/2011/11/oramics-to-electronica.cfm> (all accessed 15 June 2012)

17 See: <https://www.Facebook.com/OramicsMachine> (accessed on 30th July 2013)

18 One significant exhibition that featured displays about the Oramics Machine was a sound-art exhibition called *Sho-zyg* which is discussed in Chapter Six. Information about the exhibition can be found here: <http://sho-zyg.com/> (accessed 02 April 2014)

19 Several blogs link the Oramics Machine and electronic music to the concerns of contemporary feminism. A post on the Guardian Women's Blog about the Oramics Machine is discussed in Chapter Five (can be found at: <http://www.theguardian.com/lifeandstyle/the-womens-blog-with-jane-martinson/2011/aug/07/daphne-oram-oramics-electronic-music> (accessed 02 April 2014) and a post on the Her Noise blog can be found here: <http://hernoise.org/tara-rodders/> (accessed 02 April 2014).

20 A presentation about the Oramics Machine by the computer scientist Mick Grierson can be found here: <http://vimeo.com/50834273> (accessed 06 March 2014)

21 A performance by students of the National Youth Theatre called *Oramix* is discussed in Chapter Three, a short clip of the performance is display in the Science Museum gallery.

22 The Cafe Oto event was part of *The Wire* magazine's monthly Salon series. Information about the event can be found here: <http://cafeto.co.uk/wire-salon-daphne-oram.shtm> (accessed on 01 May 2012)

Sounds of New Atlantis: Daphne Oram, Radiophonics and the Drawn Sound Technique”²³. The organisers were perhaps not expecting such a turnout because when I arrived they were frantically rearranging furniture inside the venue so the crowd could get in. The evening's programme ranged from presentations about the significance of the Oramics Machine in relation to British computer music, to the Science Museum's Tim Boon outlining how the Museum intend to display the Machine and invited the audience to take part in curating it, while the music journalist Dan Wilson discussed Daphne Oram's interest in New Age philosophies, and the sound-artist Jo Hutton described Oram's life and role in founding the BBC's Radiophonic Workshop. The event ended with a screening of a filmed interview with the engineer Graham Wrench, who collaborated with Daphne Oram to construct the Oramics Machine. This event made clear some of the highly diverse accounts of Daphne Oram's electronic music experiments in developing drawn-sound composition technique, and these are elaborated in the discussion of Oram's experimental drawn-sound in Chapter Six.

This study will not be the first to describe some of the ways in which electronic music instruments like the Oramics Machine materially assemble very different traditions of experiment. An important reference point for the following study of the exhibition of the Oramics Machine is Pinch and Trocco's (2004) *Analog Days: The Invention and Impact of the Moog Synthesiser*, an historical account that traces the development of the Moog synthesiser from 1964²⁴ to mid-1970s. Pinch and Trocco's account of the “synthesiser culture” in which the Moog developed is broadly conceived and includes actors as diverse as musicians, engineers, artists, feminists and businessmen; objects that range from oscillators to mind-bending drugs; and settings that include studios, factories, counter-cultural arenas like the Trips Festival and concert halls. In other words, Pinch and Trocco describe the invention of synthesiser culture as distributed across heterogeneous actors, objects and settings. In their analysis of synthesiser culture, Pinch and Trocco conceptualise the synthesiser as a “boundary object”²⁵: as a “liminal entity” that moved between different social

23 Information about the event can be found here: <http://cafeoto.co.uk/wire-salon-daphne-oram.shtm> (accessed on 01 May 2012)

24 The significance of the date 1964 is that this is when Moog first built a voltage controlled synthesiser and demonstrated it to the American Audio Engineering Society. The precise dates of the Oramics Machine's construction are unknown at the time of writing but it is described in the exhibition as occurring in the early 1960s.

25 Indeed, I suggest, the concept of the “boundary object” seems particularly salient in describing the Oramics Machine as an experimental instrument. The concept was developed by Star and Griesemer (1989) to describe the ways in which objects facilitate the practices of science and technology. They describe boundary objects as the following: “Boundary objects are objects which are both plastic enough to adapt to local needs and

worlds, took on different meanings and transformed those worlds. They describe how actors become “boundary shifters”; how engineers became central players in counter-culture, how the musicians improvising with synthesisers became designers of them, and how avant-garde artists became synthesiser sales people. Like the Moog, the Oramics Machine might too be characterised as a “boundary object”, as it brings together very different traditions of experiment. But, unlike the Moog, the Oramics Machine was never demonstrated as an innovation, it never made it out of the studio where Oram and Wrench developed the Machine. So, unlike the Moog, the Oramics Machine has not circulated through different social worlds. Rather, it is the exhibition of the Oramics Machine that assembles these very different traditions of experiment together. In the analysis of this thesis, I therefore attempt to ground the analysis of *Oramics* as an experiment in material things and practices as a way to think about exhibition as an inventive practice.

One way to appreciate how the exhibition of the Oramics Machine makes relations between different modes of experiment, I argue in this thesis, is by drawing on the analytic concept of “symmetry”. Minimally, we might say that to be symmetrical about experiment simply means that we attempt to apply the same styles of analysis to the different traditions of experiment that we are presented with in *Oramics*. Indeed, many different social science approaches have stressed the importance of symmetrical analysis for socially studying science and technology. The canonical argument for symmetrical analysis was

the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual site use. These objects may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds.” (393). Star and Griesemer’s concept of the boundary object is particularly pertinent because it was developed from a museum study. In this study, Star and Griesemer showed how the creation of boundary objects was key to the successful establishment of the Museum of Vertebrate Zoology at Berkeley. Boundary objects enabled the range of different actors involved in the Museum – the scientists, the administrators, the patrons etc – to communicate effectively whilst maintaining the autonomy of their respective social worlds. Boundary objects were, the authors suggest, the basis on which the Museum of Vertebrate Zoology was founded as an institution able to do scientific research because they allowed all actors involved to achieve their individual goals. This institutional orientation of the concept of the boundary object is thus also relevant to the current study which allows us to understand why institutional experimentation would involve a multiplicity of very different actors. The cornerstone of the boundary object is its flexibility to move between different groups of actors. Boundary objects are created or emerge as a way for groups of actors inhabiting different social worlds to coordinate at the points where these worlds intersect. In other words, boundary objects facilitate comparison and cooperation between heterogeneous groups. In this respect, we can understand why boundary objects would play a central role in efforts to address the “culture” problem in science and technology exhibitions, like *Oramics*. As objects that facilitate cooperation, boundary objects may create new relations between the heterogeneous actors and settings.

developed for the social study of knowledge controversies in science and the subsequent success of some knowledge claims and failure of others. Advocates of the Strong Programme (Bloor, 1976) argued that the categories of “truth” and “falsity” could not be used to explain the relative success and failure between competing knowledge claims in a scientific controversy. They argued instead that explaining the closure of a knowledge controversy required the analyst to treat all knowledge claims symmetrically, as if there was nothing innately true or false in them. In this way, the analyst could be attentive to the social processes involved in the construction of scientific knowledge that were not accounted for in the naturalistic accounts of practising scientists and the epistemological accounts of philosophers of science²⁶. The application of the principle of symmetrical explanation to the different styles of experimentation that we find in *Oramics*, I suggest here, can help us understand how the exhibition of the Oramics Machine might be said to make particular kinds of relations between science, culture and the public.

Equipped with the analytic of symmetry, I suggest we are better placed to appreciate *Oramics* as an exhibition that materially assembles very different styles of experiment. The *Oramics* exhibition, I suggest in this thesis, does not accomplish symmetry in a way that would flatten out all differences between experimental styles between music, curating and public display. In this thesis I am not interested in evaluating whether experimental symmetry is or isn't accomplished in *Oramics*. Looked at another way, the analytic of symmetry simply enables us to identify some of the many asymmetries in the relations between science, culture and the public that are unsettled in *Oramics*. For instance, *Oramics* invites us to ask why Daphne Oram's invented Oramics Machine was largely unsuccessful in its own time, why the experiences of “women” rarely feature in accounts of technical invention, and why genres like rap and acid-house are often left out from 'high culture' displays of music we find in other museum exhibitions. The analytic of symmetry, I suggest, enables us to view *Oramics* as an experimental setting without over-determining what does or doesn't count as 'proper' experimental practice. Focusing on processes through which the curatorial experiment, the musical experiment and the experimental display are assembled in *Oramics*, I argue, we gain an appreciation of some of the ways in which the exhibition can be said to be

26 A subsequent development in this tradition of symmetrical analysis was the argument made by actor-network theorists (Callon and Latour, 1992) for a “generalised symmetry” in which no one analytical category (such as “the social”) could be used to ground explanations of the development of science¹. The argument for “generalised symmetry” is discussed at length in Chapter Two's literature review.

inventive as material practice.

Thesis structure and chapter summary

The structure of this thesis is designed to explore what happens when we apply the concept of the “public experiment” to the *Oramics* exhibition and attempt to describe exhibition as both inventive and material practice. The following two chapters present a detailed elaboration of the concept of the public experiment and discuss the methodology used to study the *Oramics* exhibition. Chapters Four, Five and Six comprise the main body of empirical analysis and are organised thematically to reflect the material practices that organised the different modes of experiment: these are public participation (the curatorial experimental), exclusion (the experimental public display) and media (the electronic music experiment). In the conclusion I discuss some of the broader implications of approaching the exhibition as a public experiment, exploring what the empirical analysis reveals about the exhibition as a particular kind of inventive format and the Science Museum as an experimental setting.

In Chapter Two, the literature review of this thesis, I elaborate the proposition of the exhibition as a public experiment. In this chapter I survey a range of literatures in social studies of science that have discussed exhibitions and related formats of public display, including: the public understanding of science, the sociology of scientific knowledge, governmentality, actor-network theory and the social construction of technology. The literature review first looks at those literatures in which experimental exhibitions have been treated as a means to keep science demarcated as a special sphere of culture. The review looks at how literatures in the public understanding of science, for instance, have sought to use exhibitions as instruments that can solve the political problems in science. The review, then, discusses some 'post-instrumental' approaches to the experimental exhibition that suggest exhibitions can be treated as inventive formats. Post-instrumental approaches like actor-network theory argue for an “ontological” understanding of experimental exhibitions, and these approaches are elaborated in depth along with some important epistemological objections. In concluding, I highlight what we might gain by applying the concept of the public experiment to the *Oramics*

exhibition.

Chapter Three is the methodology chapter of this thesis and outlines the ethnographic approach undertaken in this study. The chapter offers an overview of the empirical materials collected and how they have informed the thematic analysis of the subsequent chapters. I also outline the background to the empirical study, and specifically address why the Science Museum was chosen as a site for research. Substantive discussion is presented concerning the particular tradition of ethnography on which this study draws and the particular relation of the ethnographer to the empirical setting that is developed in this tradition. Critiques of this tradition of ethnography are also highlighted and discussed. The chapter then turns to some of the practical questions concerning how the study developed, how my initial attempts to study *Oramics* as a curatorial experiment were complicated by empirical events, and subsequently how the focus of the empirical research shifted in order to take into account the other modes of experiment that we find in the exhibition. In concluding I outline the case for the thematic analysis that appears in the subsequent empirical chapters of the thesis.

In Chapter Four I discuss the curatorial experiment in relation to the problem of public participation in the Science Museum. I focus on why public participation is significant as a problematic of the relations between science and culture at the Science Museum. This chapter foregrounds an unresolved disagreement between two groups of museum staff about the question of public participation and the cultural offer in *Oramics*. This disagreement offers insight into the different versions of curatorial practice we find in the Science Museum. Though not all staff may not be institutionally recognised as curators, they nonetheless hold practical investments in the way in which science is curated in this setting. The chapter looks at the competing ideas about public participation and the different kinds of imaginations of the Science Museum that are materialised in the practices of both of these groups. The chapter highlights that while these groups seek to use *Oramics* to develop the Science Museum's "cultural offer" by unsettling distinctions between the insiders and outsiders of science, the practices of these two groups nonetheless also have the consequences of producing new outsiders who are excluded in different ways from participating in *Oramics*.

Chapter Five focuses on the exhibition's experimental gallery display which brings together many different things that have been conventionally 'excluded'

from science exhibitions. Specifically, the chapter focuses on the display of work by a group of “women writers”, who are staged as a group that is doubly excluded by virtue of being both 'gendered' and 'vulnerable'. In the displays of *Oramics* the work of the writers, describing the lived experience of gender, is staged as giving insight into the experimental music practice of Daphne Oram. However, despite the presence of ironic gender references throughout the exhibition's displays and a narrative of social inclusion, the women writers nonetheless appear as excluded 'outsiders' in many accounts of the exhibition. The chapter discusses the problem of the exclusion of women from science, reading the displays in *Oramics* through the debate in feminist theory between “standpoint” and “post-gender” approaches. The chapter highlights the complexities of exclusion as a way of understanding the relations between science, culture and the public.

In Chapter Six, the last empirical chapter, I discuss electronic music as the experimental medium of the *Oramics* exhibition. The chapter foregrounds the staging of the electronic music experiment as mediating between musical and electro-mechanical practices. The analysis foregrounds Daphne Oram's attempt to invent new drawn-sound composition techniques, which she sought to realise in the development of the Oramics Machine. The chapter compares two approaches that might be taken to understanding what Oram's drawn-sound 'does' in the context of the *Oramics* exhibition, these are: (1) media-specific approaches, and (2) audition-centric approaches. I highlight the differences between these two approaches in terms of appreciating how the displays of drawn-sound in *Oramics* might be said to make relations between science, culture and the public.

In the concluding chapter of this thesis, Chapter Seven, I examine more broadly the implications of this study for thinking about exhibitions as inventive formats. The chapter offers a brief summary of the findings from the empirical study of the *Oramics* exhibition. I revisit the decision to apply the concept of the “public experiment” to the *Oramics* exhibition. I discuss the empirical analysis of Chapter 4-6 and how it contributes to the proposition I attempt to advance that we can understand *Oramics* as an experiment in the relations between science, culture and the public. I ask in what the implications of this study might be for considering the Science Museum as an experimental setting. And, in closing, I discuss the question of the relations between science and culture, and suggest some of the challenges that this study raises both for sociological study of science.

2. Exhibition as public experiment: a literature review

Introduction

In the first chapter of this thesis I introduced the *Oramics* exhibition at the Science Museum, an exhibition which appears experimental in various different ways. Specifically, I highlighted three distinct modes of experiment: the curatorial experiment, experimental music and experimental display. I suggested that to deal with the experimental complexity we find in *Oramics* that we needed a concept of experiment that doesn't reduce the experiment to a single procedure, style or formalism. Instead, I suggested we need a concept that can allow us to describe empirically how the *Oramics* assembles these multiple modes of experiment together in a single exhibition. In Chapter One I introduced the concept of the "public experiment" as one such concept and it is the purpose of this chapter to elaborate what this concept is and some of the implications in applying it to the *Oramics* exhibition. In this chapter I present an overview of some literatures through which the proposition of the exhibition as a "public experiment" could be understood to have emerged. In doing so, I elaborate the theoretical basis from which we might examine the proposition that exhibitions could be said to be experiments in relations between science, culture and the public.

It is worth noting that exhibitions have not always been considered significant as sites for the study of invention. It is only relatively recently that sociologists concerned with experiments have looked to exhibitions as worthwhile settings for empirical research, and as formats that do more than simply communicate or diffuse experimental results into society. In this literature review I situate the study of exhibitions in relation to the interdisciplinary field of science and technology studies (STS). Though other fields have equally sought to establish the significance of exhibitions in terms of relations between science, culture and the public, few outside science studies have attempted to describe exhibitions as inventive formats.²⁷ The proposition of the exhibition as a "public

²⁷ The omission of museum studies literatures from this literature review reflects a deliberate choice to set-up the problem of the experimental exhibition in a particular way. Though this thesis is a social study of a museum exhibition, the Science Museum was chosen principally because it is a site where science and technology are made public. So, in this literature review I am concerned to treat the Science Museum exhibition as a format that it is continuous with other genres of public display of science and technology. This literature review is therefore not concerned with developing a general framework for the study of

experiment” is therefore developed here primarily through an engagement with the issues, problematics and concerns of STS.

While studies of exhibitions in the Science Museum have in recent years been undertaken by social researchers of a broadly constructivist inclination, the contemporary social studies of science and technology exhibitions can also be situated in relation to antecedents in twentieth-century, 'pre-constructivist', sociology. Early studies in the sociology of science were broadly concerned with accounting for the 'social structure' and 'cultural context' in which science developed²⁸. In these studies, science was assumed to constitute a unified social institution and the aim of sociologists was to explain the particular ways it developed both in relation to other social institutions and through cross-cultural comparison. In an historical context in which totalitarian regimes were appropriating science to legitimise oppressive policies, sociologists like Robert Merton argued for a normative account of science that maintain the independence of knowledge production from political appropriation. An important distinction these early studies established was therefore between 'internal' and 'external' accounts of scientific knowledge²⁹. In these internal/external models of science and society, the sociological study of science was limited mostly to giving 'external' accounts of science. In this internal/external frame, exhibitions and other formats of public display appear

experimental exhibitions, qua gallery formats, but rather attempts to show what is at stake in experimental public displays of science and technology. The *Oramics* exhibition is therefore approached here principally as comparable with other forms of public display of science and technology, rather than through a comparison with other experimental museum exhibitions. The following literature review is therefore not an exhaustive listing of all possible literatures that are implicated by this study but rather an attempt to formulate the *Oramics* exhibition as a particular kind of experimental apparatus.

- 28 An early body of literature from which the concerns current study derive is the sociology of science, most often associated with the work of Robert Merton. In this sociological literature, the central problematic was to define the ways in which social and cultural factors shaped the institutional organisation and development of science. The notion that social and cultural factors constitute the external context for science is central to the development of the sociology of science (for discussion see Shapin, 1988)(for discussion see Shapin, 1988a)(for discussion see Shapin, 1988)(for discussion see Shapin, 1988a). In Merton's (1973) account, the social factors that shape scientific knowledge include the institutional structures of science and the reward systems that incentivise the work of scientists. Culture was conceived by Merton as the repository of the norms, beliefs and value systems that underlie scientific research. Science, in Merton's account, is thus socially structured and culturally situated.
- 29 In the mid-twentieth century, science appeared heavily politicised in its uses by Nazi Germany and the Soviet regime to legitimise totalitarian and fascist political ends. Sociologists like Merton were therefore concerned to develop an account of science that could critique these appropriations of science as 'misuses'. The distinction between 'internal' and 'external' accounts of science was therefore central to early studies of the political relations between science and society, and its invention is often credited to Merton (Shapin, 1992). In Merton's account, rationality, cognition and material evidence were 'internal' to science while culture was the 'external' context; the task of sociology was to assess the extent to which non-scientific cultural factors, like the Protestantism ethic, influenced the development and progress of science as a whole. Though the use of the concept of the culture often varies considerably across different social studies of science, many have worked within the framework of that seeks to specify the relations between science and its cultural 'context' (see, for example, Barnes and Edge, 1982).

significant only insofar as they communicate knowledge produced inside science to its external publics. In other words, in these science and society models we can perhaps see why exhibitions might appear relatively uninteresting as sites for sociological research.

By contrast, later sociological studies problematised the inside/outside distinction that, it was argued, limited sociological approaches to giving only external accounts of science, leaving knowledge itself 'off-limits'. Such accounts therefore also unsettled distinctions between the social structure and culture context of science, and the independence of science from politics. Studies in the sociology of scientific knowledge (SSK), for instance, attempted to show that sociology could cross between the internal and external spaces of science to describe the ways in which scientific knowledge was socially constructed³⁰. These studies sought to show that the social studies were not limited to giving merely contextual or structural descriptions of science but could also account for the facts and knowledge claims put forward by scientists. In these studies, the politics of science was not limited to a separate sphere of social life but was rather shown to present in the working practices and knowledges produced by scientists. Other constructivist approaches have highlighted that such approaches can be applied not just to scientific knowledge but to all technical practices and the artefacts they produce³¹.

30 Broadly speaking this tradition, often called the sociology of scientific knowledge (SSK), built on earlier work in the sociology of knowledge (including functionalist and Marxist approaches) and developments in the philosophy of science (particularly Kuhn's account of paradigm shifts) in an attempt to give a sociological account of the so-called 'internal' aspects of science (Bloor, 1976; Collins, 1981a; Pinch, 2008; Shapin, 1992, 1995). The central focus of internalist SSK studies was the knowledge controversies that occurred between scientists: these studies argued that in such controversies the 'rationality' or 'truth' of competing ideas could not constitute the criterion for determining the success of one position over another. In other words, scientific rationality was an effect, *post-facto*, of the closure of knowledge controversies rather than the criteria that determined the progression of knowledge. One central tenet of such studies was the "symmetry postulate", Bloor (1999) elaborates: "Both true and false, and rational and irrational ideas, in as far as they are collectively held, should all equally be the object of sociological curiosity" (84). Social studies of the natural and physical sciences, like Collins (1981b)(1981a)(1981b)(1981a) (1981b)(1981a), deployed an extreme methodological relativism in attempting to symmetrically study the closure of controversies. Relativism about knowledge claims allowed sociologists to offer explanations for the construction of scientific knowledge which incorporated social and cultural factors.

31 In sociology, the study of science developed largely independently of the study of technology. Since technology has often been considered the application of science – as applied, for instance, in commercial products, industrial infrastructures and organisation techniques, to name a few – it has also often been considered the politics. As Bijker and Law (1992) note, the politicisation of technology is common because technologies often breakdown and cause social problems, even disasters. However, more recently the social studies have highlighted the interconnections between the concerns of science and technology and politics. One important body of literature which drew attention to these interconnections were cultural studies. Within cultural studies of science and technology there are very different traditions which include the social construction of technology (Bijker et al., 1987), cyber-feminism (Haraway, 1997) and actor-network theory (Latour, 1993a). Though these approaches are distinct, all share a common assumption of the hybridity concerns about science and technology. These studies have described contemporary social life as conducted within societies of densely permeated socio-technical networks

Moving away from the language of internal and external accounts, contemporary social studies have described the “dis-unity”³² of science. In contrast to early sociology of science, these studies suggest that culture is not simply a 'context' for science because, when studied empirically, there appear many different cultures of science comprising heterogeneous practices and localised to particular settings³³. In science and technology studies (STS), the appearance of science as a unified sphere of social life is therefore no longer an analytical given but rather considered a deeply political construct³⁴. It is as formats that actively inform public perception and intervene in political life, that exhibitions have more recently been approached as more than mere intermediaries between science and society (see, for example, Barry, 2001; MacDonald, 1998). As political concerns, exhibitions have been studied as sites that produce particular kinds of relations between science, culture and the public (see, for instance, Haraway, 1984). From the perspective of contemporary STS, exhibitions therefore take on a significance which they did not have in earlier sociological studies of science. The highly situated and localised character of exhibitions, which once perhaps limited their utility as sociological research sites, is increasingly no longer antithetical to the study of science but rather symptomatic of their dis-unified practice.

Recent social studies of science and technology have argued that exhibitions are formats that can be used to conduct experiments (MacDonald and Basu, 2007; Weibel and Latour, 2007). In this literature, exhibitions are said to be experimental when they mix together very different concerns in an attempt to create new kinds of social relations. Latour and Weibel (2002; see also Latour, 2005a), for instance, created an exhibition, called *Iconoclash*, that juxtaposed the practices, genres and concerns of science, art and religion in an attempt to show the synergies between these domains of social life that are often considered separate. Experimental exhibitions, these literatures tell us, are heterogeneous in the sense that they bring together many very different styles and traditions of experiment. The experimental exhibition is therefore a “risky”

and systems.

32 The “dis-unity” of science is described in Knorr-Cetina's (1999) of the different “epistemic cultures” of high energy physics and molecular biology. The notion of “dis-unity” makes clear the departure from earlier sociological studies of science, such as Merton, in which science was considered to constitute a unified social institution.

33 Many contemporary studies of science and technology emphasise an analytical focus on “practices” (for example, Mol, 2003; Pickering, 1992). as a way to account for the socio-material

34 From the perspective of cultural studies, the unification of science and technology as a single sphere is a particular fabrication that serves the ends of an imperialist, sexist and racist political culture (Harding, 1986, 2004). In the cultural account, the unity of science and technology is a fabrication that is used by particular actors to preserve and extend existing political relations of domination.

proposition for its various participants who are required to submit themselves to experimental requirements of heteronomy (Weibel and Latour, 2007). In the account given by MacDonald and Basu (2007) exhibitions are not simply static displays that represent pre-formed curatorial choices but rather, as experiments, are “spaces of encounter”, the effects of which are highly uncertain. These accounts suggest that experimental exhibitions are like “laboratories”, sites for the manipulation and creation of novel phenomena that travel beyond the walls of gallery spaces. In contrast to formats of exhibition where displays attempt to communicate information or enact particular experiences for visitors, these literatures argue that experimental exhibitions can usefully be regarded as messy and complex displays, as “assemblages”³⁵. To propose exhibitions as experiments, these studies suggest, is to treat spaces of public display as sites in which invention occurs.

In this literature review I make the case for approaching the *Oramics* exhibition as a public experiment. I'm going to argue not only that exhibitions have the capacity to be experimental, as if to mark out a distinction between different kinds of exhibition (e.g. experimental vs un-experimental exhibitions). Rather, in this literature review I explore the claim made in the studies discussed above that exhibitions like *Oramics* can be approached in a similar way to the experiments that take place in laboratories³⁶. From some perspectives, to approach an exhibition as an experiment is an absurd proposition. Experiments and exhibitions, these accounts argue, are fundamentally different kinds of format: to conflate them is to confuse the practice of science with its public display³⁷. By contrast, the approach I propose in this literature review argues that exhibitions and laboratory experiments have much more in common than such criticisms would acknowledge. The literatures considered here are therefore mostly drawn from science and technology studies (STS) and are focused specifically on the politics of experiments and public display. In what follows I am going to outline both what is gained in the choice to approach the exhibition as an experiment and some of the analytical obligations that this places on us. Specifically, I am going to argue that the benefits of this analytical choice are that exhibitions appear as formats that: (1) invent new things, producing ontological novelty, (2) reveal the dis-unity of

35 The concept of “assemblages” has been used to describe the hybridity of social and technical relations and the processes through which they are reorganised. It is discussed below in reference to the 'post-instrumental' account of the experimental exhibition (Irwin and Michael, 2003).

36 The comparison with the laboratory experiment is used here because this genre of experiment has often been considered by sociologists to be the 'hard case' for demonstrating the social and political character of experimental practices.

37 These objections are addressed in the third section of this literature review.

science, and (3) reorder the political relations between heterogeneous actors. In this literature review, then, I seek to make the case for normatively valuing exhibitions as sites of invention rather than mere intermediaries of communication. In this way, the literature review prepares the ground for the analysis of the *Oramics* exhibition that follows in the following chapters in which I seek to explore how the exhibition produces and negotiates relations between science, culture and the public.

In this literature review I attempt to show how the proposition of the exhibition as public experiment emerged as a concept through science and technology studies (STS). In these studies formats of display, like exhibitions, take on increasing significance as settings where these relations between science and the public are unsettled and negotiated. In the first section of the literature review I look at studies of the politics of science communication and public engagement in public understanding of science (PUS) literature. I drawn attention to the ways in which, in the PUS tradition, formats of public display have been conceived as 'instruments' that 'solve' the politics of science. In the second section of the review, I discuss literatures from social studies of science and technology, such as actor-network theory (ANT), that have given an "ontological" account of public display; as formats that can be treated as processes of invention that produce novelty. Ontological approaches suggest that exhibitions not only communicate experimental findings in public but produce new kinds of publics and political actors, and I explore such implications in detail. Finally, I consider some epistemological critiques of the ontological approach to the experimental exhibition. These critiques argue that the proposition of the experimental exhibition confuses two distinct political concerns with the practice and display of science. More significantly, perhaps, the epistemological critique suggests that in adopting an ontological approach we have to give up too much analytically, since we are no longer able to simply use categories like 'the social' and 'the political' to explain the workings of science. By looking at such critiques of the experimental exhibition, I suggest that we gain a greater understanding both of the advantages of the ontological approach as well as the analytical obligations that this approach requires us to accept. What I seek to do in this literature review, then, is make the case for approaching *Oramics* as a public experiment and in doing so to describe some of the ways in which exhibitions can be seen to intervene in the politics of science and culture.

The instrumental account of the public experiment

An important context in which to situate the *Oramics* exhibition is as a response to concerns about science communication and public engagement. Two related fields of literature in which these concerns are discussed in science and technology studies are: (1) the public understanding of science (PUS), and (2) public engagement with science (PES). PUS and PES developed largely out of what has been called the 'science and society' tradition, and were particularly concerned to address controversies which mobilised the public against scientific institutions (Wynne, 1995). The former, PUS, proposed that science communication could solve controversial situations by "diffusing" scientific and technical knowledge from institutions to the public. The latter, PES, developed later and was concerned with developing a two-way "dialogue" between scientists and other technical experts and the public to establish consensus over how to manage controversies. Both PUS and PES are concerned with what has been called public "interactivity" with science and technology. The account of public interactivity offered in PUS and PES is largely conceived as a form of communication. The difference is that in PUS diffusion occurs *post-facto* as the communication of scientific knowledge while in PES public dialogue occurs 'upstream' during the research process. However, a fundamental assumption shared by both PUS and PES is that the communication of science is independent of the practice of science. In both cases, public interaction with science is conceived as a response to controversies, to which experimental forms of communication attempt to provide a 'solution'³⁸. I argue here that the notion of the public experiment developed in PUS and PES, of which exhibitions are one format, offers only a largely instrumental account of the relations between science, and politics. The communication experiments of PUS and PES assume both that science constitute a singular, united sphere of social life and that politics is a separate sphere. In controversial situations when politics becomes a problem for science, PUS and PES suggest that public experiments are instruments that can solve and settle their relations. However, critical STS accounts of PUS and PES have highlighted that this instrumental model of the public experiment offers only a limited account of the politics of science, and fails to account for the socio-technical complexity of controversies. By looking at the critical STS studies of PUS and PES, I

³⁸ In the discussion of PUS and PES I often conflate the idea that the exhibition solves the politics of science and technology with a separate idea that science, technology and politics should be kept separate. It should be noted, as is discussed in the final section, that there are other traditions which would accept the former idea while rejecting the latter.

suggest, we gain an appreciation of some of the key concerns that the proposition of the exhibition as experiment aims to address.

Sociologists have widely described the increasing controversial situations that we find in scientifically and technologically advanced societies. In these controversies, technical experts and governmental institutions lose their assumed monopoly to frame and determine the trajectory of the issues at stake. The increasingly frequent occurrence of such political controversies has raised fears in government about declining public deference. Barry (1998) offers an analysis of the way in which experimental science exhibitions attempt to 'solve' such political problems of public governance in technologically advanced societies. Barry argues that experimental exhibitionary practices can be situated within a broader political context of attempts to make institutions more responsive to the public. In Barry's account, the interactive science exhibition enacts a model of public governance that rejects the pursuit of public deference and instead promotes public experimentation. Barry describes how this form of interactivity is realised in science exhibitions in which the visitor's free experimentation with their "untutored body" facilitates a particular kind of engagement that eschews hierarchical and didactic modes of public participation. This kind of interactive science exhibition, according to Barry, facilitates the production of an active and self-governing citizen, producing a spectacle of public participation that enacts liberal ideas of progressive enlightenment and individual autonomy. Interactivity, Barry argues, offered a solution to the political problems of public governance, insofar as individual self-experimentation (whether as a visitor, consumer, citizen etc) can be institutionalised as a form of public participation. As Barry notes, though interactivity might appear as a spectacle of socio-material engagement with science and technology, in Science Museum exhibitions like *LaunchPad* public experimentation is only instrumentally enacted as simply the means for realising a more didactic, hierarchical diffusion of scientific knowledge from institution to visitor³⁹. As I will discuss in this literature review, this instrumental version of the public experiment and interactivity, as an attempt to solve politics with communication, is characteristic of PUS and PES⁴⁰.

39 Boon (2010) highlights the importance of the concept of "interpretation" in the development of "science communication" approaches at the Science Museum. The term interpretation had a very specific meaning in the Science Museum which pertained to the function of the newly established Science Communication Division in the late 1980s. Boon describes the range of techniques of interpretation which ranged from the inclusion of explainers in galleries and practical demonstrations in science shows for museum visitors, to techniques of audience research as the means to determine the most effective ways to curate displays for different audience groups (see also Durant, 1992; Gregory and Miller, 2000).

40 Indeed, Boon (2010) highlights the failure of the Science Museum's version of interactivity to solve the institution's political problems, which are not limited to matters of governance.

The “diffusion model” of science communication is premised on the one-way flow of information from science to the public, mediated in and through technologies (Latour, 1988; Miller and Gregory 2000). An account of the development of an experimental diffusion model exhibition is given in MacDonald's (2002) *Behind the Scenes at the Science Museum*. MacDonald studied the making of an exhibition – called *Food for Thought* – at the Science Museum, describing the ways in which the Museum was shifting from an institution oriented around objects to one increasingly oriented around the public. *Food for Thought* was an experimental exhibition for the Science Museum in the late 1980s, which trialled a new approach to curating based on diffusion model notions of public interpretation of science, which MacDonald's study followed ethnographically. The Science Museum of the late 1980s and early 1990s was concerned specifically with the public understanding of science (PUS), making this its corporate 'mission statement' (44). In the PUS diffusion model, the exhibition is a medium through which science can be represented to the public, conceived as the external masses who lack an understanding of science and technical knowledge. However, MacDonald argued, this PUS diffusion model inadequately accounted for the politics of curating and exhibiting science observed in the ethnographic study. MacDonald argued that what the visiting public couldn't see was the back-stage of the making of the exhibition in which the science represented in the exhibition is entangled in a host of other messy and controversial concerns hidden from the audience's view. By getting behind the scenes, MacDonald highlighted the importance of the Museum's institutional culture and politics in shaping the representation of science in the gallery displays. MacDonald showed that the science represented in *Food for Thought* was influenced by local cultural concerns within the Science Museum. MacDonald argued that the science communication model of exhibition hid from view the controversies involved in making science public. MacDonald's study, then, highlights some of the ways in which the diffusion model of PUS failed to adequately account for the politics of experimental science exhibitions.

Just as MacDonald's study highlights the significance of the local and contextual factors in shaping experiments in science communication, so too

Boon argues that while science communication occupied a central role in the work of the Science Museum in the 1990s, the focus on contemporary issues in science and developed independently of the Museum's other main focus on the history of science. Framing Oramics as an experiment in “public history”, Boon (2011) suggests the significance of other political registers in the Science Museum beyond the contemporary concerns of public governance.

other empirical research on the public understanding of science has highlighted that interpreting science is always a context specific activity that occurs in multiple different ways (Michael, 1998). Irwin's (1995) case study the public safety information of a petro-chemical complex in Manchester, for example, showed how the institution failed to take into account the diverse ways in which local residents understood the technical risks to which they were exposed. The understanding of technical advice was, Irwin argued, an intrinsically social activity and in its local context could not be separated from the other concerns of daily life. The problem with the diffusion model of PUS, these studies have argued, is that it naively assumes that given existence of knowledge asymmetries between those people who are socially identified as scientific or technical and those who are socially identified as the lay public, what Wynne (1992a) terms the "deficit model" of the public. These studies argue that by operationalising a "deficit model" of the public PUS fails to account for the relational character of knowledge asymmetries and the particular contexts in which they emerge. Wynne (1992b), for example, described the way in which Lake District sheep farmers' livelihoods suffered as a result of government scientific advice in the wake of the Chernobyl catastrophe. Wynne described how the sheep farmers were required, against their own judgements, to follow the official advice of government scientists responsible for managing the threat posed by radiation from Chernobyl, advice which later turned out to be incorrect and which had a devastating impact on the farmers' livelihoods. This happened, Wynne argued, because the local knowledges of the Cumbrian sheep farmers were ignored by the government scientists sent to advise on the radiation threat to the area from Chernobyl, who simply assumed the farmers to be lay. The diffusion model of science communication was therefore widely problematised in these critical studies of PUS which highlighted the model's failure to represent the practices of science, to take into account the context-specific ways in which science was understood, and the political effects of the "deficit model" of the public⁴¹. These critical PUS studies therefore question the extent to which science communication experiments can 'solve' the politics of science and technology.

Concerns to address the political challenges associated with the "deficit model" of PUS, have led to an emphasis on public engagement with science (PES) as an alternative to the diffusion model. A model developed in PES posits that the

⁴¹ One of the ways in which the Science Museum responded to the critique of the "deficit model" was to experiment with new models of interactivity the public. For example, in one experiment the public was assembled to deliberate in a "consensus conference" about the governance of new plant biotechnologies (Durant and Joss, 1995).

flow of information between science and the public is a two-way “dialogue” which is shaped by local and contextual factors (for an overview see Elam and Bertilsson, 2003)⁴². As a two-way model, the dialogue version of science communication is proposed as a model that addresses the political inadequacies of the one-way diffusion model (House of Lords, 2000). In this dialogue model of communication, democratic mechanisms like consultations are conceived as the experimental fora through which the public and scientists participate in mutually framing controversial issues and democratising the governance of techno-scientific innovations. Unlike the *post-facto* model of communication in PUS, in PES the emphasis is on “up-stream” public engagement that can inform the trajectory of contemporary research and technological application (Wilsdon and Willis, 2004). In the dialogue model, then, public engagements are proposed as political instruments that address the 'democratic deficit' in science and technology. This capacity of public engagements to 'democratise' science and technology is premised on a notion that public dialogue aims at establishing consensus (Horst and Irwin, 2010). However, empirical PES research has questioned the extent to which “public dialogue” experiments can establish democratic 'solutions' to the political problems of science and technology. Thorpe and Gregory (2010), for example, argue that the “two-way” dialogue model brackets the broader political context in which communication between science and the public takes place. They argue that PES models are blind to the existing political asymmetries that shape the capacities of different actors to engage in dialogue about science. In consultations, for example, the capacities of the public to participate are often often partly dependent on the framing of the issues (see also Michael and Brown, 2005). For instance, Irwin's (2001) case study of a government consultation about the regulation of biotechnology and genetic modification highlights the role that government issue framing played in both structuring the issue and allocating competencies to the public that could participate. Moreover, PES researchers have argued that the framing of issues prior to

42 In the Science Museum, this two-way PES dialogue model was one factor informing the development of the Museum's Wellcome Wing – a new multi-gallery space focused on contemporary science – which opened in 2000. The exhibition of science in the Wellcome Wing sought to abandon the didactic aesthetics of earlier PUS exhibitions while maintaining an emphasis on visitor learning. Some empirical studies have questioned whether the forms of interactivity in the Science Museum's Wellcome Wing exhibitions in fact depart from earlier PUS models, since their displays remain principally concerned with individual cognition (Heath et al., 2005). The public engagement focus of the Wellcome Wing was extended later with the opening of the Science Museum's Dana Centre in 2003, a space which was explicitly focused on establishing public “dialogue events”. The practice of dialogue events in the Dana Centre attempted to create spaces for informed public debate on contemporary socio-technical issues, with a strong focus on education (Davies et al., 2009). Dana Centre dialogue events were thus designed to introduce a fluidity and dynamism into the PUS models, and in this sense largely sought to extend the aims of PUS in attempting to solve the politics of science and technology with public communication (Davies, 2009).

public dialogue experiments renders the two-way model simply extension of the earlier one-way diffusion model (for an overview see Felt and Fochler, 2008). Leach et al (2005), for instance, argue that dialogue experiments are shaped by discourses about scientific development containing highly normative accounts of citizenship, presuming particular forms of agency held by citizens to influence the governance of science and technology. These discourses therefore tacitly frame the parameters within which public experiments take place, limiting the scope and modes of public participation. Wynne (2005) also argues that framings of controversial issues in public are highly prescriptive with respect to ways in which publics can engage in dialogue with science. Specifically, Wynne argues that public dialogue in contemporary issues is often limited to questions of the risks in the applications of new forms of knowledge; risk discourse being deeply embedded with cultural assumptions about the place of science in society and the nature of citizenship. In limiting the political possibilities of dialogue to questions of risk, the PES dialogue model, Wynne argues, enacts versions of the PUS “deficit model”. In a similar line of argument, Jasanoff (2005, 2007) shows in relation to the GM foods controversy how policy framings of the issues allocated power. Jasanoff throws doubt on the extent to which the democratic fora of the dialogue experiments can overcome existing forms of exclusion and domination in science and technology. Elsewhere, Horst and Michael (2011) argue that science communication and public engagement processes not only often fail to establish dialogue but also have the undesirable effect of producing “idiots”, outsiders who refuse communication for other forms of action which are not accounted for in PES models. These critical PES studies of public dialogue suggest some of the limitations of attempts to use public experiments as communication instruments for 'solving' or 'democratising' the politics of science and technology.

There are, then, considerable commonalities in the models of PUS and PES insofar as both treat science and technology as political unified and communication experiments serve principally to engage a public that establishes both their utility in commercial applications (diffusion) and their democratic accountability (dialogue). In these models of the public experiment, political problems are considered potentially solvable because politics is a separate sphere and that controversies are the exception rather than the rule in science and technology. However, the critical studies of PUS and PES discussed here have questioned the extent to which public experiments can 'solve' controversial situations that arise in advanced industrial societies.

These studies highlight that for all the focus on creating public relations through communication, the PUS and PES models ultimately attempt to keep science, technology and politics separate. Irwin and Michael (2003) argue that the models of PUS and PES therefore give an inadequate account of public experiments. They argue that public experiments should be thought of as context specific “assemblages” in which science, technology and politics mix together. Approaching public experiments as assemblages, they argue, highlights the failures of communication models of public experiments to account for the social-technical relations in which the participating actors are entangled. Unlike the models of PUS and PES, they suggest that the politics of science and technology are neither principally problems of communication nor that they are 'solvable'. In their account of experimental assemblages, Irwin and Michael argue for a post-instrumental model of the public experiment that isn't simply a means to close down and externalise politics from science and technology. It is in the development of such post-instrumental accounts of public relations with science and technology, I suggest, that the proposition of the exhibition as experiment becomes significant.

The ontological account of the public experiment

The discussion of PUS and PES above highlights the limitations of formulating the experimental exhibition as an instrument for 'solving' the controversies that arise in advanced industrial societies. The studies highlighted that the instrumental version of the public experiment inadequately accounts for the complex socio-technical relations that are characteristic of controversies. In what follows I'm going to explore further what has been termed 'post-instrumental' accounts of public experiments. In these post-instrumental accounts, public experiments are not simply, as they were in PUS and PES, the instrument through which public institutions attempt to solve controversies. Rather, these accounts suggest that controversial situations occur precisely as a consequence of attempts to keep domains of science, technology separate from other domains of public life. In other words, the very formats, models, techniques and programmes that present science and technology as unified spheres also produce the conditions for controversies to occur. Public experiments, in this account, do not simply describe only the instruments that are deployed in controversies but rather describe the process through which controversy occurs. The accounts of the public experiment that will be

considered in what follows describe processes that are not only disrupt but that also produce novelty. Public experiments, in these account, are inventive processes through which relations between science and the public are unsettled and reordered.

Born and Barry (2010) give one such account of public experiments highlighting how their approach differs from the experimental communication in the PUS and PES models. They argue for an “ontological” approach to the public experiment, which they distinguish in the following way:

“public experiments do not so much present existing scientific knowledge to the public, as forge relations between new knowledge, things, locations and persons that did not exist before in this way producing truth, public, and their relation at the same time.”
(116)

Where instrumental conceptions of the public experiment in PUS and PES attempts to keep science, technology and politics separate, Born and Barry propose an analytical shift to treating experiments as formats that create ontological novelty, which they describe as “new knowledge, things, locations and persons that did not exist before”. Introducing ontological novelty, they suggest that public experiments disrupt and 'reveal'⁴³ the political organisation of science and technology. So, Born and Barry's account of the public experiment is unlike the PUS/PES models of experimentation insofar as it does not attempt to 'solve' the politics of science and technology. In the ontological account of the public experiment, politics does not cross into science and technology from outside, as it is assumed to in internal/external models. This version of the public experiment, Born and Barry argue, is premised on the dis-unity of practices of science and technology which always occur within heterogeneous political entanglements. This account of the public experiment doesn't simply assume that public space and political actors provide the external context with which science and technology need to reconnect and engage. Instead, Born and Barry propose the public experiment as an institutional format that renews and reorders relations between science, technology and the public. Public experiments not only create new objects but also new public spaces and political relations between heterogeneous actors. In this sense, the ontological account of the public experiment, Born and Barry

⁴³ Born and Barry draw on Hannah Arendt's account of the revelatory character of political action in order to describe the politics of public experiments (see Arendt, 1957). Arendt's account of politics is largely developed as a critique of instrumentalisation of political action in liberal and Marxist theories.

suggest, enables us to grasp the relations between science, technology and politics without instrumentalising politics or reducing complex socio-technical issues to internal/external models. In what follows I draw on actor-network theory to suggest that the ontological account of public experiments places the following obligations on accounts of the politics of science and technology: (1) politics is issue-specific, (2) public space is not a context for experiments but is produced in socio-technical processes, (3) political action is not an innate property of individual subjects but occurs across distributed relations, and (4) non-humans are admitted into political collectives and registers of democracy multiply. In what follows, I look at how these accounts of the politics of science and technology are developed in social studies of experiments in order to make clear what is at stake in approaching the *Oramics* exhibition as an experiment.

The ontological account of public experiments draws on ideas from science and technology studies (STS) that have highlighted the similarities between the repertoires and resources of science, technology and politics (Callon et al., 2009; Ezrahi, 1990; Haraway, 1997; Latour, 1993b; Marres, 2012a). In these accounts public experiments do not properly belong to either science, technology or politics but rather are rather formats that create new things that disrupt and reorder social relations between these domains. One account of the ways in which public experiments intervene in matters of social order is found in Shapin and Schaffer's (1985) study of the historical development of the experiment in the 17th century. This study describes the way in which the experiment was invented as a particular material, social and literary technology that intervened in the contemporary problems of political order. Shapin and Schaffer describe the roles of the 17th century public in the establishment of the space for experiments to take place, in modestly witnessing and testifying to experimental demonstrations, and in providing the literary addressees for the reporting of experimental matters of fact. Shapin and Schaffer's account looks at the ways in which these various roles of the public enabled the facts performed in local experimental societies (specifically, the Royal Society) to gain virtual mobility that could transcend the local conditions of their production. Once experiments had been witness in public space and written up for a public audience, facts became mobile and immutable. Shapin and Schaffer's account makes clear the limitations of epistemological accounts of experiments: experiments, they argue, did not simply replace the deductive rationalism of philosophers like Thomas Hobbes with a new theory of knowledge. Rather, at a time of social instability in Restoration society, the

experimental method also provided a solution to problems in political philosophy about how to establish a political order that guaranteed universal assent; natural knowledge could provide the authority on which to establish political order in a way that monarchical rule had failed to. The creation of experimental facts, which at once demonstrated and commanded public assent, Shapin and Schaffer argued, provided a new basis on which a political order could be founded. Shapin and Schaffer's account of the debate between Robert Boyle and Thomas Hobbes highlights that deep interconnections between these figures' natural philosophies about the material world and their political concerns about public order; the problem of political order being intrinsic to the formulation of both Hobbes' plenist and Boyle's corpuscular materialist philosophies. In their analysis of the controversial history of the experiment, Shapin and Schaffer's account makes clear the synergies between the technologies of science and politics.

Philosophers of science (Hacking, 1983; Stengers, 2010a) have been quick to point out that this ontological account of experiments does not render experimental science indistinguishable from forms of political activity. For institutions of science and technology, the ontological account of the experiment rather poses the challenge to explain the formation of modern science despite its practical similarities with politics. Stengers (1997), for instance, argues that the ontological approach does not require philosophers to abandon normative accounts of experimental practice in science. Stengers (2000) argues that the good experiment can be considered in terms of the "risk" that it places on the "experimental author" who, in putting forward an experimental proposition, seeks to gain the authority to speak on behalf of the things on which they are experimenting. Stengers argues that risky experimenters are those that provoke the "maximum heterogeneous interests" in their experimental propositions. Where epistemologists have emphasised the importance of the disinterestedness of experimenters, Stengers argues that it is in fact only when experimental propositions are "interesting" – the Latin "inter-esse" meaning to be "situated between" (in a way that creates new relations between interested actors) – that experimental authors are conferred with the power to speak for the things on which they are experimenting. A good experiment, Stengers argues, is an apparatus that establishes itself between actors and their interests and which therefore forces actors to pass through the apparatus in order to pursue their interests⁴⁴. Ontologists like Stengers make

44 A similar account of the experiment is given in actor-network theory in Michel Callon's (1986) concept of the "obligatory passage point".

clear that the confusions and exchanges between science and politics can in part be understood as a consequence of the failings of epistemology to establish a basis on which to demarcate science from non-science. If philosophers of science invariably engage in the 'scientisation of politics', as critics might argue, the ontological version advocated by Stengers nonetheless is a form of politics that conceives the cosmological foundations of science as inherently problematic: highlighting the ontological multiplicity, heterogeneity, and risky nature of scientific practices in their relations to the common world (Stengers, 2005). Far from undermining the *raison d'être* of institutions like the Science Museum, accounts of the ontological account of experimental science and its practical similarities with politics instead can be seen to invite the renewal and reordering of the territory that is given the name of science.

One obligation the ontological approach to public experiments places on sociological analysis is to orient our descriptions of political action around the fabrication of new objects, or “things”⁴⁵. Social studies of experiments have argued that the experimental production of new things is an inherently political activity. The materiality of experimental objects is not, these studies argue, easily separable from the actions of experimental participants (Latour, 2004; Marres, 2012a; Mol, 2003; Stengers, 2010a). These studies of public experiments have argued that experimental objects are not singular, cleanly delimited and independent of context, as they are supposed to be in the communication politics of PUS and PES. Instead, in public experiments objects appear as multiple, entangled in heterogeneous relations and distributed across different settings. In this way, social studies of public experiments have complicated theories of political action that would seek to keep separate the concerns of objectivity from concerns of subjectivity. In public experiments, they argue, 'objects-in-themselves' are not clearly distinguishable from the techniques of the political actors who represent them: objects do not just constitute the material context in which political action can take place. Latour (2004, 2005a), for example, describes the ontological approach in relation to two kinds of “object-oriented politics”: Latour argues that in adopting an ontological approach to experiments we need to shift our analysis of politics from the clean objects of “matters of fact” to the messy objects of “matters of concern”. The latter objects, “matters of concern”, occur in controversial situations in which the public presentation of an object is a necessarily

45 In the essay *From Realpolitik to Dingpolitik: Or How to Make Things Public*, Latour (2005) makes the case for a “politics of things”. Drawing on Heidegger's etymology of the term “thing”, as a gathering, Latour argues that the fabrication of things, or objects, is an inherently political form of action.

experimental process which assembles many different concerned groups. The making public of an object, Latour argues, is an experiment that is constitutive both of the object itself and the public. In a representational “matter of fact” politics, actors compete to exclude all other claims about the things that occupy public space. By contrast, a politics of “matters of concern” centres on the objects that concern different actors and maps out a different kind of public space which is dynamic and distributed. In public experiments, then, the materiality of objects is not separable from the concerns of the heterogeneous actors or the particular public settings where objects are staged.

Another way to characterise the politics of “matters of concern” is as an argument that politics is an issue-specific activity (Marres, 2005, 2007). An issue-specific account of politics problematises internal/external models of the relations between science, technology and the public. Marres (2012) argues in relation to experimental situations that it is here impossible to distinguish between who the insiders and outsiders of public spaces are or should be or which should be involved in settling controversial issues and, hence, the public here becomes a fundamentally problematic category. To account for the experimental politics of issue-publics, Marres suggests, is to attend to the ways in which the problems of the public are distributed. Studies of public experiments attempt to redistribute the problems of the public from procedures for political representation to the assemblages of actors, objects and settings of which issues are comprised. For instance, Callon and Rabeharisoa (2004) highlight how articulations of public space and political action are constructed by mobilising particular distributions of issues. In their discussion of the moral agency of a patient of neuro-muscular disease, Callon and Rabeharisoa highlight how different configurations of the issue construct competing accounts of the public space in which the patient has the capacity to act, or not to act, politically. Publics, in this view, are material entanglements which, in experimental settings, appear malleable with the capacity for “movement” as issues develop and change (Lezaun and Soneryd, 2007). These studies argue that the externalisation of the public from science and technology leaves us ill-equipped to account for the issue-specific modes of public assembly we find in experimental settings.

The notion that public space is produced as a consequence of experimental situations is found in studies of contemporary political controversies in science and technology. These studies argue that the entanglement of techno-science in the fabric of daily life leads increasingly to political controversies and

therefore to experimental situations (Callon, 1998; Callon et al., 2009; Latour, 2004). Public space is therefore not simply a context for displays, or exhibitions, of science and technology but rather dense and dynamically entangled with technical practices. Attempts to contain or 'solve' controversies through governance and communication techniques, such as those described by PUS and PES, only further proliferates their entanglements in public. Callon (2009) develops the concept of the "hybrid forum" to describe the experimental settings that arise from contemporary controversies such as GM foods, BSE, nuclear waste, asbestos and so on. In hybrid forums, the asymmetries that structure the liberal democratic ideas of public space – constructs that demarcate citizens from politicians, and experts from lay people and delegate to each different capacities for acting and representing – are blurred. This blurring does not only change the interactions between different individuals and groups, as if these occurred against a static background, but rather more fundamentally reconfigures the materiality of public space. In studies of contemporary controversies, claims to objectivity – the preserve of experts and politicians in liberal democratic models of public space – are distributed in relations between the actors, objects and settings assembled in experimental situations. In experimental situations, the staging of public space is not clearly distinguishable from the actors and objects that populate it, and thus the materiality of experimental public spaces appears a 'hybrid' concern. Hence, in concepts like the hybrid forum we can understand some of the ways in which public experiments reorder the materiality of public space.

Studies of public experiments have therefore argued that the capacity for political action is not the monopoly of human actors, or at least that the capacities of the human actor becomes a much more complex proposition when they are entangled in an experimental setting. Actor-network theory (ANT) in particular has developed the idea of apply a "generalised symmetry" in the treatment of "human" and "non-human" agency (Callon, 1986). The ANT account describes the capacity of experimental formats to enrol and mobilise distributed networks of actors, or "actants" (both human and non-human actors). In ANT, public experiments are means of introducing and domesticating new entities in the collective world (Latour, 2004). ANT studies have argued that epistemic objects of experiments are never isolated, though they may appear to be in controlled settings like a laboratory, but instead are always entangled within broader socio-material relations. For ANT, then, the scientists involved in experiments are not simply epistemic participants who compete over representations of the world with other scientists, but rather

participants in competing programmes of action (Latour, 1988). These programmes of action are not limited to controlled settings, such as laboratories, but are distributed across complex networks that involve many different kinds of actors from across society. Action, in ANT therefore occurs when these networks are mobilised. This happens not only when scientists do experiments but when all sorts of other social actors develop programmes of action. Analytical models that assume, a priori, the separateness of science and society, and the concomitant distinctions between the social and natural, technology and politics (etc) fail to adequately account for the complexities of these actor-networks (Latour, 1993).

Political action considered asymmetrically to be only the capacity of humans, it is argued, inadequately accounts for the way in which non-humans also participate in the politics of experimental settings (Gomart and Hajer, 2003). In public experiments, political action is a problem that includes phenomena as diverse as microbes (Latour, 1993b), scallops (Callon, 1986), electric vehicles (Callon, 1980), and diseases (Mol, 2003). ANT studies have sought to include “non-humans” in ideas of political action by treating them symmetrically with humans as equally “actants” (Latour, 1988). Another name given to the inclusion of non-humans in politics has been called “ontological politics” (Mol, 2003). While others have argued that including non-humans in politics entails recognising that politics is not the base pursuit of a fallen humanity but a cosmological matter, in which questions of the physical world and the agency to act in it are at stake (Stengers, 2005, 2010a, 2010b). All of these accounts argue that accounts of non-human politics would necessarily move beyond ‘off-the-shelf’ notions of politics, and instead requires us to look at the ways in which non-humans become “equipped” with political capacities (Marres, 2012). Later ANT studies (Latour, 2007; Marres and Lezaun, 2011) have, for example, attempted to extend the modes of politics in which non-humans participate beyond the forms of “action” – action being a distinctly “human” political concern (Arendt, 1958) – to those modes particular to non-humans. These studies of non-human politics suggest that in experimental settings our ideas of politics are not immune to the demands of experimentality.

By admitting non-humans into political collectives, ANT therefore claims to extend theories of democracy to encompass the practices of science and technology (Latour, 2004; Callon et al 2009). Of course, in many senses, the concern to include non-humans in democratic theory is not unique to ANT. Marres (2012), for instance, makes clear that there are many existing forms of

democratic theory that include versions of non-human, or “material”, politics. However, Marres argues, public experiments are uniquely suited as testing grounds for ideas of democracy that foreground the place non-humans. Marres, for example, discusses the role of devices in sustainable living experiments, showing how in such experiments non-humans both gain and lose their capacity to participate in the public politics of climate change. Marres argues that public experiments highlight the variability of material democracy which may involve non-humans but which also does not necessarily depend on their participation for its accomplishment. Elsewhere, Lezaun (2011) describes the case of a 1970s Norwegian “offshore” labour experiment, aboard the *Bilbao* ship, which attempted to test a very particular “industrial” version of democracy. In Lezaun's study, the inclusion of non-humans in democratic politics appears to multiply the spheres of social life that are concerned with questions of democracy. And, as Latour (2007) notes, if including non-humans challenges models of democracy that asymmetrically limit the capacity for political action to humans, then the inclusion of non-humans also extends the domains and registers in which democracy circulates as a concern. Ontological accounts of public experiments, then, make arguments that both challenge and also seek to extend our ideas of the proper concerns of politics and democracy theory.

The ontological account, I have suggested here, helps to make clear what is at stake in the analytical choice to treat the *Oramics* exhibition as an experiment in the politics of science and technology. These studies tell us that experiments produce ontological novelty: so, to look at the exhibition as an experiment is not simply to treat it as a static surface of representation but to see it as a dynamic space of invention. If we accept the ontological version of the public experiment as the model for the exhibition, we find that experimental exhibitions are forms of public display that don't simply represent or communicate science and technology but rather are creative formats that invent new things, that reveal the distributed and heterogeneous character of science and technology and which reorder socio-technical relations. This version of the public experiment is not discontinuous with the 'doing' of science and technology, as it was in PUS and PES, for instance, in which public displays served simply as intermediaries for communicating the findings or products of experiments. The use of public experiments by institutions of science and technology is, as Barry and Born argue, a way of renewing and reordering the political arrangements. Producing ontological novelty, experiments disrupt existing forms of organisation and create new kinds of

socio-technical relations. In this sense, public space is not simply the context in which public experiments take place but is rather materially reassembled in the experimental process. Politics is therefore not something external to public experiments, as if experimental processes could be judged by existing political models, but is rather specific to the experimental issues. In this sense, Born and Barry argue, public experiments are politically 'revealing': they render visible the socio-technical relations in which issues are composed.

Some epistemological objections to the experimental exhibition

In what follows I look at some important objections to the proposition that exhibitions like *Oramics* can be approached as experiments. The main objections I am going to consider here are epistemological objections drawn from within STS literatures which argue that experiments are fundamentally different formats to exhibitions. Experiments, in these epistemological accounts, are formats that produce knowledge while exhibitions simply put knowledge on display. These epistemological critiques of the experimental exhibition argue that we need to separate out experiments (or the practices of science and technology) from exhibitions (the display of science and technology). They argue that this separation ensures that we aren't tricked into believing that well-rehearsed displays of exhibitions have any relation to messy and contingent practices of science and technology. These epistemological critiques suggest that the proposition of the 'exhibition as experiment' is highly unlikely: exhibitions are about 'showing' rather than 'doing' and if *Oramics* really is an experiment then, in the epistemological approach, it surely fails as an exhibition. For these epistemologists we can have either exhibition or experiment but we can't have both. The conflict between these epistemological and ontological versions of experimental exhibitions can be seen in relation to social studies of demonstrations. From the ontological approach, the demonstration appears as a genre of the public experiment that retains all the features described above: demonstrations are formats in which politics is issue-specific and which produce public spaces. To the epistemologists discussed below, by contrast, demonstrations are simply well rehearsed displays of scientific facts and are not formats that produce knowledge. Looking at epistemological objections, I suggest, makes clear both what we gain from adopting the public experiment as the model for exhibition

as well the trade-offs and obligations that are involved.

From the perspective of the ontological account described above, the demonstration appears as a genre of the public display in which new things are created and which intervene in the composition of public space. Demonstrations have often been separated into the distinct concerns of science, on one hand, and politics, on the other. In contrast, recent social studies of demonstrations, some of which have already been discussed above, argue that the political and scientific accounts of demonstration are much more closely connected than is appreciated by modern epistemology and political theory. Attempts to separate out scientific from political formats often draw distinctions between two historical meanings of the term demonstration: the earliest being the Aristotelian notion of the demonstration as a scientific proof for a finding that is doubtful or not immediately obvious, and, the more historically recent understanding, since the 17th century, of the demonstration as the performance of 'showing' new phenomena. By contrast, rather than attempting to separate out the scientific and technical content of demonstration from the politics and aesthetics of 'showing', recent social studies of demonstrations, such as Girard and Stark's (2007) analysis of public participation in the proposed rebuilding of downtown Manhattan after 9/11, suggest that it is only by treating demonstrations as inseparably socio-technical that we can adequately attend to the ways in which public space is assembled. Indeed, social studies of demonstrations have highlighted some of the problems that occur in attempts to disentangle experimental 'practice' separate from experimental 'display', and for which public space is simply assumed to be the external context in which experimental displays take place. For instance, Lezaun (2011) argues that attempts to control the public spaces in which experimental demonstrations occur can have the unwanted effect of limiting the capacity of an experiment to extend beyond the immediate site of its display. Lezaun's case study of a 1970s Norwegian "offshore" labour experiment, aboard the Bilbao ship, also highlights the many different genres of public experiments; in this case, as an attempt to demonstrate a very particular "industrial" version of social democracy. Studies of demonstration, then, not only highlight the ways in which public experiments unsettle socio-technical relations but also draw attention to the heterogeneous genres of experimentation through which public space is reordered.

An example of the way in which demonstrations intervene in composition of public space is found in Barry's (2001) study of a protest against road building

in Newbury, UK. Barry's study compares the technical direct action of protesters living in trees and tunnels, on the site on which the road building was proposed, with a Friends of the Earth (FoE) "site-specific" art exhibition as attempts to create the protest as an event for the media (for further discussion of the importance of media and mediation in demonstrations, see Callon, 2004). Barry contrasts the direct action protesters largely technical concerns about the methods of action on the site, with the FoE attempt to use the exhibition format to publicise its message to the media. Barry argues that the FoE exhibition highlighted the gulf between the organisation's generic political techniques, creating an art-exhibition and involving celebrities, and the empirically specific techniques of the direct action protesters. Living in trees and tunnels, the direct action protesters made visible the complex connections between the people and the land which was translated into a publicity event in the media. By contrast, Barry argues that the exhibition created by FoE largely failed to gain the envisaged media coverage because it was not site-specific enough. Far from being a case study of the distinction between formats of action and display, Barry's account highlights precisely the similarity between both the direct action and the exhibition as publicity formats which differ only in their relation to the object (the site of proposed road) that they sought to visualise: the direct action protesters site-specific methods made the object visible through techniques of intervention while FoE used spokespersons (celebrity artists) to represent the objects. In terms of the creation of public space, the direct action protesters were much more successful because their techniques of demonstration could be flexibly interpreted and easily be translated into media publicity. Social studies of demonstration therefore highlight the ways in which practices of public display do not simply bring new objects in an already constituted public space but rather are formats that are themselves constitutive of public space itself.

In contrast to the account in social studies of demonstration, which have argued that public space is experimentally constituted in demonstrations, the epistemological account of demonstrations argues that there is a clear distinction between experimental 'practice' and the 'display' of experimental results. The epistemological account makes a clear distinction between public space as external to experimental practice and as the context of experimental display in demonstrations. A sociological version of the epistemological account is given in Collins' (1988) study of a televised crash of a train carrying nuclear materials, a study of a public experiment designed to demonstrate the safety of nuclear science to the public. Collins' argues that it is important to

separate out the concept of experimentation as a scientific practice from experimental demonstrations which are simply well rehearsed displays that occur after experiments have been conducted. Collins' conception of public experiments is in many ways not dissimilar to that discussed above. For Collins, public experiments create new forms of knowledge, require the participation of heterogeneous participants, and are risky endeavours. However, for these precise reasons Collins finds the authentic public experiment a highly unlikely occurrence. Many events that are given the name of public experiment, Collins' argues, are inauthentic as experiments and instead as simply well-rehearsed displays. Demonstrations, Collins argues, fall into this latter category because their principal role is to educate and convince audiences; they are not themselves experimental. By separating out public experiments from demonstrations, Collins argues, sociologists are equipped to evaluate whether or not public experiments really are experimental or simply well rehearsed displays. In the case of the train crash, Collins argues that this public experiment was simply intended to demonstrate that nuclear science was safe, certain and uncontroversial. The train crash was therefore not a public experiment because it did not incorporate the uncertainties and breakdowns that, Collins suggests, are integral in scientific practice⁴⁶. Rather, Collins argues, the train crash was a staged display that attempted to allay public concerns around the issues of nuclear safety. In Collins account, demonstrations are instruments for displaying experimental results but are not themselves formats of experimental practice.

To conflate formats of demonstration with practices of experimentation, in Collins' argument, is to risk uncritically accepting idealised and unrealistic accounts of scientific practice that empirical studies in STS have sought to debunk. For Collins, staged demonstrations exaggerate the certainty of scientific practice at the expense of showing the breakdowns and failures that, Collins claims, are intrinsic (see, for example, Collins, 1987). For Collins, the outcome or progress of an experimental knowledge programme is only known after all uncertainty and controversy has been closed out. However, it is only in controversies that we see how experimental knowledge is created, and for this social scientists need to adopt a relativist epistemology in order to treat symmetrically the differing claims of participants in the experimental programme (Collins, 1981a, 1981b). In this sense, Collins account of

⁴⁶ Elsewhere Collins (1987), for example, argues that the communication of science experiments on television is often misleading in its staging of them as experimental displays. Collins argues that the image of science on television overstates the certainty of scientific knowledge at the expense of the inherent uncertainty of science – break-downs, failures and competing interpretations – integral to its production.

demonstrations is not dissimilar to arguments made in PUS and PES to promote the correct public understanding of science. The authentic public experiment is, in Collins' account, is completely unlike a demonstration or an exhibition. For Collins the experimental exhibition is therefore not only an unlikely occurrence (there are very few instances where scientists need to experiment in public as opposed to doing so in the safety of a laboratory) but when it occurs it is a highly risky endeavour for those involved that offers no guarantees of success. The epistemological challenge to social studies of demonstrations, then, is that they are unnecessarily limited to studying the public presentation of science, and offer little insight into experimental practice. Demonstrations, in Collins argument, have nothing to do with public experiments because demonstrations and experiments are fundamentally different formats. To be concerned with the empirical variety in experimental demonstrations, in this view, would simply pertain to the aesthetics of display rather than to the epistemology of the experimental claims presented. From the perspective of Collins account, the proposition to study an exhibition as an experiment either risks misrepresenting experimental practice or likely fails as an exhibition.

There are many potential benefits in the epistemological approach to public experiments described by Collins. Equipped with the distinction between public experiments and well-rehearsed demonstrations we could approach the *Oramics* exhibition and sort out whether or not it is authentic as an experiment. Moreover, Collins' relativist epistemology for studying experimental practice offers both methodological prescription and explanatory power insofar as it approaches symmetrically the competing claims of experimental participants and seeks to identify factors external to science, social factors, that account for the success of a particular version over its competitors (see Collins, 1981a; 1981b). This explanatory power is sacrificed, Collins (Collins and Yearley, 1992) argues, by ontological approaches like actor-network theory that refuse not only the distinctions between natural (internal) and social (external) accounts of experimental claims but of all asymmetric distinctions, the most controversial of which is the distinction between humans and non-humans. Where the relativist epistemology, Collins argues, allows analysts to alternate between natural and social explanations because it assumes a human-centred universe, the generalised symmetry of actor-network theory rejects any such centre around which organise its analysis. In Collins argument, the material-semiotic method of actor-network theory – semiotics being the method that allows sociological analysts to accord agency to non-human things – fails

methodologically because it offers no material foundation on which to ground its explanations of science. While the symmetrical treatment of humans and non-humans might sound philosophically radical, Collins argues that the generalised symmetry and semiotic method of actor-network theory is simply a linguistic invention that transforms the world into signs and in doing so empties it of the material distinctions between words and things. The ontological claims about non-human agency might sound radical, Collins argues, but it is epistemologically conservative because it accepts at face value scientists' and technologists' 'before and after' claims about the invention of new objects. ANT's claims about non-humans, for Collins, mask a more reductive scientific realism and technological determinism that sociologists of science and technology have long critiqued. What we gain from the (relativist) epistemological approach to public experiments, Collins' account suggests, is an understanding of the ways in which scientific knowledge is socially constructed. Collins' critique of the ontological account of public experiments and defence of relativist epistemology and social constructionist account of science and technology highlights some of the risks of the ontological approach in falling back into a form of sociological positivism, assuming that actors give an accurate account of their practices as opposed to critically situating the practices of actors in a broader social context. In these respects, the epistemological account makes clear some of the potential weaknesses, methodological and explanatory, of the ontological approach and, perhaps more problematically, that it risks giving up the very ground on which sociology can account for science and technology.

In their response to Collins, Callon and Latour (1992) defend the symmetry of ANT approach arguing that it is only by giving up their assumed monopoly over social explanations, that sociologists can adequately account for the politics of science and technology. They argue that the relativist epistemology of sociologists studying scientific knowledge is unsymmetrical in its treatment of naturalistic and sociological forms explanation, explaining scientists' naturalistic descriptions of the world in terms of social factors. Though the social constructionist approach, Callon and Latour argue, makes clear that sociological description of science and technology is possible, this approach also limits to sociology to giving 'social explanations' and in doing so maintains scientists' hegemony over natural explanations of the world. Collins' sociological relativism is an epistemology in which the ontologies of 'nature' and 'society' are simply assumed to constitute the respective domains of "things-in-themselves" and "humans-amongst-themselves". In the study of

experiments, the social constructionist approach is instrumental in its ontology, using an ontological divide between nature and society as the foundation from which to create social accounts of experimental (natural) facts. By contrast, as described above, an ontological approach finds in experiments the production of new things that cannot be reduced to either a priori 'natural' or 'social' ontologies. If experiments produce ontological novelty, then both social and natural ontologies must have to change if they are to accommodate experimental fabrications. The attentiveness to the production of novelty in experiments requires, this approach argues, that we treat ontology as variable. Treating ontology as variable obliges us to extend ontology as a property of many other things besides nature and society. The critique of demonstrations, as formats of display that simply reproduce well-rehearsed experiments but in fact do nothing new, denies that demonstrations are ontologically significant. In contrast to this critique, I will now look at some ontological accounts of demonstration given by actor-network theory.

One account of the difference between the epistemological and ontological versions of demonstrations is given in Latour's (1993a) re-reading of Shapin and Schaffer's history of the experiment (discussed above). Latour's replay of the debate between Hobbes and Boyle is between the two forms of demonstration we find conflated in contemporary usage: Hobbes' (Aristotelian) apodeictic, self-evident reasoning versus Boyle's performances of the air-pump which reveal experimental facts to witnesses who faithfully testify to their existence. Epistemological accounts, Latour shows, will either damn Hobbes and Aristotelianism to the dustbin of history – celebrating Boyle's experiments as a new form of knowledge – or render invisible the theatre of proof that Boyle requires to successfully demonstrate his facts – focusing only on Boyle's factual claim that an air-pump can produce a vacuum. Epistemological accounts, Latour argues, are unable to take into account the ontologies of science and politics that are invented with the experimental programme:

“Boyle is not simply developing a scientific discourse while Hobbes is doing the same thing for politics; Boyle's is creating a political discourse from which politics is excluded while Hobbes is imagining a scientific politics from which experimental science has to be excluded. In other words, they are inventing our modern world, a world in which the representation of things through the intermediary of the laboratory is dissociated from the representation of citizens through the intermediary of social contract” (27)

In Latour's re-reading of Shapin and Schaffer, science and politics are not fixed

ontologies through which we can explain the outcome of this Hobbes-Boyle debate. Instead, Latour argues, the outcome of this debate, Boyle's victory, created a particular ontological settlement between science and politics; a separation that, Latour argues, has shaped the modern world. Latour argues that Boyle's experiments were successful because in their public demonstration they mobilised distributed networks of actors in a way that Hobbes's water-tight logic did not. Shapin and Schaffer's account of the experiment, Latour argues, shows that the success of the format was not simply that it enrolled those who were immediately involved in the experimental setting but because in public displays experiments also mobilised large and powerful networks of actors including kings, parliaments, capitalists, merchants, publishers, revolutionaries and so on. The experimental demonstration, in Latour's account, is a process that intervenes in radically diverse networks of actors and which, in the process of creating new matters of fact, not only transforms scientific practices but fundamentally reshapes the practices of all of the other actors who are enrolled. For example, Latour's (1993b) account of Pasteur's invention of microbes shows how this invention radically reformulated the entire problem of public health from a matter of hygiene techniques to questions of microbiology. Central to Pasteur's success was the public demonstration in which it could be shown that the experimental apparatus was mobile; experiments not only worked in the local Parisian conditions but also in the French provinces. In Latour's account the demonstration does not simply disseminate the experimental knowledge so that it can be put into practice but rather, Latour argues, public demonstrations are always practices that mobilise distributed networks of actors. In the provincial demonstrations, it was not just microbes that were being mobilised, Latour argues, but France itself. In Pasteur's provincial demonstrations, a whole diversity of actors across France had to change in order to accommodate the new microbes. Epistemological accounts fail to adequately account for such distributed effects of experimental demonstrations because they assume public space to be independent from experimental practice and therefore unaffected by the novel things that experiments produce.

The ontological approach argues that once we accept that experimental displays produce ontological novelty, then we can no longer make the simple distinction between the 'doing' and 'showing' of science and technology. From the ontological perspective, there is nothing unlikely in the proposition of the experimental exhibition. By contrast, epistemological approaches argue that it is only by making a priori distinctions between formats of experimental practice

and display we are able to retain explanatory power in our analysis of experiments, to show how science and technology are socially constructed. Epistemological critiques of public experiments, such as Collins' account, argue that ontological approaches give up far too much analytically, methodologically and ethically, in accepting the proposition of the exhibition as experiment. Examining such critiques highlights that the adoption of an ontological approach obliges sociologists to treat ontology as both multiple and empirically variable and in doing so reject modes of explanation that presume an ontological foundation e.g. 'the social' or 'the political' as explanatory resources. By adopting the ontological approach we are therefore confronted with a lot more complexity: politics, science and technology cannot be a priori demarcated from one another as they were in the internal/external models of PUS and PES, for instance. It might be argued that there is a risk, perhaps, that in adopting the ontological approach we render our account of the *Oramics* exhibition too complex. However, we might also note that if ontological complexity is a challenge for the sociological analyst then it is also shared with those other participants in the experimental exhibition who accept that they too are submitting to the risks of heteronomy. In this respect, accepting ontological complexity can be seen not simply an arbitrary analytical choice but rather the condition on which the sociologist too becomes a participant in the experiment. What I have attempted to argue in this chapter, then, is that it is only by accepting the proposition that exhibitions can produce ontological novelty that we can approach *Oramics* as a setting that reorders relations between science and the public.

Conclusion

In this literature review I have condensed a large range of literature and in doing so necessarily suppressed some of the complexity of these debates in order to make an argument about what it means to treat *Oramics* as a public experiment. I have also deliberately omitted several other bodies of literature, that might otherwise be proposed as relevant to a museum study, in order to set-up the exhibition as an experiment. I will therefore use this conclusion to restate the central points of the argument to show what we gain by looking at the *Oramics* exhibition in this way. I opened this literature review by proposing that an exhibition like *Oramics* can be considered as a response to past attempts to use experimental exhibitions as instruments for 'solving' the political problems of science and technology. By looking at studies of

experiments in science communication and public engagement, I argued that these studies offered instrumental accounts of the experimental exhibition and for this reason they can be criticised for providing an inadequate account of the relations between science, technology and politics. In the second section of this review I looked at ontological accounts of experiments in order to make the case that the experimental exhibitions reorder socio-technical relations. These accounts argue that experiments are productive of ontological novelty and therefore both unsettle and 'reveal' socio-technical relations arrangements, in the process of reordering them. The ontological approach to experiments, I suggested, obliges us to rethink models of the public as the merely context or backdrop for political action: in the experimental process, I argued, the materiality of public space is recomposed. The public of the experimental exhibition is not, therefore, simply limited to the space of the museum gallery because in what the public consists is precisely what is at stake in the experiment. Finally, in the third section of this literature review I have considered some epistemological critiques of the experimental exhibition. These critiques, I have argued, not only make clear what is at stake in the proposition of the experimental exhibition but also clarify some of the analytical implications of the ontological account of the experiment. This does not mean, however, that by accepting the ontological account we necessarily 'throw out' the epistemological concerns of sociologists like Collins. Rather, the ontological account suggests some of the limitations of epistemology in presuming the basis on which social explanation can be established. What might be called a broadly social constructivist epistemology is an antidote to a world that is split into two dominant ontologies of nature and society; once we accept the proposition that ontology is variable we find a multiplicity of ontologies for which such social constructivist approaches are inadequately suited. The ontological approach proposes instead that for an empirical world of variable ontologies we require sociological approaches that are attentive to the issue-specificity of experimental practice. To approach *Oramics* as a public experiment, then, proposes that we investigate whether and how something 'new' is being fabricated in the *Oramics* exhibition.

There is, however, one significant theoretical weakness that might be said to arise from the ontological account of the public experiment described above. First, it might be objected that the ontological account of the public experiment is so highly generalised that it could be applied to almost any social phenomena. From an ontological viewpoint many things other than exhibitions could equally well be described as a public experiments, and in this sense the

concept does little to distinguish what is particular about exhibitions as public experiments as opposed to other forms of public experiments. Worse still, it might be argued that if the public experiment is simply a synonym for the creation of novelty then it is not sufficiently distinguished from the vast range of sociological concepts that do similar work. These are both pertinent challenges to the account of the public experiment developed here and both are to some extent true of the account as I have presented it. However, I argue in this thesis that what we might sacrifice in theoretical specification through an ontological account of the public experiment we gain in empirical and analytical purchase. Though the ontological account of the public experiment might seem generalisable to many other social situations, in the particular empirical setting of the *Oramics* exhibition I suggest it offers us a way to take seriously the different modes of experimentation that we find in the displays. Thus, its weakness as a sociological construct is a strength in the particular empirical setting of this study where experimentation has very particular significances (discussed in Chapter One). And, moreover, though it might be argued that the ontological account tells us little more than that novelty is created, it is precisely because exhibitions have rarely been studied as processes that create ontological novelty that applying the concept of the public experiment to the *Oramics* exhibition we might explore some of the ways in which the exhibition might be said to be an inventive format.

3. Methodology: ethnographic fieldwork and thematic analysis

Introduction

In the first chapter I introduced the *Oramics* exhibition and the central questions of the thesis, and advanced the proposition that we can understand the exhibition as an experiment in relations between science, culture and the public. In the second chapter I elaborated the central concept of the thesis, the “public experiment”, and highlighted the implications of applying this concept to the *Oramics* exhibition. In this chapter I discuss the ethnographic methodology used for the research and the different phases of fieldwork, present an overview of the empirical material collected, and outline the structure of the analysis presented in the subsequent chapters. I also raise some important methodological considerations what kind of empirical object the experimental *Oramics* exhibition is, and how to research this object ethnographically.

This thesis began with a proposal to study the relations between science and the public and to empirically research an experimental process involving a scientific institution. The identification of the Science Museum as a site for research into this subject was partially the result of connections I had made with the Museum's curators during my prior professional work on public engagement with science and technology. Though I could likely have chosen other field sites for research into public experiments, this does not mean that the Science Museum was somehow an arbitrary choice. In preliminary meetings with the curators it was clear that we shared an interest in some of the same issues in the social study of science and technology, which they sought to address through the experimental *Oramics* exhibition. The *Oramics* exhibition was the first attempt of the Museum's curators' to develop what they call a “public history” approach to curating exhibitions, which attempts to tap into the historical knowledges of 'lay persons'. The Science Museum therefore seemed an appropriate setting for the research based on a shared interest with the curators in the proposition of the experimental exhibition and the problem of the relations between science and the public. Beginning my

research by observing the curators' experimental work, I sought to explore how a public experiment developed in practice.

By attempting to apply the concept of the public experiment to the *Oramics* exhibition, I sought to use this concept to develop a better understanding in what was the exhibition might be said to be an inventive format. The empirical analysis presented in this thesis is neither a field report of the curators' experiment nor does it use the empirical material simply to confirm the concept of the public experiment, as it was discussed in Chapter Two's literature review. Rather, in the analysis I attempt to look at the different ways in which the empirical engagement with *Oramics* exhibition would problematise some existing ideas (some of which were raised in Chapter Two's literature review) about how experimental exhibitions make relations between science and the public. Such problems I hoped might reveal something about the practice of experiment in settings outside of the laboratory and thus also something of the exhibition as an inventive format.

The methodology used for this study built on a very particular version of ethnography, for which a key reference are the laboratory ethnographies developed in science and technology studies (discussed below). In this tradition, ethnographic studies of experimental settings have highlighted how “the empirical” is often difficult to disentangle from the ethnographer's own theoretical concepts. For instance, ethnographers of experimental settings have highlighted how theorising the experiment is not the monopoly of the ethnographer and that there is often role confusion between the ethnographer and others in the setting (for instance, Law 2004). This tradition of ethnography seemed particularly relevant in my case not simply because the empirical setting was publicised as experimental but also because it was clear that I was not the only actor in the setting attempting to theorise what was going on – as noted already, the Science Museum's curators had a highly sophisticated social-theoretical account of what they were doing. In the analysis below I will also point to some instances of role confusion particularly in the my attempts to observe the curatorial experiment. In the analysis below I discuss why the ethnographic fieldwork conducted for this study was both a procedure of data collection and a process of empirically immersing and testing sociological ideas about experiments and exhibitions.

This chapter begins with an overview of the fieldwork conducted for this study. I discuss the ethnographic method used to gather the empirical material and the different phases and focuses of the fieldwork process. I also elaborate the significance of the background to the study both in terms of how the research questions were shaped but also in accounting for the focus of the fieldwork in its later stages. The particular tradition of ethnography developed in laboratory studies is discussed with reference to other important methodological precedents in studies of experiments. Following this I give an empirical account of the initial stages of the fieldwork and some of the methodological problems that were raised and which led to a subsequent shift in focus away from treating the experimental exhibition as a simple empirical object to studying it as distributed across multiple modes of experiment. Importantly, I discuss some methodological objections to the approach taken to the latter phase of fieldwork and in doing so offer some insights into the challenges of empirically studying the *Oramics* exhibition as a public experiment. Finally, I conclude by outlining the rationale for the thematic analysis which is developed in the following substantive chapters of the thesis.

Overview of empirical material

There were two broad phases of fieldwork that can be broadly distinguished as the initial phase of ethnographic observation of the experimental curatorial process for *Oramics* at the Science Museum and a later phase of fieldwork studying the other two modes of experiment – experimental electronic music and the experimental display – that are also the focus of analysis in this thesis. Much of the empirical data about the curatorial process of *Oramics* was collected over the period of six months – between January and October 2011 (when the exhibition opened) – during which I was in close contact with the curators of the *Oramics* exhibition. The initial fieldwork included participating in and observing the experimental curatorial process, the curatorial and design meetings and the public events in the build-up to and launch of the exhibition. During this work I took a broad approach to studying the curatorial experiment, not simply limiting this to the work of those staff formerly called curators. During this period I conducted a series of interviews, formal and informal, with the curators and other members of staff who were involved with the *Oramics* exhibition, including Audience Research, Design, Digital Media, Conservation

and Learning and Outreach. The second phase of fieldwork focused on studying the experimental display and experimental electronic music were ethnographic in quite a different way.

In order to research *Oramics* as an experimental display, I became much more familiar with other forms of exhibition in the Science Museum. I spent some time visiting the other exhibitions taking place in the Museum and followed the Museum's social media output that would publicise new developments. I also researched the history of experimental display at the Science Museum making the occasional trip to the Museum's archive where gaps appeared in the various written histories. One key reference point in terms of appreciating the different forms of experimental public display in the contemporary Science Museum seemed to be the public understanding of science, which was incorporated as the 'mission statement' of the Museum during the 1990s. Various conversations with curators and other members of staff offered different perspectives on these other forms of experimental exhibition which are discussed in more detail in Chapter Four. This focus of the empirical research was often desk based but also guided by conversations I would have with various staff and academics who had been involved with the Science Museum at different times.

The other focus of the second phase of research was on experimental electronic music, the subject matter of *Oramics*. This research focused largely on developments in the 1960s during the time that Oram was working on the Oramics Machine. As an amateur musician, I had some loose ideas about this history but during the ethnographic work of the curatorial experiment I met many people who offered me some important guidance. During this time I interviewed, formally and informally, key researchers and artists involved in the Oramics Machine's 'rediscovery'. It was particularly fortuitous that I was based at the university, Goldsmiths, where Oram's archive was kept and where a computer scientist and sonic artist, Mick Grierson, had led the search which resulted in the Machine's acquisition by the Science Museum. In this process I interviewed several of the key people involved with the Daphne Oram Trust and several researchers investigating the significance of the Oramics Machine. Mostly researchers, these 'Oramites' not only directed me to various contemporary music and research events related to Oram and the Machine but also helped me to situate the composer's development of the Oramics Machine and the particular traditions of electronic music history in which it was significant. Importantly too, two of the researchers developed another

exhibition of materials from Oram's archive which offered an interesting and useful counter-point to the Science Museum's display (see Chapter Six). In part due to the obscurity of the subject matter – Oram was largely unrecognised within electronic music history prior to the Science Museum's exhibition (Reynolds, 2012) – I relied on several key contacts I made at Goldsmiths to guide me to materials and events which would help me to situate the Oramics Machine in the history of experimental electronic music.

It was during the initial stage of fieldwork, observing the Science Museum's curators' experiments, that I identified the themes that would be relevant to this study of *Oramics* as a public experiment (although it is fair to say that during the research process these distinctions between the different experimental focuses were not always as clear to me as they now appear in this written account). The opening of the exhibition six months after I had begun fieldwork therefore did not seem to mark the end of the empirical study. However, it did change the emphasis of my empirical orientation. In the six months prior to the opening of the exhibition I had been principally focused on following and understanding the Science Museum's curators' account of what was experimental about *Oramics*, while at the same time developing a basic understanding of the exhibition's focus on experimental electronic music. In the second six months of fieldwork this settlement was to some extent reversed and while I spent some time with the Science Museum's curators observing their follow-up work on the exhibition, I also spent a lot more time researching Daphne Oram, the Oramics Machine and the history of electronic music, the various gallery displays of the exhibition and the other forms of experimental display at the Science Museum. This shift in focus alerted me to events at the Science Museum that I might otherwise have written off as unimportant if I had only focused the study on the experimental curatorial procedures. For instance, in the last six months of fieldwork at the Science Museum I observed a series of events related to the *Oramics* exhibition including, most notably, an electronic music day and a late-night event on experimental music (these are discussed in Chapter Six). I also became aware of the significance of other publicity formats used by the Museum's curators such as the Oramics Machine's Facebook page which was regularly updated over the first year that the exhibition ran, and a resource which highlighted the diversity of audiences interested in the exhibition of the Oramics Machine. Although after one year of fieldwork I relaxed my engagement with the empirical setting, I still went to work at the Museum from time to time and this kept me in touch with major

events or developments that took place around the exhibition. For instance, after a year and a half the gallery displays were altered and several elements referring to the experimental curatorial process were removed (notably, the cinema hosting content from various participating groups - see discussion in Chapter Five). In the later stages of fieldwork I therefore attempted to balance the initial emphasis on the experimental work of the Museum's curators with an equal focus experimental electronic music and forms of experimental display at the Science Museum.

One way to characterise the scope of the empirical research would be temporal, as the six months prior to the launch of the exhibition and then six months after. In this sense, the material gathered includes both the question of the exhibition's curation and its reception. However, this is not how I have organised the presentation and analysis of the empirical material, which is instead arranged thematically. These themes derive in part from the initial research questions with which I approached the *Oramics* exhibition and from the subsequent identification of the different modes of experiment in the setting. Each theme is focused on a particular arena of material practice in which the exhibition can be said to intervene. They can be summarised as: participation (Chapter Four), exclusion (Chapter Five) and media (Chapter Six). I have attempted to show how these themes make associations between the different modes of experiment we find in *Oramics*: how they connect the experimental work of the Science Museum's curators, the experimental gallery displays and the subject of experimental electronic music. In doing so, I seek to specify some of the ways in which we might understand the *Oramics* exhibition as an experiment in relations between science, culture and the public. This format of analysis is designed to hold onto the *Oramics* exhibition as the central object of analysis without over-determining in what and where this empirical object consists.

Background

The background to the study is worthwhile briefly elaborating here as it highlights the particular orientation to the public experiment that I brought to the study of the *Oramics* exhibition as well as the methodological choices

made during the study. Prior to beginning this research I had worked as a researcher for a public participation think-tank which was involved in running experimental “dialogue” and “public engagement” processes on emerging techno-science issues, principally on a consultancy basis for government departments and agencies. Having developed connections with the Science Museum during my work with this think-tank I arranged to meet with several curators to discuss setting up a case study. The timing of my study coincided with the “project history” that the curators were developing and through which they would trial “co-curation” techniques with a range of public groups in making an exhibition. The curators were interested in how different groups of the public thought about the history of science and technology and through “co-curation” experiments sought to investigate this. I subsequently submitted a proposal to the curators to ethnographically study the co-curation processes for the exhibition. Though the proposal did not use the concept of the “public experiment” explicitly, the research questions were framed through Latour's (2005a) materialist theory of public assemblies as gatherings around “matters-of-concern”, the controversial things that unsettle and reorder public life. Since my proposed ethnographic study required significant access to the spaces in the Science Museum, it was arranged for me to be affiliated to the Museum as a “research associate”. This status gave me the security clearance to access the various Museum buildings, an email address and log-in to the Museum's computer network to access project information and search archival material, and a desk in the research department from which to work.

I proposed an ethnographic methodology for several reasons⁴⁷, but one significant factor informing this choice was that many social studies of science and technology, on which the proposed research was modelled, had used ethnographic techniques to study experimental settings. The paradigmatic use of ethnography in science and technology studies is often said to be the laboratory studies of the late 1970s and early 1980s in which ethnographers sought to give accounts of how science was made that differed from those of both practitioners (scientists themselves) and theorists (epistemologists or philosophers of science) (Collins, 1981b; for instance, Knorr-Cetina, 1999; Latour and Woolgar, 1986). As highlighted in the literature review, in some social theories a setting like the Science Museum would appear considerably distant from the experimental work of laboratories studied by these

⁴⁷ Significantly, my prior training in social anthropology had equipped me not only with the practical basis from which to develop an ethnographic study but also a broad understanding of the philosophy, history and politics associated with this mode of research.

ethnographers of science and technology; museum exhibitions, in such social theories, are located at the opposite end of trajectories of invention from the laboratories where experimental objects are produced. However, like the Science Museum's curators, I was not convinced that laboratories are the only settings of experimental practice, particularly in light of subsequent work in science and technology that drew attention to the importance of public displays and demonstrations in not only communicating experiments but also as participating in the 'doing' of experiment (see discussion in literature review on the proposition of the experimental exhibition). Discarding the false opposition between the lab and the museum exhibition, the ethnography of the science exhibition as an experimental setting seemed highly plausible.

In setting up the fieldwork I proposed to approach the (yet to be developed) *Oramics* exhibition as if it was principally the Science Museum curators' experiment; treating the curators as if they were analogous to laboratory scientists and I were the ethnographer there to study them. I went to curatorial and design meetings, I observed and participated in the experimental curatorial process for *Oramics* (discussed below), I researched the Science Museum's history and how organisational changes changed along with styles of exhibition, and I engaged in formal interviews and many informal conversations with the staff who were working on or were interested in the *Oramics* exhibition. In these early stages of the fieldwork I attempted to pay attention to the micro processes through which *Oramics* was developed as a curatorial experiment: how it disrupted the 'business as usual' curating of science and how it was troubling for the curators themselves, or raised questions about science exhibition. However, even in the early stages of my research it seemed clear that this empirical focus limited the scope of describing the exhibition as an experiment. Though *Oramics* clearly was an experiment for the Museum's curators and other staff working on the exhibition (discussed at length in Chapter Four) it was seemed that the exhibition was experimental in other ways that were perhaps equally significant.

The methodological question of how to empirically study *Oramics* as an experimental exhibition became more problematic as I realised that equally, if not more significant, styles of experiment were to be found in the subject matter of electronic music. *Oramics* was an exhibition that not only departed from the conventions of science exhibitions in terms of its curatorial procedures but also in terms of its distinctively art-oriented subject matter, namely Daphne

Oram's *Oramics Machine* and the invention of electronic music. When I realised, early on, that the *Oramics Machine* had come to the attention of the Science Museum's curators via a sonic artist and computer scientists, Mick Grierson, at my own university of Goldsmiths where Oram's archive was held⁴⁸, it seemed clear that if I was to appreciate the potential of this artefact experimentally mediated relations between science and the public I would have to expand the scope of my empirical work beyond the galleries and offices of the Science Museum.

I began this expansion in empirical focus early in the research, most memorably attending an event about Daphne Oram at the experimental music venue called Cafe Oto which occurred a few months after I'd begun fieldwork at the Science Museum and which featured both Tim Boon from the Science Museum and Mick Grierson from Goldsmiths (described in Chapter One). In fact, I was already quite familiar with this venue: as an amateur musician with an interest in electronic music I'd visited Cafe Oto on various occasions to see live music. The subject matter of the *Oramics* exhibition therefore also presented itself as a moment in which my own scientific and artistic interests might come together in new ways. Alongside my fieldwork at the Science Museum, then, I also established relations with those musicians, computer and media artists who were actively involved in the exhibition in some way, including those participating in curating its displays and researchers (most of whom were at Goldsmiths) studying Daphne Oram and working on her archive. My experiences as an amateur musician helped in making these connections and in doing so opening up the question of what kind of 'rediscovery' Daphne Oram's *Oramics Machine* was. In what follows, I outline some of the methodological implications of my choice to shift the focus of my fieldwork to settings beyond the experimental curatorial procedures at the Science Museum.

There is one highly significant discrepancy between the original aims of this study – to research how the *Oramics* exhibition might be understood as an experiment in relations between science and the public – and the analysis presented in the thesis which adds to this a focus on the relations between science and culture. This additional focus on culture was perhaps already latently present in my research proposal to study a museum exhibition as

48 A video of the *Oramics Machine* being received by Grierson can be found at: <http://vimeo.com/21310959> (accessed 20 October 2014)

opposed, for instance, to a political event such as a science dialogue. However, during the early part of the study I had no intention of making culture into an analytic focus. There were many reasons for my bracketing of the cultural question. One highly significant factor was my former training as an anthropologist had left me with some serious doubts about the value of the concept of culture as an analytic category⁴⁹. However, in the empirical work I came to discover that culture was a concept of considerable importance within the setting of Science Museum. Not only were notions of material culture central to the curators' self-understandings of their work, but culture appeared a concern of many other staff in whose work the Museum appeared variously an institution of multiculturalism, a repository of high-culture and as a competitor in the culture industries. Moreover, these concerns about culture were articulated through the *Oramics* exhibition in various ways (see discussions in Chapter One and Chapter Four), not least in the subject matter of the exhibition which was distinctly removed from the mainstream concerns of professional science. In my empirical work it seemed that in order to appreciate the *Oramics* exhibition as an experiment in relations between science and the public I also had to take into account the relations between science and culture.

Ethnographic approaches to studying of experimental settings

Methodologically, the ethnographic fieldwork conducted for this study was the means to immerse a set of sociological concepts and problematics within an empirical setting. This does not mean that the fieldwork was simply an attempt to confirm via empirical study the validity of the proposition, developed in the previous chapter, that *Oramics* can be understood as an experiment. Rather, by going to a setting where the concept of the public experiment was being put into practice, in this case by the Science Museum's curators, the ethnographic fieldwork offered the prospect of exploring and problematising social theories about both experiments and exhibitions. The practice of the ethnographic method was therefore not only envisaged as the instrumental means of collecting data for subsequent analysis. Rather, alongside the collection of observations I was also interested in how the practice of ethnography might

⁴⁹ Some of the central criticisms of the use of culture as an analytic category in anthropology include Clifford and Marcus (1986) and Abu-Lughod (1991). For a good overview see Brightman (1995).

itself unsettle my own prior framing of *Oramics* as an experiment in relations between science and the public. And indeed, when I subsequently found out that the exhibition would be about electronic music, the framing of the exhibition as an experiment in the relations between science and the public became a much more complex proposition to advance.

The particular ethnographic methodology used in this study takes its influences from studies of experiments developed in science and technology studies. In these traditions ethnography provided largely a way for the researcher to offer a social description of science independent of both theoretically overdetermined accounts of scientific practice in epistemology and the naturalised accounts of the practising scientists. Different traditions in social studies of science including ethnomethodology (Lynch, 1985), social constructivism (Knorr-Cetina, 1999), controversy studies (Collins, 1981b) and actor-network theory (Latour, 1999) have all used ethnographic techniques as a means to study experiments. The uses of ethnographic techniques to study experiments, often grouped together as 'lab studies', are often said to mark an innovation that introduced a new kind of empirical focus into the social study of science. One significant character of lab studies was the capacity of the ethnographer to recast the experiments by playing the 'stranger' to the practising scientists, the most extreme version of which was Latour and Woolgar's (1986) anthropological descriptions of the lab scientists as if they were a "tribe" engaged in exotic rituals. Empiricising the social study of experimental science through ethnographic observation therefore could be said to offer social studies of science a very particular methodological solution and way out of the bind between 'internal' and 'external' accounts of scientific practice. The particular capacities of ethnographic techniques to both offer micro and mundane observations of the experimental practices that were presented as 'extraordinary' by philosophers and scientists, have often been pointed to as significant in establishing the possibility of empirically describing experimental practice (Hess, 2001). In the lab studies tradition, the use of ethnography is therefore not only an instrument through which to collect raw data or to make the empirical world transparent to sociological description. Rather, in this tradition of social studies of science, ethnographic observation is also a method that in its practice demonstrates the possibility of sociologically describing the experimental practices which are overdetermined in the accounts of philosophers and scientists.

One reason for situating my own use of ethnography in relation to social studies of science is to highlight its specificity as an empirical methodology. This is not to claim that the techniques I practised as an ethnographer were somehow radically distinct from those practised in other fields of anthropology and sociology. From the perspective of methodological technique and procedure alone it is likely that my own use of ethnography is comparable and even identical in many respects with research practices in fields as diverse as organisational ethnography or urban ethnography, for instance. The specificity of using ethnography to study science experiments, I suggest, is not distinguished from other kinds of ethnographic research on the grounds of research techniques or procedures. Rather, as we see in the laboratory studies, the use of ethnography to study experimental practice takes on methodological significance in its relation to the analytical problems of social studies of science: the bind of inside/outside distinctions of science, the over-determination of the experiment in epistemology, and so on. To situate my own use of ethnography in relation to this tradition, then, is to highlight the importance of particular problematics to the orientation and development of the empirical research. In this sense, my use of ethnography can be understood as both the use of a particular set of research techniques coupled with a particular set of analytical commitments. By practising ethnography to study the *Oramics* exhibition my research situates the significance of this empirical object in relation to particular problematics in social studies of science.

Social studies of science have argued that in public experiments empirical objects do not come already composed but are rather the subject of contestation between participants in the experiment (Irwin and Michael, 2003; Latour, 2005b; Law, 2004). Such studies have argued instead that in the “mess” of experimental settings we find that methodology offers no guarantee of a researcher's privileged capacity to represent the empirical object. Indeed, in experimental settings the 'special' status of a method often appears problematic and the capacities of the researcher distributed in the practices of heterogeneous actors: for instance, informants become theorists (Callon and Rabeharisoa, 2004), expert and lay participants switch roles (Whatmore, 2009), and scientific research appears difficult to distinguish from political practice (Latour, 1993b; Stengers, 2005). These studies argue that procedural accounts of methodology, as simply the unproblematic application of 'off-the-shelf' techniques to the study of an empirical object, inadequately account the ways in which experimental settings unsettle and redistribute the capacities of

the researcher to represent an empirical object (Marres, 2012b). Rather than looking to methodology for the epistemological basis on which to ground empirical descriptions, these studies suggest that the study of experimental objects problematises ontologies of method that would separate out as radically distinct questions of research practice from the object of research (Law, 2004)⁵⁰.

In attempting to shift methodological discussion away from abstract procedures that are radically distinct from the objects they are used to describe, several traditions in the social studies of science have argued that rather than attempting to find procedures that can ground empirical descriptions of an experimental object, social researchers should instead attend to the ways in which the experimental object becomes operationalised in the practices of heterogeneous actors (Mol, 2002; Latour 2005a)⁵¹. One version of this approach to methodology has been called the “sociology of translation”; which simply attempts to describe the different ways in which an experimental object is translated in practice. In doing so, the sociology of translation attempts to assemble the heterogeneous and distributed actors participating in a public experiment who are “concerned” by a particular empirical object (Callon et al., 2009; Latour, 2005a). To study processes of translation is therefore to account for the very different ways in which an object of one group of actors is 'problematised'⁵² by the practices of another. Following the ways in which an object becomes problematic in practice both reveals the distributed character of that object and is a process of making associations between between very different groups of actors. To describe the different ways in which an object is translated the researcher describes an assemblage of different actors that are concerned around it; the researcher describes how relations are created between these actors and in doing so also assembles the experimental object.

Another approach to the problem of studying a distributed object is found in Annemarie Mol's (2003) ethnographic study, *The Body Multiple: Ontology in*

50 There is of course a long history of ethnographers challenging this account of the practice of ethnography, one significant account is Clifford's work on the character of ethnographic authority (see Clifford, 1983).

51 Another version of this argument has been called “multi-sited ethnography” (see discussion in Marcus, 1995).

52 The notion that researchers should account for the “problematisation” of empirical objects is not particular to actor-network theory but is found in other sociological traditions. One particular important version of problematisation is given by Michel Foucault (Foucault and Rabinow, 1997) who argued that to describe empirical objects through their problematisations is to facilitate the conditions for new modes of political action to develop, because problems, Foucault suggested, are means of unsettling and reordering relations between political actors.

Medical Practice, which describes a methodological approach Mol calls “empirical philosophy”: an approach that attempts to show how a single conceptual problem appears multiple and more complex when it is immersed in a fieldwork setting. Though Mol's theoretical questions come from philosophy rather than social science, her ethnographic approach is nonetheless relevant to the question of methodology discussed here. Mol's study presents an ethnography of a singular object, the disease atherosclerosis, which is diagnosed, analysed and treated across a range of settings in a hospital. Mol argues that an object like atherosclerosis has a very different ontology depending on the practice in which it is “enacted” (e.g. outpatient diagnosis compared with pathology). To study how the singular disease, atherosclerosis, can have very different ontologies, Mol argues that the ethnographer has to be attentive to the specificity of its practical enactments. Representation of the empirical object, usually the monopoly of the researcher, is in Mol's ontological approach distributed in the practices of actors – doctors, patients, machines, tools, veins, forms, drugs – found across the various departments of a hospital. Despite the ontological multiplicity of the disease and the body of the individual patient it inhabits, Mol describes how both cohere as shared objects across the hospital. The singularity of the disease and the patient body, Mol argues, is assembled in the negotiations and relations created between different practices. Mol's ontological approach to ethnographic study thus permits the ethnographer to both account for the very different practices used to enact the object while also maintaining its singularity by describing the relations between these practices; the forms of coordination, collaboration and engagement between different actors through which the singularity of the empirical object is accomplished. Mol's “empirical philosophy” approach highlights the ways in which ethnography can facilitate the empirical exploration and development of concepts.

Various social studies of science exhibitions have used ethnography as a technique to explore the politics of knowledge (Lavine and Karp, 1991; MacDonald, 1998). In relation to my study one significant ethnographic precedent is found in Sharon MacDonald's (2002) ethnographic study in the late-1980s of the making of an experimental exhibition at the Science Museum. As the title of MacDonald's study *Behind the Scenes at the Science Museum* makes clear, the sociologist's role in observing the exhibition was to get behind the appearance of the exhibition “to find out how it works, what kinds of passions and ideas motivate practice, and whether and how this

percolates into the science that is put on public display". By getting behind the scenes, MacDonald highlighted the role of the Museum's curatorial culture and politics in shaping the way that the science and technologies of food (the focus of the exhibition) were represented in the gallery displays. This model of the exhibition as a format of representation, therefore permitted the ethnographer to get behind the scenes and to study what was taking place off-stage, behind what was represented in the gallery displays. Significantly, MacDonald's study concluded:

"What is also clear, then, is that there is no sovereign author: the agency to shape the outcome of the exhibition is distributed among multiple actors – non-human as well as human, conceptual as well as material. Nevertheless, it is distributed." (2002, 256)

MacDonald's claim that exhibitions have "no sovereign author" is an argument against the notion that exhibitions are simply the materialisation of a curator's ideas and, hence, an extension of the critique of the exhibition conceived as a space of representation. Instead, MacDonald argues, the curating of exhibitions is "distributed", extending the scope of exhibition ethnography to the various settings where the knowledge represented in an exhibition circulates.

Unlike MacDonald, in this study I do not treat the experimental exhibition as principally an epistemological format which represents knowledge. Rather, as the study of an experimental exhibition one of the central questions of this thesis is precisely what kind of empirical object an exhibition is. As highlighted in the previous chapter, applying the concept of the public experiment to the exhibition obliges us to approach the relations between science, culture and the public as not only epistemological but also ontological matters. For this reason the question of the politics of knowledge, though one important way of characterising the relations between science and the public, is not the dominant focus of the current study of the *Oramics* exhibition. The politics of knowledge is significant insofar as this seems to be precisely what the Science Museum's curators are investigating in their co-curation experiments. Indeed, one way to understand the Science Museum curator's experimental co-curation approach would be as putting MacDonald's conclusion about the distributed multiplicity of curatorial agency into practice. But if we extend the question of the distribution of curatorial agency to the concerns of exhibition

ontology, as I argued for in the previous chapter, then we have to take into account not only the sites where the politics of knowledge is played out but also to other formats of publicity beyond the gallery displays. Ethnographically, then, to study the exhibition as a public experiment requires treating the exhibition as an empirical object which is not limited to a single material site, such as a gallery display, or in a single procedure, such as the curatorial procedure, but instead attempt to take into account the way in which this empirical object is distributed in multiple modes of experimental practice and display.

Ethnographic challenges: the experimental exhibition as multiple and distributed object

In this section I'm going to describe some of the events that occurred in the first six months of fieldwork that led to the shift in empirical focus, from the initial focus on experimental curatorial practices to the study the multiple modes and styles of experiment that we find in the *Oramics* exhibition. Specifically, I'm going to describe my experiences of observing two "co-curation" procedures for the *Oramics* exhibition. Observing these procedures threw up some important questions about how to study the *Oramics* exhibition as an empirical object. The co-curation events may have been experimental curatorial procedures for the Science Museum's curators but as sociological events they seemed to be experimental in various other ways. For instance, the seemingly unrelated identities of the two groups (musicians and theatre students, elaborated below), both to each other and to the Science Museum as a scientific institution, highlighted the significance of the subject matter of the exhibition – electronic music and the *Oramics* Machine – in establishing both as participants in the experimental exhibition. Also significantly, my own relationship to the *Oramics* exhibition became more complicated than simply one of detached observer as I joined the group of musicians as a "co-curator". In these events which were filmed, photographed and blogged by various participants I was clearly not the only observer. My status as an ethnographer at these events therefore seemed both challenged – if I had assumed I would be the only one making notes and describing these events, the presence of note takers, a film maker, and other observers, made clear I wasn't - and expanded, as my experience as an amateur musician became a way for me to

not only observe but also to participate in defining the exhibition's subject matter that would go on display in the gallery. In what follows I describe how my initial attempts to use ethnographic techniques to study the curatorial experiments raised the problem of what kind of empirical object the experimental exhibition is and how to study it ethnographically.

My access to these “co-curation” procedures was depended heavily on the Science Museum's curators on whom I relied for information about locations, times, and access to the participants. The two groups around whom the co-curation processes were focused were: (1) a group of students on a course with the National Youth Theatre (NYT) designed for young people not in education or employment to gain the qualifications needed to enter higher education⁵³, and (2) a group of electronic musicians who formed as a group specifically for the purpose of curating three cases in the *Oramics* gallery displays. These two groups clearly have very different relations to the Science Museum and the proposed focus of the exhibition, the *Oramics* Machine: the NYT students are largely comprised of individuals 'excluded' from formal education and as a group hold no determinate relation to electronic music, while the musicians are a group of amateur 'enthusiasts' who use technology to make electronic music. And indeed, my relation as an ethnographer with these groups was very different: I attempted to observe the NYT students from 'outside' while, by contrast, I became part of the co-curating group of musicians. The co-curation events with the NYT students also involved a wide range of other collaborators including choreographers, script writers, film makers, students, a creative writer, a sound artist, and a range of staff from the Science Museum including audience researchers, members of the outreach team, and explainers. By contrast, the events with the musicians involved principally this group and the Museum's curators along with an independent film-maker. In the subsequent gallery displays of these co-curation processes these other participants are largely absent. In what follows, then, my empirical description of the co-curation processes departs quite significantly from the way in which they are made public in the gallery displays of *Oramics*. Where the gallery displays present the Science Museum's curators as the 'convenors' of the experiment and the NYT students and musicians as the 'participants', my ethnographic descriptions feature many more participants in the curatorial experiment.

⁵³ On an access course for higher education, many of the students have previously been excluded from mainstream education establishments.

In the early months of 2011, 6 months before the *Oramics* exhibition opened, I observed the first co-curation procedure involving a series of five workshops that took place at the Science Museum with students of a National Youth Theatre's access course. As mentioned before, these were explicitly designed for young people not in education, employment or training to gain the necessary qualifications to enrol on a higher education course. The Science Museum's curators had described the workshops in largely procedural terms to me, stating that it would involve five workshops focusing on the Oramics Machine with the aim of developing content for a performance by the students. The workshops were focused largely on the Oramics Machine and Daphne Oram's compositions with the students engaging in various activities including sound recording, creative writing, watching and discussing films, and visiting different parts of the Museum. Present at each workshop were various staff from the Museum and the National Youth Theatre and the workshops themselves were run by different associates whom the Museum had contracted, including several academics: a creative writer, a computer scientist and a sound artist. The workshops also involved staff from different departments across the Museum, including the curators, outreach staff, gallery explainers, and audience researchers, several of whom highlighted to me that they had never met and that their departments rarely collaborated on projects. The number of intermediaries participating in the event and facilitating the NYT students working with the Science Museum's curators seem to highlight the relative distance of this 'excluded' group from the institution and the concerns of science. In the events with the NYT students the Oramics Machine, the object of focus, seemed to take on a multiplicity of significances for the different actors involved. In the computer scientist's⁵⁴ presentation to the workshop group, the Oramics Machine was a highly technical artefact that was a forerunner of graphical computer music software. In the curator's account presented to the students the Machine was an artefact from the history of electronic music. In films shown in the workshops, scored by Daphne Oram, the Oramics Machine was enacted as an experimental instrument for film composers. The sonic artist⁵⁵ presented the Machine as an heir of Edwardian recording technologies, recording the scripts of some students onto wax cylinders. And, in the students' performance (discussed below) the Oramics

54 A presentation about the Oramics Machine by the computer scientist Mick Grierson can be found here: <http://vimeo.com/50834273> (accessed 06 March 2014)

55 An interview with the sonic artist Aleks Kolkowski discussing his role in the project here: <http://jussiparikka.net/2011/04/11/%E2%80%9Csonic-alchemy%E2%80%9D-an-interview-with-aleks-kolkowski/> (06 March 2014)

Machine appears as the radical innovation of an underdog pioneer, Daphne Oram, whom the students appropriate from the pedagogue scientists. What for the Science Museum's curators was an experimental curatorial procedure appeared a much more complex sociological event involving multiple groups and individuals and issues.

Following the workshops the NYT students staged a multi-media performance called *Oramix* which took place in the Science Museum's *Flight* gallery at various times over a week. Boon later asked me if I would produce an analysis of the way in which “science” was represented in the NYT students' performance in order to assist the Museum's public history research, to which I agreed. The role of the NYT students as participants in a science exhibition was clearly still a question for the Museum's curators. Boon asked me to treat the performance as a work of art that contained stories and which encoded the encounter of the students with the Science Museum. Following this broadly structuralist mandate, the analysis I produced drew on a video of the performance and a draft rehearsal script provided by NYT. The analysis I submitted described the performance as an encounter between a groups of students and sound scientists, in which the latter attempted to educate the students about the pioneering work of Daphne Oram. The trope of the pedagogical relationship between the scientific institution and the students was central to the organisation of the performance. But this trope is also subverted: the students challenge the scientists arguing that they do not need to be educated about sound science because they already “know” music, demonstrating this through a series of scenes in which movement replaces dialogue. The scientists do not reappear and the performance ends with the students appropriating Daphne Oram from the sound scientists as someone with whom they identify: an underdog who realised her own ambition and became a pioneer in spite of considerable hardship and obstacles. In my analysis I suggested that the brief given to the students that the performance should “reflect their [the students] experience” with the Museum appeared to have followed quite literally – the main focus of the performance being the encounter between the students and the scientists who attempt to educate the latter about Daphne Oram – and that traces of the workshops appeared throughout. And indeed, I was not alone in suggesting this. One video of the performance also included an interview with Boon who enthuses about what he's just seen. Boon suggests in the interview that he thinks he might have been “spoofed” in the performance's depiction of the sound scientists, adding

“but I'm not even a scientist”. The findings of my analysis and Boon's response to the students' performance, both of which identified traces of the co-curating workshops, raised significant questions about the status of these events for the participants; who had ownership over these events and the ends to which they were used. Moreover, it also highlighted that the status of science in *Oramics* was in question both for the curators and for the students. The entangled and complex character of the performance was perhaps one of the contributing factors to the curators' decision to give it only very limited display in the *Oramics* gallery, as a two-minute edit of some of its scenes incorporated into a longer loop of other video content.

I was not the only observer of the co-curation workshops with the students. Notably, a film crew comprised of a participatory arts company and students from City University were producing a documentary about the project⁵⁶ and various staff from the Museum, including curators and audience researchers, also dropped in to observe workshops. In observing the workshops I had usually positioned myself with the other observers at the back or to one side of the room, making clear my detachment from the process taking place. However, the distinctions between the observers and observed were not so easy to make. The multiplicity of identities among observers of the process – the various museum staff, the camera crew, the NYT staff, the audience researchers – gave observation multiple significances. For some participants, the scale of observation was deemed to be a problem. The Museum's internal evaluation of the project called '*Lessons Learned*', conducted by the audience research department, was highly critical of the scale of observation. The evaluation report noted:

“The participants themselves [the NYT students] were very unsure of who was involved, where everyone was from (multi-partner project) and how they were contributing to the project. This led to some of them reporting that they felt like ‘guinea pigs’ – pawns in an experiment done by people they didn’t know and for reasons they were unsure of.”

The evaluation report was critical of the way in which the workshops had been conducted: the various observers, it argues, left the students feeling like

56 This project video can be found at: <http://www.togetherproductions.co.uk/oramix.html> (access 10th December 2011)

experimental subjects⁵⁷. The observers, of which I was one, are, in the evaluation report, described to have created obstacles to realising the collaborative aims of the curatorial experiment. Far from being neutral outsiders to the experimental process, the evaluation suggests that the observers appeared conspicuous to those they thought they were observing. And yet, that participants like Boon recognised themselves and the workshop process in the students' performance suggests that the capacity for observing and recording the workshops was also a capacity of the students. Although the museological perspective of the Audience Research evaluation locates the capacity to observe in many actors except the students, if we focus on the performance which left Boon amused that he was "spoofed" suggests the students were also observing the co-curation process. In this sense, observing the co-curation process appeared as a capacity of several of the actors involved and seemed to be materialised in quite different media, including a report, a film and a performance. Should these other publicity media be counted as equally part of the *Oramics* exhibition alongside the gallery displays that would eventually materialise? If not, in what ways is it meaningful to consider the theatre performers as "co-curators" of the exhibition? And, what would be left out of an ethnographic description of these workshops as simply curatorial procedures? Such questions suggested to me the need to revisit the question of what kind of experiment the *Oramics* exhibition might be said to be, and the methods required to study it as an empirical object.

Other, often similar, complexities were apparent in the second co-curation experiment I observed involving a group of 12 electronic musicians. Unlike the first co-curation with the NYT students which I had observed as an outsider to the group, in this group I participated as one of the group of electronic musicians. Being an amateur musician and having tinkered making laptop music, the Science Museum's curators invited me to join the group and become a "co-curator". In contrast with the NYT students, who were already constituted as a group prior to their engagement with the co-curation process, the contemporary electronic musicians were formed as a group through the co-curation process. The participants were recruited via an online advert on the Museum's blog and social media⁵⁸. They numbered 12 in total and included

57 For the audience researchers, the workshops should have been a process of the Museum working collaboratively with groups who are under-represented, but the experience of the students interviewed for the evaluation report suggested that the workshops in fact worked counter to this aim. See further discussion in Chapter Four.

58 This advert can be found at: <http://sciencemuseumdiscovery.com/blogs/insight/electronic-musicians-wanted/> (accessed 15 April 2013)

practising musicians, artists, DJs, journalists, software developers, and academics. All participated in a series of 5 workshops, and many clearly demonstrated an awareness that the process of co-curation was linked to particular concerns in the Science Museum about broadening the appeal of their exhibitions beyond the immediate focus on Daphne Oram and electronic music: for example, during introductions one participant noted that they'd run similar processes for art organisations to engage with external groups. Even if the such concerns hadn't been made explicit, they were built into the structure of the co-curation process through which the group was formed; the workshops featuring a significant focus on the challenges of museology and curating at the Science Museum alongside the focus on the Oramics Machine. The five workshops included: an introduction to the Science Museum and the Oramics Machine, and the planned *Oramics* exhibition; a tour of the conservation department, the Museum's electronic instrument collection, and an early session on exhibition planning; a tour of the *Oramics* gallery space and an exhibition planning session with the Museum's audience researchers; a meeting with original members of the BBC Radiophonic Workshop and Electronic Music Studios, and; the making of detailed thematic plans for three cases. This co-curation process was therefore also presented by the Science Museum's curators as a procedure of group formation in relation to the concerns of the Oramics Machine, electronic music and curating at the Science Museum.

Though presented as a group in the gallery displays and publicity for the exhibition, it seemed clear that all of the individuals in the co-curation experiment had joined the process to advance their own particular interests, from promoting their art/music, collaborating with other musicians, advertising their business or to developing their careers in particular ways. Many of the musicians, for instance, kept blogs⁵⁹ in which they would document and comment on the process of co-curation alongside other posts about their interests as musicians and artists. Others wrote or gave interviews for magazines⁶⁰. Others featured in podcasts discussing the Oramics Machine⁶¹. One participant from a music tech company sponsored the drinks reception for the exhibition. After meeting Peter Zinovieff of the Electronic Music Studios,

59 See for example: <http://www.fluid-radio.co.uk/2011/06/history-of-electronic-music-week-one> , <http://www.djdownfall.com/post/7054240334/we-have-harmonies-which-you-have-not> and <http://jobinatinnemans.com/category/sound-art/> (all accessed on 15 April 2013)

60 See, for example: <http://www.m-magazine.co.uk/features/m-captures-oramics-opening/> (access 06 March 2014)

61 See, for example: <http://www.sonicstate.com/news/2011/07/21/podcast-sonic-talk-226-a-dalek-from-birmingham/> (accessed 06 March 2014)

one of the participants worked with him on an interactive computer music piece⁶². Another produced a radio show about the exhibition⁶³. Others collaboratively arranged a synth/noise concert at one of the Science Museum's Late events. And, in an email chain that was set up during the co-curation, there were many discussions about collaborations on a range of projects ranging from small concerts to large scale sonic art exhibitions.

In this sense, the presentation of the musicians as a group in the gallery displays appeared to assimilate many of the practical differences between members of the group. The gallery displays created by the musicians comprised three cases of objects addressing the history of electronic music thematically. The emphasis of the case displays was to represent the diversity of electronic music history. The themes of the cases were: (1) the democratisation of electronic music (represented largely as the shift towards cheap, mass-produced technologies), (2) sonic frontiers (emphasising the role of algorithmic and sampling techniques in sonic invention), and (3) make do and mend (suggesting the DIY ethos of electronic music). Each case display comprised a different theme represented by the objects assembled inside, comprising mixtures of historical and contemporary music technology, home-made and mass produced instruments, and artefacts associated with both popular and art-music forms of electronic music. And yet, though these objects might represent a diverse perspective on electronic music history, they also present a distinctly museological approach to the task of co-curating; in effect evidencing the successful assimilation of the musicians into museum curators. This point is further suggested in the documentary film about the making of the exhibition which, shown in the gallery's cinema, stages the co-curation procedure as a process of consensus. The workshops with the musicians were filmed from the beginning by an independent film maker⁶⁴ who had been contracted by the Museum's curators. The film maker created the 11-minute documentary of the co-curation process that is on display in the gallery's cinema, as well as on the exhibition's webpage⁶⁵, its procedural focus clearly stated in the gallery as "a documentary about how we made this exhibition". The documentary replays the central issues around which the group of musicians formed: the film begins with an interview in which Boon discusses the public history project, the co-curation process and the Oramics Machine.

62 For more information see: <http://jobinatinnemans.com/2011/11/08/mess-zinovieff-tinnemans/> (accessed 06 March 2014)

63 See: <http://ntslive.co.uk/17051/> (accessed 06 March 2014)

64 This video can be found at: <http://vimeo.com/29318062> (accessed 15 April 2013)

65 See: <http://www.sciencemuseum.org.uk/ORAMICS> (accessed 9th April 2013)

The film then evidences Boon's narrative, showing the group of musicians in various scenarios discussing the Machine, electronic music, and the task of curating part of the exhibition (in which I appear in one section discussing genres of electronic music). In interviews, individual participants are shown speaking, expressing their views and aspirations for the exhibition; the participants are shown to agree with and consent to the film's narrative. This emphasis in the gallery displays on consensus between the participants and the success of this groups in curating an exhibition in the style of museum curators appeared, on one hand, relatively unproblematic since few of the group members contested the film or the exhibition displays to any significant extent. However, on the other hand, the emphasis on consensus in the gallery displays also seemed necessarily to omit from these displays much of the complexity of the events that I had participated in and observed.

Two methodological problems were raised as a result of my experiences in observing and participating in these experimental curatorial procedures: first, the object of the study, the experimental exhibition, appeared much more complex than I had anticipated and, second, the capacity to observe these events which I had naively assumed was the monopoly of the ethnographer was clearly also the capacity of other actors in the setting. These two problems are linked insofar as they are predicated on a particular assumption that the events I was observing were principally the Science Museum's curators experimental procedures and that the gallery displays would mark their closure. In fact, it seemed clear that the gallery displays, alone, offer only a very limited account of what I experienced to be experimental in these events. Instead, it seemed to me that much of complexity that I observed in these events – the range of participants, my different ethnographic experiences in these events, and the variety of forms of publicity (blogs, performance, film, concerts, and so on) – was deeply significant to appreciating the particular ways in which *Oramics* could be said to be an experiment. Rather than assuming that the co-curation workshops were only the experimental procedures of the Science Museum's curators, it seemed to me more promising to consider these workshops as events that were more experimentally complex in terms of the modes and styles of experiment and the distribution of experimental publicity. This subsequently required me to rethink how to describe the experimental exhibition as an empirical object, and to specify the particular ways in which it might be considered experimental beyond the curatorial experiment. In other words, to attend the experimental

exhibition not only as a single procedure or site but as a multiple and distributed object.

Objections: too much complexity, too little agency?

In what follows I'm going to argue that attending to the experimental exhibition as a multiple and distributed object does not mean abandoning ethnographic practices: ethnographic researchers have long debated the use of this methodology for studies beyond single sites, such as multiple settings or of objects in circulation (for instance, Marcus, 1995). However, attending to the exhibition as an empirical object that is distributed across multiple modes of experiment does require reformulating some of the claims that are often made on behalf of the methodology, principally that method can unproblematically provide the epistemological grounding on which to distinguish the knowledge claims of social scientists from other knowledge claims about the empirical object. I'm going to elaborate this argument by exploring two significant objections to the proposition that the experimental exhibition constitutes a multiple and distributed object and that the task of the ethnographer is to assemble these distributed versions of the object rather than using method as the ground to claim priority to represent it. The first objection is that by adopting this account the ethnographer gives up too much autonomy and risks passively accepting at face-value, and thus naturalising, the accounts given by powerful actors at the expense of the articulations of the empirical object in the practices of less powerful actors. In effect, this objection proposes that in giving up their monopoly claim to represent the object the researcher simply reinforces hegemonic and asymmetric arrangements that structure an empirical setting. The second related objection is that by attempting to describe the heterogeneous actors and distributed settings mobilised by an experimental object the ethnographer makes the empirical site too complex to say anything sociologically meaningful about it. One argument levelled against such approaches, like actor-network theory for instance, is that they have simply adopted an ontology of method that assumes empirical complexity and in doing so have sacrificed sociological explanation in favour of mere description (Collins and Yearley, 1992). In what follows I suggest that these objections give us an insight into events that occurred during my study of the *Oramics* experiment. In elaborating and countering these objections I go on in the following section to demonstrate what we gain through an attentiveness to

the *Oramics* exhibition as an empirical object that is distributed across multiple modes of experiment.

One of the central risks of attending to the distribution of an empirical object is that the ethnographer unintentionally ends up 'going native': that is, the ethnographer becomes naïve about the empirical setting and fails to distinguish their own sociological account from their informants. The gesture of ethnographers to gain “behind the scenes” access to the empirical setting has been one of the central ways in which researchers have attempted to avoid such empirical naïvety. In such accounts, ethnography is invested with privileged access to an empirical setting while also maintaining the distinctiveness of the ethnographer's account from other participants in the setting. By virtue of their methodology, the ethnographer maintains the reality of their own description of the setting as distinct from both a priori theoretical accounts and from the local native accounts. As Clifford (1983) notes, this mode of authority has been defining of ethnography since it was pioneered by early social anthropologists. Anthropologists like Malinowski, for instance, opposed the ethnographer's capacity to access the “native's point of view” with what they saw as the naïve comparative approach of the Victorian 'armchair' anthropologists. So too, similar claims about ethnography are found in social studies of science and technology which also present their methodology as offering a critique of the unrealistic and abstract accounts of science given by both philosophical theories and scientist's practical accounts (Bloor, 1976). Indeed, the use of ethnography in fields like the public understanding of science enact similar gestures of “contextualising” abstract diffusion models of science communication and redescribing public engagement with science as a political practice (for a discussion, see Irwin and Michael, 2003; Wynne, 1995). As social anthropologists have long debated (for example, Clifford and Marcus, 1986), in giving up the gesture of ethnographic realism the researcher risks sacrificing the methodological ground on which to demarcate their accounts from accounts of the setting given by outsiders and insiders. The proposition of redistributing the task of ethnographically researching the experimental exhibition therefore risks sacrificing the methodology that enabled the ethnographer to tack back and forth between the native accounts and the theoretical frame and which made the ethnographic researcher a powerful figure in modern social research.

This risk was particularly clear in the case of my relationship with the Science

Museum's curators on whom I depended for the access and information necessary to carry out ethnographic observation of the experimental co-curation processes. The curators' accounts of these experiments were often developed through reference to ideas from social studies of science and technology, and as seasoned academic researchers their familiarity with these ideas was in many cases more advanced than my own. The proximity between the curators' accounts and my own, often drawing on similar texts and vocabularies, therefore increased the likelihood of my complicity with the curators' framing of the experiment (which they called "public history"). Indeed, 'going native' emerged as an explicit issue when during my study a new Department of Research and Public History was launched in the Museum. At the launch event I found my thesis featured on this list of 10 PhD students affiliated with the new Department; the title named as the following:

"Public History and Making Audiences for Science"

Though I have given my research several titles during the course of its development, none have ever included the concept of "public history". Significantly, at the launch event my thesis appeared as the only one addressing the new Department's focus on public history. At the launch, my research appeared as the only study attempting to advance the public history agenda of the new Department: not only was I presented as a researcher for the Science Museum but my research was also publicising the curators' public history agenda. In this setting the independence of my ethnographic account of the experimental exhibition appeared conflated with the Science Museum's curators; my research had become about the curation of history in museums and the development of new audiences for science exhibitions.

At this event it was clear that my research was "enrolled" in the curators' public history project. However, being "enrolled", I suggest, is not the same as 'going native'. Going native suggests that the ethnographer uses the native's categories in their own account. It is a criticism that suggests that studying the *Oramics* exhibition as an "experiment" uses a 'native' category, since this is how the Science Museum's curators describe the exhibition. In this respect, the 'going native' criticism presupposes that the natives of this ethnographic study are the Science Museum's curators and that they hold the monopoly to account for the exhibition. In the 'going native' account, the "co-curation"

process would appear as procedural decision taken by the Science Museum's curators to extend their own curatorial authority to other actors. Events such as Boon's experience of being "spoofed" in the NYT students' performance, would simply appear as momentary disruptions to a curatorial procedure that is otherwise under the control of the Science Museum curators. In other words, it is an account of co-curation in which curatorial authority for the *Oramics* experiment remains the monopoly of the Science Museum's curators. However, as the analysis of the co-curation processes made clear, the gallery displays of *Oramics* are not the only formats of experimental publicity. In the above analysis I have highlighted how the curators' account of co-curation processes, that we find in the gallery displays, gives a very limited account of these processes when compared with my own ethnographic experiences. If we mistake my enrolment in the public history project, at this very specific event, for the much broader problem of 'going native', we would close out all discussion of other kinds of relations between myself and the Science Museum's curators. By contrast, if we allow that there might be multiple 'natives' of the experimental setting, then the experimental setting appears less clearly structured by a single hegemonic arrangement of power. This is not to suggest that power relations are absent from the setting, but rather that they are not determining of the experiment. The actor-network theory (ANT) concept of "enrolment" offers one account of the ways in which power relations can both exist in an experimental setting and appear contingent and indeterminate in their exercise. In ANT, the "enrolment" of one actor by another is an attempt to demonstrate and mobilise a power relation and it is the main way in which actors create relations with one another. However, as many ANT studies have highlighted, enrolment is also always a process that risks betrayal by those who are enrolled (for a discussion, see Callon, 1986). For this reason, successful enrolment is more often a sign that there is a common proposition of interest to both actors, or groups of actors, rather than the exercise of absolute subordination or control of one actor over another actor (Latour, 2004). Rather than generalising the relation of the ethnographer to the setting, that is implied in the 'going native' critique, I suggest here that the concept of enrolment allows us to account for my close relation to the Science Museum's curators, and to their public history account of the *Oramics* experiment, while also allowing that there are other styles of experiment and formats of experimental publicity beyond the Museum's gallery displays. At the launch of the new department, my enrolment in the public history research programme seems more obviously to demonstrate limited extension of the curators' public history account – the Museum's curators need to enrol PhD students to

demonstrate the saliency of the public history research programme – rather than a generalised co-option of my ethnographic research.

The second objection to this methodological focus on the distributed character of the experimental object argues that by making this decision the ethnographer imposes too much complexity on the empirical setting. An important line of argument here is that by making the experimental setting complex, the ethnographer gives up explanatory power and is reduced to simply describing differences between actors. To impose complexity on the empirical setting, in this argument, is to adopt an extreme epistemological relativism in which all accounts of the experiment are equally valid. Indeed, epistemological relativism has been a key methodological tool for ethnographers studying experimental controversies in the sociology of scientific knowledge tradition (SSK) (Collins, 1981b; Shapin, 1995; Wynne, 1992b). Methodological relativism enabled the ethnographer to treat symmetrically the competing knowledge claims of different participants in experimental controversies. Complexity was therefore in this sociological tradition a methodological tool for studying scientific controversies ethnographically and avoiding asymmetrical explanations that occurred post-closure (i.e. that the victor in the controversy won because their account was more true, accurate, rigorous etc). But, crucially in this tradition the symmetrical method was not extended to the level of analytical explanation: methodological relativism was supplemented in the analytical stages of research with social theories of interests, power and action. In this way ethnographers in the sociology of scientific knowledge were spared from the criticism that they had both imposed too much complexity onto the empirical setting and that their accounts were mere descriptions with no explanatory power. To extend the relativism to the modes of explaining the closure of controversies would, for SSK researchers, be to debunk the entire endeavour of creating objective knowledge about the world (Barnes et al., 1996).

One significant limitation of the limited methodological relativism of SSK for the current study arises on the matter of experimental closure. However complex and disputed they appear when studied close-up, for SSK experiments are ultimately (social) procedures for constructing knowledge that are always settled at some point. The closure of experiments therefore contains and delimits the complexity which the relativist ethnographer has to account for. Disentangling themselves from the experimental complexity, SSK

ethnographers therefore maintain the power to explain experiments using a sociological analytic that is 'external' to the empirical complexity it describes. But, as their critics have pointed out, this attempt to both admit empirical complexity and maintain the plausibility of detached sociological explanation seems to reintroduce the problem of asymmetry into the social description of science (Callon and Latour, 1992), for instance between internal/external accounts of science that ethnographic study attempted to get beyond. It has been argued, for example, that the attempt of the SSK account to maintain an independent role for sociological explanation has to effectively deny that 'internal' participants of experiments have any purchase on explaining how experiments close (Galison, 1987). By contrast, the proposition that the ethnographic study of experiments requires attending ontologically to the distribution of experimental objects, enables us to repose the problem of experimental analysis without reimposing asymmetries in sociological explanation, for instance between internal/external and open/closed experiments. From this perspective, experiments do not 'close'⁶⁶, in the instrumental sense of a single linear procedure, because every translation of the experiment by different actors – as method, as fact, as invention, as history etc – modifies the experiment in some way (on the sociology of translation, see Callon, 1986). If we foreground the question of the ongoing translation of the experiment rather than its closure, we find that the multiple modes of practice, style and forms of publicity that we find in *Oramics* all participate in assembling the exhibition as an experiment. In other words, we allow that the experiment is both distributed, multiple and dynamic: the experiment ends when it stops being translated. The complexity of experimental settings, then, is not antithetical to the closure of an experiment and the process of sociological analysis but is rather necessary to describing how experiments are assembled. Complexity is not antithetical to the successful 'closed' experiment but is rather a condition of inventive processes.

To treat experiments as sites of invention we have to accept that complexity is there in the setting and that it isn't simply an arbitrary choice that the researcher imposes or rescinds at their discretion. As discussed in the literature review of the previous chapter, if complexity is simply a methodological choice, as it is for SSK researchers (Barnes et al., 1996; Collins, 1981b), this leaves the social researcher unable to account for

⁶⁶ Though I would occasionally be reminded by senior staff at the Science Museum that they couldn't be expected to experiment all the time, in the museum setting experimental 'closure' appeared much less of a concern than it perhaps is in the laboratory settings studied by SSK.

experimental inventions except as social constructs; the world of things remains unaffected by the scientist's contingent representations. In Chapter Two, by contrast, I argued that experimental settings are complex precisely because they introduce and domesticate new 'things' into the world and unsettle existing empirical arrangements. Inventions are not only social constructs but are ontological novelties. By limiting complexity to the choices of scientists representing the world, SSK suggests that experiments create social novelty but do not fabricate new things in the natural world. The attempts to limit complexity to a methodological choice in the SSK account makes clear an important trade-off: to maintain that experiments invent new empirical things, objects, actors (and so on) we cannot simply limit complexity to the representations of scientists or the methodological choices of ethnographers. To account for experiments as processes that produce ontological novelty we must allow the empirical world the capacity to increase and decrease complexity in the same way that SSK grants to ethnographers. In this perspective, to follow-through the proposition of the *Oramics* exhibition as an experiment is to methodologically approach the exhibition as assembled across multiple and distributed settings, practices and formats of display.

Conclusion: a thematic account of *Oramics* as a public experiment

In this chapter I have discussed several important methodological problematics that have shaped the direction of the research and its presentation in this thesis. It is worth here restating them in order to show why the analysis presented in subsequent chapters is arranged thematically.

The central research question that has guided this research is in what ways the *Oramics* exhibition might be considered an experiment in relations between science and the public. In the process of this ethnographic research this question appeared increasingly challenging to answer principally because there appeared to be multiple modes of experiment at work in *Oramics*; namely the curatorial experiment, experimental electronic music and experimental display. Not only was the register of science conspicuously absent from *Oramics*, but as an empirical object the exhibition appeared much more complex both than models of the exhibition as curatorial procedure and gallery

display would allow. The experiment is, in this sense, not only a discursive category used by the Science Museum's curators (though it is this too) but also modes of socio-material practice that we find in electronic music and in the gallery displays and other forms of publicity. Furthermore, the challenges I experienced in attempting to practice ethnographic techniques highlighted that methodological claims alone would provide only very weak epistemological ground on which to distinguish my empirical descriptions of the *Oramics* exhibition from those of other participants in the experimental setting. While I had envisioned myself as the observing ethnographer it seemed clear that my background as an amateur musician was also important in structuring my relation with the setting (as a co-curator, for instance) but also for making relations with informants who could help me situate the *Oramics* Machine within electronic music history. Rather, than putting aside my amateur interests as irrelevant to the sociological study I wanted to conduct, it seemed that this background could in fact help me appreciate more clearly why the 'rediscovered' *Oramics* Machine was such an interesting object to so many different actors. Accepting the complexity of the ethnographic task, I therefore chose to broaden the ethnographic focus and attend to what seemed like the three most significant modes of experiment that we find in *Oramics*. In this way, I sought to collect data through which I might elaborate the proposition that the exhibition can be understood as an experiment in relations between science, culture and the public. This was a methodology through which I sought to give a social description of the experimental exhibition that was at once symmetrical with respect to the different modes of experiment and capable of describing the exhibition as material practice.

The empirical material collected in the empirical research for this thesis is therefore of quite different styles: field notes from events at the Science Museum and interviews with staff working there sit alongside media publicity about Daphne Oram and the *Oramics* Machine, archive materials, recordings of concerts, installations in other exhibitions, and notes about electronic music histories. In the analysis that follows I have attempted to construct thematic analysis that addresses the central proposition of the thesis – how the *Oramics* exhibition can be understood as an experiment in relations between science, culture and the public – and in which I can bring together these very different kinds of materials. The first theme is “participation” (Chapter Four) and is one of the central concepts around which the curatorial experiment is organised. Participation, as I treat it here, is not simply a question of techniques of

inclusion or of the competencies of a given group but also about particular issues in the role of culture in the Science Museum. The second theme is “exclusion” (Chapter Five) and centres its analysis on the ways in which the experimental public displays can be said to both unsettle and to reinforce asymmetries in relations between science and culture. Exclusion here is not only a social problem for science to solve but, I suggest, is a more complex problem of the relations between objectivity and subjectivity, rationality and aesthetics. The final theme is “media” and addresses the exhibition's subject matter of experimental electronic music. Focusing on the staging of electronic music in *Oramics* as experimental collaborations between musicians and engineers, the chapter examines the particular capacities of sound (such as auditory engagement) as an experimental medium. These themes were arrived at after the empirical data was collected, and they are designed to both reflect the central concerns of the research and some of the ways in which the *Oramics* exhibition might be said to be inventive as material practice.

4. Participation: the curatorial experiment and the 'cultural turn' at the Science Museum

Introduction

The front cover of the Science Museum Group's⁶⁷ *2011-2012 Annual Review* (2012a) features one large slogan: "Five museums; world-beating collections; one powerful cultural force". What connects the Group's science museums, railway museums and the media museum is, the front cover suggests, "culture". The *2011-2012 Annual Review* is significant insofar as it is the vehicle through which the Science Museum's new director Ian Blatchford published a manifesto outlining a series of reforms for the family of museums over a ten year period. The cultural offer of the Science Museum is elaborated in Blatchford's manifesto, in which he writes:

"Ultimately, the Science Museum Group rejects the idea of science and culture leading parallel lives. Our kaleidoscopic collections show so vividly that science has always been part of culture. The collections are an epic story about civilisation and human ingenuity, as vital as anything on the walls of the British Museum or the National Gallery. And it is hardly surprising that planned partnerships with music, drama, dance, literature and film are very popular with scientists." (4)

In this chapter I am going to argue that Blatchford's manifesto is one symptom of a broader 'turn to culture' at the Science Museum. Blatchford's remarks tell us both that science and technology have always been part of culture and that the Science Museum is a cultural institution comparable with art and national history museums. In this sense, Blatchford's manifesto might be said to bring together two distinct ideas of culture that are important to distinguish between for the analysis of the following chapter. In one version, which might be called the liberal humanist⁶⁸ version, science museums are considered institutions

67 The Science Museum Group is the name given to the family museums under the Science Museum and includes the National Media Museum, the National Railway Museum, and the Museum of Science and Industry in Manchester. More information can be found at the following web page: http://www.sciencemuseum.org.uk/about_us/smg.aspx (accessed 21st August 2013)

68 The association between Blatchford's statements on culture and those of nineteenth

that represent the progress of enlightenment. Science museums, on this view, are repositories of those elements of culture that need to be preserved from the churn of social life. Characterising museums as institutions of 'high-culture', this view locates science museums within a hierarchical understanding of the relations between science and society. The liberal humanist view of culture has often been contrasted with the anthropological view of culture, a version of culture as the totality of heterogeneous elements in a way of life. In this version of culture, that we often find presented in social studies of science, science cannot be demarcated on a priori grounds as intrinsically more 'special' than any other social activity. Science museums, in this view, are institutions that tell us about the social activities of science, as one cultural practice among many others. In these different traditions, the cultural offer of the Science Museum looks very different and so too does the institution's relation with the public. From the perspective of one tradition, Blatchford's remarks might appear as the elitist cultural politics of museology, to the other tradition they appear to as a democratic appraisal of science. We could plausibly read both versions of culture into Blatchford's remarks, which in this sense embody well the tensions of the cultural turn at Science Museum. In this chapter I look at how the tensions between these different accounts of the relations between science and culture play out in the curatorial experiment of *Oramics*.

In this chapter, then, I discuss the curatorial experiment of *Oramics* in relation to the 'turn to culture' at the Science Museum. I do so through the cross-cutting theme of "participation", and focus specifically on the question of public participation in *Oramics*. The chapter foregrounds a conflict between two accounts of public participation in *Oramics*, emerging in an unresolved dispute between staff working on the exhibition. Both sides of the dispute agree that the curatorial experiment of *Oramics* attempts to unsettle existing *hierarchies* in the relations between science, culture and the public by recognising the *heterogeneity* of these relations. Both sides of the dispute, I suggest, see the

century humanists like Matthew Arnold who argued the culture was "the best which has thought and said in the world" seems pertinent (see discussion of Arnold and nineteenth century liberal humanist accounts of culture in Williams, 1963). Blatchford's appointment from the V&A, a museum that holds 'art' objects in its collections that are historically and geographically expansive, and the comparisons he draws between science and the fine arts would suggest a version of culture not dissimilar to the nineteenth century liberal humanist tradition. As a museum of 'the arts' the V&A is often considered more cultural than the Science Museum. It is telling that, in the opening line of the above quotation, the idea of "parallel lives" between science and culture is one that the Science Museum has had to "reject"; the idea of their hybridity has clearly not always been considered the case. The very fact of the creation of the Science Museum and the V&A as separate institutions from a common origin in the Great Exhibition embodies well both the historical significance of the "parallel lives" thesis described above: located on opposite sides of Exhibition Road illustrate the separation of the art and science museum (or the "non-art" museum) is both a stark reminder of this parallel settlement.

'turn to culture' as a way to multiply the registers through which the public can engage with science and technology, and also to change the kinds of relationships the public can have with science. Both sides agree, for instance, that Science Museum exhibitions should not only be about technical pedagogy and cognitive in their focus, but can also be displays that draw on registers of aesthetics, gender and subjectivity. And, as I show, both sides of the dispute agree that the cultural turn at the Science Museum is about institutional change with a view to engaging those 'outsiders' that are excluded in hierarchical accounts of the relations between science, culture and the public. However, crucially, they disagree over the role of public participation that such a turn to culture would entail. In their respective accounts of the curatorial experiment, the way in which the *Oramics* exhibition makes relations between science, culture and the public appears considerably different.

In this chapter, I analyse this dispute between staff working on *Oramics* to bring into view some of the tensions and limitations of the cultural turn, and to highlight that culture does not 'solve' the problems of relations between science and the public. On one hand, I look at other Science Museum exhibitions curated to emphasise the relations between science and culture and how these exhibitions multiply registers with which the public engage with science and technology. I highlight how such exhibitions at the Science Museum, for instance, blur distinctions between insiders and outsiders of science. However, on the other hand, the curating of science and culture at the Science Museum is also often bound within a hierarchical ontology in which, for example, subjectivity, affectivity and aesthetics stand simply as the negative of the objective, rational and technical. Exhibitions curated to emphasise the relations between science and culture in the Science Museum, I suggest, are not free of the hierarchies. The curatorial experiment of *Oramics*, I suggest, embodies similar tensions. An important question that emerges in the dispute between the staff working on *Oramics* is whether and to what extent public participation can 'solve' problems like social exclusion in science, or the extent to which public participation simply reproduces the established hierarchies and asymmetries in science. This chapter, then, discusses the curatorial experiment of *Oramics* by examining the role of public participation in addressing problems in the relations between science and culture.

In what follows I first introduce the problem of public participation in *Oramics* and the dispute between the two groups of staff over the curatorial experiment.

In this chapter I situate the dispute about public participation and curating science principally in relation to literatures on the cultural politics of modern museums. Social studies of museum have argued that they are institutions of elite culture that participate in the politics of population governance and control. In these studies, the cultural politics of museums is hierarchical and based on relations of domination. I situate the Science Museum's cultural turn in relation both to these museum studies literatures and science and technology studies (STS) literatures discussed in previous chapters. In doing so, I highlight the complex ways these different accounts of culture intersect in the Science Museum. I then return to the problem of public participation in *Oramics* and look in depth at the different perspectives of the disputing groups in relation to these literatures. I suggest that the dispute can be understood in relation to *procedural* and *issue-specific* accounts of public participation. While both sides of the dispute agree that there is an imperative to recognise that the relations between science and culture are heterogeneous, their different accounts of public participation highlight the complexities involved in such an account. What we see from this dispute, I suggest, is the ways in which the participatory displays of *Oramics* do not collapse the problem of hierarchy, such as between 'insiders' and 'outsiders' of science. Rather, I argue that in *Oramics* we can identify new kinds of 'outsiders' and zones of exclusion produced through the curatorial experiment. The purpose of highlighting these problems with the participatory displays of *Oramics* is not to suggest that the curatorial experiment 'fails' to effect a 'turn to culture', but rather to make visible some of the challenges, obstacles and tensions that characterise the relations between science and culture at the Science Museum.

The public participation dispute: co-curation vs. co-creation

Public participation has become something that museums 'do', it is a museological practice. Many museums now have specific public engagement programmes and there is a burgeoning interdisciplinary field of museum participation⁶⁹. The Science Museum is no different from most museums in this respect and indeed is considered by many of its staff to have pioneered some of the public participation techniques that are common place in the sector. The

⁶⁹ A key text in this field is Nina Simon's (2010) *The Participatory Museum*. This book was regularly discussed in my meetings with various staff at the Science Museum, and Simon herself took part in a conference hosted by the Museum in October 2010 called 'Co-curation and the Public History of Science and Technology'.

proposition of the curatorial experiment, however, appears to problematise the Science Museum's existing approaches to public participation. On the first day of my ethnographic engagement with the Science Museum, in mid-December 2010, I arrived to the first general meeting of the public history project involving staff across the Museum, which formally marked the start of work on *Oramics*. Three presentations were given at the meeting: an introduction by Tim Boon to the concept of "public history" (described in Chapter One), a talk by another curator about developing a new technique called "co-curation", and an overview from Boon of the planned *Oramics* exhibition. A fast and energetic discussion followed. Some staff questioned whether the public history proposals added anything new to existing practices of public participation at the Science Museum. Others questioned the value of one-off participatory exercises and the reputational risks associated with experimental curating. Some highlighted the need to develop new audiences and engage currently excluded groups. A number of staff argued the problem was principally a matter of developing new ways of displaying the vast number of objects in the Science Museum's collections, currently languishing in storage. The focus on improving the relationship of the Science Museum to local museums and historical groups was juxtaposed with the danger of the Museum becoming provincial in failing to recognise that 40% of its visitors are from abroad. There were many other points which I failed to follow or record. For staff at the meeting, the proposition of public experimentation of the kind proposed under the concept of public history and the *Oramics* exhibition both seemed problematic in relation to the Science Museum's current practices of public participation and clearly also linked to a broad range of museological issues.

That the curatorial experiment problematises the Science Museum's practices of public participation was further suggested in the evaluation of *Oramics*. The evaluation of *Oramics* was conducted by the Museum's Audience Research⁷⁰ team, based in the Museum's Learning department. Evaluations in the Science

⁷⁰ In this chapter I attribute the team of Audience Researchers a particular position that differs from Boon's public history account of *Oramics*. Because Boon is represented here through an individual persona there is a risk that the presentation of this disagreement appears asymmetric, personalising and rationalising Boon's position while oversimplifying and homogenising the various views of individuals in the Audience Research team. However, what I hope to show in this chapter is that the position ascribed to the Audience Researchers, like the position ascribed to Boon, is not simply surmised from the individual's agent's contingent opinions. Rather it is intended that the positions ascribed to both are done so by showing how these positions are enacted in, and distributed across, a broad range of techniques, tools, models, publications (etc) as well as in the individual's views voiced in meetings, interviews, and other ethnographic encounters. The personalisation of Boon and the anonymisation of the Audience Researchers is in part a pragmatic decision because anonymising Boon would severely limit the analysis of *Oramics* (for example, see analysis of Chapter One). It is also a stylistic choice to limit the individual persona that appear in this thesis.

Museum are carried out from the visitor's perspective on the premise that it is to the visiting public that the Science Museum, as a public institution, should be principally accountable. In the meetings about the evaluation of *Oramics* there was strong disagreement between Boon and the Audience Research team about of whom, or what, this public consisted or should consist. Boon argued that for the evaluation to reflect the exhibition's experimental aims it needed to include the views of visitors who were interested in, or practitioners of, electronic music. The Audience Researchers, on the other hand, were adamant that, though experimental curatorially, the public for *Oramics* was not fundamentally different from other participatory exhibitions in the Science Museum and, hence, that the evaluation should not depart from existing models. The Audience Researchers argued that while it was notable that the curatorial experiment involved a range of different specialises, these people were not representative of Science Museum visitors and should not be the target of the evaluation. For the Audience Researchers, the notion of designing an exhibition for such a niche audience suggests an exclusivity that conflicts with the Museum's commitment to its core non-specialist audiences. The disagreement between Boon and Audience Researchers about *Oramics* extended to the use of terminology used to describe the participatory process. Boon's description of the participatory process of *Oramics* as "co-curation" was introduced at the initial public history meeting, described above, and is closely linked to the public history account of the experiment; both co-curation and public history are new concepts in the Science Museum. However, in a subsequent meeting about *Oramics* one of the Audience Researchers contests the use of the term arguing that it is disingenuous for the Science Museum to claim co-curation as an innovation when the techniques it describes have been widely used for some time in the museum sector, not least in the practices of smaller local history museums. The Audience Researcher instead suggests they use a more widely recognised concept of "co-creation", a term used across public and commercial organisations, which was subsequently adopted for the evaluation. The *Oramics* evaluation is important for both Boon and the Audience Researchers because it is a document that codifies the successes and failures of the exhibition in relation to the public. The disagreement between Boon and the Audience Researchers about the evaluation of *Oramics* is an issue not only about audiences and visitors but also about the nature of the curatorial experiment and how it problematises the 'insiders' and 'outsiders' of science.

Evaluations occupy a central place in the practices of exhibition-making in the Science Museum. In an interview, one of the Audience Researchers described to me the methodologies used for evaluating exhibitions. Currently, for a typical exhibition Audience Researchers would undertake formative research during the planning stages of the exhibition to understand who the prospective audiences are, followed by testing the exhibition materials with these audiences during the design phase of the exhibition, and a final summative evaluation after the exhibition has opened. In evaluations Audience Researchers use qualitative research techniques such as interviews, guided visits, and focus groups that enable them to represent the public's subjective perceptions of the galleries and other projects undertaken by the Science Museum. In collaboration with the Museum's marketing department, Audience Research also uses descriptive statistical techniques to profile and segment visitors to the Museum which in more recent work has informed the target audiences in evaluations⁷¹. Audience Research also encompasses a practice called Audience Advocacy⁷². Audience Advocacy is, as the name suggests, a practice that attempts to promote the views of audiences (collected through research practices) in the Museum's work. Operationally based within the Museum's Audience Research team, Audience Advocates are deployed on all exhibition projects to ensure that the Science Museum's exhibitions address the needs of its various audience groups. Where MacDonald's study (2002) in the late 1980s argued that through the working practices of the Science Museum the public was inscribed in the exhibition's representation of science, this inscription of the audience became an institutional practice with the establishment of the audience advocacy role. Audience Research is thus not simply a passive collecting of public opinion but, in its Advocacy function, is a practice that explicitly attempts to transform the way other practitioners in the Science Museum conduct their work. Evaluation is a research practice that

71 One of the important tools shared by Audience Research and Marketing is the "audience profile" that specifies the relationship of a particular group of the public to the museum. One of the Audience Researchers sends me an early piece of audience profiling research from 2001 that dissects the Museum's audience. The report draws not only by the common demographic and socio-economic measures but also measures that specify the visitor's relationship to the Science Museum including the frequency and purpose of visiting the Museum. The data on audience profiles in this report is presented quantitatively: audience profiles are constructed on the basis on statistical data collected through an exit survey of visitors attending the Museum. The exit survey is now an annual feature, according to a senior Audience Researcher I interview, and provides a longitudinal perspective on the kinds of people visiting the Science Museum. As statistical constructs that are subject to annual revisions, audience profiles maintain a dynamism that reflects changes over time in the Museum's visiting public.

72 One of the Audience Research team I interview describes the development of Audience Research in the Museum as simultaneous and closely linked to the development of Audience Advocacy. The researcher explains that both advocates and researchers were employed to work on all of the Museum's exhibitions developed for the Wellcome Wing, a three storey exhibition space which opened in 2000 with a focus on public engagement in contemporary science issues.

also informs this advocacy function. The evaluation of *Oramics* is important, then, not least because it has potentially *practical* implications for museology at the Science Museum. In short, the dispute between Boon and the Audience Researchers is not simply abstract theory but one of deeply practical significance.

One way to understand the dispute between Boon and the Audience Researchers over the curatorial experiment and public participation is through a caricature of the corporate structure of the Science Museum which, as it was often relayed to me by staff, suggests there is a “front-end” and a “back-end” to the organisation. At the front-end is the Learning Department, responsible for outreach, gallery interpretation and education programmes among other functions, while at the back-end is the Curatorial and Collections Department, responsible for maintaining objects and undertaking research. It is a split that suggests the separation of the concerns of subjectivity (front-end) and objectivity (back-end). Audience Research, located in the Learning Department, is oriented towards the front-end and is where public participation, as a museological practice, is located operationally. Boon, as a curator and historian, is located principally in the back-end of the Museum. Research is a function split between the two ends of the Museum by its concerns with audiences (subjects) and history (objects). This caricature of the institution would offer a simple way to explain the conflict between Boon and the Audience Researchers as the conflict between professional outlooks that accord to a series of dichotomies of each side of the back/front end. It is a caricature which provides us with a kind of structural-functionalist account of the dispute – a perspective that I attempt to avoid falling into here – in which the ideas of each side being understood as determined by their position and function within the corporate structure of the Science Museum.

The weakness of the structural-functionalist imaginary is, as many sociologists have pointed out, that it can't adequately account for changes in practice. Though a useful caricature among some staff I met, in the practice there appear many more 'ends' to the Science Museum that do not neatly reduce to a front/back end organisational model⁷³. At the time of study the Science

⁷³ In the late-1980s in response to a failed attempt to rationalise the exhibition space in the Science Museum, the then director invented the concept of the “multi-museum” (MacDonald, 2002), a term which is still used to describe the institution (Boon, 2010). The reflects the proliferation of different departments in the Museum, of which recent additions include the web and social media teams. For example, in the 1990s a separate private enterprise NMSI Enterprise was established as a revenue generating arm of the Science

Museum was undergoing a corporate restructuring, and indeed continual restructuring is characteristic of contemporary organisations (Thrift, 2005). In fact, many of the corporate developments related to *Oramics* attempted to reorganise the working practices in the Science Museum and to overcome some of the corporate “Divisions” in the Museum⁷⁴. The various staff from across the Museum whom I encountered working on *Oramics* were well aware of the exhibition's experimental aims, and many saw the exhibition as an opportunity to challenge the modus operandi for exhibition-making in the Museum. Moreover, a new department founded by Boon in 2012, titled “Department of Research and Public History”, relocated staff from both Curatorial and Audience Research departments. More importantly perhaps, to use a structural-functionalist approach would be to assume the composition of the very object, the Science Museum, that this chapter seeks to interrogate. In this respect, I don't attempt here to explain the disagreement between Boon and the Audience Researchers by appealing to a preconceived ontology of the Science Museum but rather seek to use the dispute to show the ways in which the ontologies enacted in and with the Science Museum are problematic. However, as I will show below in the discussion of museum theory, this front/back end caricature is not unfounded and indeed might be said to reflect a particular version of the cultural politics of museums. Specifically, the caricature is not dissimilar to models of the museum that we find in some museum studies which suggest that objects are historical in character and internal to museums while the public are the external subjects of museums. The museum studies I survey here are not structural-functionalist accounts. However, some museum studies have nonetheless theorised museums as institutions that engage in particular kinds of cultural politics. In analysing the dispute between Boon and the Audience Researchers about the *Oramics* experiment I therefore seek to highlight some of the ways this exhibition problematises some museum studies accounts of cultural politics. In this chapter, then, I seek to analyse this dispute to clarify the heterogeneous ways in which the Science Museum is enacted as a democratic cultural institution.

The hierarchies of the liberal museum

Museum. These departments and corporate arms of the Science Museum clearly do not neatly conform to the front/back end caricature.

74 Boon (2010) describes the divisive nature of the Museum's corporate reorganisation under the Thatcherite director Neil Cossons who established a series of “Divisions” in the Museum.

Prior to the empirical work of this study I had regarded museum studies as only a background literature with which I might need to lightly familiarise myself, but not one that would shape my conceptual analysis of the *Oramics* exhibition as a public experiment. However, this separation between the museum studies literature and the literatures of social studies of science became more difficult to maintain during the empirical research as various staff at the Science Museum I met during the research would draw from both to characterise *Oramics* as a curatorial experiment. One of the curators, in particular, has been trained in museum studies and would often draw references from this body of literature to describe the public participation experiments. And, in interviews with the Audience Researchers it seemed to me that I would need to confront the museum studies literature in order to appreciate properly their position on public participation.

From certain perspectives in museum studies, the proposition of the exhibition as an experiment in the relations between science and culture is highly implausible. In many museum studies the museums is institutions built on hierarchical relations that represent culture for ends of political domination. In the exhibitions of science museums, culture is represented as consisting of particular values and discourses, access to which is unevenly distributed in society. Science exhibitions are then public displays from which the masses are excluded and which function to reproduce social elites (for example, Bennett, 1995; Hooper-Greenhil, 1992). Museums, in this perspective, are public institutions from which the public is largely excluded. However, as public institutions museums espouse the values of liberal democracy and Enlightenment. By promoting liberal values of self-governance through education museums participate in the governmental politics of population control. Attempts by museums to democratise the way they publicly represent knowledge would, according to these studies, undermine the very basis on which the institution is founded. Displays of popular and mass-culture in museum exhibitions rather extend the hierarchies of the institution. The proposition of the museum exhibition as an experiment in relations between science and culture appears, in relation to these studies, as not only highly implausible but a threat to the very institution of the museum. I will here briefly survey some of these museum studies, drawn from a plurality of traditions. The purpose of doing so is not to close down the distinctions between these different accounts of the hierarchies of science museums. Rather, it is to highlight the diversity of traditions from the perspective of which the exhibition

as a public experiment appears as an implausible proposition.

The political ontology of the modern museum, according to museum studies looked at here, was formed in the historical period of modern nation-state formation when it is realised as an instrument of government⁷⁵ (Anderson, 1991; Hooper-Greenhill, 1992). Exemplary of the modern public museum, according to Hooper-Greenhill, is the Louvre which was established in the immediate aftermath of the French revolution and played an important role in the invention of a democracy (see also Duncan and Wallach, 1980). However, the political ontology of museums is, these studies suggest, in many ways antithetical to the ideals of democratic culture that they espouse. Hooper-Greenhill argues, for instance, that the Louvre participated in disciplining⁷⁶ the democratic subjects of the new French Republic. Fundamental to this disciplinary function, Hooper-Greenhill argues, is the museum's establishment of a division between the private spaces where knowledge is produced and organised and the public spaces where knowledge is made visible for the public. The public are, in this account, the passive subjects of an institution that has aristocratic relations of domination inscribed in its practices. In other words, this division between private and public was not simply a division of knowledge, but also one of power and advantage. As an institution derived from royal power, the Louvre was repurposed to serve as an instrument of both state control and surveillance. Hooper-Greenhill's study thus both specifies the political ontology of the modern museum and the ways in which governmental functions of surveillance and domination are inscribed into museological practices of collecting and display. This account of the modern disciplinary museum is extended, and importantly qualified, by Bennett (1995) who describes the modern museum not only in terms of epistemology but also as

75 This governmental account of the museum was in fact often shared by staff at the Science Museum, in part an effect of the fact that the Museum used to be formally part of government. More importantly though, this governmental role often appeared as a resource to describe and legitimate different museological practices. For example, the Museum's legal status was often the most useful way for staff at the Museum to formalistically describe programmes of work: documents such as funding proposals, board briefings, and project summaries often presented as derived from the first principles of the Science Museum's statutory obligations defined in the UK's 1983 Heritage Act, according to which the Museum's object collection is held on behalf of the UK public. In this legal conception of the Science Museum as an instrument for the governance of heritage – albeit one that operates at arms-length from the departments of government as a non-department public body – the “public” pertains to that governed by the British state which is reflected in public participation practices such as Audience Research (discussed below) which often model the Science Museum's public in terms of British population demographics. If the *Oramics* experiment attempts to unsettle the hierarchical cultural politics of the modern museum then it is also, as will be discussed below, likely to problematise these museological practices in which the public is simply derived from the idea of the Science Museum as an instrument of the nation-state.

76 The concept of discipline in Hooper-Greenhill's account is, like Bennett's below, drawn from Foucault's analysis of the distributed practices of government.

an instrument of for promoting a particular form of democratic culture. Bennett's study situates the modern museum in relation to other governmental instruments, including parks and libraries, which attempt to civilise the population and replace those forms of culture, such as the raucous amusement parks, which represented a threat to bourgeois cultural values. In Bennett's account, the modern museum serves a particular form of elite culture: the public is disciplined in bourgeois cultural values, such as self-betterment through education, through the exhibitionary practices of the museum. The opening up of the museum to the public not only made museum objects publicly visible, Bennet's argues, but in doing so created a cultural spectacle of a visible public which was civilized with the capacity for learning and self-governance. In this way, Bennett argues, museums can be seen to 'solve' the challenges faced by modern liberal governments of population control.

In Bennett and Hooper-Greenhill's accounts, the claims of museums to represent the public masks the processes through which elites dominate the masses (see also Bourdieu, 1984). While the object collections held by modern museum purport to represent public culture, museum studies have argued that exhibitions of these artefacts in fact represent the processes of elite domination and control. An important theoretical antecedent to this account of museum culture is in the critical theory of the Frankfurt School, in particular Adorno and Horkheimer's (1972) account of mass-culture and Habermas's (1991) account of the bourgeois public sphere. Adorno and Horkheimer's account of the "culture industries" emphasised how, under the conditions of late capitalism, culture was becoming homogeneous, its seeming diversity to consumers masking the centralisation and monopoly control of its production. Cultural forms such as film, radio and popular music had become standardised and organised as industries of mass-production. Culture, for Adorno and Horkheimer, under conditions of industrial production had lost its critical political function. Individuality was becoming a property only realised in the consumers' choices, a pseudo-individualism. This account of culture was later extended in Habermas's political history of the public sphere. In Habermas's account, the conditions of industrially organised culture limited the possible development of critical forms of public expression and reduced publicity to a mere form of advertising. The emergence of institutions like museums to represent public culture reflects culture's centralised organisation and the monopoly control its production. Museum exhibitions, in these accounts, do not

democratise culture but rather extend existing relations of domination⁷⁷.

Though the above accounts of modern museums, as public institutions, are in many ways quite different common to all is the idea that exhibitions are spaces of representation that reduce museum objects to signifiers of particular forms of elite culture. Adorno (1967), for instance, argues that museums reduce objects to mere “historical signifiers”, to representatives of history, and therefore suggests that the modern museum is like a “mausoleum”; it is a repository of (almost) dead objects⁷⁸. Elsewhere, Baudrillard (1995) extends this idea of the museum, arguing that it is not only museums but rather all practices of mass production that produce dead objects. This mass-production of dead objects is, Baudrillard argues, a process of “museumification”⁷⁹. For Baudrillard, the self-conscious attempts by museums to become centres that reflect popular culture (rather than elite culture), such as the Pompidou Centre and related museums in the Beaubourg district of Paris, are fundamentally flawed because they continue to participate in the systems of mass-production that produce dead objects.

“Beaubourg could have or should have disappeared the day after the inauguration, dismantled and kidnapped by the crowd, which would have been the only possible response to the absurd challenge of the transparency and democracy of culture—each person taking away a fetishized bolt of this culture itself fetishized.”
(49)

⁷⁷ Where museum objects are used to represent other kinds of cultures, such exhibitions of indigenous objects in anthropology museums, they are nonetheless shown within the narratives and discourses of Western colonial elites (Ames, 1992; Stocking, 1988).

⁷⁸ The museum, Adorno states, brings objects close to death by reducing them to signifiers of history. The museum absorbs the object into history by extracting it from the context of its existence and by bringing it into relation with other objects which have no immediate connection other than history. The role of the object in the museum is principally to illustrate history. History is thus a property that the museum attributes to the object, it is not innate to the object, and hence the museum can never entirely assimilate the objects it collects. For Adorno, then, museums are institutions that represent history. In this role, museums participate in the Enlightenment project in which man attempts to master objects and narrate history as progress; one effect of the Enlightenment project was the catastrophe of the Holocaust, according to Adorno and Horkheimer. The claim that museums bring objects close to death but never in fact 'kill' them is linked to Adorno's (1973) broader philosophy of objects in *Negative Dialectics* in which he argues: “objects do not go into their concepts without leaving a remainder” (5). In effect, objects never entirely reduce to the historical signifiers that they come to represent in museums.

⁷⁹ Baudrillard (see also Baudrillard, 1993) situates the modern museum within what he describes as “the order of production”; the second of three historically progressive “symbolic orders”. The order of production was instituted by the industrial revolution. Baudrillard develops a semiotic analysis of the order of production to argue that this entailed the mass production of identical signs. The logic of production established signs as a pure series, in contrast to earlier hierarchical ordering of signs, and production was thus developed on a logic “equivalence” and “replication”. Baudrillard's analysis in many senses echoes Adorno and Horkheimer's analysis of mass-culture under the conditions of late-capitalism. Modern science and museums, Baudrillard argues, are of the symbolic order of production.

If Beaubourg really was about democratising culture, Baudrillard argues, then it would have ceded control over the representation of culture entirely to the masses: in doing so it would have failed entirely as a museum. Baudrillard's argument makes clear why museums that claim to represent mass culture are ontologically no different from the 'high culture' museums they seek to distance themselves from. Museums, for Baudrillard, can never become institutions that authentically represent the public because, for Baudrillard, museums are institutions that belong to the regime of industrial-capitalism and mass-production: hierarchy and domination is intrinsic to the museum.

The above critiques of the modern museum as a public institution that represents democratic culture provide a good framework within which to situate the museological challenge of the curatorial experiment of *Oramics*. Politically, these accounts suggest that the modern museum participates in the project of population governance and control. It does this by promoting the liberal democratic values of the modern nation-state in order to civilize those sections of the population, such as the working classes, that represent a threat to the established political order. In these accounts, museums are highly conservative and undemocratic institutions that embody older hierarchical notions of disciplinary power. In this political ontology, public participation in museums is simply an extension of this disciplinary governmental function. The modern museum participates in a particular form of mass culture, that is centralised and industrially produced. The museum reduces objects to mere signifiers, museums are where objects go to die. Where museum exhibitions attempt to mimic the heterogeneity of democratic culture, the museum only further extends the domination and homogenisation of mass-culture. The institutional organisation of the modern museum is thus antithetical to authentic public participation and experimentation that is the proposition of the curatorial experiment in *Oramics*. From the perspective of the museum studies surveyed, the proposition of the experimental exhibition is highly implausible without, as Baudrillard describes, the collapse of the museum. Or, to frame Baudrillard's point differently, such experimentation would entail a radically different kind of institution which would be entirely antithetical to that of the modern museum. Critical studies accounts of the modern museum, drawing on Foucault, the Frankfurt School and Baudrillard, therefore make clear that if the curatorial experiment of *Oramics* is authentic then it is also an experiment more broadly with the Science Museum as a cultural institution.

From hierarchy to heterogeneity

In the introduction I introduced the notion of a 'turn to culture' in the Science Museum. Underlying the disagreement between Boon and the Audience Researchers, I argued, was a notion that the relations between science, culture and the public should be understood as heterogeneous rather than hierarchical. Culture, in this disagreement, is a concept that unsettles, and in some cases collapses, the demarcations on which the hierarchies of the modern museums is based. These include the demarcations (many of which were discussed in previous chapters) between science and art, expert and lay, objects and subjects, men and women, rationality and affectivity. In the introduction I also highlighted the tensions within Blatchford's rendering of culture which, on one hand, suggested the anthropological position of 'science as culture' while, on the other hand, also suggested a liberal humanist rendering of culture as the accomplishments of elite specialists. The three accounts of the Science Museum's cultural turn, Blatchford's, Boon's, and the Audience Researchers are clearly neither completely at odds with one another – since Boon and the Audience Researchers find considerable common ground from which to establish a disagreement – but clearly are neither entirely in agreement. In these different accounts we see some of the tensions that are contained within the shared rubric of culture in the Science Museum. In this section I look at how these tensions between hierarchy and heterogeneity are suggested in other exhibitions we find in the Science Museum.

Though the Science Museum has recently dropped its long-held subtitle of “National Museum of Science and Industry”, Blatchford's manifesto makes clear that the presenting of science 'as culture' can also be compatible with an older idea of the Science Museum as a governmental instrument that promotes British industry. In Blatchford's manifesto, titled 'Moving up a Gear', the emphasis on culture is accompanied by a distinctively macho⁸⁰ rhetoric; Blatchford writes:

⁸⁰ This point is elaborated in the discussion of the gender politics of science and technology in Chapter Five.

“It’s time for the Science Museum Group to punch its weight, because the nation’s future prosperity and quality of life depend on an urgent commitment to science and technology. The Group should flourish as a flagship for the best that a rational explanation of our world can offer” (4)

Emphasising the economic utility of science and technology to account for the public function of the Science Museum has been commonplace in the rhetoric of the institution's directors at least since the 1980s when, under the neo-liberal reforms of Margaret Thatcher's government, the Museum was separated from state control, becoming a semi-autonomous organisation and part of the market place of the emerging museum industries⁸¹. The promotion of national industry has also been a politically powerful resource for the Science Museum, and science exhibitions remain potential vehicles for publicising British industry. This was perhaps most explicit in a 2012 temporary exhibition hosted by the Museum which was curated by the Department for Business Innovation & Skills (BIS) called *Make it in Great Britain*. The gallery of *Make it...* was plastered with Union Jack imagery and comprised a series of stands, many of well known British manufacturers like Airbus and Rolls Royce, which showcased shiny and sleek-looking products. Described on the BIS website, the *Make it...* exhibitions was: “a celebration of the success of British manufacturing, featuring some of the most exciting great British innovations of today and firmly dispelling the myth that Britain 'doesn't make anything anymore’.”⁸² The promotion of British industry was very nakedly the focus of *Make it...*; the exhibition was publicity in the most commercial sense of the term. In relation to exhibitions like *Make It...*, the idea of the museum as an instrument of industry and governance still characterises well many of the activities of the Science Museum.

Clearly the industrial and the economic utility of science and technology for the national political community of Great Britain is a significant focus of exhibitions in the contemporary Science Museum (though there is perhaps also a sense in which their current emphasis in Science Museum publicity might be exaggerated by the contemporary economic crisis and the cuts in public

81 This was the result of the reforms contained in the 1983 Heritage Act. In this legal conception, the Science Museum operates at arms-length from the departments of government as a non-department public body. The entry of the Science Museum into the market place of the culture industries is described well in MacDonald's (2002) ethnographic account in the late 1980s.

82 See the *Make it in Great Britain* exhibition website: <http://makeitingreatbritain.bis.gov.uk/> (accessed 30th April 2013)

funding that the Science Museum Group is facing⁸³). And yet, in many other ways the brash commercialism of the *Make it...* exhibition and Blatchford's emphasis on the economic utility of applied science seems somewhat at odds with some of the other concerns of the Science Museum. The Science Museum's recent institutional publicity, for instance, appears more obviously to highlight the heterogeneity of concerns addressed by the Museum than to push a single institutional narrative⁸⁴. Indeed, the most recent 2012-2013 *Annual Review (2013)* prefers to emphasise the “global”, as opposed to “national”, orientation of the Science Museum Group: the opening page charting “The Science Museum Group's (sic) influence around the globe”, by showing on a map of the globe the location of its various institutional partnerships. Both globe and nation are clearly important but elsewhere in the public history work of the Science Museum there is also a strong emphasis on the “local” histories of the Museum's objects⁸⁵. One of the challenges for the contemporary Science Museum is clearly to make the connections between these different registers in a way that enables the institution to satisfy the imperatives of each. Or, put another way, it would require a lot of work for the Science Museum to maintain the limited nexus of the 'national industry' museum when contemporary publicity for science increasingly emphasises heterogeneous concerns such as 'local knowledges' or 'interdisciplinarity'. Situating the *Oramics* exhibition in relation to a broader turn to culture in the Science Museum is, I suggest, one way to appreciate its significance as a curatorial experiment.

Another version of the cultural display of science and technology can be found in the Science Museum's flagship gallery *Making The Modern World* (MMW), which opened in 2000. Occupying the spatial centre of the Science Museum, *MMW*, subtitled “a cultural history of industrialisation from 1750 to the present

83 In many ways the narrative of Blatchford's manifesto echoes that observed at the Science Museum by Sharon MacDonald in the late 1980s with the appointment of the Thatcherite director Neil Cossons. Just as Cosson's directorship coincided with drastic cuts in public funding to the Science Museum, leading to an early decision by the director to introduce admissions charges, a similar crisis in public funding provides the backdrop both to this study and Blatchford's directorship of the Science Museum. At the time of writing, discussions are being had in public about whether the Science Museum Group will close one of its “northern” museums in order to address a funding deficit. See for example: <http://www.museumsassociation.org/museums-journal/news/05062013-science-museum-group-would-close-museum> (accessed 21st August 2013)

84 For instance, corporate publications such as the Museum's most recently *Strategic Plan* (2012b) opens with a description of the Science Museum as “one of the most important cultural institutions in the world”¹(2).

85 The 'local' focus of the Science Museum was the focus of other “public history” projects that were developed during my study – although discussion of these are not included in the final version of this thesis, the local dimension comprised a significant focus of the work developed by Boon under the public history project..

day"⁸⁶, is a large gallery arranged in chronological ordered displays. In many senses, walking into the *MMW* gallery feels like entering a distinctly hierarchical celebration of modern industrial icons that would be expected given the museum studies accounts of the relationship between museums and the conditions of late-capitalism and mass-production. From this perspective, the DNA Double Helix evidences the capacity of scientific modelling to explain and predict individual lives; the Model T Ford is testament to the transformative power of automation and industrial mass-production; jars of penicillin remind visitors of the extent to which they rely on medicine to cure or relieve them from pain and suffering; and the V2 Rocket embodies the great utility of engineering both for enabling humans to escape the earth and to destroy it. From this vantage point, *MMW* is a testament to a hierarchical and asymmetric politics of the industrialisation of science and technology. But, *MMW*, as its subtitle makes clear, is also an exhibition deeply concerned with the cultural 'context' of modernity. To this end, case displays around the sides of the gallery offer multiple historical narratives of the different ages of technological change from which the icons are drawn, models of the iconic objects draw attention to questions of their scale and diverse significations industrialisation, and vast displays of 'everyday' domestic products address visitors as a public of consumers. These displays of cultural context of the icons in *MMW* here serve to qualify what might otherwise appear a text-book gallery display of industrialisation. But, I suggest here, there are also ambiguities in what the cultural context of industrialisation, shown in *MMW*, includes and what it leaves out.

If we take just one of these versions of the cultural context of industrialisation we can see that there are some tensions in the way that *MMW* enacts the relations between science, technology and culture. The focus of the displays on consumption, which display mass-produced consumer objects and in this sense address the visitor in part as a consumer, in particular bring out these tensions. The exhibition of the icons of the modern world are staged alongside cabinets filled with the more 'everyday' objects, including many of domestic significance: for example, a Sunbeam Ironmaster Model X21 electric dry iron, Con Edison's Plan Your Kitchen Kit, and a Kenwood Sodastream. The inclusion of low-technology domestic objects addresses the visitor as consumer of mass-produced artefacts. This focus of the consumption could be

86 See the Science Museum's webpage for *Making the Modern World* at: http://www.sciencemuseum.org.uk/visitmuseum/galleries/making_the_modern_world.aspx (accessed 20th May 2013)

read a number of ways. In narratives of modernity, the consumer is a figure that has often been polemically described as either the cultural “dope” or, conversely, the “hero” of the modern world (Slater, 1997). There is a significant question about the extent to which the cultural displays of *MMW* transgress such modern narratives of consumption for the many other potential logics of consumption (for discussion of logics of consumption see Baudrillard, 1998). For example, if the displays of mass-produced consumer objects in *MMW* are an attempt to represent of the heterogeneity of the consumer's lived experiences then these displays seem to depart little from those mass-culture museums that are described by Baudrillard in Beaubourg, Paris. The display of these everyday objects would, in this reading, suggest a curatorial imagination in which these objects can be deployed to instrumentally 'affect' visitors, who can relate to them experientially. In such an account, the icons of science and technology, being 'text-book', offer visitors largely cognitive experiences whereas 'low-technologies' like irons can engage with the lived, sensorial experiences of visitors. In this sense, the displays of *MMW* might be said to simply instrumentalise culture in service of an asymmetrical and hierarchical account of industrialisation as technological determined. We might ask, to what extent the displays of culture as context which is populated by consumers and not producers simply reinforces the “culture of no culture” for science and technology described by Sharon Traweek (1992)? These tensions in the different uses of culture in Science Museum exhibitions can help us, I suggest, understand and elaborate some of the tensions that we find in the *Oramics* experiment, and specifically, in this chapter, the disagreement between Boon and the Audience Researchers.

Procedures for representing outsiders

Not long after the opening of *Oramics* to the public, one of the Audience Researchers gave me a draft of a forthcoming “Co-creation Strategy for Making Modern Communications”⁸⁷, a strategy for the Museum's forthcoming permanent exhibition that explains the concept of co-creation in greater depth. The Strategy lays out a series of public participation definitions which are arranged in a three stage hierarchy from the lowest level “contribution” to

⁸⁷ “Making Modern Communications” is a new permanent gallery being developed in the Science Museum, now renamed *Information Age*. More information about the gallery can be found at: http://www.sciencemuseum.org.uk/about_us/masterplan/information_age.aspx (accessed 28th August 2013)

“collaboration” to the highest level “co-creation”. The Strategy specifies “co-creation” as: “this means we give audience groups the tools and skills, then support their activities”. Co-creation, the highest level of public participation, is oriented to the activities of the outsider publics with the Museum attempting to enable them to realise their own aims. The ends of co-creation, this definition suggests, are not determined by the museum but rather by the public; the museum simply supports the public's activities. Co-creation is experimental because the Museum doesn't stipulate or control the end product that results from the participatory process. In a strange way, this definition “co-creation” echo's Baudrillard's assertion, quoted above, about the necessary dismantlement of the modern museum by the masses for it to become an institution of public participation and democratic culture. It is a logic of public participation which taken to its extreme, or its highest level in co-creation, might seem to collapse the hierarchical public museum into radically heterogeneous “public activities”. Baudrillard might have been pessimistic about the possibility of museums realising the democratic promise of public participation but the Co-creation Strategy suggests that these aims are in fact not so distant from the practical aims of contemporary museums. In this sense, the Audience Research account of *Oramics* as a public experiment shares with Boon's public history account (see description in Chapter One, also discussed below) the aims of curatorial experimentation, but, as will become clear, they differ in the assumptions they make about the public.

However, there is a sense in which the Audience Researchers idea of the co-creating public is also derived from distinctly governmental concerns. The Co-creation Strategy makes clear that public participation activities should target particular groups which include “BAME [Black, Asian and Minority Ethnic] communities, deaf and disabled groups as well as families and individuals who are less economically active”. These groups comprise very particular kinds of minority and marginalised communities and this policy is linked to governmental concerns with what, in the UK, has been called “social exclusion”. The socially excluded are those segments of the governable population that are under-represented and marginalised in other ways from democratic institutions. Indeed, recent governments in the UK have been keen to encourage the idea that museums and other cultural institutions could be instrumentally useful for addressing social exclusion. This governmental discourse is often linked to the cultural policy of the post-1997 New Labour government, such as the introduction of the free admissions policies to

national museums (Sandell, 2003). In one sense, the discourse of social inclusion has translated the critique of the political ontology of the modern museum, in studies such as those of Hooper-Greenhill and Bennett described above, into a project of institutional reform. This cultural reformist approach to public participation was evident in a research report from 2002, sent to me by a member of the Audience Research Team, which developed panels of “new audiences” comprised of groups of people who did not visit the Science Museum. Titled 'Culturally diverse visitors – a report on work with a panel from the black community', this report documents the first visits of the panel members and their families to the Science Museum, focusing on their preconceptions prior to visiting and their subsequent perceptions of the Museum. The report's introduction summarises the research:

“The Science Museum is currently undertaking a research project looking at the needs, wants, and expectations of groups who are under-represented in our current audience or who may feel excluded if they do come to the Museum. The project has begun by looking at the black community. The purpose of this research was to explore why black people do not come to the Museum, what their experience is like when they do visit, and what we could do to attract them in the future.”

The aim of this piece of research, the introduction summarises, is for the Science Museum to understand why particular groups, here the black community, don't visit, with the suggestion that such awareness can lead to practical change that can include and engage these groups. The focus of engaging new and underrepresented groups, the outsiders, suggests a political concern not only with making museums accessible to the public but in reforming museums as public institutions

Six months after the opening of *Oramics*, the Museum's Audience Research team sent me a copy of the evaluation of *Oramics* titled “Oramics to Electronica: The public's perception of a co-created gallery”. The report's executive summary states the following:

“Visitors were in general very positive about the idea of working collaboratively with non-museum members of the public to enhance the breadth of knowledge and diversify the perspectives and stories told by the Science Museum in its exhibitions. They see this as a modern, inclusive and forward thinking way of working.”

In the Oramics to Electronica exhibition the co-created elements of the gallery were quite subtly imbedded in the interpretation and the visitors were not able to readily access the differing voices and stories being told.”

In the Audience Researchers' evaluation a firm demarcation is made between the Science Museum's 'insiders' and 'outsiders' in the concept of the “non-museum members of the public”. The suggestion is that the public is external to the Museum and co-creation is a technique for including the public in the work of the Museum. The evaluation is critical of *Oramics* arguing that it is largely unsuccessful as a co-created exhibition. The “differing voices and stories” are only “subtly embedded” in the displays which fail to represent the heterogeneous perspectives of the Science Museum's visiting public.

Co-creation, the evaluation makes clear, pertains to particular exhibits and groups in the exhibition rather than being a general term that describes the exhibition. In other words, co-creation describes the activities of only some of the groups participating in *Oramics*, rather than providing an overarching classification for the exhibition. An important distinction in the Audience Researcher's co-creation account, which was briefly described in the introduction, is between those groups who constitute the Science Museum's core audience of “non-specialists” and those groups who hold an existing interest in a subject. In the evaluation this distinction is manifest in the division of the groups participating in the exhibition into “interested stakeholders” and the “public”. In the evaluation, the students from the National Youth Theatre, the Women Writers, and the 12 electronic musicians are considered as the public groups participating in co-creating the gallery. The report considers the participants from the Radiophonic Workshop, the Electronic Music Studio and the academics from Oram's archive at Goldsmiths as the “interested stakeholders”. The term “interested stakeholders” used in the evaluation is particularly significant because it suggests a further distinction of particular pertinence at the Science Museum. Chapter One quoted an early Science Museum director Henry Lyons, a director often credit with defining the Museum as a public facing institution, who argued that in order for a visitor to a science museum⁸⁸ become “interested” they must first hold a technical understanding of what they were looking at. In this account, Lyons outlined the basic tenet of

⁸⁸ As noted in Chapter One, Lyons' drew a sharp distinction between science museums and art museums which pertained a broader conceptual separation between reason and aesthetics.

a problem of which a later version in the public understanding of science (PUS) is the “lay public”. The problem⁸⁹ of the Science Museum's public, in the PUS account, is that they are principally 'outsiders' of the institution who hold no immediate interest in technical objects. This problem is repeated, in a different way, in the evaluation's separation between stakeholders and the public on the grounds of “interest”. In the Audience Researcher evaluation, just as in Lyons' account, the interested stakeholders are those groups who are unproblematic for the Science Museum. Because the interests of “stakeholders” are already clearly defined in relation to the concerns of *Oramics* it is easy to see why the evaluation does not consider their contributions as part of the experiment: there is, in this account, little that is experimental about the participation of the Radiophonic Workshop and the Electronic Music Studios in *Oramics*. Stakeholders are the 'insiders' whose participation is not experimental because they are already implicated in the exhibition. By contrast, it is precisely because the public are 'outsiders' that their participation is, in this account, experimental: 'outsiders' will challenge and expand institutional narratives, 'insiders' won't. The Audience Researcher's distinction between stakeholders and the public groups, as insiders and outsiders, therefore implies a particular account of the *Oramics* experiment, one that differs considerably from Boon's public history account (discussed below).

The Audience Research account of co-creation is of a procedure, or set of procedures, that attempts to represent the diversity of public cultures that are excluded from the Science Museum. The problem that co-creation in the Science Museum addresses, then, derives from the unrepresentative character of the institution and the reduction of museum objects to signifiers of the homogeneous culture of the museum. In this respect, it is an account of the museum that is not dissimilar to that given by the museum studies literature, described above. The formulation of these problems assumes that the cultural offer of the Science Museum is structured by hierarchical relations of domination. In this account of the hierarchical institution, public participation is a project of reforming the entrenched forms of elite domination. The role of evaluation, in this model, is to determine the relative success or failure of public participation experiments; experimentation ends once the contributions are displayed in the gallery. The problem of hierarchy that the Audience Research practices of public participation address are, in potential at least,

⁸⁹ In PUS this lay public is considered a threat to institutions of science and technology, one proposed solution to which is science communication initiatives. See discussion in Chapter Two.

presumed to be solvable by devising the correct procedures for representing the diversity of the public. By contrast, I will suggest in the following section that one way we can understand the contestations between the Audience Researchers and Boon is that where the former seek to devise the correct procedures for representing public diversity which is already known, the latter uses issues to amplify public diversity as a problem.

From procedures to issues

The Audience Researcher's account of co-creation frames the problem of public participation as a question of insiders ("interested stakeholders") and outsiders (the public), and attempts to 'solve' the problem by devising techniques for representing the latter. By contrast, Boon's argument that the evaluation of *Oramics* should consider the groups termed "interested stakeholders" by Audience Research, does not principally formulate the question of public participation in terms of *procedures* but rather in terms of *issues*. The concept of "co-curation" that Boon develops appears unlike the public participation procedures used by Audience Research because, linked to the concern with "public history", it appears more obviously premised on a distinction between issues: between historical and contemporary issues in science and technology. In purely procedural terms, it is easy to understand the Audience Researcher's criticism that Boon's concept is 'nothing new' in the museum sector. However, the public history accounts given by Boon, which I will discuss here, suggest that what makes "co-curating" unique is its emphasis on historical issues. In an oversimplified summary, we can see the difference between these accounts of the *Oramics* experiment as the conflict between an *issue-specific* and *procedural* accounts of public participation. As we saw in the above discussion of Audience Research evaluation, procedural accounts formulate the problem of public participation as a matter of 'insiders' and 'outsiders'. By contrast, the issue-specific approach, I suggest, formulates public participation in terms of different groups' particular relationships to problems or shared concerns in which insiders and outsiders become indistinguishable. I suggest here that one source of the disagreement can be found in Boon's account of public participation which differs from the Audience Researchers' in its emphasis on issues over procedures, suggesting to some extent a dissolution of the problem of insiders and outsiders. However, the contrast between procedural and issue-specific approaches in the accounts of

the Audience Researchers and Boon is not absolute; their accounts are limited in detail and to some extent draw on a similar vocabulary. In particular, I suggest that Boon's "co-curation" account of *Oramics* still appears to apply demarcation criteria to issues in such a way that we find new 'outsiders' appearing.

The specificity of Boon's idea of co-curation to historical issues was suggested in a journal article just prior to the opening of *Oramics*. In the journal's introduction, Boon (2011) describes the relationship between public history and co-curation as a "kinship of two phenomena". He elaborates:

"In broad terms, "public history" can refer to the ways in which lay people pursue historical interests—whether that be family and local history, collecting, consuming historical magazines and television programs, or museum visiting—for fun. Co-curation and similar techniques gathered together under the umbrella of "participation" describe a range of practices in which lay people work to develop displays and programs within museums." (383)

Though Boon makes clear that the concepts of public history and co-curation are related, his account also leaves this relationship relatively under-developed, and this is perhaps one source of the conflict with the Audience Researchers. Public history and co-curation are clearly not concepts that Boon has extensively theorised. Public history is equated with what "lay people" do for "fun"; where the concept perhaps suggests a playfulness in the project, it does little to distance the concept of the public from the "non-specialist" public of the Audience Research account. It is not difficult, for instance, to see how 'what lay people do for fun' quite easily appears simply as the negative correlate of the 'experts who practice serious science'. Moreover, by positioning the concept of co-curation under the "umbrella of participation", Boon's accounts offers little to differentiate co-curation from the other techniques of public participation deployed by the Science Museum. It is thus perhaps easy to see why, in relation to the well developed models of public participation practice used by Audience Research, co-curation would appear to add little to the array of techniques already used by the Science Museum. In purely procedural terms, there appears little to distinguish public history and co-curation from other concepts and techniques of public participation.

The way in which Boon distinguishes “co-curation” from the techniques of the Audience Researchers is in relation to issues in science and technology, specified in an opposition between historical versus contemporary issues. Boon made this case in an introduction to a three-day international conference hosted by the Science Museum in October 2010 titled *Co-curation and the Public History of Science and Technology*⁹⁰:

“Our intention is that we will look back on today as the beginning of a revolution in how we engage our audiences in the history of science, technology and medicine similar in scale to what we achieved in contemporary science. We have always held and curated our collections on behalf of the public. This project is about developing better ways of doing this by working ‘upstream’ with audience groups.”

In this introduction, Boon assumes a clear distinction between the participation of audiences in contemporary science, which he suggests is a very effective practice in the Science Museum, and the participation of audiences in the historical work of the Science Museum. This distinction between contemporary science and the history of science thus allows Boon to suggest the uniqueness of developing the practice of public participation in relation to curatorial concerns which address the history of science. However, by linking participation to a specific set of issues, Boon's account also implies that public participation is not simply a concern with procedures. In this sense, we can see how Boon's claim might be said to conflict with the approaches of the Audience Researchers that describe public participation as a concern with procedures.

In this sense, then, Boon's issue-specific account of “co-curation” evokes a similar emphasis as recent accounts of public participation in science and technology studies (STS). These studies (see for example Callon et al., 2009; Irwin and Michael, 2003; Marres, 2012a) have highlighted the inadequacy of purely procedural versions of participation to account for the political relations between publics and issues. They argue instead that publics are constituted in relation to issues and that participation occurs by virtue of a public being entangled in complex socio-material relations with issues. This issue perspective is also shared by political theory which has suggested publics form a “community of the affected”. The public as the “community of the affected”

⁹⁰ A detailed account of the programme can be found at: <http://ccphworkshop.pbworks.com/w/page/30709922/Detailed%20Programme> (accessed 11th February 2013)

spans a range of different political philosophies has a long history within liberal, republican and materialist accounts of the public (see Marres 2012 for an overview). In this respect, the issue-specific public is not necessarily incompatible with procedural versions of participation. Traditions like classical liberalism have, for example, long formulated 'being affected' as a condition determining who should participate in a particular issue (such as JS Mill's harm principle). However, recent STS accounts depart from these classical procedural formulations of the community of the affected by highlighting the empirical difficulty of distinguishing between those who are inside or outside the community. Unlike insider-outsider formulations of the public (such as those implied in concepts like "interested stakeholders") which attempt to provide solutions to the problems of participation by reforming, extending or inventing new procedures, STS accounts of issue-publics suggest that such clear cut distinctions become blurred when looked at from the perspective of the actors' entanglement in issues (Callon and Rabeharisoa, 2004). Where procedural accounts of participation in issues purport to clearly identify the public, or those who are affected by an issue from those who are not, STS accounts have suggested that the issue-public is necessarily problematic (Marres, 2012). The idea of being "problematic" is in STS accounts not considered negatively as the absence of a solution, but is rather valued positively as a way of 'doing' politics. Problems are positively valued in STS because they are considered sites for the invention of new forms of politics: as Foucault notes (Foucault and Rabinow, 1997; see also discussion in Rabinow, 2002), the creation of problems is also the invention of new relations between actors, discourses and infrastructures. Problematization, for Foucault and the STS accounts following, is a form of politics that therefore goes beyond procedural accounts of political action. Public participation in STS accounts, then, is a mode of problematization in which the problem, or issue, is constitutive of the public: issue-publics are deeply political in this account insofar as they are problematic. From this perspective, the experiment is not simply the procedural means which ends in the exhibition's displays, as it is in the co-creation account of Audience Research. From an STS perspective, then, we might view the curatorial experiment of *Oramics* not as an attempt to 'solve' the problems of hierarchy in the relations between science, culture and the public but rather seeking to amplify this problem experimentally, to dramatise it so that it can be explored.

From the point of view of these studies, we can see why Boon's account of

public participation as issue-specific would problematise accounts, such as those of Audience Research, that assume an a priori procedural distinctions between the public and interested stakeholders. One reason for this is that the issue-specific account problematises the model of the Science Museum that assumes a clear demarcation between insiders and outsiders. In a publication distributed at the launch of *Oramics*, Boon describes participation in *Oramics* in the following way:

“the project has been an exploration of how various groups think about the history of electronic music. Those groups have included at the most knowledgeable end of the spectrum, people such as those at the heart of Electronic Music Studios in the 1960s and 1970s, and the BBC Radiophonic Workshop. We have also worked with the responses of women writers, and young people on an access course at the National Youth Theatre. In between has been an expert group of twelve current day electronic music practitioners and enthusiasts.”

Boon's public history account of participation is notable for not marking the distinction between insiders (or stakeholders) and outsiders in its formulation of all the groups contributing to the *Oramics* as participants in the experiment. The inclusion of all the groups in the experiment in Boon's public history account is qualified by some hierarchical distinctions between the participants. Boon's framing of the hierarchy of the participants' in terms of knowledge “spectrum”⁹¹ appears consistent with the issue-specific approach to participation insofar as it avoids the externalisation of groups that occurs in procedural accounts between expert/lay and stakeholder/public. By framing the participants knowledge in relational terms, rather than absolute terms, Boon's public history account suggests an assumption that the public is defined relationally by historical and social proximity to the issues of *Oramics*, here framed as the history of electronic music. The curatorial experiment appears here not simply as the means through which these groups have been involved in the exhibition, but more obviously the experiment seems to pertain to the very proposition by which this range of groups are related by a common issue. If *Oramics* is, what Boon described to me as, a “multi-viewpoint” exhibition, then the experiment is in establishing the common concern from

91 Boon's focus on knowledge here suggests an account of the experiment which is in many ways unlike the 'cultural' version of *Oramics* I have argued for in this chapter. However, as the broader analysis of Boon's public history account in this chapter and others has argued, what is meant by 'knowledge' is clearly not the conventional cognitive category that is familiar to the Science Museum, since knowledge here pertains to a range of heterogeneous practices and experiences.

which multiple view-points can obtain. In other words, the curatorial experiment, or at least an important part of the experiment, is in the proposition that there is a common issue that unites these diverse groups in some way. In contrast to exclusively procedural accounts of public experiments, Boon's account suggests that it is the "issue-public" of *Oramics* which is itself the curatorial proposition of the exhibition.

But, Boon's account of the groups participating in the exhibition has its limitations as an issue-public. For example, notable exceptions from Boon's public history account are the artist Aura Satz whose video *Oramics: Atlantis Anew* is exhibited in the gallery's cinema, and whose film strips painted in the *Oramics* style are draped over the *Oramics* Machine in the display case, and the film-maker Nick Street's⁹² documentary about the process of making the exhibition. The contributions of both of these participants were paid-for commissions for the exhibition. Where an issue-public would make distinguishing between 'insiders' and 'outsiders' highly problematic, the omission of these participants from Boon's public history account suggests a demarcation criterion about who are and who aren't participants in the *Oramics* experiment. If Boon's public history account describes an issue-public then it also reproduces insiders and outsiders in new ways⁹³. In the case of the omissions of Street and Satz, we might speculate that monetary transaction has some impact on their omission as participants from Boon's account. It might be suggested, for instance, that where money is involved the experimental politics can be economised, or shortcut, allowing the Science Museum to specify the nature of the product to be delivered. Moreover, once we begin to interrogate the demarcation criteria of Boon's account we might find many other participants who are rendered invisible in Boon's public history account. Street and Satz are two highly visible exceptions because they are named contributors to the exhibition, but there might equally well be many others who participate in *Oramics* but who fail to meet the demarcation criteria to be counted as co-curators. In this sense, Boon's co-curation account is limited as an issue-specific discourse of the participants in the *Oramics* experiment. Where issue-specific approaches to participation purport to make

92 Street had previously been involved in documenting the *Oramics* Machine as it was first delivered to the UK to Goldsmiths' Mick Grierson from its previous owner in France. See: <http://vimeo.com/21310959> (accessed 28th August 2013)

93 The chapters in this thesis draw on both Satz's video and Street's documentary in order to make connections between different contributions to the *Oramics* experiment. The inclusion of both Satz and Street's contributions within the *Oramics* experiment is one important point at which the account given in this thesis clearly departs from Boon's public history account; unlike Boon's public history and co-curation accounts, I don't exclude either of these contributions as participating in the *Oramics* experiment.

visible the complex entanglements in which publics form, in this case of Boon's co-curation account it seems that issue-specific discourses of public participation can also render invisible or exclude particular entanglements. Though Boon's public history and co-curation account of participation in *Oramics* appears issue-specific in relation to the Audience Researcher's procedural accounts, it nonetheless does not dissolve the problem of 'insiders' and 'outsiders' in science.

Conclusion

The curatorial experiment of *Oramics* attempts to create ways to facilitate public participation in science. Applying the concept of the “public experiment” to *Oramics* I have attempted to avoid choosing between the different versions of the curatorial experiment we find among staff in the Science Museum. Rather, I have suggested, the concept of the public experiment enables us to examine some of these different versions of the curatorial experiment without evaluating which is a better or more accurate account. By analysing these different versions of the curatorial experiment I have attempted to describe some of the different ways in which public participation becomes significant in the relations between science and culture. Specifically, I've focused here on the contestations between Boon and the Audience Researchers in part because both sides agree that the *Oramics* curatorial experiment is a response to the problems of the hierarchies in the relations between science and culture. Both of their versions of the curatorial experiment present the relations between science, culture and the public as heterogeneous. But, in their disagreement we also see that there are potentially many different ways in which to account for the heterogeneous relations between science, culture and the public. I have characterised the difference between these two positions in terms of their accounts of public participation in *Oramics*: the Audience Researchers' account of co-creation foregrounds *procedures* for representing cultural diversity of the public while Boon's co-curation account attempts to give an *issue-specific* description of the public. These are not absolute differences, and the purpose of comparing them is not to suggest that Boon and the Audience Researcher's accounts fail to capture the true nature of the curatorial experiment. Rather, I have sought to show that even within the curatorial experiment we can find multiple versions of the relations between science, culture and the public, and in this sense the curatorial experiment

does not 'solve' the problems of hierarchy in the Science Museum.

In the analysis of this chapter I've therefore attempted to situate the curatorial experiment in relation to the Science Museum's 'turn to culture'. I've shown that in the Science Museum "culture" has many different meanings that often conflict in practice. I've argued that the cultural turn cannot 'solve' absolutely the problems of public exclusion or the hierarchies between science and culture. The purpose in highlighting the incomplete nature of the turn to culture in the curatorial experiment of *Oramics* is not to suggest that this has somehow 'failed'. The public participation initiatives developed for the *Oramics* exhibition successfully problematise particular approaches to curating science, such as those premised on 'deficit' models of the public. And, in focusing on the disagreement between Boon and the Audience Researchers I am suggesting that we see not just differences but also a series of shared assumptions about the importance of culture in the Science Museum. By looking at the limitations of the cultural turn I have therefore attempted to make clear not only its local challenges and limitations for these actors but also more broadly challenges for the relations between science, culture and the public. These are explored in more detail in the next chapter in which I look at particular problem of exclusion from science.

5. Exclusion: the experimental display and the problem of 'outsiders'

Introduction

As visitors enter the *Oramics* gallery they are confronted with signs alerting them that what they are about to see is of an experimental character. The gallery displays of *Oramics* present us with an account of the invention of electronic music that shuns positivist and nomological explanation of invention, as a single identifiable 'discovery', in favour of a heterogeneous display of some of the many varied musical and technological developments that have taken place between the 1960s and present day. In the *Oramics* gallery displays we find amateur musicians mixing with professional engineers, artefacts from pop music and high art-music in the same cases, technology that has been hacked and repurposed by DIY electronics, sub-cultural styles like acid house and displays about the "co-curators" who include a youth theatre group and a group of "women writers". As I described in the Introductory chapter, for visitors of the Science Museum many of the displays in the *Oramics* gallery might seem equally at home in an art museum; the displays do not seem to draw boundaries that would obviously demarcate science and technology as culturally extraordinary. We might say that the *Oramics* exhibition presents visitors to the Science Museum with a heterogeneous account of the invention of electronic music and in so doing stages the experimental gallery display as an 'inclusive' format.

This chapter presents an analysis of the experimental gallery display via the theme of exclusion. It draws on the analysis of the previous chapter which described how different versions of the problem of public participation in science shaped the experimental curatorial procedures of *Oramics*. In this chapter I extend the analysis of Chapter Four into the gallery displays of *Oramics*. I suggest that like the experimental curatorial procedures, the experimental gallery displays they do not solve the problems of hierarchies and asymmetries in the relations between science and culture. But in the staging of the gallery display we do see some of the key issues around which exclusion from science has been organised, including art, amateur practices

and gender. The question of curating an 'inclusive' exhibition about electronic music history had animated several of the co-curation processes I participated in and observed. In several instances with the musicians, for instance, a question was raised about the extent to which histories of electronic music we curated (for a series of case displays) should 'include' female artists. The (perhaps tacit) consensus in the group, however, seemed to be to avoid turning what seemed like a complex issue into an issue about gender. As one of the musicians noted in an email: "By including things such as the Detroit and early 80s New York scenes this would also fulfil the inclusiveness brief, getting away from the 'white male with a beard' image so closely associated with electronic music". However, in the analysis of this chapter I foreground the exclusion of women in part because throughout my research this appeared as among the most frequently raised issue around which the problems of 'exclusion' emerged, and not least because the gallery displays feature the works of an explicitly gendered group of "women writers". The "women writers" written works feature as aural performances on a film loop in the cinema of *Oramics*. The exclusion of women has, of course, been a central problematic for contemporary science and the staging of the work of the women writers, I suggest in this chapter, provides an interesting insight into the subtleties of this problematic. Specifically, I look at how the experimental gallery displays, though inclusive in their staging, have the unfortunate consequence of producing the women as 'outsiders' to the exhibition in new ways. In doing so, I seek to show how exclusion provides a useful theme around which to analyse the experimental displays of the *Oramics* exhibition.

Such an approach brings some risks: this chapter might be read as an argument that the Science Museum is unable to successfully assemble experimental gallery displays. By contrast, I suggest we can only focus on exclusion in the relations between science and culture because in the heterogeneous displays in *Oramics* we are invited to treat symmetrically the practices of artists and engineers, amateurs and professionals, and pop musicians and trained Western art musicians in appreciating the invention of electronic music. In other words, I suggest that through the problem of exclusion that we are able to better appreciate the experimental public displays we find in the *Oramics* gallery.

The inclusion problem

Scheduled to close in December 2012, after a year and a half after opening in October 2011, the *Oramics* exhibition is extended for a further year. The Oramics Machine's Facebook page publicises the extension of the exhibition:

*“Good news everyone: My exhibition is being extended for all of next year. There'll be a minor facelift in the Spring, but now you get an extended opportunity to come and see me...”*⁹⁴

The “minor facelift” entails the removal of the cinema from the exhibition to make way for a new gallery entrance and cafe in the adjoining space. The cinema included contributions from the women writers and students from the National Youth Theatre (NYT), along with two other films about the Oramics Machine (both of which are discussed in Chapter Six). From the perspective of the Oramics Machine, in its anthropomorphic Facebook form, the removal of the cinema is largely insignificant, it is only “minor”. Indeed, the suggestion of the Facebook publicity is that, as a “facelift”, the removal of the cinema from the gallery will in fact enhance the display of the Oramics Machine; it is after all, according to the Machine, “my exhibition”. In the Machine-centred publicity, the removal of the cinema from the *Oramics* gallery is of little consequence.

The Oramics Machine's “facelift” publicity reflects a view found in other accounts of *Oramics* that suggest the content in the gallery's cinema was particularly difficult to engage with. To many visitors it was not clear what the contributions of the women writers and the NYT students added to the display of the Oramics Machine. In particular, the contributions of the groups of women writers appeared almost incomprehensible to some visitors. One blogger, a sound artist and DJ, bluntly questions the inclusion of the women writers' monologues in the exhibition:

“The museum's curators, in their wisdom, appear to have decided that what is REALLY needed in an exhibition concerning said development of electronic music is in fact not music at all, but a handful of videos largely consisting of a number of plummy youngsters engaged in a 'site-specific dramatization' loosely

⁹⁴ See entry on December 10th 2012 at: <https://www.facebook.com/OramicsMachine> (accessed 28th March 2013)

connected to the subject (though in another room on a different floor, which doesn't strike me as very site-specific at all). There's much histrionic shrieking and lots of 'Am-Dram' prancing, but it completely fails to answer questions or explain anything about the lady or her work. This is then followed by a series of completely spurious monologues apparently produced at workshops focusing on 'sound, invention and oramics', which in layman's terms appears to be a polite way of saying sixth-form poetry, with very little invention and not a shred of Oramics in sight. Seriously, it's teeth-grinding stuff:

What do these things have in common with the work of Daphne Oram or the history of electronic music? Practically nothing, as far as I'm concerned."⁹⁵

To the blogger, the inclusion of the content produced by the women writers and NYT students in the *Oramics* exhibition is a poor curatorial decision. The blogger's critique is scathing: the monologues, and to a lesser extent the performance, have practically nothing to do with Daphne Oram, the Oramics Machine or the invention of electronic music. There is at best a 'loose' connection between the NYT students performance and these concerns, whereas in the women writer's monologues there is "not a shred of Oramics in sight". The title of the blog 'Righting a Radiophonic Wrong' makes clear the interests of the blogger, as a sound artist and DJ, and the perspective from which the NYT students and women writers appear as 'outsiders' in the exhibition.

In relation to the cinema content a division appears between the different modes of experiment in *Oramics*⁹⁶. From the perspective of the blogger, the performance and monologues fail to engage with the issues of *Oramics* and reflects an arbitrary curatorial decision to include these groups. On the basis of the performance and monologues displayed, it is clear to the blogger that the inclusion of the work of the NYT students and the women writers has nothing to do with the invention of electronic music but was rather related to concerns about curating science and technology. Here, a divide appears between the curatorial experiment and the experimental gallery display: the blogger invites

95 See: <http://robinthefog.com/2012/01/15/righting-a-radiophonic-wrong/> (accessed 4th March 2013)

96 It is notable that the blogger's critique is not simply a quality judgement about the 'bad' cinema content, although this is clearly an important part of the blog post, but rather is a critique that foregrounds the question of 'inclusion' as a decision made by the Science Museum's curators.

us to purify the experimental exhibition into discreet concerns of curating and display. For the blogger, the experiment is simply a parochial curatorial concern that involves the women writers and NYT students and hence appears divorced from the concerns of the invention of electronic music. In this account, the gallery displays of *Oramics* appear to produce new demarcations and divisions between the modes of experiment.

The Museum's Audience Research evaluation of *Oramics* (discussed in Chapter Four), which analyses the responses of different visitors to the exhibition, also reported the general difficulty visitors had engaging with the content in the cinema. The evaluation's executive summary notes:

“The cinema space which delivered a number of the co-creative outputs [the women writers' monologues and the NYT students' performance] was confusing and little engaged with by the visitors who felt it lacked a clear context and framework within which they could make sense of the content.”

To visitors surveyed by the Audience Researchers, then, the cinema displays of the women writers monologues and the NYT students performance lacked a “context and framework” with which to engage. The difficulty visitors have making sense of the cinema content is, according to the Audience Researchers, a failure in the staging of the content contributed by the women writers and NYT students. Unable to understand the context within which the women writers' and NYT students' contributions “make sense”, these groups appear to visitors as separated from the other displays of *Oramics*. In the Audience Researchers' evaluation, there is nothing intrinsically wrong with the women writers or NYT students contributions. Rather, the appearance of these groups as the outsiders in the exhibition is an effect of their staging in the gallery which fails to adequately contextualise and frame them.

The Audience Researcher's evaluation further confirms the blogger's observations that it is the women writers' monologues in particular that appeared disconnected from concerns about the invention of electronic music. The evaluation notes:

“The monologues were particularly confusing for the visitors. They

were not aware that these were produced by a group of women writers and that they were a response to the Oramics machine and the themes being put forward in the gallery – knowing this, they claimed, would have allowed them to engage properly rather than trying to make connections and links that weren't there."

The analysis suggests that visitors were forced to invent connections and links between the monologues and the other displays that in fact "weren't there" because they were a "response". As a "response", the monologues operate at one remove from the object, simply interpreting and representing the exhibition's concerns rather than engaging and intervening in them. The evaluation's classification of the women writers' monologues as a "response" can be seen as consistent with the distinction made by the Audience Researchers between "interested stakeholders" and the excluded public, of which the women writers comprise the latter.

Other sources of publicity for the *Oramics* exhibition further complicate the staging of the women writers' work. Unlike the NYT performers, the women writers do not feature anywhere on the Oramics Machine Facebook page through which the exhibition is publicised: from the perspective of the Machine the women writers are largely insignificant. Elsewhere on the exhibition's webpage⁹⁷ the women writers are excluded from those groups that "co-produced"⁹⁸ the exhibition and instead their contributions are simply listed as a statement of fact at the bottom of the page, lacking any justification for their inclusion. Surveying some of the many sources publicising *Oramics* leaves us with a highly ambiguous staging of the women writers works.

What follows is an attempt to understand why the staging of the women writers works appear so problematic in an experimental display which is presents us with an 'inclusive' account of the invention of electronic music. One reason, I suggest in the analysis that follows, is that the relations between objectivity and subjectivity are deeply asymmetrical in a setting like the Science Museum.

97 The exhibition's webpage states: "This exhibition has been co-produced with a group of musicians and with the help of people who made electronic music in the 1960s". It can be found at: www.sciencemuseum.org.uk/oramics (accessed 13 March 2013)

98 The use of the term "co-production" on the website is interesting since it is not found in any of the other discussions of *Oramics*. Co-production differs from both "co-curation" and "co-creation" which, the analysis of Chapter Four argued, are terms that pertain to particular orientations in the Science Museum to museology. In *Science and Technology Studies* it is a term that is used in science and technology studies to describe the production of knowledge as mutually implicated in social and scientific practices (see for example Jasanoff, 2004).

Exhibitions in the Science Museum are necessarily an object-centred. And, though the experimental displays in *Oramics* clearly show that object-centred exhibitions do not necessarily exclude the concerns of subjectivity, they nonetheless do not stage subjectivity in and for itself. The monologues of the women writers, I suggest, appear problematic because they appear to stage displays of subjectivity without object.

The argument made in this chapter is structured in two broad sections. In the first, I contextualise the problematic staging of the women writers' works as a problem of gender and subjectivity in science. In the second section, I look at how the experimental gallery display of the *Oramics* exhibition includes subjectivity, but how this experimental staging produces new asymmetries between objectivity and subjectivity. In this first section, I look at the particular problem of subjectivity in science and why subjectivity 'in-itself' is problematic for a science exhibition. I survey feminist and cultural studies that locate such asymmetries between objectivity and subjectivity in science within a broader gender politics of androcentrism. I show how from this perspective the women writers' monologue contributions might appear as 'feminine'; that is, as symptomatic of everything that an androcentric science is not e.g. subjective, partial, situated and so on. I then look at how the experimental gallery displays of *Oramics* unsettle many of the asymmetries implied in androcentric accounts of science and technology, not least in the displays of Daphne Oram and the *Oramics* Machine. In the second part of the argument, I examine the question of 'inclusion' in science via some feminist debates: specifically, those between standpoint feminism and "post-gender" feminism. Subverting traditional gender asymmetries, "post-gender" critiques of science provide one lens through which to appreciate the experimental displays of *Oramics* as 'inclusive'. However, I also show how the post-gender interpretation of the *Oramics* gallery displays also has the paradoxical consequence of excluding the women writers, as a gendered group. I argue that the problematic staging of the women writers works in *Oramics* points to some of the ways in which experimental display can reproduce androcentric asymmetries. I close with a discussion of the possibility of 'inclusion' in science through feminist literatures.

The women writers and the problem of subjectivity in science

The group identity of the women writers is unique within the groups participating in the exhibition both because it is the only gendered group in the exhibition and because it is a group comprised of anonymous individuals. Each member of the group women writers has contributed a monologue, all of which are screened in the gallery's cinema, interspersed between a range of short films that play on a repeating loop. The monologues are performed by unnamed actors and only the first name of each writer is shown (e.g. Corinna). Nothing is displayed about their prior writing, backgrounds or interests of the individual writers. The women writers stand out from the other groups on display in *Oramics* because they are gendered, anonymous⁹⁹ and individuated.

Unlike the other groups participating in *Oramics* I was unable to observe the workshops in which the women writers created the monologues. I was told by various Museum staff involved that the women writers were a vulnerable group and that the workshops would be women-only environments run by an external agency. In the very terms of their involvement the women writers a divide was constructed between the group and the Science Museum. It was not only myself who was excluded from the engagement with the women writers but also the Museum's male staff involved in *Oramics*. The vulnerability of the group was here constructed in relation to men but also in relation to the Science Museum as an institution of science and technology. During the workshops the women writers themselves were not, in the first instance, told that the workshops were a collaboration with the Science Museum. In an interview one of the Science Museum's associates who facilitated the workshops with the writers, described to me the dilemma of when to tell the writers that their writings were being developed for an exhibition at the Museum. The vulnerability of the group of women writers here was clearly constructed in relation to both masculinity and to science and technology. The safe space of the workshops, in which the gendered vulnerable group could be realised as writers, is defined here principally as the absence of men and science and technology. The gendered vulnerability of the group is, in this sense, a relational construct which in its formulation, and in the displays of *Oramics*, enacts a particular relation between the group and the Science Museum.

⁹⁹ It could be argued that the NYT students are also largely anonymous. However, this is quite a different form anonymity: the students are visible in the performance and images of them in workshops appears on the *Oramics Machine's* Facebook page. Unlike the women writers, the NYT students may not be named or individuated.

The monologue format through which the women writers participate in *Oramics* dramatises the individual member's subjectivity. The monologue is most commonly a dramatic form through which the inner experience, the subjectivity, of a character is externalised for an audience, and the monologues contributed by the women writers by and large conform to the conventions of the format. In dramatic settings the monologue is a technique for staging entirely individualised forms of expression. Through a monologue, the individual disentangles themselves from the other characters and dramatic situation to articulate something that is otherwise unable to be voiced in the interactive setting of performance. The use of the authors' first names as the credit for each monologue enables members of the group of women writers to participate in *Oramics* preserving the anonymity of the women writers while also acting as a marker for the individuation and subjective expression of each of the group's members. Whether or not the monologues in fact reflect the individual writer's own subjective experiences is irrelevant because in their display in *Oramics* the monologues are staged as vehicles for personal expression. This personalisation of the anonymous participants of the group through their contributions makes them unlike the other participants in the exhibition. Where the contributions of the other groups tend to emphasise the collective identity of the group and downplay the individuality of their members¹⁰⁰, the women writers' contributions are intended to distinguish the individuals from the collective identity which is gendered and anonymous. The staging of the women writers as a group of gendered individuals is therefore not simply innate to the group but at least in part an effect of the group's relation to the other groups in the *Oramics* display.

As a technology for the presentation of personal experience, the monologue is a format that is very different to conventional presentations of subjectivity in the Science Museum. In science, personal expression is often conceived negatively as an absence of objectivity. By contrast, displays of subjectivity in science exhibitions usually hold a necessary relation to objectivity. Asymmetries between objectivity and subjectivity are apparent from the moment visitors enter the Science Museum where an exhibition titled *James Watt and Our World* is located on the Museum's main entrance concourse directly below the *Oramics* gallery. Subtitled "the workshop, the man and the

¹⁰⁰I am not claiming here that individuals from other groups do not appear in the exhibition, because they do. For instance, there are interviews with the electronic musicians and the case displays of the BBC's Radiophonic Workshop and Electronic Music Studios Ltd include quotations from individual members. However, in these instances, the focus of the displays is on the collectivity rather than the individual members.

new industrial age” this exhibition shows Watt in his workshop which is positioned next to a number of enormous steam engines, including the most famous Boulton-Watt engine, that are specifically designed to demonstrate Watt's engineering principles. The image publicising the *James Watt...* exhibition which is simply a bust of Watt's head against a black background; the bust making clear the importance of “the man”. *James Watt and Our World* in many ways appears the paradigmatic modern science exhibition. Science and technology can be seen enacted in entirely different frames and at different scales: a small and simple idea made by a lone man in the workshop has a practical technological application which revolutionises ... *Our World*. In this display, James Watt, “the man”, could be seen as an ideas man made heroic through technological application. Though many other exhibitions in the Science Museum foreground men, these exhibitions do not stage gender in any significant sense. And indeed, in the gallery displays of *James Watt and Our World* Watt's gender is not a significant factor in the presentation of his engineering principles. Though Watt is gendered in the publicity, the gallery displays, like most other Science Museum exhibitions foregrounding men, suggest that gender is not an important factor in accounting for Watt's accomplishments. And indeed, the display of Watt's subjectivity is also like the displays of male subjectivity in other exhibitions in the Science Museum insofar as the significance of subjectivity derives from a necessary relation with an object. Watt's thoughts are presented as significant in their relation to the steam engines in the gallery displays. In science exhibitions, subjectivity is conventionally exhibited in object-centred formats of display; subjectivity for-itself is not part of the world of the Science Museum that visitors enter.

From the perspective of science exhibitions like *James Watt and Our World*, it is easy to see why the women writers monologues would appear as displays of subjectivity liberated from the concerns of objectivity; as simply accounts of personal experience with no bearing on the objective concerns of science. The monologues' focus on personal experience is well illustrated in one called *I'm free, I'm free, I'm free* by a member of the group named Corinna. The first half of Corinna's monologue is quoted here:

“The calmness of nature on this beautiful land. Feeling safe, secure, loved and adored.

Mentalness, mentalness, you CAN'T catch me! I'm free of your shackles, suffering and darkness.

*I thought I was mad, I thought I was crazy, but ... it was always you.
You who forced me into a relationship with the black dog, seeking
solace for too long with that enemy.*

*Married to you, married too long. But, now you are gone you can't
hurt me any more. I feel. I live. I'm adored and I love. No more time
shall I waste being used and abused, trodden down till I know not
who I am.*

*Peace and serenity wrap me in your arms, I'm free, I'm free, I'm
free."*

The monologue is, as its title "I'm free, I'm free, I'm free" makes clear, a work about individual freedom. The protagonist of the monologue, the text suggests, has been liberated from a traumatic and abusive marriage. Personal freedom is here presented in relational form, as self-realisation free from the domination of another person: "I'm free of your shackles, suffering and darkness". Madness is a key theme in the narrative and is again relational in character: "I thought I was crazy but ... it was always you". With the end of the relationship that dominated her and made her appear mad, the protagonist is free. Corinna's monologue is a deeply personal account of a woman who is liberated from an abusive relationship. In many senses, the domination described in the monologue serves as a reminder of the asymmetric distribution of the capacity for action; the agency to act is attributed principally to the male actor who dominates the woman. It echoes feminist critiques about the invisibility of gender in conventional accounts of political action and thus the importance of the feminist demands for symmetry, embodied in slogans such as "the personal is political". In the *Oramics* exhibition, the monologue appears an important statement of forms of subjectivity that have typically been excluded in object-centric science exhibitions.

It is in this respect that we can understand why the staging of the women writers' work might appear problematic to visitors of the Science Museum. In relation to object-centred displays of science, the women writers' monologues might appear 'merely subjective'. However, in an inclusive display of *Oramics* we might expect that the displays of the women writers' monologues of personal experiences would demonstratively connect or create relations with other displays in the exhibition. Indeed, reviews such as the blogger's, discussed above, paradoxically provide some of the connections which might justify their inclusion. For example, though the blogger suggests that he fails to

comprehend how the group's monologues could in any way connect with the “common” concerns of the *Oramics* exhibition, the criticism also makes connections that are not apparent in the gallery displays:

“It’s impossible to work out how a...few disembodied voices speaking of their attempts to avoid ‘MENTALNESS’ relate in any way to Daphne Oram’s life of strange audio adventures beneath the respectable facade of a converted Oast House in Kent.”

There is a paradoxical dualism to the blogger's observations. On the one hand, the blogger argues there is no relation between the women writer's monologues and Daphne Oram's work. However, on the other hand, the blogger also seems to provide a clear link between women writers' monologues Daphne Oram's own subjective experience that would plausibly justify the former's inclusion in the exhibition. This connection between the women writers and Oram, which the blogger suggests isn't a connection, is constructed on the basis of the common experience of both as gendered subjectivities. Though the blogger argues that he fails to find the relation between the women writers monologues Daphne Oram's life, he nonetheless implies a plausible relation based on the lived experience of gender. The blogger's connection with the domestic space of Oram's Oast House here is in this respect particularly significant; domestic space being highly significant in traditional constructions of femininity. However, though the blogger appears to suggest a relation between Oram and the women writers on the basis of common gendered experience, he nonetheless rejects this relation as irrelevant.

Gender and the invisible culture of science

Where visitors to the *Oramics* gallery struggle to perceive a relation between the women writers and Oram on the basis of gender, for other participants gender clearly appeared an important lens through which to understand the significance of Daphne Oram. In the National Youth Theatre students' “site specific” performance, which took place before the opening of *Oramics*, one important theme that recurred throughout the performance was the idea of “female pioneers”. The first appearance of the female pioneer in the

performance was the pilot Amy Johnson with the focus shifting later to Daphne Oram. Performed in the Science Museum's *Flight* gallery, the performers pointed out that one of the two planes suspended from the ceiling of the gallery was the first used by Johnson to fly solo from Britain to Australia. Next to the plane is a large wall display detailing Johnson's achievement. In the Science Museum, Johnson's achievement of solo flight is exceptional because it is a gendered achievement; other people, men, had already made the solo flight before Johnson but their gender is not a significant part of the display. In the NYT performance, Johnson and Oram are made comparable on the basis of their gender as "female pioneers". In the NYT students' performance, Oram's gender is foregrounded as significant and comparable with other displays of women in the Science Museum.

The NYT students' highlighting of the significance of Oram's gender in the setting of the Science Museum reflects an asymmetry that is commonly found in science exhibitions. Feminist studies of science exhibitions have shown how gender is an asymmetric category that gets applied to women but not to men (Haraway, 1984). Science exhibitions about women tend to emphasise their exceptionalism in science, marking them by their gender. The gender of men, by contrast, is rarely, if ever, a significant factor of museum displays; in science museums, masculinity is largely invisible¹⁰¹. In this respect, gendered displays in science museums can be seen to reflect the broader asymmetries in scientific and technology. Cultural studies of science have widely noted what Traweek (1992) coined as the "culture of no culture" of science, and similarly the invisibility of masculinity in the displays of science museums can be seen in this way as the gender of an ungendered science. Traweek's study of the culture of high energy physics showed that the ways in which the practices of physicists were gendered – such as in the division of labour in laboratories – they did not appear as such in the physicists own accounts of their practices. Elsewhere, Wajcman (1991) highlights that while technology is often presented

¹⁰¹The James Watt exhibition is one an exception insofar as it raises Watt's gender. However in the exhibition itself gender is not presented as in anyway a significant or determining factor in Watt's scientific and technological achievements. In most other respects, *James Watt and Our World* is an exhibition that conforms to the asymmetries of gender in scientific culture. Another exhibition that was notable for its foregrounding of gender issues during the period of research was called *Codebreaker* and was about the life of Alan Turing, the mathematician who broke the Enigma code during the second world war. The was exhibition was noted for its treatment of Turing's sexuality, featuring, for example, displays about his boyhood relationship with Christopher Morcum, and since its staging a posthumous pardon was granted for his conviction under anti-homosexuality legislation. However, a more critical account of the exhibition might argue that the focus on Turing's sexuality is a minor part of what is otherwise a relatively uncritical celebration of another heroic male scientist in the Science Museum. The explicit presentation of gender issues does not necessarily subvert the broader gendered asymmetries in scientific culture.

as “socially neutral” its social organisation and structuring reflects gender inequalities and forms of patriarchy. In Wajcman's analysis, there is nothing inevitable about the construction of technology as masculine, however its presentation as socially neutral serves to render invisible the gender politics of masculine dominance inscribed in technology. Indeed, feminist analysis of technical systems of organisation, variously described by Lucy Suchmann (1995) and Susan Leigh Star (for instance, Star and Strauss, 1999), have highlighted the ways in which the forms of technical work that has typically been done by women is made “invisible” and “silenced”. The marking of women as exceptional is the effect of an implicit androcentric structuring of science and technology. In this respect, the gendering of Oram in the “site specific” performance of the NYT students can be seen to reflect Oram's exceptionalism in the Science Museum.

It is perhaps unsurprising that feminist accounts of science, which are principally concerned with issues of gender, have tended to also be cultural studies. Haraway (1997) highlights how the invisibility of masculinity is fundamental to the 20th century culture of science. Paradigmatic, in Haraway's account, is the “modest witness”, a figure who is integral to the founding of modern science. The modest witness is the man present at the public demonstration, whose presence and testimony gives the experimental fact being demonstrated the virtual mobility to detach from the conditions of its production (see also Shapin and Schaffer, 1985). The figure of the witness is modest precisely because he participates in the project of making himself invisible and is thus a figure through which the invisibility of techno-scientific culture was written as masculine. Masculinity and femininity correspond, in Haraway's account, to respective regimes of the invisible and visible in science. These asymmetries in gender and science are further elaborated in Harding's (1986) *The Science Question in Feminism* in which the author describes the “androcentrism” in science's gender symbolism, gender structure (division of labour), and in its construction of individual gender. The masculinity of science is also addressed historically by Fox Keller (1985) who gives an account of the mutual construction of the categories of gender and science. Fox Keller argues that the asymmetries of scientific culture arise from an historic conjunction between science and masculinity and an historic disjunction between science and femininity. Gendered presentations of Daphne Oram in the Science Museum, such as in the NYT students performance, in many respects reflect the feminist accounts of the asymmetric

culture of science.

And yet, in other accounts of Daphne Oram such asymmetries in science are unsettled. We can see this, for example in the publicity for the *Oramics* exhibition. Two months prior to the opening of the exhibition the Guardian Women's Blog runs a story called 'Daphne Oram: An Unlikely Techno Pioneer'¹⁰². The Women's Blog is concerned with contemporary women's issues and is hosted on the website of the left-leaning British newspaper the Guardian. The post about Oram is in part the result of the Science Museum's public relations drive to promote the exhibition in the months leading up to its official opening. The *Oramics* exhibition's appeal to a female audience is clearly an important publicity angle. As the title of the blog post suggests, the trope through which the exhibition is publicised to women is the seeming implausibility that someone like Daphne Oram could be the founder of contemporary forms of electronic music. But why is Oram's status as a pioneer of techno so "unlikely"? If Oram's gender is removed as a consideration, it seems, in fact, relatively plausible that a person who builds an early synthesiser would have influenced those who produce its contemporary forms, e.g. "techno", in the present day. The blog post elaborates its "unlikely" claim:

"Next to a pile of transistors and exposed metal, a woman with a pinroll hairdo tilts her head to one side and offers the camera a tight, prim smile. This is Daphne Oram, who, according to Science Museum curator Tim Boon, looked "like Margaret Thatcher . . . with a cut-glass accent", but helped lay the foundation for techno music."

The opening lines of the blog post, quoted, make clear that Oram's gender is hugely significant to the claim that she is an "unlikely pioneer of techno". Oram's gender and class are specified through her appearance as pertaining to a particularly conservative mid-twentieth century image of femininity. This conservative femininity of Oram's appearance makes for a stark contrast with the radical "pioneering" nature of her work, symbolised by the disorganised and rustic image of the *Oramics* Machine. The deliberate precision of Daphne Oram's feminine aesthetics – the "prim hairdo" – is juxtaposed with crude technological materials – the "pile of transistors and exposed metal" – from which the *Oramics* Machine is comprised. Oram's conservative feminine appearance is reinforced by the quote from the Science Museum's Tim Boon:

¹⁰²See: <http://www.guardian.co.uk/lifeandstyle/the-womens-blog-with-jane-martinson/2011/aug/07/daphne-oram-oramics-electronic-music> (accessed 22 March 2013)

Oram looks like Britain's first female prime minister “Margaret Thatcher”. The comparison with Thatcher implicitly suggests that Oram's gender and class are legitimate comparative factors for contextualising the significance of her work e.g. Oram's place in the history of electronic music as potentially comparable with Thatcher's in the history of British politics. Both Oram and Thatcher were female pioneers in worlds dominated by men. However, the comparison with “Thatcher” is not naïve, it is not simply a comparison of two pioneering women, but is – particularly in the context of a left-leaning blog – deliberately ironic. The comparison between Oram and Thatcher makes an implicit cultural juxtaposition between the latter's political conservatism and the artistic radicalism of the former. This contrast is intensified in the blog post's positioning of Oram as the founder of “techno”, not only a music genre that takes its name from the aesthetic of technology but also a genre most commonly associated in Britain with youth sub-cultures and to the late 1980s rave culture which the Conservative government attempted to shut down by legislating against it. In short, Oram's conservative feminine appearance provides an important symbolic register which the *Oramics* exhibition deliberately subverts. By gendering Oram in this particular way the *Oramics* Machine is staged in *Oramics* as a radical and innovative invention, both technologically – through the aesthetic contrast of the conservative woman and the radical technology – and artistically – by subverting the conservatism of Oram's appearance, associating it to the radicalism of contemporary electronic music's sub-cultures. Oram is only an “unlikely pioneer of techno” to the extent that her gendered appearance symbolically conflicts with the aesthetics of being both a technological pioneer and an artistic radical.

The gendered staging of Oram in such publicity for *Oramics* is heavily ironic, subverting the asymmetries of science. The “unlikely” claim that Daphne Oram is the founder of techno is premised on gender and cultural symbolism that is deliberately subverted e.g. Oram's conservative appearance is simply a means to highlight radicalism of her work. This ironic use of gender and cultural symbolism in the blog post is a resource for the left-leaning Guardian Women's Blog to highlight Oram's radicalism technologically, artistically, and, perhaps latently, politically. In other words, there is in fact little that is “unlikely” about the claim that Oram is a pioneer of techno, or at least this claim is no more unlikely than any other claim about Oram's influencing other contemporary forms of electronic music, but this particular staging of Oram as the 'godmother' of techno is a particularly effective way to subvert the symbolic

registers of gender in culture. In this sense, the common ironies in both Boon and the Guardian Women's Blog's treatment of Oram's gender can, I suggest, be seen to reflect broader changes in the cultural associations within which femininity, technology and art are enacted. It is only "unlikely" that Oram was the pioneer of techno from the perspective of an androcentric view of technology.

It is not only in the Guardian Women's Blog's staging of Oram, as a feminine technologist, that *Oramics* unsettles gendered asymmetries. The presentation of electronic and experimental music in *Oramics* also indirectly unsettles cultural asymmetries through which gender is constructed. Specifically, *Oramics* is an exhibition that appears to thrive on transgressing notions of domesticity; the domestic being a space which is highly determined in gendered divisions of labour and gender symbolism (see on this Harding, 1986; and Wajcman, 1991). In the gendered division of labour, femininity is conventionally allied with domesticity; the home being a place of mundane action and consumption or reproduction, as opposed to production which is constitutively masculine. We find this gendered version of domesticity in Science Museum displays such as the 1990s exhibition *The Secret Life of the Home* in which mundane domestic space is made interesting by virtue of its "secret" technological ontology beneath the surface of the appliances used for the execution of banal housework tasks. In contrast, the *Oramics* exhibition presents the domestic as a necessary space for innovation, for the invention of electronic music. A "do-it-yourself" trope characterises the exhibition's narrative about the invention of electronic music. Electronic music composers, the exhibition tells visitors, worked "with whatever came to hand" and included explicitly domestic items such as "kitchen gadgets". In this narrative the self-reliance and craft of electronic musicians could be said to be cognates of economisation and more obviously attributes of domesticity¹⁰³ than qualities, such as leadership and professionalism, that are more readily associated to professional science and technology. In other words, in these displays about the invention of electronic music the domestic is staged as a sphere of technical innovation. Oram's development of a high-tech electronic music studio in an old "oast house" perfectly complements this symbolic subversion. What once was the location of an historic craft – oast houses being the places where the hops used to make beer were dried out – was repurposed by Oram as both a place to live and a space for musical experimentation and the

¹⁰³The link between economic matters and household life being a very ancient one that was central, for example, to Aristotelian ideas about politics (see discussion in Arendt, 1958).

technological development of the Oramics Machine. Moreover, the subversion of this domestic trope extends to the display of the Oramics Machine itself. The Oramics Machine is very literally 'home made'. The gallery's Computer Information Point (CIP), for example, describes Oram's brother John playing a "vital" role in the Machine's early construction. Moreover, a sign next to the Machine's wave-scanners notes that these are contained within an old "commode"¹⁰⁴ - a piece of furniture which served as convenient domestic storage is, in this display, the necessary container of the sound producing components of the Oramics Machine. The power of the symbolic tropes of domesticity within the exhibition's narratives of the invention of electronic music rest on subverting the tacit assumptions of the gendered division of labour in which the domestic stands in opposition to science and technology, household life is opposed to productive work. Just as the ironic publicity of Oram as a feminine technologist directly unsettles gender asymmetries, so too the broader categories through which gender is indirectly constituted, such as domestic space, are also transgressed in the displays of electronic and experimental music in *Oramics*.

***Oramics* as cyborg display**

The ironic staging of gender is one of the ways in which the *Oramics* experiment unsettles other asymmetries associated with androcentric objectivity in science. On the wall behind the display of the Oramics Machine is an image of Wendy Carlos sitting in front of an enormous early Moog synthesiser. Wendy Carlos is famous in electronic music for her 1968 album called *Switched-on Bach*, reproducing Bach's contrapuntal music on the monophonic Moog synthesiser, as the first classical record ever to achieve Platinum record sales. Wendy Carlos is also famous for changing her gender, having been born a man, Walter Carlos. The image of Wendy Carlos embodies well many of the cultural mixtures we find in the displays of *Oramics*: classical and pop music become hybrid in electronic music and gender positions are unsettled (see discussion in Pinch and Trocco, 2004). In the gallery displays we see other examples of this unsettling of asymmetric cultural categories of science and technology. We saw this for example in Chapter One's discussion

¹⁰⁴Boon tells me that shortly after the exhibition opened a visitor wrote to correct the Museum that this was in fact not a "commode" but rather the container of an old HMV record player. Though this fact does not undermine the cabinet's domestic connotations, it is interesting that the Museum left the sign with the word "commode" in the case display of the Oramics Machine long after the error had been noted.

of the staging of the Oramics Machine as a “boundary object”¹⁰⁵. The Oramics Machine appears a very different kind of object from the closed objects of galleries such as *James Watt and Our World* where objects univocally represent single ideas, principles or models. In *Oramics* the Oramics Machine, I argued in Chapter One, is staged as an object which is “multivalent” and which “co-articulates” many different registers which would normally be excluded from exhibitions of science and technology. Indeed, it is not only the Oramics Machine that is staged in this way but also other displays in *Oramics* that unsettle many of the other asymmetries such as high/low culture, science/art, which would normally be correlated with masculinity/femininity. Elsewhere in the gallery images, pop stars like the Pet Shop Boys sit alongside those of art-music composers like Karlheinz Stockhausen. In the case themed “sonic frontiers”, the pop star Bjork's latest app-album *Biophilia*, an album which is generated by users' interaction with mass-produced touch-screen technology like smart phones and tablets, shares a case with the Triadix Muse, a high-tech and limited edition algorithmic music generator built in the 1970s by digital physicists at MIT. Elsewhere, a case display themed “make do and mend”, shows a children's Speak & Spell toy that has been circuit bent into a noise instrument by a member of the group of electronic musicians (participating in the public history project); a display of contemporary amateur, DIY, sub-culture, it contrasts strongly with the professionally produced, historic synthesisers on display in the Electronic Music Workshop and BBC Radiophonic Workshop cases. The unsettling of androcentric asymmetries in *Oramics* is also enacted more broadly in the exhibition's displays that mix together categories correlated with the asymmetric object/subject ontology of science.

One way to describe the kind of inclusive displays found in *Oramics* is in the vocabulary of cybernetics. Cybernetics is a reference that holds particular significance in *Oramics*. One obvious reference to cybernetics is found in the work of Peter Zinovieff from the Electronic Music Studio who was one of the participants in the 1968 *Cybernetic Serendipity* exhibition. Held at the Institute of Contemporary Arts in London, *Cybernetic Serendipity* was an exhibition that brought together a range of contemporary artists and scientists and featured luminaries such as John Cage. In the catalogue to *Cybernetic Serendipity*, the

105 Star and Griesemer (1989) describe boundary objects as: “abstract or concrete. Boundary objects have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable” (393). It is notable that the concept of the boundary object was developed in relation to Star's studies of gender politics of science and technology (Star, 2010).

exhibition's curator Jasia Reichardt described its aims in the following way:

“The aim is to present an area of activity which manifests artists' involvement with science, and scientists' involvement with the arts; also to show the links between the random systems employed by artists, composers and poets, and those involved with the making and use of cybernetic devices” (Reichardt, 1968: 5)

Reichardt's description of the aims of *Cybernetic Serendipity* suggests a “systems”¹⁰⁶ perspective on the exhibition's staging of interactions between science and art (for broader significance, see discussion of cybernetics in Turner, 2008). The mixing of science and art in *Cybernetic Serendipity* bears comparison with the premise of *Oramics*. In Chapter One, I argued that *Oramics* appeared as an experiment in what Born and Barry (2010) described as “art-science”; a hybrid field in which scientific and artistic objects, practices, and ideas mix together with the aim of producing novelty which is reducible to neither art nor science. In *Oramics* the mixing of science and art is one of the ways in which experiments with new forms of interactivity between science and the public is accomplished. The link between cybernetics and experimental interactivity is highlighted by Barry (1998) who notes that one important accomplishment of *Cybernetic Serendipity*, and cybernetics more generally, was to complicate the hierarchical and asymmetric accounts of interactivity in science that accorded the capacity for interaction exclusively to humans, and rendered non-humans as inert. In Barry's account, cybernetics is one approach which offers a potential symmetry in the treatment of interactivity between humans and non-humans. In an historical account of British cybernetics, Pickering (2010) argues that the symmetrical treatment of the capacities of humans and non-humans by cybernetics constituted a critique of the ontology of modern science. Pickering argues that cybernetics replaced modern science's ontology of knowing and control with an ontology which, in transgressing the asymmetric object/subject divide of modern science, was performatively democratic (what Pickering describes as a “nonmodern” ontology)¹⁰⁷. What I suggest here is that the cybernetic emphasis on mixing,

¹⁰⁶One of the legacies of cybernetics is the development of “systems theory” which in the social sciences is most closely associated with the work of Niklas Luhmann (see, for example, Luhmann, 1989).

¹⁰⁷I have here principally considered recent social studies of cybernetics, as opposed to the texts from which the terms originates, because I'm principally interested in the contemporary translation of cybernetics as a culturally significant phenomenon. It is worth noting that though cybernetics in this literature is widely presented as a symmetrical approach to techno-science, that historically this was not necessarily the principal aim that informed the development of cybernetics. Indeed, as a historical event cybernetics is quite culturally asymmetric in many ways as, Pickering's study of British male cyberneticians

found in the experimental art-science of *Cybernetic Serendipity*, offers one framework within which to understand the significance of the way in which gender is staged, or isn't staged, in *Oramics*.

Significantly, the influence of cybernetics has been translated into feminist approaches to gender politics. Haraway's (1994) *Cyborg Manifesto: Science, Technology and Socialist-Feminism for the late 20th Century*¹⁰⁸ is highly significant for its invention of the "post-gender" figure of the "cyborg" that has been crucial in the way that the social sciences and humanities have reappraised the relations between science and culture. Haraway describes the cyborg as a "cybernetic organism, a hybrid of machine and organism" (117) and argues that cyborgs are everywhere and everyone is a cyborg: "the cyborg is our ontology" (118). For Haraway, the cyborg is a critique of the ontology shared by both politics and epistemology in feminist thought. Haraway argues that an essentialised construct of "women" has been at the centre of feminist politics and epistemology. By focusing on one half of the male/female dichotomy, Haraway argues, feminist politics and epistemology has relied on a binary ontology of gender that essentialises the category of women. Haraway's cyborg is a critique of this essentialising of gender difference which limits feminist politics to an oppositional stance to male-domination and feminist epistemology to policing the construction of "women's experience". In contrast, the cyborg is Haraway's attempt to develop a new basis for feminist politics and epistemology. In polluting the purity of gender categories, Haraway's cyborg also collapses the ontological foundations of other related asymmetries between organism and machine, nature and culture, materialism and idealism etc. Haraway describes the cyborg ontology in the following way:

"The cyborg is resolutely committed to partiality, irony, intimacy, and perversity. It is oppositional, utopian, and completely without innocence. No longer structured by the polarity of public and private, the cyborg defines a technological polis based partly on a revolution of social relations in the oikos, the household. Nature and culture are reworked; the one can no longer be the resource for appropriation or incorporation by the other. The relationships for forming wholes from parts, including those of polarity and hierarchical domination, are at issue in the cyborg world." (119)

highlights.

¹⁰⁸Originally published as *Manifesto for cyborgs: science, technology, and socialist feminism in the 1980s*, I am using Haraway's updated version for the purposes of this analysis.

In Haraway's account, the cyborg gives feminism a new ontology based on the interconnectedness of networks and processes of translation as opposed to the politics of hierarchical and essentialised gender categories. With little respect for boundaries, the cyborg is a construct that establishes connections between heterogeneous and distributed groups of actors and fields of endeavour. Cyborgs are resources through which to conceive the way in which gender politics and epistemology are entangled within the complex issues and networks that characterise advanced industrial societies. By rendering visible these complex entanglements, the cyborg opens up new and different possibilities for feminist thought and action.

Post-gender cybernetics appears a compelling lens through which to interpret the staging of *Oramics*. There is in the exhibition's publicity, for instance, a fundamental ambiguity with regard to whether the exhibition is foregrounding Daphne Oram or the Oramics Machine. *Oramics* is an exhibition in which the concerns of the Oramics Machine and Daphne Oram appear to collapse into one another: the exhibition's publicity image, for instance, displays Oram at work with the Machine with neither obviously foregrounded over the other. The name "Oramics" – in the exhibition's title *Oramics to Electronica: Revealing Histories of Electronic Music* – therefore appears as a hybrid term that pertains both to Daphne Oram and the Oramics Machine¹⁰⁹. This coupling of Machine and female pioneer through the shared name of *Oramics* weaves together the concerns of objectivity and biography each of which is integral to the other. In its idiosyncrasy, the Oramics Machine needs Oram's biography to situate it in history. In the exhibition this is achieved by bringing the Oramics Machine into relation with the inventions of Oram's contemporaries with whom she collaborated and critically responded. The inventive work of Oram's contemporaries are displayed in the cases immediately adjacent to the Oramics Machine featuring the BBC Radiophonic Workshop – the studio founded by Oram which is credited with revolutionising the use of sound in the broadcasting corporation (Niebur, 2010) – and the Electronic Music Studios (EMS) – founded by Peter Zinovieff who Oram had taught to cut tape and create music concrete (which Zinovieff subsequently rejected in favour of computer music). These case displays are both significant of Oram's personal and professional relationships with the people who worked in both studios and therefore brings the Oramics Machine into a comparative relation with their

¹⁰⁹And indeed, the term "Oramics" has other referents, including her studio and philosophy, in its usage in Oram's (1972) only published book *An Individual Note of Music, Sound and Electronics*.

inventions and impact in electronic music. It is as an effect of Oram's biography that the Oramics Machine is brought into relation with these particular inventions as opposed, for example, to inventions of Bob Moog (the Moog synthesiser). Just as Oram's work in the BBC and in relation to EMS establishes the Oramics Machine as an invention worthy of comparison with the more established inventions of these studios, so too Daphne Oram as a biographical personality attains legitimacy in the Science Museum through the machines surrounding her in the gallery's images and in the cases. *Oramics* appears inseparably both a display of the Machine and of Oram and at the same time is irreducible to either. In this cybernetic staging of the exhibition "Oramics" appears the name of a cyborg.

We can see therefore how *Oramics* could be interpreted through post-gender cybernetic theory as an inclusive exhibition exhibition. Unsettling the demarcations of androcentric models of science, we might see how the cybernetic displays of *Oramics* propose new hybrid relations and forms of interactivity between science and culture. In other words, it allows us to see how those previously excluded from science exhibitions – such as the public, women, art, pop music and so on – could be included in an experimental gallery display. Through a cybernetic post-gender lens, the gallery displays could be interpreted as an attempt to stage the relations between science and culture as heterogeneous. However, as I will argue now, such an interpretation of *Oramics* does not 'solve' the problem of exclusion from science. If *Oramics* is interpreted as a cybernetic post-gender displays of science then, I suggest, it nonetheless reproduces some of the asymmetries that Haraway's figure of the cyborg was invented to critique.

Discontinuities between curatorial experiment and experimental display

The interpretation of the *Oramics* gallery displays as cybernetic and post-gender offers one explanation for why the women writers appear as outsiders and not participants in the experiment: in relation to the "post-gender" cyborg staging of the *Oramics* experiment, the women writers' monologues appear as displays of the "women's common experience", as a staging of gender that concepts like Haraway's cyborg critique. In contrast to the cyborg displays that

unsettle and mix together categories like art/science, high/low culture, masculine/feminine (etc), the women writers' monologues appear as expressions of pure gendered subjectivity. Where a cybernetic interpretation of the *Oramics* exhibition would blur the asymmetric demarcations of androcentric science, the monologues appear to confirm these asymmetries by inhabiting the categories belonging to latter side of the male/female dichotomy: femininity, subjectivity and vulnerability appear mutually constitutive of the asymmetric ontology that the cybernetic displays critique. From the perspective of the cybernetic post-gender interpretation of *Oramics*, we can see why the women writers' monologues might appear to enact asymmetric relations between science and culture that the cyborg critiques and, as such, present the inclusion of the women writers works as a separate curatorial concern.

A version of this explanation was offered to me by Boon who suggested that the problematic appearance of the women writers work was a procedural failure in the experimental curatorial collaboration with the group. In a conversation, Boon tells me that the women writers monologues were an “incompletely realised and risky experiment”; their failure to engage with the concerns of *Oramics* are, for Boon, principally a failure in execution in the curatorial experiment. The decision to involve the women writers, Boon says, was because he considers Oram's gender to be a significant issue. The groups the Museum had invited to participate in curating the exhibition, were overwhelmingly male dominated and Boon therefore describes the decision to involve the women writers as a political choice. The logic of the women writers participation, sketched by Boon, was therefore a logic of identity politics. The involvement of the women writers was both “risky” and “an incompletely realised experiment” because it was conducted at arms length from the Science Museum through associates. It was a process from which Boon and others were excluded on the basis both of their gender, as men, and, in part also, their institutional affiliation to the Museum. However, Boon suggested to me that if the techniques of involving the women writers had been different then they could have made important contributions to the experimental exhibition. If there had been more workshops, more time and more contact between those in the Museum staff working on the *Oramics* exhibition and those running the workshops, the women writers could have contributed materials that really engaged with the exhibition's concerns about the invention of electronic music. Had the curatorial experiment with the women writers been executed more effectively by the Museum they could have produced 'cyborg-

like' contributions in which the women's concerns could be demonstrably related with the Oramics Machine. However, the exhibited monologues are an "incompletely realised" experimental curatorial procedure and, as such, the women writers works appear problematic in the experimental displays of *Oramics*.

Boon's account of the "incompletely realised" curatorial experiment can be understood as a procedural explanation for why the women writers appear as 'outsiders' in the *Oramics* gallery displays. This procedural account maintains the integrity of the curatorial intentions informing the collaboration with the women writers and attributes the problematic display of the monologues to the technicalities in the procedural execution. In this account, the gendered women writers' could have been made cyborg-like through the process of collaborating with the Science Museum's curators: the vulnerable subjectivity of the writers could have been synthesised with the curators' concerns about science and technology. Instead, in the incompletely realised monologues, the women's subjectivity is simply left hanging, unattached to an object. Without an object to attach to, monologues like Corinna's appear more like displays of "women's common experience"; in relation to the cybernetic interpretation of the *Oramics* gallery displays the monologues appear as the very thing that the post-gender cybernetics critiques. In relation to the cybernetic displays in the exhibition, the monologues appear as pure expressions of subjectivity and vulnerability, the women writers appear disconnected from the issues of *Oramics* and as "incomplete" participants in the curatorial experiment. From the perspective of the cybernetic, post-gender interpretation the gallery displays, the procedural account gives a simple explanation of the problematic staging of the women writers' work.

In the procedural account, the gendered women writers monologues are judged by the extent to which they assimilate to the post-gender staging of *Oramics*. In this respect, the procedural explanation is also a highly asymmetric account of the place of gender in the curatorial experiment. On one hand, gender is said to be significant enough in the exhibition of Daphne Oram that the women writers' gender alone qualifies them as participants in the curatorial experiment. On the other hand, in their "incomplete" realisation the displays of the women writers monologues appear problematic; gender alone is insufficient to establish connections with the other displays in *Oramics* gallery. The curatorial experiment and the experimental display appear here as

discontinuous activities, one of which is concerned with gender while the other isn't.

Partial objects and situated knowledges

The problematic appearance of the women writers' work can, I have suggested, be seen as an effect of discontinuities between the curatorial experiment and the experimental display. In establishing a discontinuity between these two modes of experiment, it also fragments the object of the *Oramics* exhibition. One account of objectivity in science that perhaps offers a 'partial' solution to the problems of the gallery displays in *Oramics* is found in feminist standpoint theory. The relationship between feminist standpoints and concepts of objectivity in science has, as Sandra Harding's (2004) overview of standpoint theory since the 1970s makes clear, always been controversial. One account of the relationship between objectivity and feminist standpoints is found in Haraway's (1988) concept of "situated knowledges". The concept of "situated knowledges" was an attempt by Haraway to respond to tensions in feminist accounts of objectivity identified by the feminist scholar Sandra Harding. In *The Science Question in Feminism*, Harding (1986) had critiqued the limitations in the contemporary feminist accounts of science. Where feminism had highlighted the androcentrism of science, Harding sought to extend feminism from the "Woman Question" – asking how women could be equitably treated by science – to the "Science Question" – asking whether a masculinist science could still be used for the emancipatory ends of feminism. In *The Science Question...* Harding therefore sought to develop a "feminist epistemology". Harding argued that the tensions and dissonances of feminist critique were not counter to science but rather embodied the same tensions and dissonances within science. Harding therefore called for feminists both to maintain a critique of science while also constructing a "successor science". Haraway's "situated knowledges" was a response to the tensions of Harding's dual aims which sought both to realise the radical contingency of all knowledge claims while also maintaining a feminist critical empiricism. In Haraway's cultural account, objectivity has never been opposed to either radical contingency or empirical criticism; in effect, Haraway argued, Harding's problematic dualism is unfounded. Objectivity in Haraway's conception is partial and situated:

“Objectivity turns out to be about particular and specific embodiment, and definitely not about the false vision promising transcendence of all limits and responsibility. The moral is simple: only partial perspective promises objective vision. All Western cultural narratives about objectivity are allegories of the ideologies governing the relations of what we call mind and body, distance and responsibility. Feminist objectivity is about limited location and situated knowledge, not about transcendence and splitting of subject and object. It allows us to become answerable for what we learn how to see.” (1988: 582-583)

For Haraway, feminist objectivity as “situated knowledge” is not an epistemological solution to the dual concerns of feminism and objectivity. Instead, the concept of “situated knowledges” offers a cultural re-description of objectivity as always partial and limited; these are the only conditions in which objectivity is possible. Feminist standpoint theory thus offers one model for the inclusion of subjectivity in science.

The problems of the experimental gallery displays of *Oramics* to accommodate the work of the women writers can, I suggest, be better appreciated from the perspective of standpoint feminism. Though gender is clearly important in the staging inclusive gallery displays, both in the presentation of the gendered women writers and the ironic staging of Daphne Oram as a feminine technologist, it is notable that references to feminist concerns of the experimental curatorial process – such as the reasons for including the women writers as participants – appear largely absent from the gallery displays exhibition. Given the significance of feminist analysis of science, which identify gender as one of many conceptual asymmetries in science, it is surprising that *Oramics* does gender but not feminism. As Chapter Four made clear, the turn to culture at the Science Museum is more often formulated as a critique of epistemology, of text book histories of science, and of demarcationist accounts of science. Hence, for all the discussion of the importance of gender in the Science Museum's “cultural offer”, feminism is not explicitly included or referenced at any point. For instance, in the same corporate publicity that celebrates the cultural offer of the Science Museum also makes clear the importance of gender issues in science but makes no reference to feminism. A section of the Museum's (2013) *Annual Review 2012-13* is, for example, titled “Celebrating Women Who Excel” and emphasise the importance of more women entering careers in science. However, without situating this as a feminist approach, the publicity appears more obviously like the assimilation of

women into science. If it is not a feminist approach, then the publicity's championing of the participation of women in science seems more obviously to repeat the same asymmetries in publicising the relations between science and culture. The absence of feminism as a reference point in *Oramics* can, I suggest, give us insight into why the work of the women writers appears discontinuous between the curatorial experiment and experimental gallery display.

From the perspective of feminist standpoint theory, the problematic appearance of the women writers in *Oramics* gallery displays would appear less the failure of the women writers' monologues to make connections with the objective concerns of the exhibition – the machines, technologies etc – and more the failure of the experimental display to be sufficiently inclusive to encompass the lived experiences described in the women writers' works. The problematic appearance of the women writers is dramatised in the various publicity for the exhibition which presents different and conflicting characterisations of the women writers as participants, respondents, co-curators, co-creators, co-producers. The 'problem' of this gendered group is perhaps in part that their works of subjective expression remind us of the demands of equity feminism for gender symmetry. Harding (1986) summarises the symmetrical challenge of equity feminism as the following:

“Until both the “emotional labour” and the “intellectual and manual labour” of housework and child care are perceived as desirable human activities for all men, the “intellectual and manual labour” of science and public life will not be perceived as potentially desirable activities for all women” (53)

In many respects, the challenge of equity feminism is much greater for the Science Museum than the challenge of the cultural turn. For the Science Museum to acknowledge the symmetry of equity feminist arguments, it would also have to recognise its inadequacy as an institution to address gender issues in science. The challenge of equity feminism is not simply about assimilating more women into science but rather the much bigger, almost totalising, challenge of changing gender structures, symbolism, and the gendered division of labour. In short, the challenge of equity feminism could seem to require nothing short of the complete dismantling of the Science

Museum in its contemporary guise¹¹⁰. And in this sense, it also makes clear why asymmetries between objects and subjects in science are not easily 'solved'.

The problematic appearance of the women writers in the *Oramics* gallery highlights a discontinuity between the treatment of objectivity and subjectivity in the curatorial experiment and the experimental displays. If we were to interpret these discontinuities through feminist theory we can see the tensions between standpoint approaches and cybernetic post-gender approaches to the question of gender in science.

With the removal of the women writers, and the other contributions in the cinema, from the *Oramics* gallery, the exhibition is comprised solely of cases displays of objects. From the perspective of the *Oramics* Machine's Facebook page this may be an improvement to the experimental gallery display but from the curatorial perspective the removal of the cinema would seem to suggest a problem in the experimental curatorial procedure. By looking at the problems caused by the experimental displays of the women writers' works we see some of the complex empirical obstacles to 'solving' asymmetries in the relations between science and culture.

Conclusion

This chapter has looked at the experimental *Oramics* gallery displays in relation to the problem of exclusion. I've focused here on the display of work by the women writers in the *Oramics* gallery which I have discussed in relation to the more complex problem of the exclusion of women from science. In the chapter I have highlighted some of the ways in which the display of the women writers' work becomes empirically problematic. To explain the problems of the display of the women writers' work, I have spotlighted debates within feminist theories of science, specifically between standpoint theory and the 'post-gender' cyborg theory. In these debates we see different ways in which gender is a problem for science. The display of the gendered women writers in

¹¹⁰It is not too hard to find parallels between the equity feminist perspective and that, discussed Chapter Four, of Baudrillard's critique of the capacity of museums to function as democratic cultural institutions. For Baudrillard, the proposition of the democratic museum would entail its dismantlement as an institution.

Oramics, and the responses they stimulate in the curators, Audience Researchers and reviewers poses the question of gender in science as a practical problem. In discussing feminist theory I have tried to show that how these debates affirm the *problem* of gender in science. This does not mean they simply admit failure in identifying a solution to the exclusion of women from science but instead affirm the value of this problem for unsettling many very different kinds of exclusion in science. I've attempted to highlight this empirically by describing the displays of the women writers' works not only as a problem that is particular to this group, but which is linked to much broader asymmetries in the relations between science and culture. For instance, the criticisms of the women writers highlight problems concerning the relations between objectivity and subjectivity, technology and art, and rationality and affectivity. Using the problem of the women writers as a way into discussing the asymmetries in the relations between science and culture importantly enables us to better appreciate the accomplishment of the experimental displays in *Oramics* which bring together musicians and engineers, amateurs and professionals, and so on. When we recognise the scale of the challenge of exclusion from science, we appreciate better the accomplishment of the experimental displays of *Oramics*.

By applying the concept of the public experiment to *Oramics*, we find the problem of the women writers reveals the challenge of assembling the exhibition as an experimental apparatus. As a public experiment, the *Oramics* exhibition can be seen to bring together very different modes of experiment: of which in this thesis I foreground curatorial, display and music. In the problematisation of the display of the women writers we also see the problem of maintaining continuity between the different modes of experiment. In the responses to the women writers' works we find criticisms that they neither relate to the subject matter of experimental electronic music nor are they experimental enough to fit with the cyborg-like displays in the gallery. In the curator's response we find the women writers as too challenging for the experimental procedures devised to facilitate their participation in the exhibition. In different problematisations of the women writers we find discontinuities emerge between the various modes of experiment: was the women writers' participation just tokenistic part of the curatorial experiment, in what ways does their writing address experimental electronic music, and how does their experimental display relate to science and technology? Highlighting the appearance of these discontinuities enables us to appreciate more clearly

the work involved in making relations between the different modes of experiment we find in *Oramics* as well as the fragility of the exhibition as an experimental apparatus.

It might be objected that by presenting gender as a problematic in *Oramics* it is actually me who is 'gendering' the experimental setting, not only forcing a problem artificially onto the exhibition but also reinforcing, rather than challenging, the exclusion of women from science. This has not been the intention of the analysis in this chapter, but I accept that it is a risk that accompanies the analytical choice to foreground gender and the issue of exclusion. In the analysis I have attempted to show empirically how gender becomes problematic in relation to the experimental gallery displays and in doing so to discuss more broadly both asymmetries in the relations between science and culture, and the challenge of continuity in assembling *Oramics* as a public experiment. To affirm that the *Oramics* exhibition does not 'solve' the problem of the exclusion of women from science is not to say that it fails as an inclusive exhibition. Instead, highlighting the absence of a solution serves to affirm that multiplicity and heterogeneity of the relations between science and culture in which asymmetries and exclusions are problems. In other words, rejecting the notion of the experimental experiment as a solution to the culture problem of science enables us to be attentive empirically to the ways in which the multiple modes of experiment in the *Oramics* exhibition and the very different kinds of work involved in bringing them together. I discuss the work involved in making relations between science and culture in the next chapter in which I focus on the work of experimental electronic musicians like Daphne Oram in mediating relations between music and electro-mechanics.

6. Media: the Oramics Machine as electronic music experiment

Introduction

The use of music in experimental exhibitions is not new, not least in the Science Museum. Music has often been used both in exhibitions that communicate experimental results, and in interactive exhibitions as a means of engaging the public with science. Indeed, we arguably find both of these uses of music in the *Oramics* gallery in which a track titled 'Introduction' composed on the Oramics Machine by Daphne Oram is played on loop from loudspeakers, and a touch-screen interactive installation simulates the Oramics Machine allowing visitors to experiment with composing their own sounds. Experimental science exhibitions have often drawn clear demarcations between sound-science and art-music: science can explain sound to the public as vibration physics while music is presented for public appreciation. In *Oramics*, by contrast, electronic music is staged as a hybrid medium that is part art-music and part sound physics¹¹¹. In other words, in *Oramics* we find that electronic music is staged as an *experimental medium* itself: the Oramics Machine, for instance, is the material evidence of Daphne Oram's experiments with "drawn-sound" composition techniques. This chapter address the theme of electronic music as an experimental medium and in so doing explores further the ways in which the *Oramics* exhibition might be said to address the 'culture question' in the Science Museum.

Visitors to *Oramics* are told that electronic music experiments like those staged in the gallery displays lead to the invention of new sounds that revolutionised the public soundscape. As an exhibition about the invention of electronic music, *Oramics* foregrounds the experimental collaborations between

¹¹¹ In this chapter I focus the analysis around the concept of sound rather than music. This is both to emphasise the fact that the electronic music we find in *Oramics* is staged as sonic invention and because unlike the concept of music, which is highly loaded, sound is less determined as a sociological analytic and therefore more amenable to the analysis of experimental things.

musicians and engineers through which new sounds were created. This is exemplified in the exhibition's centre-piece, the Oramics Machine which was developed in a collaboration between the composer Daphne Oram and an electronic engineer Graham Wrench. In Oram's home-studio at Tower Folly the composer collaborated with Wrench (and other engineers) throughout the early 1960s in an attempt to build a machine that could realise Oram's aim to develop graphical composition techniques, or "drawn-sound". Though the Oramics Machine was never demonstrated as a technological or artistic innovation in Oram's lifetime, it is nonetheless staged in *Oramics* as the invention through which Oram created drawn-sound compositions. Having never left the studio where it was developed, the Oramics Machine is an invention in which we find many traces of the collaboration between Oram and Wrench; in the Oramics Machine, Oram's drawn-sound is staged as the result of complex and difficult work that brought together musical and electro-mechanical practices. In Oram's drawn-sound experiments electronic music appears a highly 'impure' medium that is part music, part electro-mechanics.

In the *Oramics* exhibition visitors do not have to look hard to see some of the traffic between the different modes of experiment I have identified in this thesis so far (i.e. curatorial and musical experiment, and experimental display). In the documentary film show in the *Oramics* gallery the curator Tim Boon enthuses about the Oramics Machine and Daphne Oram's sound experiments:

"The discovery of the Oramics Machine has been one of those great events in a curator's working career. It's a real bit of home brew. Just by looking at it you can tell that it was always work in progress, that it was always being modified, and it's unique. Daphne Oram is an absolute gift to an exhibition-maker. What was going on in her head was a sort of unbounded musical imagination, where she was thinking in terms of pure sound."

Boon tells viewers that one of the reasons Oram is such a "gift" to an experimental curator like himself is her highly experimental approach to musical practice, her thinking as "pure sound". Indeed, during my ethnographic fieldwork in the Science Museum I came across many other examples of how music and sound were used as mediums with which to experimentally curate displays of science. For instance, at the launch of *Oramics*, Boon announced a

public contest¹¹² to remix some of Daphne Oram's compositions¹¹³. During the period of my research, the Science Museum also hosted an interdisciplinary conference on sound called *Supersonix*¹¹⁴, bringing together very different kinds of academics, artists, musicians, and technologists¹¹⁵. On other occasions the Museum hosted two separate performances of the contemporary experimental music group Icebreaker – a hybrid group of orchestral and electronic instruments – performing songs from Brian Eno's album *Apollo: Atmospheres and Landscapes* and Kraftwerk's back catalogue¹¹⁶. And during the period of study, the Science Museum employed its first ever “sound artist in residence”, the composer and academic Aleks Kolkowski who performed at various events using early mechanical recording and amplification technologies, such as the auxetophone¹¹⁷, an early phonograph, from the Museum's collection. Indeed, in numerous informal conversations Boon would discuss with me the ways in which electronic music and experimental sound permitted curatorial experimentation, even going so

112 The remix contest is in many ways another example of some of the tensions of the 'cultural' logics of experimentation that are enacted in different Science Museum staff's accounts of *Oramics*. A celebrity judging panel, which included luminaries such as Brian Eno and DJ Spooky, were convened to choose a winner from the many entries to the contest. The remix contest suggests a cultural logic of participation in which multiple translations of the same object, the *Oramics Machine's* audio samples, are produced by heterogeneity and distributed individuals/groups. The audio samples constitute a means of assembling a range of heterogeneous individuals and groups from which a winner emerges. In many ways, the format of experimental contestation invoked by the remix contest is not dissimilar to the forms of experimental contestation through which early modern science developed (for discussion of experimental contest in early modern science see Shapin and Schaffer, 1985). For more information see: http://www.sciencemuseum.org.uk/about_us/press_and_media/press_releases/2012/03/Winner%20announced%20for%20OraMIX%20remix%20competition.aspx (accessed 5th February 2014)

113 The Museum subsequently released online several tracks of audio recorded by Oram on the *Oramics Machine*, with an open invitation for anyone to remix these samples into contemporary tracks. The remixing of audio here became a practice that extended the experimental curatorial and museological logics informing the *Oramics* exhibition. Oram's digitised audio tracks here invent a new material means through which the Museum could facilitate mass participation from groups with heterogeneous knowledges and practices. In contrast to procedural or instrumental accounts of experiment, the remix contest makes clear how media are indissociable from the modes of experimental practices we find in *Oramics*.

114 See the *Supersonix* conference website: <http://www.exhibitionroad.com/supersonix/conference> (accessed 20th September 2013).

115 The conference's subtitle, “celebrate the art and science of sound”, makes that sound was considered an object of interdisciplinary concern and in this sense the conference evinces a particular experimental form that Born and Barry (2010) have called “art-science”. As discussed in Chapters One and Two, art-science, Born and Barry argue, is a form of interdisciplinarity that seeks to multiply the interactions between science and society. In its experimental form, art-science can create new forms of interactivity – in objects, practices, discourses – between science, art and the public.

116 Performing the concert in the Science Museum's lecture theatre, the Icebreaker performances enacted a mix of cultural dichotomies, most obviously perhaps the genres of popular and classical music. A short essay by Boon discussing the Icebreaker performance in relation to the *Apollo* space mission makes clear its curatorial and museological significance. This can be found at: <http://www.icebreakerapollo.co.uk/content/tim-boon-chief-curator-science-museum> (accessed 5th February 2014)

117 More information about Kolkowski's use of early recording and amplification technologies can be found at: http://www.sciencemuseum.org.uk/smap/collection_index/aleks_kolkowski_sound_artist_in_residence.aspx (accessed 9th September 2013)

far as to suggest that it was the “easy case” for curating an experimental cultural display. Such examples highlight some of the diverse traffic between experimental sound, curatorial experiment and experimental display that we find in the Science Museum, and would seem to pose quite clearly the questions of 'relations' between science and culture.

Indeed, culture is a particularly important category in the field of electronic music. Electronic music has, for instance, often been associated with both counter-cultural movements and their subversive uses of technology. From synthesiser and tape music events in the US counter-culture scenes of the 1960s (Bernstein, 2008; Pinch and Trocco, 2004; Turner, 2006)¹¹⁸, to the multimedia “happenings” of the 1960s New York downtown art scene (Turner, 2008)¹¹⁹; to sub-cultural exchanges that took place in UK “sound-system” clubs and dance halls (Hebdige, 2002; Henriques, 2010)¹²⁰; to the 'moral panics' in newspapers generated by large scale rave events in the late 1980s and early 90s (Reynolds, 2013; Toop, 2001)¹²¹: such diverse studies illustrate some of the ways in which electronic music innovations have often developed around new cultural movements that respond critically to developments in science and technology. While such studies make clear the case for why electronic music experiments are interesting in terms of relations between knowledges, technologies and social identities they largely do not address how these relations are negotiated in electronic music innovations, instead focusing more on the effects of musical and technological developments (Pinch and Trocco,

118 During the 1960s and early 70s experimental sound exhibitions were key sites through which the counter-culture movement emerged in the US and UK. Pinch and Trocco's (2004) account of synthesiser demonstrations discusses the significance of these events in the establishment of counter-culture scenes. For instance, they discuss how the San Francisco Tape Music Centre served as the venue in which artists, composers, political dissidents, engineers, and entrepreneurs mixed (Bernstein, 2008).

119 Fred Turner (2008) describes how the experimental “happenings” and other experimental electronic music events in the 1960s downtown scene New York, involving musicians like John Cage and David Tudor, repurposed cybernetic technologies and techniques of “automation” for a counter-culture political imagination. In opposition to the top-down, rationalised bureaucracies of cold-war corporate America, Turner shows how the chance interactions central to Cage's experimental sound displays created interconnected spaces which liberated individual participants from such political hierarchies. Turner argues that these were important events in the popular imagination of contemporary “cyber-culture”.

120 Hebdige (2002) describes how the sound-system club nights were introduced into Britain by the West Indian migrants and began as an institution of the black working-class youth sub-culture. Hebdige argues it was fundamental to British reggae culture and influenced the development of punk in the 1970s, through a dialogue between these different working-class youth sub-cultures. Elsewhere, Henriques (2010) describes the ontological significance of sound-systems and dance-hall culture in the formation of Jamaican diaspora.

121 Reynolds (2013), for example, describes the 'moral panics' created in the UK press by the “folk devils” of the drugs acid and ecstasy during the development of rave culture in the 1980s. Reynolds describes the how, in their conspicuous consumerism and ideologies of individualism, rave events subverted the Thatcherite politics. Reynolds discusses how the introduction of anti-rave legislation transformed rave into a highly organised leisure industry.

2004; and, Turner, 2006, 2008 are clearly exceptions here).

In order to better appreciate the *Oramics* exhibition as an experiment in the relations between science and culture I want to explore approaches to the study of musical invention that open up the division between the technical and cultural. The approach that gives the theme of this chapter focuses on how musical inventions can be said to be processes of “mediation” (for an overview see Hennion, 2003). Mediation, in these studies, describe as the processes of material exchange, modification, distortion and translation that reorder the relations between people, things, knowledges and practices. Such studies have described the ways in which music can be said to mediate relations, for example, between computing and art-music (Born, 1995) or elsewhere shown how such an approach can create associations between groups as diverse as drug users and amateur musicians (Gomart and Hennion, 1998). Approaching musical invention as a process of mediation, I suggest in this chapter that the electronic music experiments we find in *Oramics* are not only bring together music and electro-mechanics as discreet formalisms, but rather reveal their complexity as practices. By looking at the electronic music experiments in *Oramics* as mediations between practices we can appreciate better the ways in which the exhibition could be said to be an experiment in the relations between science and culture.

In this chapter, then, I'm concerned with how the electronic music experiment – of which Oram's experimental work in developing drawn-sound composition techniques and building the Oramics Machine to realise them are staged as exemplary – can be said to raise the question of culture in the Science Museum. To describe the electronic music experiment as mediating relations between music and electro-mechanics is to offer an account of electronic music as a medium that is materially complex. In this chapter I'm going to contrast this complex “media-specific” approach to the electronic music experiments of Daphne Oram with what I describe as “audition-centric” accounts. Audition-centric approaches are concerned principally with the auditory perception and experience of sound. In audition-centric models, the concerns of materiality – the 'objective' character of sound – are the concerns of sound production and are considered to some extent separate from the 'object-less' experience of auditory perception, the consumption of sound. Audition-centric approaches to experimental sound, I suggest, propose very different relations between science, culture and the public than do media-

specific approaches. In this chapter, then, I seek to demonstrate what we gain from media-specific approaches to the experimental sound with the aim of appreciating how *Oramics* might be said to experimentally mediate relations between science and culture.

This chapter first looks at Daphne Oram's experiments with "drawn-sound" and the collaboration with the electronic-engineer, Graham Wrench, to build the Oramics Machine. In Oram's drawn-sound experiments I suggest that the relations between music and electro-mechanics cannot be grasped if we reduce their practice to simple formalisms but only if we accept that they are "multivalent". I suggest this enables us to see how Oram's experiments with drawn-sound blurred the lines between technical and artistic practices and in this sense can be seen to mediate relations between science and culture. Following this account of Oram's drawn-sound experiments, I then address an important critique that focusing on the material mediations of sound 'objectifies' sonic invention and participates in the domination of culture by science and technology. This criticism argues of the need to construct a cultural account of sound based on its auditory perception; that is, the ways in which people listen to, are affected and engage with sound aurally. In the following section I then compare media-specific and auditory-centric approaches to the experimental sound exhibition using a case study of another exhibition featuring the work of Daphne Oram alongside contemporary sound artists. I argue that auditory-centric approaches to the experimental sound exhibition, like the interactive public understanding of science model, risk "black-boxing" the materiality of sound and offer us only a very limited account of what is experimental about the electronic music we find in *Oramics*. In concluding, I specify some of the ways in which the exhibition of the Oramics Machine in the Science Museum can be said to an experiment in relations between science, culture and the public.

'Drawn-sound' as mediating between music and electro-mechanics

In this section I'm going to discuss the Oramics Machine built by Daphne Oram through which the composer attempted to realise her aspiration to develop

“drawn-sound” composition techniques; a vision to control all parameters of sound using graphical forms. In the analysis below I discuss Oram's drawn-sound experiments drawing on an approach to sound developed in the sound studies of Pinch and Bijsterveld (2012) who describe sound as “thing-like”, as something materially complex. Pinch and Bijsterveld argue that by foregrounding the materiality of sound we gain an appreciation of how sonic inventions from synthesisers to noise campaigns produced new kinds of relations between science and culture (see also Bijsterveld, 2008; Pinch and Trocco, 2004). Being attentive to the materiality of drawn-sound, I suggest here, enables us to similarly describe some of the ways that Oram's drawn-sound experiments mediated heterogeneous relations between music and electro-mechanics. In the analysis that follows I'm going to look at how electro-mechanics and music are staged as “multivalent” mediations of drawn-sound. Where music and electro-mechanics might be considered separate formalisms that offer aesthetic and technical explanations of electronic music experiments, I show how the drawn-sound experiments of Daphne Oram can be appreciated as more complex practices in which the making of relations between these two spheres were often frustrated in practice and a long time in the making.

Daphne Oram was a musician at the heart of developments in electronic music in Britain. As an electronic musician and an employee at the British Broadcasting Corporation (BBC), Oram founded the Corporation's Radiophonic Workshop in 1958 with the aim of creating an electronic music studio comparable to others in Paris and Cologne and to experiment with the respective *musique concrete* and *elektronische musik* techniques they had developed (Niebur, 2010). Beginning largely with creating sound effects for radio dramas, the Workshop subsequently also became renown for the music and jingles it produced for flagship BBC radio and television programmes, such as the theme tune for the cult British television series *Dr Who*. In the BBC's own history of the Radiophonic Workshop (from which Oram is largely absent¹²²), the studio is celebrated as the setting in which engineers and composers worked together, often on tiny budgets, to innovate musically and technically, inventing new kinds of sound and music for consumers of the broadcast media (Briscoe and Curtis-Bramwell, 1983). Entering the BBC in the 1942 as a junior programme engineer, for which she gave up a place to study at the Royal College of Music, Oram continued to pursue her music by using

¹²²Oram's absence from the BBC's formal history of the Radiophonic Workshop has been discussed by several authors (Marshall, 2008; Niebur, 2010).

empty radio studios to work on electronic music compositions outside of working hours. According to recent biographers (for example, Hutton, 2003), Oram's particular interest in drawn-sound developed while at the BBC where she encountered an oscilloscope for the first time, an instrument that visualises a sonic frequency, and inquired whether the process could be reversed to create sound with graphical techniques. However, Oram's vision for the Workshop differed greatly from the BBC's leading to her departure after less than a year working there. Leaving the Corporation behind, Oram sought to pursue her ambition to create a machine that could control sound graphically, setting up her own studio in a converted oast house called Tower Folly in the British countryside. After receiving a grant from the Gulbenkian foundation to build the Oramics Machine, Oram later employed an electrical-engineer named Graham Wrench. Despite having few sources of funding for her work – beyond the Gulbenkian grant Oram received a handful of commissions for advert and film soundtracks – Oram nonetheless pursued the development of the Oramics Machine with Wrench in order to realise her drawn-sound ambitions. Beginning work on the Oramics Machine in the early 1960s, the first composition to be recorded using the Machine, called *Contrasts Esssonic*, was completed in 1968 (Grierson and Boon, 2013). The Oramics Machine's slow realisation now appears perhaps even more exaggerated within a decade of electronic music history that saw the invention of the synthesiser and a new intensity of artistic experimentation in an emergent counter-culture (Pinch and Trocco, 2004).

The Oramics Machine is unique – there are no others Oramics Machines – and is an invention that never made it out of Oram's home-studio. As such, it is an artefact in which we find distinctive traces of the collaborative work undertaken between Oram and the electronic-engineer Wrench. The Science Museum's exhibition stages the Oramics Machine as an instrument that mediated an experimental collaboration between a music composer and an electro-mechanical engineer. In the display the Oramics Machine is comprised of two central components¹²³: (1) its programmer¹²⁴, and (2) its wave-form scanners¹²⁵. The programmer was designed so that Oram could draw shapes

¹²³This account of the Oramics Machine as comprised principally of a programmer and wave-scanners is that presented in the Science Museum's exhibition, but it is also found in Oram's and other accounts of it (Manning, 2012; Oram, 1972).

¹²⁴The programmer is the most iconic of the two components, comprising the film-strips onto which Oram is pictured drawing (above). Like the black and white keys of a contemporary keyboard synthesiser, Oram used the programmer to control the pitch, the volume and the application of vibrato to the sound that the wave-scanners produced.

¹²⁵The wave-scanners were designed specifically to read the idiosyncratic shapes that Oram drew onto them: Oram's graphical approach an attempt to bring precision to the definition of the wave shape that was lacking in the geometrically defined sine, square and triangle waves of standard oscillators used in electronic music.

onto 35mm film strips running across it, each strip assigned to a different parameter and processed with photoelectric sensors. The frame of the programmer is made from repurposed Dexion, an industrial system for producing light metal shelving. Both of 35mm film and Dexion were mass-produced materials and relatively cheap to acquire, and (in contrast to Oram's account in which design followed artist specification) their use in the Oramics Machine has been subsequently characterised as more likely the use of an expedient material which met Oram's immediate practical needs rather than a prior design choice (Mullender, 2011). A similarly resourceful inventiveness is suggested by the Machine's electro-mechanical design which evidences Wrench the bricoleur as much as it does the engineer. The photoelectric sensors that read the shapes Oram drew onto the film are particularly conspicuous in the case display of the Oramics Machine as they hang limp and corroded from the programmer's Dexion frame. In an interview for a music technology magazine, the engineer, Wrench, describes the unorthodox engineering practice of repurposing ordinary transistors to create the Machine's photoelectric sensors:

"We had so little in the way of components in those days. Transistors had only recently appeared on the general market, so they were still pricey. I needed to use light-sensitive photo-transistors but they were far too expensive, at almost a pound each. This was at a time when a good wage was about £25 a week! But I started experimenting and discovered that I could take apart the ordinary transistors. Scraping off their covering of paint turned them into photo-transistors, so I made my own." (Marshall, 2009)

Wrench's description of the choice to repurpose ordinary transistors to create the Oramics Machine's photoelectric sensors makes clear that this was not only a theoretical determination of electro-mechanics but also a consideration of home-economics. In Wrench's account thrift in consumption, the budgeting of income and reusing existing materials were all significant considerations in building the Oramics Machine's programmer.

Traces of the particular biographies of Oram and Wrench also appear in the particular assemblage of other main component of the Oramics Machine, its "wave scanners" which were designed to read hand-drawn wave-forms that Oram drew onto glass slides. The wave scanners are comprised of two cathode ray tubes that scan the shape of the drawn wave-forms, controlling

both the pitch of the Machine's oscillators and producing the timbre of the sound. This very particular electro-mechanical design of the wave scanners was in large part an effect of professional background of the engineer, Wrench, who had worked with radar technology in the British airforce¹²⁶. And, what is perhaps most striking about the wave scanners, certainly when we see them somewhere like the Science Museum, is the faded white wooden container, formally a piece of storage furniture in Oram's house, used to house the electrical components. The contrast is stark: the once stylish and delicate piece of home furniture is presented with its doors and top open to reveal the bright yellow cathode ray tube scanners and corroded circuitry. The cabinets open top section makes visible the exposed circuitry that tuned the oscillators below which are Oram's handwritten notes E, A, D, G: "it's tuned like a guitar" one sonic artist noted¹²⁷. The unique electro-mechanical design of the wave-scanners and their casing in a piece of furniture at once material traces of the particular social identities of Oram and Wrench, the setting and the economic necessities the shaped their collaboration in the pursuit of drawn-sound.

The exhibition of the Oramics Machine at the Science Museum stages drawn-sound in a way that, I suggest, makes experimental particular styles of practice that are conventionally considered proper to science and technology. Drawn-sound is presented in the display of the Oramics Machine as a multivalent invention: it was a composition technique which Oram sought to realise, an electro-mechanical design of the Oramics Machine, and a concept within a broader philosophy about the 'vibrational universe' outlined in Oram's (1972) only published book *An Individual Note of Music, Sound and Electronics*. By looking at the experimental display of drawn-sound I suggest we can elaborate further ways in which the exhibition of the Oramics Machine can be said to be an experiment in relations between science and culture.

¹²⁶On the influence of Wrench's background in the British airforce see Marshall (2009) and Manning (2012). The notion that sound technologies are shaped by earlier advances in the military existence of modern societies was perhaps most forcefully argued by Kittler (1999), who advanced a kind of military-technological determinism in his discussion sound media. That the Oramics Machine was developed by Oram in collaboration with an airforce engineer repurposing radar technology could very easily be interpreted as further conformation of Kittler's thesis. However, in this chapter I argue that such determinism would leave us poorly equipped to account for the Oramics Machine as an experiment of the home-studio, since we would have already determined that its inventiveness lies in technology. By contrast, in this chapter I argue that once we consider the home-studio as a domestic experiment then the question of technical practice is no longer easily separable from the other modes of practice that we find there. In this sense, the juxtaposition of Wrench's military background with Oram's imaginative compositional background marks the particularity of the Oramics Machine as an artefact that mediates not only between different practices but also between different biographies.

¹²⁷See video of the sonic artist receiving the Oramics Machine as it is delivered to the UK from France: <http://vimeo.com/21310959> (accessed 20 September 2014)

At its opening, the exhibition of the Oramics Machine included a recent copy of *Wire* magazine, open at the pages where a feature article describes Daphne Oram's work with "drawn-sound". The article, titled 'The Woman From New Atlantis' (Wilson, 2011), describes at length Oram's philosophy of drawn-sound (the title of the article reflecting Oram's fascination with Bacon's description of the sound-house), its abstract summarising the piece:

"Best known for her co-founding of the Radiophonic Workshop, Daphne Oram was more than just a pioneer of electronic music. Developed in the 1960s her Oramics machine and drawn-sound technique were components in a radical holistic philosophy that synthesized multiple strands of New Age thought in an attempt to unlock the mysteries of the vibrational universe." (29)

The article outlines Oram's interest in spiritualism from an early age and its application in the drawn-sound techniques Oram developed for the Oramics Machine. The article also discusses at length the forms of New Age thought that later culminated in the publication of *An Individual Note* (Oram, 1972). Both the *Wire* article and *An Individual Note* suggest that the drawn wave forms are central to understanding Oram's aspirations for the Oramics Machine. Drawn sound was not simply a subjective preference that informed the machine's electro-mechanical design or the development of a new compositional technique, although it was also these, but in these publications the concerns of machine design and composition technique are synthesised in Oram's own idiosyncratic philosophy which sought to reconfigure the relations between musicians and machines. In these texts Oram attributes particular significance to particular shapes suggesting that drawn-sound is far from an arbitrary aesthetic preferences¹²⁸. Indeed, we see this further in the gallery's cinema where a film of the Oramics Machine by the artist Aura Satz was accompanied by Oram reading from *An Individual Note*:

"We're going to enter a strange world and we're going to find composers will be mingling with capacitors, transistors are going to be transmuting triplets, and, perchance, metaphysics may creep in, to mate memory, music and magnetism in some strange sort of eternal triangle."

¹²⁸See discussion of "CELE" and "ELEC" shapes in both the *Wire* article and Oram's book

As Satz's camera moves over the body of the Oramics Machine, Oram describes drawn-sound in relation to the concerns of electronics, music, metaphysics and human psychology, which are entangled within Oram's idiosyncratic "Oramics" philosophy¹²⁹.



Daphne Oram's drawn wave forms, displayed in the Science Museum

In the gallery information, the Oramics Machine is described as a “mechanical system”¹³⁰ built in the 1960s which Oram later abandoned in the 1980s in order to develop the system on an Apple II computer¹³¹. Mechanical philosophies,

¹²⁹The hybridity of these different concerns about sound are discussed at length in *An Individual Note* which provides an account of what Oram calls the “Oramics philosophy”. Like texts written by other experimental composers of the mid-twentieth century (such as John Cage and Pauline Oliveros), *An Individual Note* is a highly eclectic and idiosyncratic mixture of influences: combining, amongst other things, contemporary music criticism, didactic explanation of electronics theory and musical theory, and a highly idiosyncratic metaphysics that draws on sources from Western classical tradition (Greek myth, Latin etymology) and Eastern spiritualism (ancient Chinese symbolism, for example). By synthesising all of these aspects into a coherent philosophy is Oram created the blue-print for a “machine-with-humanising-factors” that could enhance, rather than diminish, the composer’s individuality (for broader discussion of the text’s cultural relevance see Henriques, 2010). *An Individual Note* is structured in such a way that the Oramics Machine is presented as though derived from these problematics (although it was published considerably later than the Machine was built), the text specifically emphasises the importance of its graphical control system in maintaining the composer’s control over all parameters of the sound produced by the Machine. Oram’s sonic experiments with electronic music thus entailed a particular approach to technology, locating its central concern in the relation of the human composer to the machine.

¹³⁰This is the phrase used in the gallery’s Computer Information Point positioned in front of the Oramics Machine.

¹³¹The idea that the Oramics Machine was a forerunner of computational developments in electronic music was a common view among some of those working at the Daphne Oram Trust who worked with the Science Museum to create the display.

which have occupied a central position in the knowledges and practices of modern science and technology (see Shapin, 1998; Whitehead, 1926)¹³², offer accounts of the materiality of experimental machines as aggregates of their component parts. As we saw in Chapters One and Two, machine displays in science and technology exhibitions have often emphasised the need for rational understanding of mechanical components, often established in direct contrast to the aesthetic appreciation of an object. A mechanical explanation of the Oramics Machine's drawn sound would relegate the status of Oram's drawn shapes to an arbitrary aesthetic preference i.e. that the Oramics Machine's drawn sound can be reductively explained simply by looking at the mechanics of the object. However, in the gallery displays of *Oramics*, the Oramics machine's electro-mechanical functioning does not appear reductively explained but rather staged as one mediation of drawn-sound. It is a display in which the aesthetics and mechanics of drawn-sound are not easily separable. In the Science Museum, this staging of the Oramics Machine as a “mechanical system” is distinctly heterodox in comparison with many other exhibitions of mechanical science and technology¹³³. In *Oramics*, the concerns of electro-mechanical design are staged in hybrid relations with a range of concerns to which they are typically antithetical. The staging of the Oramics Machine suggests that, far from being an arbitrary aesthetic preference, drawn sound is a significant factor in accounting for what was inventive about the Oramics Machine, as a machine.

On the wall of the case housing the Oramics Machine displays the quotation from Bacon's *New Atlantis* described as “Oram's favourite passage”. The quotation describes “Sound-houses” where sonic experiments take place:

“Wee have also Sound-houses, wher wee practise and demonstrate all sounds and their Generation. Wee have harmonies and lesser slides of sounds. Wee make diverse tremblings and Warblings of Sounds [...] Wee have also diver Strange and Artificall Eccho's. We have also means to convey Sounds in Trunks and Pipes, in strange Lines and Distances.”

The passage of Bacon's text was pinned to the wall of the BBC Radiophonic

¹³²Of course, the Oramics Machine was an electronic device, but the analogy with mechanical philosophy – as a philosophy that seeks to explaining the functioning of a system as an aggregate of its smaller elemental parts – still holds as the philosophy informing its display.

¹³³See, for instance, Chapter One's description of the presentation of steam engines in the Science Museum's *Energy Hall*

Workshop by Daphne Oram: several accounts suggest that the text embodied Oram's aspirations for the Radiophonic Workshop, which she later sought to realise in the Oramics Studio and in the invention of the Oramics Machine (see Niebur, 2010). The sound-house, described by Bacon, is a space in which the experimenter can “practise and demonstrate all sounds”; the quotation describes a space that is specifically organised for sound experiments¹³⁴. Though Bacon is widely recognised as a pioneer of experimental natural philosophy, the display of the *New Atlantis* here is also a display of Oram's subjectivity, sonic imagination and biography¹³⁵.

¹³⁴In Bacon's *New Atlantis*, the sound-house is just one space of experimentation among others and in this sense the quotation above can be situated within a broader account of a civilization organised around the practices of experimental science. The *New Atlantis* is a novel that describes the discovery of a remote island civilization called Bensalem by a European ship voyaging in the Pacific Ocean. The central institution of organisation described in the book is “Soloman's House” and which is ordered by intellectual specialisation to serve the interests of its imperial rulers. Shapin (1998) locates the *New Atlantis* at the intersection of Bacon's natural and political philosophies; as well as being a natural philosopher Bacon was also a highly successful politician at the turn of 17th century England, serving as both Attorney General and Lord Chancellor. Shapin argues that the *New Atlantis* makes the link between Bacon's natural and political philosophies: the symbiosis of knowledge and political order depicted in the *New Atlantis* is the utopian imagination on which the institutions of modern science are founded. Solomon's House in the *New Atlantis*, Shapin suggests, provides a “blue print for the formal organization of scientific and technical research in 17th England” (Shapin, 1998: 68); it is a model of coordinated specialisation that anticipated the bureaucratic arrangement of science within the modern state. The quotation about the “sound-houses” can, according to Shapin, be situated more broadly within Bacon's utopian imagination of a society in which scientific research is politically co-ordinated through bureaucratic structures. In the utopian unity of Bacon's respective natural and political philosophies knowledge and order enacted a symbiotic and mutually reproductive relationship. Though the display of the quotation from the *New Atlantis* appears in one sense as a display of Oram's personal influences, although clearly not a claim that Oram was in any way advancing a Baconian agenda, the display nonetheless makes clear that both Oram and Bacon found sound significant as a media of experimentation.

¹³⁵See also Boon's blog about the Bacon quotation on the Science Museum's website here: <http://blog.sciencemuseum.org.uk/collections/2011/03/25/we-have-also-sound-houses/> (accessed 10 May 2013)



Publicity image for the Oramics exhibition, courtesy of the Daphne Oram Trust.

In the gallery displays, Oram's drawn-sound technique is presented as a form of “programming” staging the Oramics Machine as an early computing instrument. In the gallery information, for instance, we are told that the display of the Machine was “co-curated” with computer scientists from Goldsmiths. And yet, in the Science Museum the Oramics Machine appears a distinctly heterodox computing instrument. The publicity image¹³⁶ for the exhibition shows Oram programming the Oramics Machine by drawing onto the 35mm film strips that run across it. The programmer is the most iconic of the two main components of the Oramics Machine, the other being the wave scanners (discussed above)¹³⁷. The programmer, the text tells us, controlled the pitch of the sound, the volume and the application of vibrato to the sound. The text describes a binary system on the Oramics Machine's programmer through which Oram could very precisely specify the pitch of the sound. However, there are notably no images displayed in the gallery of Oram doing this kind of precise binary programming. Instead, and in contrast to the dominant image of machine programming associated with the submission of the programmer to the machine, in the gallery's images Oram's programming is presented as a form of drawing. Oram does not sit to programme but rather stands over the Oramics Machine. It is an image of programming that emphasises the

¹³⁶Publicity as a concern with the spread of ideas and information that has been highly influential in Western notions of political action, and in this respect the image of Oram and the Oramics Machine is highly significant.

¹³⁷The difference between the programmer and the wave-scanning components of the Oramics Machine was often characterised by Museum curators and researchers as the difference between the white and black keys on a keyboard synthesiser (the programmer) and the pre-set buttons (the wave-scanners) that change the sound from, for example, a horn to a violin.

movement of the programmer's body and aesthetic form which contrasts strongly with the conventional displays of machine programming that appear in the Science Museum's computing gallery. The male programmers displayed in the computing gallery appear seated or in another position in which they are physically subordinated by the enormous early computing machines such as ERNIE¹³⁸ with which they work. Women appear in the gallery's images of programming, predominantly working in punch card offices. In a particularly striking image, a woman sits punching cards in the foreground while a man at the back of the room stands to stare intently at the switches and lights on the machine. In contrast to the displays of the computing gallery that present programming as a practice of submitting to the machine's demands for order and discipline, Oram's programming appears a form of compositional liberation in which human gesture and aesthetic intuition are used to discipline and control the Oramics Machine. The display of Oram's approach to programming is not, as we might consider it today, principally a cognitive or linguistic practice but rather an embodied material practice that is aesthetically intuitive. The staging of Oram's drawn-sound technique as "programming" thus allows us to appreciate a broad range of concerns that are left out of singularly mechanical explanations of programming. It is a display that does not explain drawn-sound as "programming" – that is, programming is not simply a technique of electro-mechanical control – but rather allows us to appreciate programming as a multivalent practice that is historically situated, gendered and embodied.

By focusing on both Oram's experiments with drawn-sound and the experimental display of the Oramics Machine in the Science Museum gallery, I suggest, we gain an appreciation of the ways in which electronic music inventions can be said to be experimental in terms of the relations between science and culture. By describing some of the mediations of drawn-sound we see how musical, electro-mechanical and programming practices appear difficult to disentangle from the setting of invention at Tower Folly, Oram and Wrench's biographies, Oram's philosophical writings, and the display of machines in science exhibitions. In the exhibition of Oram's drawn-sound experiments, conventionally technical styles of practice such as electro-mechanics are "co-articulated" with a range of other concerns (Marres, 2011) which include musical composition, philosophy and human-machine interaction. In the displays of the Oramics Machine we find that music, electronic engineering and programming appear much less easy to

¹³⁸Information about ERNIE can be found at the Science Museum's object-wiki: http://objectwiki.sciencemuseum.org.uk/wiki/ERNIE_1 (accessed 02 August 2013)

disentangle than technical pedagogy and aesthetics have often suggested they are. In the exhibition of the Oramics Machine in the Science Museum we see the work of mediation: the struggles, frustrations and DIY approach of Oram and Wrench over many years and the collaborative work of computers scientists and curators in staging the Machine in the Science Museum. In short, we see some of the very different ways in which relations between technical and musical practices were mediated in Oram's invention of drawn-sound.

Objectifying culture? An auditory critique of sonic mediation

It might be objected that by foregrounding the material mediation in the above account of Oram's "drawn-sound" experiments that I've paid little attention to drawn-sound as auditory experience. This is to some extent true, and it is not the intention of this chapter to present an account of sound as media without listening. But it is nonetheless true that in treating sound as materially mediated we risk overlooking the fact that most cultural appreciations of sound are experiential. Critics might argue that sound is material in its production but becomes culturally significant when it is consumed as auditory experience. At worst, it might be argued that focusing on the material mediation of sound 'objectifies' sound as a technological form; extending and legitimating the domination of culture by science and technology. Certainly it is true that in the social sciences and humanities there are many approaches to the study of sound that are concerned principally with auditory experience, foregrounding the ear and practices of listening as the means to apprehend sound. Examples of such approaches include auditory culture (Bull and Back, 2003), anthropology of the senses (Ingold, 2000), soundscape studies (Thompson, 2004), and music criticism (Toop, 2001). In approaches centring on auditory experience, the study of sound is concerned with the particular ways in which we come to know and interact with the world. What might be loosely called 'audition-centric' approaches – that is, approaches whose principal concern is with the auditory perception and experience of sound – are concerned with different modes of sense perception, the various social meanings of sounds, and the ways in which sonic phenomena are used by different actors to achieve political ends. From the perspective of these cultural approaches to sound, it might be argued that by failing to foreground the lived experiences of

sound the materially mediated account gives an inadequate account of sound as a cultural phenomenon. By 'objectifying' sound in particular material mediations, this critique suggests that sonic culture is here reduced to a technological issue.

Social theories including critical theory, cultural studies and public understanding of science (PUS) have widely highlighted the risks of the 'objectification of culture' by science. I focus here on PUS because it arguably the most empirically significant in the context of the Science Museum (in the sense that it informs the categories and narrative of the curators, see Chapter Two's discussion). In PUS models, culture forms the context into which experimental inventions produced by science are introduced¹³⁹. To avoid the objectifying and dominating culture, PUS researchers argue that we need to correct our understandings of the relations between science and culture. One model of these relations that has been particularly influential for experimental sound exhibitions is "interactivity", as described by Andrew Barry. As discussed in Chapter Two's literature review, Barry's (1998) account of the Science Museum's *LaunchPad* exhibition, the 'hands-on' children's exhibition developed in the 1980s, argues that the experimental interactive exhibition created particular kinds of relations between science, technology and culture. Though the visitor's free experimentation with their "untutored body" enacts a spectacle of the active and self-governing citizen – an act that embodies liberal ideas of progressive enlightenment and the realisation of individual autonomy through participation – the interactive exhibition in fact serves as a vehicle for the diffusion of science. For Barry, the interactive exhibition helps 'solve' the problem of population governance in advanced technological societies. Indeed, in the contemporary *LaunchPad* gallery we find several 'sound' exhibits that aim to teach children about physical principles through interactive engagement. Exhibits in *LaunchPad* such as the "Vibration Station"¹⁴⁰ and "Sound Patterns"¹⁴¹ use sound as a medium for this particular didactic form of interactivity. In interaction with these *LaunchPad* exhibits the materiality of sound is made knowable to visitors haptically as vibrations; sound in these

139 See discussion in Chapter Two's literature review. In critical PUS accounts like Wynne's (1992b) study of the Lake District sheep farmers, we see how undervaluing the cultural context of technical practices and the lived experience of the individuals they concern risks undemocratic and technological domination of lay cultures.

140 Further information about the Vibration Station can be found at:

http://www.sciencemuseum.org.uk/objects/interactives/launchpad/vibration_station.aspx
(accessed 9th September 2013)

141 Further information about Sound Patterns can be found at:

http://www.sciencemuseum.org.uk/objects/interactives/launchpad/sound_patterns.aspx
(accessed 9th September 2013)

exhibits is reduced to a basic physics and knowledge is transmitted through individual sensation and cognition¹⁴². Following Barry's account, we can see how in exhibitions like *LaunchPad*, sound is used instrumentally to enable interaction between science and culture.

In the interactive PUS-inflected model of the experimental sound exhibition, the individual's experience of sound is largely unmediated by objects; it is first and foremost auditory or haptic. In the PUS models there is implied, then, a distinction between the 'objective' production of sound and the 'object-less' auditory perception of the consuming listener. In PUS models, sound is valued principally for its capacity to affect individuals experientially; it is what might be described as a "diffusion model" of sound¹⁴³. MacDonald's (2002) study of an experimental PUS exhibition in the late-1980s, for instance, notes how Jean-Michel Jarre's electronic music was pumped through the Science Museum, conveying "a sense of the dramatic mystery of science" (45). In MacDonald's account, Jarre's music is used instrumentally by the Science Museum for its capacities for affect and assemble a public of consumers for science. Indeed, as Supper (2014) discusses, practices of "sonification" have often been used for the public understanding of science; the experimental sound display, Supper suggests, has the power to grip the public with the promise of "sublime" experience. In PUS approaches, then, the cultural account of sound focuses on the affects of the public's auditory experiences and how this facilitates particular kinds of interaction with science. From the perspective of these interactive models, the focus on the material mediations of sound appears to unnecessarily diminish the centrality of auditory perception in sonic culture and, in doing so, risks 'switching sides' and participating in the 'objectification' of sound, and the domination of culture by science. In the PUS models, paying attention to the role of auditory perception in exhibitions enables us to give an account of the ways in which interactive relations between science and the public as also interactions between science and culture.

In contrast to the material complexity of approaches to mediated sound, described above, the PUS model of interactive sound offers us a 'dualist' account of sound which can be both produced objectively and consumed

¹⁴²Though the *LaunchPad* installations are haptic rather than audio installations, they nonetheless fall within the auditory culture model which privileges sensation as the locus through which sound is known.

¹⁴³See discussion of the "diffusion model" in Chapter Two.

subjectively. In this dualist account, I suggest, we find that audio installations in exhibitions 'sound twice': aural sound is translated into two registers of perception that I will call here the 'idealist aesthetic' register, sound as genres of music, and the 'reductive materialist' register, which rationally understands the material properties of sound as vibration physics¹⁴⁴. In both the 'idealist aesthetic' and the 'reductive materialist' versions, sound is a neutral medium through which music and physics are perceived interactively by the public. Though they are related through sound, the purity of the concerns of music and physics are at the same time maintained in public understanding of science exhibitions as entirely separate and distinct. These two accounts of sound are not mutually exclusive but rather can be seen as the complementary sides of the philosophies of mechanics and aesthetics that we find in accounts of modern science (see, for example, Shapin, 1998; Whitehead, 1926): music can be subjectively appreciated as aesthetic sound and objectively explained as physical principle without implying a necessary contradiction. In public understanding of science exhibitions which use audio sound, the public is able to interact with music and physics without the mediation of objects. Displays of music may not teach the public anything about science but they have the capacity to affect the public aesthetically and therefore to assemble a public to which science can be demonstrated as complete, accountable and applicable. We might summarise the PUS model of sound in the following four related ways: (1) in PUS sound is an instrument of science communication and engagement, (2) sound is valued for being 'object-less', (3) PUS holds a dualist model of sound as comprising both 'idealist aesthetic' and 'reductive materialist' components, and (4) the experimental sound exhibition facilitates interaction between science and culture. In PUS models, then, the auditory perception of sound in public is valued as an instrument through which to accomplish experimental interaction between science and culture.

Indeed, we can further specify this PUS model of the experimental sound exhibition by looking at an empirical example of an interactive music exhibition that was held in the Science Museum during the period of my research called *Universe of Sound*. The exhibition comprised a vast interactive installation, spread across a number of gallery spaces, of a virtual Philharmonia Orchestra playing Gustav Holst's 'The Planets'. The *Universe of Sound* was an exhibition that contained precisely no objects from the Science Museum's collections but

¹⁴⁴I use the term "physics" here in the sense used by the philosopher Isabelle Stengers (1997) to refer to the concern for "fundamental laws" of reality rather than the "merely phenomenological" domain of appearances.

was an exhibition that was highly conspicuous in its deployment of cutting edge interactive technologies. The press release for the exhibition describes how the technological design of the exhibition attempts to give visitors the experience of being part of a symphony orchestra:

“Using giant screens, unconventional projecting surfaces, touch screens, movement-based interaction and planetarium-style projection, visitors can step inside the heart of a symphony orchestra taking on the role of a musician, conductor or even a composer.”¹⁴⁵

Through the use of cutting edge interactive technology, the *Universe of Sound* exhibition facilitates the immersion of the visitor in the experience of the symphony orchestra. In interaction, the individual is facilitated to adopt a range of “roles” within the symphony orchestra. Unlike the media-specific approach, describe above, the interactive approach locates the multiplicity of sound not in its materiality but in the individual's experience of it. In *Universe of Sound* the flexible individual is able to experience the plural practices through which the sound of the symphony orchestra is produced. In this sense, the materiality of sound is limited to one side of the production and consumption divide; the interactive experience of sound is not mediated by objects but is 'object-less'. Indeed, a version of the dualistic account of sound described above is given in the press-release for *Universe of Sound*, in which the Science Museum's director Ian Blatchford enthuses about music as an ideal:

“Music conquers all the boundaries between art, science, technology and medicine and this incredibly imaginative project will surprise and delight our audience.”

Music, in Blatchford's statement, is not reducible to the bounded spheres of art, science, technology or medicine. The experience of being moved, or affected, by music is to be 'surprised and 'delighted'; distinctly mental forms of affect in contrast to the spectacle of bodily movement with which interaction presents us. The individual experimenter's body interacting with the exhibition's advanced technological displays produces sound for the mind to appreciate. Approaching the experimental sound exhibition through the lens of PUS models of the interactive exhibition, we can see how *Universe of Sound* can be

¹⁴⁵See press release for *Universe of Sound* at: http://www.sciencemuseum.org.uk/about_us/press_and_media/press_releases/2012/05/Universe%20of%20Sound.aspx (accessed 12th September 2013)

said to enact the divide in which material interaction is put in the service of intellectual and aesthetic diffusion; and in this sense reminiscent of Barry's observations about the way in which the interactive exhibition participates in 'solving' the democratic issues of science and technology. The *Universe of Sound* doesn't simply bring visitors to the Science Museum to appreciate Holst's "Planets" but also to marvel at the technological infrastructure (the applied science) facilitating their interactivity. In the PUS model of the experimental sound exhibition, then, we gain an understanding of the way in which sound is used instrumentally to facilitate particular modes of interaction between science and the public, and in this way, it is suggested, we avoid the trap of 'objectifying' sound and simply extending the domination of culture.

The PUS models therefore offer an account of how the experimental sound exhibition facilitates interaction between science and culture. The interactive model shows how experimental sound can be used instrumentally to affect and assemble the public in relations with science. Through auditory sound, the individual is facilitated to experimentally interact with science, which can demonstrate their accountability and social utility. The model of interactive sound, however, only works if the auditory perception of sound is accounted for as distinct from the concerns of the material production of sound. In the PUS model, materiality is a concern with the production of sound, and for this reason the concerns of the media-specificity of sound alone fails to account for the ways in which sound creates interactive relations between science and culture. To be concerned with the materiality of sound alone, the PUS models suggest, is to risk 'objectifying' sound and participating in the technological domination of culture. Auditory perception, the consumption of sound, is therefore central to the interactive model of the experimental sound exhibition. Foregrounding the auditory experience of sound, its 'object-less' consumption, the experimental sound exhibition 'solves' the problem of the separation of science and culture by constructing a socio-technical interaction in which information can be exchanged between these domains.

Mediated and interactive sound in exhibition

When applied to *Oramics*, the PUS models of the interactive sound exhibition seem to offer only a very limited account of the exhibition. There are only a couple of audio installations in the *Oramics* gallery displays that might be said to conform to the PUS model of auditory interaction. Displayed next to the *Oramics* Machine's case is a sign explaining why the *Oramics* Machine itself will never work (discussed in Chapter One) but telling visitors that they can nonetheless 'experience' the Machine via an interactive emulator that permits individual experiments with a touch-screen, a computer that simulates the drawn-sound of the *Oramics* Machine; visitors are facilitated to create their own "drawn-sound" by touching the screen and to hear the experimental audio resulting through headphones attached. Elsewhere in the gallery, an audio installation plays a composition Oram produced on the *Oramics* Machine. Titled "introduction", the composition plays on loop from speakers on the Machine's case; the audio animating the object and enabling visitors to aurally engage with the Machine that is otherwise separated from them by a glass case. From the perspective of a PUS model we can see how in both of these audio installations in the *Oramics* gallery, sound is diffused from the *Oramics* Machine to the visitor, facilitating the unmediated interaction between science and culture. However, the interactive account of the experimental sound exhibition appears limited in the case of *Oramics* because it decouples notions of sonic experimentation from materiality. In other words, as long as experimental sound is only an auditory phenomenon then the interactive model of the exhibition effectively excludes all material mediations of sound from its account of sonic experiment. In what follows, I'm going to argue that audition-centric accounts of the experimental sound exhibition, like interactive PUS models, risk "black-boxing" the materiality of sound and in doing so limit the account of the electronic music experiment that we find in *Oramics*.

I want to begin by separating out the concepts of "mediation" and "interaction" as offering two very different accounts of the relations between science and culture, and also as suggesting contrasting accounts of both experimental sound and experimental exhibition. I'm going to argue that the model of experimental interaction offers only a very limited account of how relations are made between science and culture, and risks 'black-boxing' the multiplicity of actors, practices and settings that participate in electronic music experiments. To draw out this distinction between the interactive experiment and the mediated experiment it's useful to turn to a contrast made in actor-network theory (ANT) between two genres of actor: "mediators" and "intermediaries"

(Latour, 1993a). ANT describes experimental actors as mediators that transform, distort and modify settings and technologies in the process of creating relations with other actors. The work of experimental action in ANT is the work of mediating an object (see discussion in Chapters Two and Three). In contrast, intermediaries present themselves as neutral or at least unremarkable transporters of objects, or information, unchanged from one group to another; intermediaries may claim neutrality with respect to the different actors participating in an experiment. However, in ANT there is no such thing as a neutral actor because all action is a work of mediating the interests of other actors. ANT argues therefore that the distinction between mediators and intermediaries is not a distinction between two different types of actors but rather between actors and 'false' actors. On one hand, if those claiming to be intermediaries are de facto actors, then they are mediators and the claim to being an intermediary is simply a disguise: these intermediaries are particular kinds of mediators the actions of which are “black-boxed” and this way the work of translation that takes place in mediation is rendered invisible. On the other hand, if intermediaries really are neutral with respect to action – if they really don't translate or mediate an object – then they are not actors at all. In interactive experiments the experimental apparatus is proposed as a mere intermediary through which interaction between science, technology and culture occurs. By focusing on the individual body as the site of experimental interaction, the material apparatus of the interactive exhibition is rendered neutral with respect to the experiment. However, from the perspective of ANT, such a sharp distinction between the experimental apparatus and the experimental interaction it affords is a false distinction. In ANT, then, the interactive experiment's claims to be neutral with respect the experimental interactions between science, technology and culture is more obviously an apparatus that “black-boxes” the a more expansive account of experimental action. On the basis of this distinction in ANT, I suggest, we can describe the ways in which the focus on auditory experience in interactive sound exhibitions “black-boxes” the experimental mediations of sound.

An empirical description of an experimental sound-art exhibition can help make clear the different accounts of the experiment that we find in media-specific and auditory-centric approaches. Called *Sho-zyg*¹⁴⁶, the exhibition took place a

¹⁴⁶The exhibition's title *Sho-zyg* is a name derived from a family of instruments invented by the composer Hugh Davies, who founded the Goldsmiths electronic music studio in 1967. The shozyg instruments invented by Davies comprised found scrap metal and were built inside “unusual containers”. As a musical instrument, the significance of the shozyg is principally derived from its materials and the practices of its construction rather than its auditory distinctiveness; and in this sense, it underlines the limitations of audition-centric

year after the opening of *Oramics*. Principally an exhibition of experimental sound art created by researchers at Goldsmiths, University of London, the exhibition also featured displays about Daphne Oram curated by researchers from the Daphne Oram archive. The principal format of display in the exhibition were installation pieces in which audio played from loud-speakers. The gallery displays of *Sho-zyg* present a highly varied presentation of experimental sound works including, for example, audio-visual installations using screens and computers, multi-channel compositions with multiple speakers arranged in particular spatial configurations, and installations that use specific media such as radio. *Sho-zyg* is an experimental sound exhibition that stages the 'artifices' of sound art; in the exhibition we find sound mediated in many very different ways involving many different kinds of materials, techniques and knowledges. This is particularly evident, I suggest, in the displays about Daphne Oram which illustrate the varied forms of labour required of the producer of experimental sound. In *Sho-zyg* the material production of sound is not an ontologically separate concern to the public consumption and interaction with sound.

From audition-centric perspectives, *Sho-zyg* and *Oramics* appear very different as experimental exhibitions. *Sho-zyg* featured the works of over 50 artists and held live performances, lectures and discussions every evening that it was on. Indeed, the curators' introduction to the exhibition makes clear the centrality of audition, and sensory experience of visitors, to the experimental exhibition:

“Experimental sound practice and sound art are comparatively new and thriving fields, operating within a historically visually dominated art world. It is our hope that through this showcase we can allow the audience a space to listen: a platform for auditory exploration and new aesthetic experiences”

The aural experiences of visitors to *Sho-zyg* are, its curators suggest, integral to this experimental sound exhibition. As an auditory display, the exhibition aims to enable audiences to have “exploratory” and “new aesthetic” experiences. Through listening practices, the curators aim to facilitate new forms of interaction with visitors to the exhibition. In common with auditory culture approaches, the curators emphasise the importance of auditory interaction in experimental sound exhibition. And yet, though there are many

accounts of experimental sound practice. Further information about the exhibition can be found at: <http://sho-zyg.com/> (accessed 19th February 2014)

more and varied audio displays in *Sho-zyg* than there are in *Oramics*, the exhibitions are in other ways very similar as displays of experimental sound.

The curatorial organisation of the gallery space in *Sho-zyg* is designed to reflect broad differences in experimental practice: for example, the gallery has separate rooms for audio-visual compositions, soundscape works, and disklavier performances. In this sense, the staging of the exhibition is designed to draw attention to the differences in the materials and techniques used, the spatial arrangements in the galleries and the technologies are used to amplify the audio the installations. It is a display of experimental sound art that emphasises artifice. Indeed, we see this most clearly in cases where this curatorial logic is subverted. One installation called Technotronic¹⁴⁷ appears to ironically subvert the practical rather than auditory focus of *Sho-zyg's* curators, a curatorial logic which is in many ways typical of experimental sound art exhibitions more generally. Technotronic is an installation comprised of a small box with one speaker and two LEDs, and is displayed, spotlit, at the end of an entirely empty, blacked out, room with no textual information¹⁴⁸. Rhythmic sounds are made by the box, to which the LEDs flash in sync, but the practical process – the digital and analogue electronics mediating the rhythmic sound – through which the audio is produced is rendered opaque. Indeed, the presentation of Technotronic appears to omit almost everything that would be extra-sensorial in audition-centric models and in this sense might, ironically, be described as an attempt to contrive a purely interactive display. In its opaque staging, Technotronic is a work of art that is effectively black-boxed (ironically, perhaps, the box is painted white). The minimal staging of Technotronic, I suggest, draws our attention to all of the material complexity that has to be removed, or black-boxed, in order to contrive a purely auditory or sensation-centric account of interaction with experimental sound art.

The dualist account of sound in PUS models of experimental sound sets up an ontological divide between the producer and the consumer of audio. An alternative account of the interconnections between producer and consumer of audio is given by Hennion (1989) who has described the experimental music producer as a networker who translates between the interests of the different

147Technotronic was built by the sonic artist Tom Richards. The name references the 1980s house-music act whose famous chart hit was the track "Pump up the Jam". A demonstration of Richard's Technotronic installation can be found at: <http://vimeo.com/61549256> (accessed 11th February 2014)

148The exhibition's programme offers a minimal description of Technotronic: "Electronic sound sculpture. Pre-fabricated electronics with hand made analogue and digital electronics".

groups concerned by a musical-auditory object, the process of which creates a consuming public for the music. As Hennion points out, at no point in the cycle of musical production is there a moment when the producer abandons all techniques and releases their audio to a public of consumers. Rather, producer and consumer of music are linked through many intermediaries who are enrolled in the music studio: the studio, Hennion argues, is a laboratory for the production of cultural objects. We can apply Hennion's description to *Sho-zyg's* displays of materials from the Daphne Oram archive at Goldsmiths. The archival displays are principally texts written by Oram (there are also two audio installations that present some of Oram's recently digitized compositions) mostly in the form of letters and correspondence; the exhibition is a display that stages Oram's personality and private life. The exhibition puts on display documents detailing the composers Oram corresponded with about her work, the grants she applied for to fund the development of the Oramics Machine, the plans and the logs of errors generated while working on the Machine, and the notes and drafts that informed her published work *An Individual Note*. In their introduction the curators describe the scope of the display:

“The selected documents chronicle Oram's definitive public performances, and also illustrate some of her technical, aesthetic and interpersonal trials and tribulations; how she evaluated competitors, dealt with technical problems and kept her research going with an unpredictable and modest income”

The displays about Oram foreground the private (domestic¹⁴⁹) labour involved in supporting the experimental sound production that took place in Oram's studio in the converted oast house, Tower Folly, where she also lived. The emphasis of the display, the curators make clear, is both an account of Oram's public successes but also a 'behind the scenes' look into the troubles and uncertainties with which an experimental sound producer contends. In this respect, Oram's public recognition as an experimental sound producer is staged, in this display, as an accomplishment that entailed many different and varied forms of labour. The art of the experimental sound producer is, in the Daphne Oram displays, shown to incorporate the coordination of many different spheres of activity and to mediate between competing concerns. As the displays of the “trials and tribulations” experienced by Oram demonstrate, like the scientist in the laboratory, the experimental sound producer's attempts to isolate and manipulate aspects of the auditory world in their studio are

¹⁴⁹For the discussion of the relation between Oram's work and domesticity see Chapter Five.

highly contingent and often unsuccessful. Like the laboratory scientist, the producer is an inventor who mobilises heterogeneous networks in order to domesticate their invention in the common world. Oram's public success was not realised simply by releasing audio into the world hoping that it would be received by listening consumers, but rather, as the displays show, was accomplished through attempts (not always very successful) to enrol the allies needed to demonstrate her work in public.

The *Sho-zyg* displays of Oram's "trials and tribulations" make clear, then, that we cannot adequately account for the sound experiments that took place in Oram's Tower Folly studio only through auditory engagement or simply by through formalist descriptions of her inventions, like the Oramics Machine. The interactive model of the experimental sound exhibition can only offer an account of the displays from Oram's archive as 'extra-auditory' content. But as extra-auditory content, the displays of Oram's archive are reduced to little more than a 'historical context' in which to situate the contemporary sound displays; they might aid the visitor's auditory appreciation of contemporary sound works but formulated as extra-auditory exhibition content, the archival displays are discontinuous with the experimental sound practice showcased in the installations. There are two problems that arise from such discontinuity. First, in the black-boxing of the artifice of sound production, experimental practice becomes centred on the consuming public ear as the locus of invention. Second, audition-centric approaches leave us unable to account for developments in the experimental practices of sound, which include the rise of curating and archival research as thriving practices within the field of sound art. The interactive model of the experimental sound exhibition therefore not only places considerable conditions on what can be considered to participate in the sound experiment (those things that are aurally perceived), but on its own gives only a very limited account of those practices for which sound is an object.

This brief excursion to *Sho-zyg*, I suggest, illustrates what we gain from media-specific approaches to the sound experiment and the limitations of audition-centric approaches. Media-specific approaches give us an account of the material complexity of experimental sound; the very different actors, practices and settings that participate in the electronic music experiment. Media-specific accounts enable us to appreciate that the relations between the participants in the experiment are 'mediated'; that is, they are relations that are reordered

through processes of material modification or translation. In the media-specific approach, the curated displays of Oram's archive are equally modes of experimental sound practice alongside soundscape composition, computing, electronics, video and so on. Indeed, as the displays of Oram's archive make clear, the media-specific approach enables us to appreciate the work of the experimental sound producer not as an actor radically divorced from consumers (as in interactive models) but rather as an actor who in the work of sound production has to experimentally to create relations with other very different actors in order to interest and enrol them. As the displays of the Oram's archive make clear, Oram often struggled to enrol even those who should have been close allies. All of the material complexity of sound, just described, risks being black-boxed and excluded from the experiment in audition-centric approaches. In audition-centric approaches to the experimental sound exhibition, the consumer of audio is the experimental subject. In this sense, auditory approaches alone risk assuming sound as unmediated, 'object-less', leaving its materiality demarcated as the concern of technical production. Audition without mediation demarcates sound as an aesthetic concern while mediation with audition demarcates sound as a technical concern. If experimental sound exhibitions are both interactive and heavily mediated displays then in order to appreciate sound as an experimental medium we cannot simply demarcate as separate the aesthetics and technologies of sound.

Conclusion

In this chapter I have explored some of the ways in which electronic music experiments can be said to mediate relations between musical and electro-mechanical practices. In the analysis, I have foregrounded the collaboration between Daphne Oram and Graham Wrench in attempting to pursue the former's aim to compose using graphical techniques, "drawn-sound". In the Oramics Machine, the vehicle through which Oram attempted to create "drawn-sound", I have suggested we find material traces of the work involved in mediating between musical and electro-mechanical practices: the Machine is assembled from cheap and thriftily sourced materials, the electronics are idiosyncratic in design, and traces of the home-studio setting are evident. But, Oram's experiments in developing a Machine that could realise "drawn-sound"

were clearly not entirely successful. The Oramics Machine was never demonstrated as an artistic or technological innovation in Oram's lifetime and effectively never left the home-studio in which Oram and Wrench collaborated. And, as we see in the later discussion of the *Shozyg* exhibition, the process of developing the Oramics Machine was long and often frustrating. In other words, mediating relations between music and electro-mechanics in building the Oramics Machine was clearly not a simple task and involved much work and personal sacrifice on the part of Oram.

In the analysis I have attempted to describe some of the ways in which the exhibition of the Oramics Machine, as the material instantiation of Oram's drawn-sound experiments, might be appreciated as an experiment in relations between science and culture. There have been two parts to this line of argument. First, I have identified some of the particular registers of science that are staged in the exhibition of the Oramics Machine, namely electro-mechanics and programming. I have shown how, in the display of the Oramics Machine, programming and electro-mechanics appear far from straightforwardly scientific but instead appear "multivalent". In this sense, I have suggested why the display of the Oramics Machine might be said to be experimental as a display of science. Second, I have compared the *Oramics* exhibition with other exhibitions of music and sound that we find in the Science Museum. To this end, I have drawn a contrast between two approaches – media-specific and audition-centric – to experimental sound exhibition. As I have described them here, each approach proposes a different account of the ontology of sound (multiple vs. dualist), its materiality (object-centred vs. object-less), and the experimental apparatus (mediation vs. interactivity). I have highlighted problems with both approaches: auditory-centric models risk black-boxing the material complexity of sound while approaches that focus on the mediation of sound risk objectifying sound. To this end, I have attempted to elaborate some of the different ways in which the exhibition of experimental electronic music – in the Oramics Machine and other displays we find in *Oramics* – might be said to be an experiment in the relations between science, culture and the public. In appreciating the different ways in which exhibition of the Oramics Machine might be said to be experimental, I have argued that we gain a greater appreciation of why the *Oramics* exhibition can be said to address the 'culture question' in the Science Museum.

7. Conclusion.

Introduction

In this thesis I have applied the concept of the “public experiment” to the *Oramics* exhibition in an attempt to understand better what it is that experimental exhibitions 'do'. In this thesis I've distinguished the exhibition as public experiment from two other versions of the experimental exhibition: exhibitions that publicise experimental facts and artefacts, and the experimental display. As a public experiment, I've suggested that the exhibition is more than simply a neutral intermediary between science and society that only diffuses the findings of experimental processes or enables novel artefacts to circulate beyond the laboratory setting where they are fabricated. Experimental exhibitions of course do these things too. But in this thesis, I've argued that experimental exhibitions like *Oramics* also participate in the 'doing' of experiments and can be considered as formats that are themselves inventive in particular ways. By using a vocabulary of “practices”, “relations” and “actors” to talk about the exhibition studied here, *Oramics*, I have attempted to describe the exhibition as a lively and complex empirical object. More than a static surface for representing experimental practice, the exhibition, I've suggested, is something that intervenes in the material world and a format that has the capacity to fabricate novelty.

Staged in the Science Museum, I have advanced the proposition in this thesis that we can understand the *Oramics* exhibition as an experiment in the relations between science, culture and the public; relations which in this setting have often been highly ordered. In *Oramics* we find very different styles of experiment assembled together in an exhibition: the exhibition foregrounds collaborations between musical and electro-mechanical practices and stages the electronic music experiment as a complex process involving heterogeneous knowledges, people, instruments and techniques; the experimental curatorial process involves many different kinds of participant demonstrating that the knowledge about the history of science and technology is not only the preserve of professional historians; and, the exhibition's public displays about invention of electronic music include many of the people and

things conventionally 'excluded' from scientific accounts of invention including amateurs, artistic practices, genre styles, women, and so on. If *Oramics* is an experimental science exhibition, it is one considerably that is considerably 'impure' and removed from the concerns of professional science. Departing from the conventions exhibitions that promote technical pedagogy, interactive science and cultural literacy, in this study I have sought to explore what other kind of relations between science, culture and the public might be being produced in the experimental *Oramics* exhibition.

In introducing this study, I began in the *Oramics* gallery describing how its displays of experimental electronic music related to, or rather were distinct from, other Science Museum exhibitions. To visitors who have navigated displays of technological progress, demonstrations of universal truths and who engaged their own agency through interactive displays, the exhibition of experimental electronic music in the *Oramics* gallery raises many questions. Why is the Science Museum hosting an exhibition about musical invention, in which the studio rather than the laboratory is the setting of experiment, and in which amateur knowledges and practices are foregrounded over those of professionals? From the displays about Daphne Oram's "early life" in music, her "drawn-sound" method and *Oramics* philosophy, to the "women writers" monologues and the images of acid-house artists there are many features of the *Oramics* gallery that might well appear more at home in an art museum than the Science Museum. Unlike others exhibitions in the Science Museum, *Oramics* puts its curators into the displays of the gallery where we find the Museum's curator Tim Boon describing the experimental "co-curation" process of the exhibition, we find listings of the various "co-curators" of the exhibits, and in a film we see some of them (and myself) in workshops and giving interviews about the exhibition. And, unlike other experimental exhibitions in the Science Museum – in which experimental instruments materialise abstract principals and interactive displays facilitate diffusion of knowledge from expert science to lay public – in *Oramics* we find that the scientific experiment is conspicuous by its absence and the problem of the relations between science and culture explicitly problematised in the gallery displays. When compared with experimental exhibitions promoting technical pedagogy and public engagement with science, *Oramics* appears almost carnival-like in the multiplicity of experimental traditions and styles we find in the exhibition. An exhibition about electronic music studios in which engineers and musicians collaborated to invent new sounds, *Oramics* invites us to take seriously the proposition that the experiment has a life beyond the laboratory and in

practices that do not fall under the rubric of professional science.

I have attempted to show how applying the concept of the “public experiment” to *Oramics* enables us to both account for the co-existence of multiple modes of experiment that we find in *Oramics* and give a materialist account of their assemblage in the exhibition. In *Oramics* there appear three relatively distinct modes of experiment: first, the curatorial experiment in which different groups participate in “co-curating” the displays; second, the electronic music experiment which concerns the invention of new sounds; and third, the experimental gallery display which is distinguished as “a new kind of exhibition” and therefore different to other formats of experimental exhibition in the Science Museum. I have attempted to organise the analysis in the empirical chapters around these three versions of experiment, describing the particularities of each mode of experiment. In this analysis I have attempted to show that assembling these different modes of experiment in *Oramics* is not only an abstract operation but also a messy material practice. I have argued that the *Oramics* exhibition produces relations between these modes of experiment through processes of public participation (Chapter Four), in different formats of public display (Chapter Five) and in the media of exhibition (Chapter Six). In this final chapter I am going to revisit the central arguments made in the thesis. I first, trace the arguments made in the three empirical chapters (4,5 and 6) and highlight how the analysis presented in each contributes to the question about how the *Oramics* exhibition can be understood as an experiment in the relations between science, culture and the public. I, then, restate the central proposition of the thesis – that as a public experiment we can understand the experimental exhibition as an inventive format – and explore some of the broader implications for social studies of experiment and invention. Finally, I revisit the Science Museum with the reader to ask how we might approach this setting differently after spending so much time in the *Oramics* exhibition.

Summary of empirical analysis

In the empirical chapters I have attempted to focus on the central modes in which *Oramics* can be said to be an experiment: curating, public display and electronic music. Since these are considerably distinct versions of experiment which might seemingly have little to do with one another, I attempted to use the concept of the public experiment to bring them together analytically and to give

a materialist analysis of their assembly together in the *Oramics* exhibition. Applying the concept of the public experiment was not simply a means to explain away the complexity of *Oramics*, as if complexity were simply the ontological condition of an experimental exhibition. Rather, in the analysis I have attempted to show how valuing particular kinds of experimental complexity enables us to appreciate better what the *Oramics* exhibition is 'doing' in the Science Museum. The themes used for the analysis were participation (Chapter Four), exclusion (Chapter Five) and media (Chapter Six). In the analysis I have attempted to show the ways in which these themes at once raise both theoretical questions and practical concerns about the assemblage of the *Oramics* exhibition. This thematic organisation of the analysis was designed to demonstrate the different kinds of work involved in assembling the *Oramics* exhibition, and in doing to offer an explanation for why the Museum's curators are attempting to develop new public participation procedures, why the exhibition's displays 'includes' the work of groups like the women writers, and why electronic music is a medium excites such interest in a museum dedicated to industrial history and contemporary science. This thematic analysis is not an attempt to organise the empirical material only to confirm the utility of applying the concept of the public experiment to make sense of *Oramics* as an experimental exhibition. Instead, the thematic analysis is an attempt to specify some of the different and distributed kinds of material practice go into assembling an experimental exhibition like *Oramics*.

In Chapter Four I examined the curatorial experiment. In the Science Museum's curators' accounts, the curatorial experiment is a public participation initiative to involve of different groups in curating a gallery display about the history of electronic music. The curatorial experiment is largely concerned with creating new procedures through which new people and knowledges can participate in curating science and technology exhibitions. Examining a disagreement between one of the Science Museum's curators, Tim Boon, and a group of Audience Researchers over questions of public participation in *Oramics* we see some of the different ways in which the curatorial experiment problematises the relations between science and culture. What public participation means to each side of this disagreement is framed by particular issues concerning the relations between science and culture: for Boon these issues concern historical epistemology and the "cultural offer" of the Museum's object collection while for the Audience Researchers these problematics concern social inequalities and the Museum's development of a "multi-cultural" audience. By applying the concept of the public experiment to the study of the

curatorial experiment, I attempted to show how public participation can be described not only in terms of procedures but is also through particular issues concerning the relations between science and culture.

The analysis of Chapter Five addressed the theme of exclusion, a problematic which is registered in the *Oramics* exhibition's experimental gallery displays in various ways including publicising gender as an issue, foregrounding the participation of 'vulnerable' and marginal groups, and in staging inventions that don't feature readily in the history of technology. In this chapter I centred the analysis on gender because in my ethnographic fieldwork this seemed in various ways (described in the chapter) to be among the most controversial of exclusions in the gallery displays of the exhibition. Where some versions of the experimental exhibition, discussed in Chapter Two's literature review, would attempt to 'solve' the problem of the exclusion of women from science (for example, through communication, interactivity and inclusion), in this chapter I suggest that *Oramics* is interesting precisely because the exclusion of women is staged in the gallery displays as a much more complex issue. The chapter also highlighted the tensions inherent in attempts to 'dissolve' the problem of exclusion. In the analysis I foregrounded debates within feminist science studies between "standpoint" and "post-gender" approaches to the question of the exclusion of women from science. Through this debate, I sought to show how by valuing experimental complexity in the gallery displays we are better able to appreciate how the exclusion of women is linked with broader problematics. For example, we see how the exclusion of women from science is related to the exclusion of subjectivity, style and artistry from experimental exhibitions, as the antithesis of objectivity, rationality and technology. Applying the concept of the public experiment, then, enables us to see how problem of the exclusion of women is posed in the experimental gallery displays of *Oramics* as a more complex problem of the relations between science and culture.

Chapter Six's analysis focused on the subject matter of *Oramics*, experimental electronic music, taking the Oramics Machine as its empirical focus. As the chapter highlighted, in many ways music is not a new medium for the experimental exhibition: music has often been used in experimental exhibitions for its affective capacities to assemble a public for science. But, in experimental science exhibitions distinctions between sound-science and art-music are often staged as absolute. By contrast, in *Oramics* we find much more porous relations between sound and music: the exhibition staging

electronic music as the invention of new sounds and Daphne Oram as both sonic inventor (specifically, of “drawn-sound”) and a composer of music. The analysis of the chapter attempted to show how applying the concept of the public experiment to *Oramics* allows us to take seriously the notion that experimental music is not only the 'content' that is communicated but is also the experimental 'medium' of the exhibition. As the analysis made clear, Daphne Oram was a highly unconventional composer, spending many years working to develop drawn-sound techniques through the Oramics Machine and so too the electro-mechanical design of the Machine is highly idiosyncratic, comprised of many repurposed and sourced components. In the analysis of the Oramics Machine I attempted to describe some of the ways in which this “drawn-sound” instrument not only constituted exhibition content to be aesthetically appreciated and technically understood, but how it also materially *mediates* relations between music and electro-mechanics in very particular ways. Applying the concept of the public experiment to subject matter of *Oramics*, I argued, therefore enables us to be attentive to the ways in which the electronic music experiments can be said to mediate relations between science, culture and the public not only communicatively but materially.

In the empirical analysis I have attempted to show how these three themes (participation, exclusion and media) enable us to appreciate some of the forms of work and practice through which the different modes of experiment as assembled together in *Oramics*. Allowing for experimental complexity, applying the concept of the public experiment, I've argued, enables us to see that bringing together these different modes of experiment in exhibition is not simply an abstract operation but also material practice. In other words, it draws our attention to the fact that relations between science, culture and the public do not simply already exist but rather these relations have to be made. Had I focused only on differentiating and purifying the modes of experiment that we find in *Oramics* – as opposed to exploring their connections – we would be left no clearer as to how and to what ends they are brought together in the exhibition. From the thematic analysis we might summarise some findings about the how relations between science, culture and the public are produced: we find that public participation in science initiatives are not only inventive as procedures but also in the material form they give to issues concerning the relations between knowledge, politics and social identities; exclusion is not simply a social issue for science to 'solve' but a complex material problematic that raises questions about the reality of rationality, objectivity and expertise; and, the media of experiments – here, electronic music – are not only neutral

intermediaries or communication vehicles (e.g. music as an auditory phenomenon) but are materially complex and assembled through experimental processes, in the case of electronic music in the collaborations between the practices of musical composition and electronic-engineering. One reason for describing the material complexity of these themes is to appreciate the work involved in assembling the different modes of experiment through the practice of exhibition. This also enables us to describe the exhibition as a material practice without falling into unhelpful distinctions between subjects vs. objects, agents vs. structures, humans vs. non-humans or practices vs. materials. Dispensing with such analytical distinctions, I've argued, enables us to recognise the significance of the *Oramics Machine* to the curatorial experiment (as the engaging object), the experimental public display (as, for instance, a 'home made' artefact invented by a woman) and the electronic music experiment (as Oram's "drawn-sound" invention) and thereby to appreciate why we find it as the centre-piece of the *Oramics* exhibition. Describing the experimental complexity of these themes is not therefore to suggest that the *Oramics* exhibition fails to make coherent and strong relations between science, culture and the public. Rather, I have argued it is only when we look closely at the experimental complexity of *Oramics* that we start to see how new kinds of relations between seemingly different and heterogeneous things can materialise. In short, experimental exhibition is not only a process of abstractly representing experimental facts and artefacts but is also a materialist practice concerned with the 'doing' experiment.

The exhibition as an inventive format?

By applying the concept of the public experiment to *Oramics* I've attempted to investigate whether and in what ways this experimental exhibition might be said to be inventive. In this study I've attempted to show both the experimental exhibition is not absolutely divorced from the 'doing' of experiment and that experiments are not only scientific genres of practice. As highlighted in the literature review, many approaches to the study of invention, such as the science and society tradition, have told us that exhibitions are the antithesis of experiments. In these studies, experiments take place at the beginning of a trajectory of invention, exhibitions come at the tail end as the experimental artefact becomes domesticated in society. From the perspective of such studies applying the concept of the public experiment to an exhibition seems a

confusion of categories which conflates the well rehearsed experimental demonstration with an experiment conducted in public. Such a conflation, they claim, risks naively accepting the naturalistic and idealised accounts of experiments given by natural scientists and philosophers. To adequately account for the social reality of invention, these studies argue, sociologists need to maintain analytical distinctions between experiments and exhibitions: public experiments when they happen should appear nothing like the museum exhibition. By applying the concept of the public experiment to an exhibition in the Science Museum I have therefore risked unsettling the ground on which to distinguish the social account of invention from the 'idealised' accounts of scientists and philosophers and in doing so could be accused of over-complicating an event that is in fact quite simple.

By applying the concept of the public experiment to an exhibition at the Science Museum I have been making the claim, contra the science and society tradition, that experimental exhibitions are not simply events that occur in the later stages of a trajectory of invention; as the well rehearsed and controlled representations of experimental results that occur after the experiment has ended. In applying the concept of the public experiment I am claiming that exhibitions are more than mere intermediaries that simply communicate or diffuse experiments. As a public experiment, I have argued for a less instrumental approach to the experimental exhibition, one that would allow us to appreciate the particular kinds of work that are performed by exhibitions.

I have used many different concepts throughout this thesis to describe the different kinds of work that the *Oramics* exhibition performs, including: mediating, translating, assembling, negotiating and problematising. These are quite distinct kinds of work and my use of these concepts in this thesis might appear sometimes as if they were interchangeable. There is perhaps some truth to this criticism, since I draw such concepts largely from science and technology studies which have attempted to describe invention without falling back into positive and nomological explanations of invention as 'discovery'. If such concepts appear interchangeable it is because they propose, in different ways, that the creation of novelty does not arrive from nothing – as, for instance, a 'spark of inspiration' or 'touch of genius' – but is rather a material process that unsettles, manipulates and reconfigures relations between things. In the case of the concept of mediation, for instance, I have attempted to use this concept in a particular way to show how experimental electronic music

does more than simply communicate sonic experiment for aesthetic appreciation or technical understanding. Instead, electronic music provides the medium through which relations can be made between very different kinds of genres of inventive practice, such as pop culture, amateur electronics and media arts. In describing the work that the *Oramics* exhibition performs as a material process I have therefore also attempted to demonstrate that exhibitions are not so simply the mundane material procedures that accounts of exhibition as representation would have us believe. Assembling an exhibition in a science museum around an artefact (the Oramics Machine) that has never been demonstrated an innovation and which was invented by a female musician in her home-studio, I have argued, involves multiple forms of experimental practice. Experimental exhibitions, I have argued, cannot simply be considered as events that occur in the late stages in trajectories of invention, after the experiment has ended.

The 'rediscovered' Oramics Machine is the material object that is the centre-piece of the *Oramics* exhibition. The concept of rediscovery would purport to tell us that its object is uncontroversial as a discovery; it is a concept that suggests we already knew the significance of the rediscovered thing but that perhaps we had forgotten about it or overlooked it. But, the rediscovery of the Oramics Machine is clearly not the recovery of a forgotten but demonstrably important material artefact: little is known of its history, its electro-mechanical design is opaque, it no longer functions as a musical instrument and its designer Daphne Oram is not an established inventor. As I observed in the research for this study musicians are largely unfamiliar with the drawn composition techniques Oram developed it for, electronic engineers are still mapping its circuitry and little is known about the different stages of the Machine's development and use during the 1960s or indeed its relation to innovations like the synthesiser. It is fair to say that little is known about exactly what has been 'discovered' in the rediscovery of the Oramics Machine.

And yet, one of the dominant narratives of the 'rediscovery' of the Oramics Machine that I encountered during this study was as a form of enlightened atonement. This tragic narrative about the Oramics Machine was told to me by many of the people I encountered during this study: the time and work Oram put into building the experimental instrument were to no avail, the Oramics Machine was overtaken by other inventions and Oram ended her life in relative obscurity and poverty. To many of the people I've met, Oram's lack of success in her own lifetime cannot simply be attributed to her own decisions – although

many acknowledge her highly individualistic and belligerent mentality – but is symptomatic of conservative and blinkered cultural institutions that failed to support her inventive practice. To some, the discovery of the Oramics Machine is a vindication of Oram's perseverance in the face of extreme personal hardship and a hostile culture that refused to recognise the value of her electronic music experiments. In this narrative, Oram's tragic fate is a wrong which is rectified through the exhibition of the Oramics Machine in the Science Museum. The recent revival and celebration of Oram's work – not least at the BBC, the corporation that couldn't support Oram's electronic music experiments leading to her 'going solo' and setting up the Oramics studio – in this narrative, reflects a general change in cultural attitude. It is a narrative in which the *Oramics* exhibition in the Science Museum demonstrates our enlightened recognition of the inventive significance of Oram's experiments. It presents 'rediscovery' as an effect of our progressive enlightenment: science can atone the past mistakes of culture. Though this account of the Oramics Machine's 'rediscovery' is perhaps compelling to a certain kind of moral sentiment it also obscures many of the questions and problematics that I have raised in this thesis about the Oramics Machine as an invention.

In this thesis I have attempted to argue that the Oramics Machine is sociologically interesting as a 'rediscovery' precisely because very little is known about this artefact that would confirm its importance as an invention. The reason I use inverted commas around the term 'rediscovery' is to highlight that the exhibition of the Oramics Machine is not the bringing to light of an artefact whose capacities are known but which has simply been overlooked. At the current time of writing, three years after its first exhibition, there is still little clarity about the extent to which the Oramics Machine can be said to be a technological or artistic innovation. The narrative of rediscovery that accompanies its exhibition, I have argued in this thesis, tells us that if there is something innovative about this artefact it is not yet something we can name. Rather, the exhibition of the 'rediscovered' Oramics Machine would more obviously seem to reveal something about our the limits of our existing ideas of invention. The big question mark over exactly what has been discovered in the 'rediscovery' of the Oramics Machine, I have argued in this thesis, proposes invention itself as the concern to be addressed. As we have seen, the unknown quantities clearly does not make the Oramics Machine any less interesting to the musicians, artists, engineers and Science Museum staff that we have encountered in this thesis. In their actions – organising events, putting on concerts, exhibitions, blogging, and so on – we see clearly demonstrated

that there is something inventive about the Oramics Machine even if it cannot be precisely identified and named. It is for this reason that I have favoured the concept of experiment over that of discovery in this thesis. The Oramics Machine seems to me an artefact with some very different experimental capacities: in the analysis I have attempted to show how in the Machine appears quite differently as the object at the centre of the curatorial experiment, the instrument used for musical experiment and the centre-piece of the experimental display.

In this thesis I have described how the staging of the Oramics Machine in the *Oramics* exhibition might be considered inventive insofar as it is also a process of assembling multiple modes of experiment. The concept of the public experiment has enabled me to provide an analysis of the work of exhibiting the Oramics Machine through which these relations are made. Subsequently, I have given an account of two empirical objects, the Oramics Machine and the exhibition, which are not easily separated out from one another: how can we describe the Oramics Machine as an important invention independent of its display in the Science Museum? How can we discuss the *Oramics* exhibition independent of its centre-piece object? Applying the concept of the public experiment I have suggested that in the experimental complexity of *Oramics* we find that the exhibition is a format that is simply the tail end of processes of invention as the antithesis of experimental practices. Instead, I have attempted to specify some of the ways in which experimental exhibitions might be considered inventive formats in their own right.

Reassembling the Science Museum as a setting of experiment

The opening journey through the Science Museum to the *Oramics* gallery, described in the introduction, was highly selective. The purpose of this journey was to introduce, via a series of exaggerated contrasts, the problematic of the relations between science, culture and the public that the thesis would consider. Through displays of reason's triumphs, celebrated industrial history and cutting-edge technoscience I introduced the Science Museum as a setting where science is promoted as the method creating universal truths, as driving technological developments, and as the guarantor of our progressive Enlightenment. In this introduction, science appeared as a special sphere of culture defined in its opposition not just to forms of falsehood, irrationality and

mysticism but also to spheres of cultural practice such as art and politics. Next to displays of steam engines and space rockets, the *Oramics* exhibition appeared a considerable contrast: using these exhibitions (quite instrumentally) to stage the relations between science and culture in the way just described, I introduced *Oramics* as an exhibition that messes up this cosy settlement, as a radical intervention that tells us that the former exhibitions have taken too much for granted. My introduction, however, somewhat overstated the case. It was not dishonest, the problematic it introduced is very real in this setting, but as a portrait of the Science Museum it was highly selective. Now, after having specified the ways in which the *Oramics* exhibition can be considered experimental we are perhaps in a better position to return to the Science Museum to ask what kind of setting this is, and what kind of relations between science and culture do we find there.

Oramics is not exceptional in the Science Museum simply because it is an experimental exhibition removed from the concerns of pure and professional science. There are in fact many other galleries in the Science Museum in which the concerns of professional science make only a minor appearance or are absent all together. I could, for instance, have taken the visitor via the permanent media-art installation called *Listening Post*¹⁵⁰ which stages an experimental sound display composed from real-time internet data. *The Listening Post* occupies an entire darkened room, one wall of which is filled with small screens and speakers scrolling live text-data from internet chat-rooms which is played through computer-synthesised voices that read and sing the text. The visitor could have passed the *Toaster Project*¹⁵¹, a toaster built from scratch by the artist Thomas Thwaites who mined and processed all the raw materials himself; the final piece costing 300 times more than a mass-produced toaster. Or, since the opening of *Oramics*, we could also have stopped at the temporary *Hexen 2.0*¹⁵² exhibition by the artist Suzanne Treister which investigates the development of cybernetics and the interdisciplinary Macy conferences of the 1940s through imagery of the alchemical and the occult. Alchemy was also the theme of another temporary exhibition called

150Further information about *The Listening Post* can be found at:

http://www.sciencemuseum.org.uk/smap/collection_index/mark_hansen_ben_rubin_listening_post.aspx (accessed 9th September 2013)

151For more information about the *Toaster Project* see:

http://www.sciencemuseum.org.uk/smap/collection_index/thomas_thwaites_the_toaster_project.aspx (accessed 12 April 2014)

152Further information about *Hexen 2.0* can be found at:

http://www.sciencemuseum.org.uk/smap/collection_index/suzanne_treister_hexen_2_0.aspx (accessed 12 April 2014)

*Signs, Symbols, Secrets: an illustrated guide to alchemy*¹⁵³ that for two years occupied the gallery opposite *Oramics*. In *Signs, Symbols, Secrets* we find a host of very old texts and scrolls that document medieval alchemy practices, which were superseded and displaced to the realm of pseudo-science with the rise of professional chemistry; the exhibition foregrounding the quest of alchemists for the “philosopher’s stone” and the use of imagery to document alchemical practices. Indeed, it is notable that two years after the opening of *Oramics*, the adjoining gallery was radically redeveloped as a photography and art gallery named *Media Space*¹⁵⁴. The first exhibition in this gallery was a display of photography from the 1960s and 70s called *Only in England*¹⁵⁵ focused around the work of the artists Martin Parr and Tony Ray-Jones. Had the visitor taken a detour through these various displays of art, social critique, the occult, pseudo-science and media, *Oramics* might not have seemed quite so unsettling as an experimental exhibition.

My reason for making reference to this range of the Science Museum exhibitions that depart from the concerns of professional science at this point in the conclusion is not to water down the distinctiveness of *Oramics*. If the distinctiveness of *Oramics* in the Science Museum were only that it addressed concerns removed from professional science then I would not have chosen it for this empirical study. Highlighting the broader landscape of exhibitions within which *Oramics* is situated is rather a way to repose the question of what kind of setting the Science Museum is. In the chapters of this thesis I have argued that the Science Museum is a setting in which relations between science and culture are produced in the material practice of exhibition. Though many of the exhibitions I have just described display small signs explaining that they are “art” projects, many exhibit material that nonetheless enacts many of the registers of the “science” exhibitions from which they are distinguished (and vice versa): in the Museum’s “art” exhibitions we find knowledge, data, technology, philosophy, invention just as in its “science” exhibitions we increasingly find visual culture, music, literary references and so on. In other words, when we look close up we find that there is considerable traffic between the different kinds of exhibitions we find in the Science Museum.

153For more information about *Signs, Symbols, Secrets* see:

http://www.sciencemuseum.org.uk/Home/visitmuseum/Plan_your_visit/exhibitions/alchemy.aspx (accessed 12 April 2014)

154For more information about *Media Space* see:

http://www.sciencemuseum.org.uk/visitmuseum/media_space.aspx (accessed 12 April 2014)

155For more information about *Only in England* see:

http://www.sciencemuseum.org.uk/visitmuseum/plan_your_visit/exhibitions/only_in_england.aspx (accessed 12 April 2014)

Such traffic underscores the inadequacy of demarcationist theories of science to account for what we find in Science Museum exhibitions. Situating *Oramics* in this broader landscape of exhibitions, the exhibition may not appear quite as 'different' but it also makes clear that the Science Museum is not a setting in which the relations between science and culture are premised on a series of oppositions such as rational/irrational, technical/aesthetic, truth/power (and so on) that would mark science out as distinct and special, on a priori grounds, in comparison to politics or art (etc).

In this study I have focused on the concept of the experiment to describe such traffic: in *Oramics* we find the experiment not demarcated as a properly scientific format but rather a reference that circulates across very different modes of practice. The centrality of experimental registers in *Oramics* brings the exhibition into relations with others that we find in the Science Museum – such as the pedagogical exhibitions of experimental instruments, and the interactive displays that communicate 'pure' science to the public – and, hence, by foregrounding the experiment in my analysis I have attempted to highlight why science is an issue that is at stake in the exhibition. I am not here advancing an argument that attempts to 'scientise' *Oramics* but rather an argument that this exhibition intervenes in concerns about science, despite the absence of professional science from its displays. By focusing on the experiment I have therefore attempted to make clear why we cannot simply settle with classifying *Oramics* as an art exhibition in a science museum, and thus why we should take seriously that this exhibition can tell us something about the relations between science and the public. It is on this basis, I suggest, that we can generalise from an analysis of *Oramics* to a broader account of the Science Museum as an inventive setting. In the Science Museum we are afforded the opportunity to make associations between heterogeneous things via references, such as experiment, that circulate between them. Science is therefore not only a category that unifies or separates out the exhibitions we find in the Science Museum. In this sense, we might say that the Science Museum could be considered an inventive setting to the extent that in the material practice of exhibition we find new associations made between heterogeneous things and thus a science that is also continually unsettled and reordered. In experimental exhibitions like *Oramics* we are perhaps better able to appreciate not only what an unlikely assemblage of heterogeneous things make up a science museum but also the impressive work that goes into maintaining a museum dedicated to an entity, science, that

is being continually changed and refashioned.

Opening up the culture problem

The one question I have left largely unaddressed in this conclusion is the role of culture as an analytic category used in this study. This is in part due to pragmatic considerations in how the analysis of this thesis developed: culture only made an appearance late in the research process and therefore did not shape the direction of empirical study in the same way that the analytic categories of science and the public did. Though the concept of culture in many ways seems entirely necessary to appreciating what *Oramics* is 'doing' in the Science Museum, this analytic of culture entered into the study after much of the empirical research was complete and as the analysis was developing. In some sense, then, this empirical study has not sufficiently developed the basis on which to conclude the question of in what ways the *Oramics* exhibition makes relations between science and culture. What I introduced as “the culture question in the Science Museum” is also to some extent a question for this thesis.

Though I have attempted to articulate the conceptual problematic of *Oramics* – the public experiment – in relation to a very particular tradition in social studies of science, literatures from very different traditions such as critical theory and cultural studies has nonetheless proven useful for empirically describing how the experimental complexity of *Oramics* is translated in different ways into concerns about the relations between science and culture. In other words, though I have attempted to maintain a closed circuit of reference to formulate the conceptual problem of the public experiment, the different modes of experiment that we find in *Oramics* and the problems in many ways have forced these circuits of reference to be broken open to some extent. In the empirical chapters I have described several problematics – participation, exclusion, media – in which the relations between science and the public also appear significant as relations between science and culture. So too, in the empirical chapters I have drawn from a range of literatures in which these tripart relations are said to be significant including: actor-network theory, governmentality, social constructivism, cultural studies and critical theory. In

some cases the use of this literature has been quite instrumental: for instance, my uses of critical theory were more as a means to illustrate an empirical problem – the Science Museum as a participant in the cultural industries – rather than on the basis of its conceptual contribution to the central argument of the thesis. Nonetheless, my use of such literatures has not been entirely instrumental. And, indeed one reason I drew on these broader range of literatures is because I'm not convinced that the relations between science, culture and the public has been sufficiently addressed in social studies of science.

In the study of the relations between science and the public, the dominant lens in social studies of science traditions is political. When we look at the relations between science and the public, scientific practice appears not dissimilar to political practice (for instance, in its modes of representation and demonstration). The strength of traditions that developed around this issue in social studies of science, for instance actor-network theory, is that they not only revealed something important about how science works but also addressed directly the epistemological problem of a materialist social science: ideas do not simply float from science and to the public (or society) but instead the processes of demonstrating ideas and putting them into practice is a material process of making relations between very different kinds of actors, and as such is amenable to social description. These traditions have argued that to offer a materialist account of the creation of new ideas in science we cannot simply reductively assume we already know where and in what their materiality resides. Social studies of science therefore invites us to take serious that new ideas are not just imposed by the mind onto an unchanging material substrate or simply 'internal' representations caused by 'external' public events. Actor-network theory, for instance, makes an ontological argument about invention as a process that reorders the material composition of the public world. To invent, ANT tell us, scientists have to translate public interests, enrol them and force them to confront material problems through demonstrations. In the relations between science and the public, for ANT, science can be described, symmetrically, as a practice that is not unlike politics.

However, when we add culture into the mix of relations between science and the public we can no longer straightforwardly apply theories like ANT that tell us science is like politics. This is in part, I suggest, because theories

developed in social studies of science tend to offer us a theory of culture that is totalising; these traditions often simply affirm an anthropological account of culture as the entirety of connected elements in a way of life. The critique of science made by social studies of science is, in this respect, closely linked with another critique of a liberal humanist view of culture – which, in Matthew Arnold's phrase, can be described as “the best which has been thought and said in the world”. To caricature we could say that in social studies of science, science is culture as long as culture is totalising, ontologically complex but also un-extraordinary to social description. In other words, though social studies of science might accept that there can only ever be partial descriptions of culture when they are given they are nonetheless assumed to be socially mundane. To be sure, such accounts of the relations between science and culture have served the social study of science well: once science loses its aura as a special form of cultural practice that is opaque to social description we can see how it is in fact not so extraordinary and even not so different to those spheres of culture that social scientists have long studied, like politics. And yet, as I have suggested in this study, in a setting like the Science Museum such a settlement between science and culture, in which the latter provides the repository in which to dissolve the problems of sociologically accounting for the former, seems deeply unsatisfying. In short, in the Science Museum we cannot simply describe science 'as culture' because this is a setting in which culture, just like science, is a construct that is not only complex conceptually but also materially and practically.

If I am going to leave open the culture question in this study, then, I am also querying the extent to which social studies of science has solved its cultural problems. I suggest there are two implications that follow from this. First, it suggests that in considering the relations between science and the public we cannot simply assume culture as either irrelevant or as a totalising concept into which we can dissolve these relations. Second, and perhaps more ambitiously, it suggests a need to revisit the shared circuits of reference in social studies of science that would purport to hold in common a critique of the treatment of science and culture in traditions such as critical theory or cultural studies. In this latter sense, the culture question is not only about social studies of science but rather about the relations between the different traditions of social science. In other words, once we accept that science is not so amenable to being studied 'as culture', as social studies of science has often presented it, then we are also invited to ask questions of the traditions of social science, and the

relations we presuppose between them, which have claimed to hold the keys to the social description of science. For social studies of science, then, the question is perhaps reposed as to whether and in what ways we have assumed culture as a resource for the social description of science. This is clearly beyond the remit of this study but, I suggest, it nonetheless seems significant if social studies of science is to develop an adequate materialist account of science.

In this study I have used the concept of the experiment as the vehicle through which to examine the relations between science and culture. Once we focus on experiments that take place beyond the laboratory setting we inevitably ask what made us think that laboratory practice was more magical or materially forceful than the other social practices that call themselves experimental. The multiple modes of experiment that we find in *Oramics* highlights how complex experiments are when they take place in public. The exhibition shows how experiment might well appear less serious once it is dislocated from a pure and professionalised science: we cannot, for instance, ignore the element of 'play' we come across in the experiments of electronic musicians who, after all, work extremely hard in order to play their music (this observation is of course not new to social descriptions of experiments). But, this should not be taken as a damning critique of the laboratory experiment. Instead, as many in social studies of science have argued, the task when we encounter experimental complexity is to recompose our social description of experiment as material practice. In other words, the experimental practices of the sciences are not problematised by the *Oramics* exhibition, only those efforts to unify and demarcate them as identical under the name of Science. The experiment, as we know, is much more heterogeneous in practice than such epistemological approaches would allow. The proliferation of experimental practices that we find in the Science Museum, and the traffic we can trace between seemingly unrelated or functionally differentiated spheres of social practice, highlights the importance of the concept of the public experiment for appreciating both the complexity and dynamism of the experiment and the relations between science, culture and the public. Such experimental complexity, I have argued, enables us to appreciate how material practices like exhibition, that have often been passed over as socially mundane and epistemologically unremarkable, can be valued as inventive and significant for social analysis.

Bibliography

- Abu-lughod L (1991) Writing Against Culture. In: Moore HL and Sanders T (eds) *Anthropology in Theory: Issues in Epistemology*. John Wiley & Sons.
- Adorno TW (1967) Valéry Proust Museum. In: Weber S and Weber S (trans) *Prisms*. MIT Press, 173 – 187.
- Adorno TW (1973) *Negative Dialectics*. Routledge.
- Ames MM (1992) *Cannibal Tours and Glass Boxes: The Anthropology of Museums*. UBC Press.
- Anderson B (1991) *Imagined Communities: Reflections on the Origin and Spread of Nationalism*. Verso.
- Arendt H (1958) *The Human Condition*. Chicago: University of Chicago Press.
- Armitage A (1957) The Science Museum: The First Hundred Years. *Bulletin of the British Society for the History of Science* 2(17): 74.
- Barnes B, Bloor D and Henry J (1996) *Scientific Knowledge: A Sociological Analysis*. Bloomsbury Publishing.
- Barnes B and Edge DO (1982) *Science in Context: Readings in the Sociology of Science*. MIT Press.
- Barry A (1998) On Interactivity: Consumers, Citizens and Culture. In: MacDonald S (ed) *The Politics of Display: Museums, Science, Culture*. Routledge, 98–117.
- Barry A (2001) *Political Machines: Governing a Technological Society*. London: Continuum.
- Baudrillard J (1993) *Symbolic Exchange and Death*. SAGE.
- Baudrillard J (1995) *Simulacra and Simulation*. University of Michigan Press.
- Baudrillard J (1998) *The Consumer Society: Myths and Structures*. SAGE.
- Bennett T (1995) *The Birth of the Museum: History, Theory, Politics*.

Routledge.

- Bernstein DW (2008) *The San Francisco Tape Music Center: 1960s Counterculture and the Avant-garde*. University of California Press.
- Bijker W, Hughes T and Pinch T (1987) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT Press.
- Bijker W and Law J (1992) *Shaping Technology/building Society: Studies in Sociotechnical Change*. MIT Press.
- Bijsterveld K (2008) *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*. MIT Press.
- Bloor D (1976) *Knowledge and Social Imagery*. University of Chicago Press.
- Bloor D (1999) Anti-Latour. *Studies in History and Philosophy of Science Part A* 30(1): 81–112.
- Boon T (2010) Parallax Error? A Participant's Account of the Science Museum, c.1980-c.2000. In: Morris P (ed) *Science for the Nation: Perspectives on the History of the Science Museum*. Palgrave Macmillan.
- Boon T (2011) Co-Curation and the Public History of Science and Technology. *Curator: The Museum Journal* 54(4): 383–387.
- Born G (1995) *Rationalizing Culture: IRCAM, Boulez and the Institutionalization of the Musical Avant-Garde*. University of California Press.
- Born G and Barry A (2010) Art-Science: From Public Understanding to Public Experiment. *Journal of Cultural Economy* 3(1): 103–119.
- Bourdieu P (1984) *Distinction: A Social Critique of the Judgement of Taste*. Harvard University Press.
- Brightman R (1995) Forget Culture: Replacement, Transcendence, Relexification. *Cultural Anthropology* 10(4): 509–546.
- Briscoe D and Curtis-Bramwell R (1983) *The BBC Radiophonic Workshop: The First 25 Years*. British Broadcasting Corporation.

- Bull M and Back L (2003) *The Auditory Culture Reader*. Bloomsbury Academic.
- Callon M (1980) The State and Technical Innovation: A Case Study of the Electrical Vehicle in France. *Research Policy* 9(4): 358–376.
- Callon M (1986) Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen. In: Law J (ed) *Power, Action and Belief: A New Sociology of Knowledge*. Routledge, 197–225.
- Callon M (1998) An Essay on Framing and Overflowing: Economic Externalities Revisited by Sociology. *The Laws of the Markets*. Blackwell, 244–269.
- Callon M (2004) Europe Wrestling with Technology. *Economy & Society* 33(1): 121–134.
- Callon M, Lascoumes P and Barthe Y (2009) *Acting in an Uncertain World: An Essay on Technical Democracy*. London: MIT Press.
- Callon M and Latour B (1992) Don't Throw the Baby Out with the Bath School! a Reply to Collins and Yearley. In: Pickering A (ed) *Science as Practice and Culture*. University Of Chicago Press, 343–369.
- Callon M and Rabeharisoa V (2004) Gino's Lesson on Humanity: Genetics, Mutual Entanglements and the Sociologist's Role. *Economy and Society* 33(1): 1–27.
- Clifford J (1983) On Ethnographic Authority. *Representations* (2): 118–146.
- Clifford J and Marcus GE (1986) *Writing Culture: The Poetics and Politics of Ethnography*. University of California Press.
- Collins H (1981a) Son of Seven Sexes: The Social Destruction of a Physical Phenomenon. *Social Studies of Science* 11(1): 33–62.
- Collins H (1981b) Introduction: Stages in the Empirical Programme of Relativism. *Social Studies of Science* 11(1): 3–10.
- Collins H (1987) Certainty and the Public Understanding of Science: Science on Television. *Social Studies of Science* 17(4): 689.
- Collins H (1988) Public Experiments and Displays of Virtuosity: The Core-Set

- Revisited. *Social Studies of Science* 18(4): 725.
- Collins H and Yearley S (1992) Epistemological Chicken. In: Pickering A (ed) *Science as Practice and Culture*. University Of Chicago Press, 301–327.
- Davies S (2009) Doing Dialogue: Genre and Flexibility in Public Engagement with Science. *Science as Culture* 18(4): 397–416.
- Davies S, McCallie E, Simonsson E, Lehr JL and Duensing S (2009) Discussing Dialogue: Perspectives on the Value of Science Dialogue Events That Do Not Inform Policy. *Public Understanding of Science* 18(3): 338–353.
- Duncan C and Wallach A (1980) The Universal Survey Museum. *Ariel* 137: 212–199.
- Durant J (1992) *Museums and the Public Understanding of Science*. NMSI Trading Ltd.
- Durant J and Joss S (1995) Introduction. In: Joss S and Durant J (eds) *Public Participation in Science: The Role of Consensus Conferences in Europe*. London: NMSI Trading Ltd.
- Elam M and Bertilsson M (2003) Consuming, Engaging and Confronting Science. *European Journal of Social Theory* 6(2): 233.
- Ezrahi Y (1990) *The Descent of Icarus: Science and the Transformation of Contemporary Culture*. Cambridge: Harvard University Press.
- Felt U and Fochler M (2008) The Bottom-up Meanings of the Concept of Public Participation in Science and Technology. *Science and Public Policy* 35(7): 489–499.
- Follett D (1978) *The Rise of the Science Museum Under Henry Lyons*. Science Museum.
- Foucault M and Rabinow P (1997) Polemics, Politics and Problematizations. *Ethics: The Essential Works of Foucault Volume 1*. New Press.
- Galison P (1987) *How Experiments End*. University of Chicago Press.

- Girard M and Stark D (2007) Socio-Technologies of Assembly: Sense Making and Demonstration in Rebuilding Lower Manhattan. In: Mayer-Schönberger V and Lazer D (eds) *Governance and Information Technology: From Electronic Government to Information Government*. MIT Press, 145–176.
- Gomart E and Hajer M (2003) Is That Politics? In: Nowotny H and Bernward J (eds) *Social Studies of Science and Technology: Looking Back, Ahead*. Springer, 33–61.
- Gomart E and Hennion A (1998) A Sociology of Attachment: Music Amateurs, Drug Users. *The Sociological Review* 46(S): 220–247.
- Greenaway F (1951) *A Short History of the Science Museum*. H.M.S.O.
- Gregory J and Miller S (2000) *Science in Public: Communication, Culture, and Credibility*. London: Basic Books.
- Grierson M and Boon T (2013) The Oramics Machine: The Lost Legacy of British Electronic and Computer Music? In: Weium F and Boon T (eds) *Material Culture and Electronic Sound*. Smithsonian Scholarly Press/Rowman & Littlefield Publishers.
- Habermas J (1991) *The Structural Transformation of the Public Sphere: An Inquiry Into a Category of Bourgeois Society*. MIT Press.
- Hacking I (1983) *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*. Cambridge University Press.
- Haraway D (1984) Teddy Bear Patriarchy: Taxidermy in the Garden of Eden, New York City, 1908-1936. *Social Text* (11): 20–64.
- Haraway D (1988) Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist studies* 14(3): 575–599.
- Haraway D (1997) *Modest Witness@Second Millennium.FemaleMan Meets OncoMouse: Feminism and Technoscience*. Routledge.

- Harding SG (1986) *The Science Question in Feminism*. Cornell University Press.
- Harding SG (ed) (2004) *The Feminist Standpoint Theory Reader: Intellectual and Political Controversies*. Routledge.
- Heath C, Lehn D and Osborne J (2005) Interaction and Interactives: Collaboration and Participation with Computer-Based Exhibits. *Public Understanding of Science* 14(1): 91–101.
- Hebdige D (2002) *Subculture: The Meaning of Style*. Taylor & Francis.
- Hennion A (1989) An Intermediary Between Production and Consumption: The Producer of Popular Music. *Science, Technology & Human Values* 14(4): 400–424.
- Hennion A (2003) Music and Mediation: Towards a new Sociology of Music. *The Cultural Study of Music: A Critical Introduction* 80–91.
- Henriques J (2010) The Vibrations of Affect and Their Propagation on a Night Out on Kingston's Dancehall Scene. *Body & Society* 16(1): 57–89.
- Hess D (2001) Ethnography and the Development of Science and Technology Studies. In: Atkinson P (ed) *Handbook of Ethnography*. SAGE.
- Hooper-Greenhil E (1992) *Museums and the Shaping of Knowledge*. Routledge.
- Horkheimer M and Adorno TW (1972) *Dialectic of Enlightenment*. Crossroad Publishing Company.
- Horst M and Irwin A (2010) Nations at Ease with Radical Knowledge. *Social Studies of Science* 40(1): 105.
- Horst M and Michael M (2011) On the Shoulders of Idiots: Re-Thinking Science Communication as “Event”. *Science as Culture* 20(3): 238–306.
- House of Lords (2000) *Third Report of the Science and Technology Committee*. London: House of Lords.
- Hutton J (2003) Daphne Oram: Innovator, Writer and Composer. *Organised Sound* 8(1): 49–56.

- Ingold T (2000) *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill*. Psychology Press.
- Irwin A (1995) *Citizen Science: A Study of People, Expertise, and Sustainable Development*. London: Burns & Oates.
- Irwin A (2001) Constructing the Scientific Citizen: Science and Democracy in the Biosciences. *Public Understanding of Science* 10(1): 1.
- Irwin A and Michael M (2003) *Science, Social Theory and Public Knowledge*. Open University Press.
- Jasanoff S (2005) "Let Them Eat Cake": GM Foods and the Democratic Imagination. In: Wynne B, Leach M and Scoones I (eds) *Science and Citizens: Globalization and the Challenge of Engagement*. London: Zed Books, 20–23.
- Jasanoff S (2007) *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton University Press.
- Keller EF (1985) *Reflections on Gender and Science*. Yale University Press.
- Knorr-Cetina K (1999) *Epistemic Cultures: How the Sciences Make Knowledge*. Harvard University Press.
- Latour B (1988) *Science in Action: How to Follow Scientists and Engineers through Society*. Harvard University Press.
- Latour B (1993a) *We Have Never Been Modern*. Harvard University Press.
- Latour B (1993b) *The Pasteurization of France*. Harvard University Press.
- Latour B (1999) *Pandora's Hope: An Essay on the Reality of Science Studies*. Harvard University Press.
- Latour B (2004) *Politics of Nature: How to Bring the Sciences into Democracy*. Cambridge: Harvard University Press.
- Latour B (2005a) From Realpolitik to Dingpolitik. *Making Things Public: Atmospheres of Democracy*. MIT Press, Cambridge, Massachusetts.
- Latour B (2005b) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press, USA.

- Latour B (2007) Turning around politics: A note on Gerard de Vries' paper. *Social Studies of Science* 37(5): 811–820.
- Latour B and Weibel P (eds) (2002) *ICONOCLASH: Beyond the Image Wars in Science, Religion and Art*. The MIT Press.
- Latour B and Woolgar S (1986) *Laboratory Life: The Construction of Scientific Facts*. Princeton University Press.
- Lavine S and Karp I (eds) (1991) *Exhibiting Cultures: The Poetics and Politics of Museum Display*. Smithsonian Books.
- Law J (2004) *After Method: Mess in Social Science Research*. Routledge.
- Leach M, Scoones I and Wynne B (2005) Introduction: Science, Citizenship and Globalization. In: Leach M, Scoones I and Wynne B (eds) *Science and Citizens: Globalisation and the Challenge of Engagement*. Michigan: Zed Books.
- Lezaun J (2011) Offshore Democracy: Launch and Landfall of a Socio-Technical Experiment. *Economy and Society* 40(4): 553–581.
- Lezaun J and Soneryd L (2007) Consulting Citizens: Technologies of Elicitation and the Mobility of Publics. *Public Understanding of Science* 16(3): 279.
- Luhmann N (1989) *Ecological Communication*. University of Chicago Press.
- Lynch M (1985) *Art and Artifact in Laboratory Science: A Study of Shop Work and Shop Talk in a Research Laboratory*. Routledge & Kegan Paul.
- MacDonald S (1998) *The Politics of Display: Museums, Science, Culture*. Routledge.
- MacDonald S (2002) *Behind the Scenes at the Science Museum*. Berg Publishers.
- MacDonald S and Basu P (2007) *Exhibition Experiments*. John Wiley & Sons.
- Manning P (2012) The Oramics Machine: From Vision to Reality. *Organised Sound* 17(02): 137–147.
- Marcus GE (1995) Ethnography in/of the World System: The Emergence of Multi-Sited Ethnography. *Annual Review of Anthropology* 24(1): 95–117.

- Marres N (2005) Issues Spark a Public into Being. a Key but Often Forgotten Point of the Lippmann-Dewey Debate. In: Latour B (ed) *Making Things Public: Atmospheres of Democracy*. The MIT Press, 208–217.
- Marres N (2007) The Issues Deserve More Credit. *Social Studies of Science* 37(5): 759.
- Marres N (2011) The Costs of Public Involvement: Everyday Devices of Carbon Accounting and the Materialization of Participation. *Economy and Society* 40(4): 510–533.
- Marres N (2012a) *Material Participation: Technology, the Environment and Everyday Publics*. Palgrave Macmillan.
- Marres N (2012b) The Redistribution of Methods: On Intervention in Digital Social Research, Broadly Conceived. *The Sociological Review* 60: 139–165.
- Marres N and Lezaun J (2011) Materials and Devices of the Public: An Introduction. *Economy and Society* 40(4): 489–509.
- Marshall S (2008) The Story of the BBC Radiophonic Workshop. *Sound on Sound* (April). Available at:
<http://www.soundonsound.com/sos/apr08/articles/radiophonic.htm>.
- Marshall S (2009) Graham Wrench: The Story of Daphne Oram's Optical Synthesizer. *Sound on Sound* (February). Available at:
<http://www.soundonsound.com/sos/feb09/articles/oramics.htm>.
- Merton RK (1973) *The Sociology of Science: Theoretical and Empirical Investigations*. University of Chicago Press.
- Michael M (1998) Between Citizen and Consumer: Multiplying the Meanings of the "Public Understanding of Science". *Public Understanding of Science* 7(4): 313.
- Michael M and Brown N (2005) Scientific Citizenships: Self-Representations of Xenotransplantation Publics. *Science as Culture* 14(1): 39–57.
- Mol A (2003) *The Body Multiple: Ontology in Medical Practice*. Duke University

- Press.
- Morris P (2010) *Science for the Nation: Perspectives on the History of the Science Museum*. Palgrave Macmillan.
- Mullender R (2011) *Silent Light, Luminous Noise: Photophonics, Machines and the Senses*. PhD Thesis (unpublished), London, London College of Communication, University of the Arts London.
- Niebur L (2010) *Special Sound: The Creation and Legacy of the BBC Radiophonic Workshop*. OUP USA.
- Nyman M (1999) *Experimental Music: Cage and Beyond*. Cambridge University Press.
- Obrist H-U and Eliasson O (2009) *Experiment Marathon*. Reykjavik Art Museum.
- Oram D (1972) *An Individual Note: Of Music, Sound and Electronics*. Galliard Ltd.
- Pickering A (ed) (1992) *Science as Practice and Culture*. University of Chicago Press.
- Pickering A (2010) *The Cybernetic Brain: Sketches of Another Future*. University of Chicago Press.
- Pinch T (2008) Relativism: Is It Worth the Candle. In: Mazotti M (ed) *Knowledge as Social Order: Rethinking the Sociology of Barry Barnes*. Hampshire: Ashgate Publishing, 35–48.
- Pinch T and Bijsterveld K (2012) *The Oxford Handbook of Sound Studies*. Oxford University Press.
- Pinch T and Trocco F (2004) *Analog Days: The Invention and Impact of the Moog Synthesizer*. Harvard University Press.
- Rabinow P (2002) Midst Anthropology's Problems. *Cultural Anthropology* 17(2): 135–149.
- Reichardt J (ed) (1968) *Cybernetic Serendipity: The Computer and the Arts*. Studio International.

- Reynolds S (2012) What's Behind the Reissue Boom in "Outsider Electronics"? *Frieze Magazine* (145). Available at: http://www.frieze.com/issue/category/issue_145/.
- Reynolds S (2013) *Generation Ecstasy: Into the World of Techno and Rave Culture*. Routledge.
- Sandell R (2003) Social Inclusion, the Museum and the Dynamics of Sectoral Change. *Museum and Society* 1(1): 45–62.
- Science Museum Group (2012a) *Annual Review 2011-2012*. London: Science Museum Group, 46.
- Science Museum Group (2012b) *Strategic Ambitions 2012-2022*. London: Science Museum Group, 16.
- Science Museum Group (2013) *Annual Review 2012-2013*. London: Science Museum Group, 46.
- Shapin S (1988) Understanding the Merton Thesis. *Isis* 79(4): 594–605.
- Shapin S (1992) Discipline and Bounding: The History and Sociology of Science as Seen Through the Externalism-Internalism Debate. *History of Science* 30(90): 333–369.
- Shapin S (1995) Here and Everywhere: Sociology of Scientific Knowledge. *Annual Review of Sociology* 21.
- Shapin S (1998) *The Scientific Revolution*. University of Chicago Press.
- Shapin S and Schaffer S (1985) *Leviathan and the Air-Pump*. Princeton University Press.
- Simon N (2010) *The Participatory Museum*. Museum 2.0.
- Slater D (1997) *Consumer Culture and Modernity*. Wiley.
- Star SL (2010) This is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology & Human Values* 35(5): 601–617.
- Star SL and Griesemer J (1989) Institutional Ecology, Translations and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* 19(3): 387.

- Star SL and Strauss A (1999) Layers of Silence, Arenas of Voice: The Ecology of Visible and Invisible Work. *Computer Supported Cooperative Work (CSCW)* 8(1-2): 9–30.
- Stengers I (1997) *Power and Invention: Situating Science*. University of Minnesota Press.
- Stengers I (2000) *The Invention of Modern Science*. University Of Minnesota Press.
- Stengers I (2005) The Cosmopolitical Proposal. In: Latour B and Weibel P (eds) *Making Things Public: Atmospheres of Democracy*. MIT Press, 994–1003.
- Stengers I (2010a) *Cosmopolitics I*. University of Minnesota Press.
- Stengers I (2010b) Including Nonhumans in Political Theory: Opening the Pandora’s Box? In: Braun B and Whatmore S (eds) *Political Matter*. University of Minnesota Press, 3–33.
- Stocking GW (1988) *Objects and Others: Essays on Museums and Material Culture*. University of Wisconsin Press.
- Suchman L (1995) Making Work Visible. *Communications of the ACM* 38(9): 56–ff.
- Supper A (2014) Sublime Frequencies: The Construction of Sublime Listening Experiences in the Sonification of Scientific Data. *Social Studies of Science* 44(1): 34–58.
- Thompson EA (2004) *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933*. MIT Press.
- Thorpe C and Gregory J (2010) Producing the Post-Fordist Public: The Political Economy of Public Engagement with Science. *Science as Culture* 19(3): 273–301.
- Thrift N (2005) *Knowing Capitalism*. SAGE.
- Toop D (2001) *Ocean of Sound: Aether Talk, Ambient Sound and Imaginary Worlds*. Serpent’s Tail Limited.

- Traweek S (1992) *Beamtimes and Lifetimes: The World of High Energy Physicists*. Harvard University Press.
- Turner F (2006) *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. University of Chicago Press.
- Turner F (2008) Romantic Automatism: Art, Technology, and Collaborative Labor in Cold War America. *Journal of Visual Culture* 7(1): 5–26.
- Wajcman J (1991) *Feminism Confronts Technology*. Pennsylvania State University Press.
- Weibel P and Latour B (2007) Experimenting with Representation: Iconoclasm and Making Things Public. In: MacDonald S and Basu P (eds) *Exhibition Experiments*. John Wiley & Sons, 94–108.
- Whatmore SJ (2009) Mapping knowledge controversies: science, democracy and the redistribution of expertise. *Progress in Human Geography* 33(5): 587–598.
- Whitehead AN (1926) *Science and the Modern World*. Cambridge University Press.
- Williams R (1963) *Culture and Society: 1780 - 1950*. Penguin Books.
- Wilsdon J and Willis R (2004) *See-Through Science: Why Public Engagement Needs to Move Upstream*. London: Demos.
- Wilson D (2011) Daphne Oram: The Woman From New Atlantis. *The Wire* 330: 28–35.
- Wynne B (1992a) Public Understanding of Science Research: New Horizons or Hall of Mirrors? *Public Understanding of Science* 1(1): 37.
- Wynne B (1992b) Misunderstood Misunderstanding: Social Identities and Public Uptake of Science. *Public Understanding of Science* 1(3): 281.
- Wynne B (1995) Public Understanding of Science. In: Jasanoff S, Markle G, Peterson J and Pinch T (eds) *Handbook of Science and Technology Studies*. Sage Publications, 361–389.

Wynne B (2005) Risk as Globalizing “Democratic” Discourse? Framing
Subjects and Citizens. *Science and Citizens*. London: Zed Books, 66–
82.