

The Artists' Footprint:

Investigating the distinct contributions of artists engaging the
public with climate data

by

Rachel Jacobs, BA. MA.

**Thesis submitted to the University of Nottingham
for the degree of Doctor of Philosophy**

December 2013

**Horizon Doctorate Centre
Department of Computer Science**

Abstract

This thesis investigates the distinct contributions of artists who engage the public with climate data, exploring the role of the artists and the value of their contributions by focusing on two studies of artist-led projects. The first investigates how the author's own artist led collective, Active Ingredient, engaged the public with climate data through a touring interactive artwork. The second study explores the design of an online platform for capturing, authoring and 'performing' climate data. This platform was developed and tested by Active Ingredient in collaboration with researchers from the University of Nottingham, and then used by other artists to engage with climate data.

The studies reveal how the artistic projects were designed and experienced, through a mixed methods approach requiring the author to shift perspectives in order to investigate her own arts practice alongside the work of other artists in this field.

The findings from these studies suggest that the artists adopt a distinctive voice that fosters an emotional engagement with climate data, rather than an informative or persuasive one, that goes beyond '*environmental knowing*' towards human-scale, embodied, localized and personalized sense making. This research reveals how the artists use the key strategies of *performing data*, *sensory experience* and *multiple interpretations* to provoke these emotional responses. Highlighting the challenges and opportunities of engaging *temporal structures* and *narratives* to represent climate data; treating the data as a *new material* that is *embedded* into the artworks and *embodied* in various sensory forms; *abstracting* and *juxtaposing* multiple, contrasting and yet related datasets so as to invite comparisons, while opening up spaces between them for interpretation and *dialogue*.

This results in a discussion of the role of technology within the artistic process, how the artists walk a line between *authenticity* and *emotional engagement* in their interpretations of climate data and the importance of an ongoing dialogic collaboration between the artists, researchers and climate scientist that support authentic and meaningful engagements with climate data.

The research presents rich descriptions of the artists' strategies for engaging the public with climate data and revealing that artists have a distinctive and powerful role to play in relation to climate change and sustainability; one that Human Computer Interaction (HCI) and Climate Science need to understand as they continue to move into this territory, and where HCI in particular might ultimately learn about how to bring an emotional treatment to many other forms of data.

Acknowledgments

I would like to thank the partners, funders and audiences involved in *A Conversation Between Trees* and *the Relate Project*, especially Matt Watkins, Robin Shackford, Mark Selby and Rebecca Lee (the Active Ingredient team), Silvia Leal, Dr Carlo Buontempo, Prof Gabriella Giannachi, my supervisors Prof Steve Benford and Andrew Greenman, Prof Derek Mcauley, Dr Martin Flintham, Dr Jesse Blum, Mike Golembewski and all the additional support from the Mixed Reality Lab, Horizon DTC and Horizon Digital Economy Research Institute.

I would also like to give a special thank you to Dr Jesse Blum, Suzy Rosenthal, Joelle Chess, Jo Cranwell, Ewa Luger, Jackie Toothill, Hilary Jacobs and Michael Jacobs for all the support and advice.

I gratefully acknowledge support from the Horizon Doctoral Training Centre (EP/G037574/1), RCUK, EPSRC Dream Fellowship award (EP/J005215/1) and the Arts Council of England.

Copyright

This work is licensed under the Creative Commons Attribution-NonCommercial 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc/4.0/>.

Table of Contents

Abstract	p.2
Chapter One. Introduction	p.12
1.1 Terminology	p.13
1.2 Motivations	p.15
1.3 Research Statement and Objectives	p.17
1.4 Research Questions	p.17
1. 5 Approach	p.18
1.6 Background of the Work	p.19
1.7 Contributions	p.20
1.8 Thesis Outline	p.26
Chapter Two. Literature Review and Related Work	p.28
2.1 Introducing The Venn Diagram	p.29
2.2 Set 1: Contemporary Art	p.31
2.3 Set 2: HCI	p.36
2.4 Set 3: Climate Science	p.40
2.5 Set 4: HCI and Contemporary Art	p.45
2.6 Set 5: HCI and Climate Science	p.48
2.7 Set 6: Contemporary Art and Climate Science	p.52
2.8 Set 7: Environmentally Engaged Art and Climate Data	p.57
2.9 Conclusion	p.64

Chapter Three. Methodology	p.68
3.1 Overview	p.69
3.2 Theoretical Context	p.70
3.3 Approach	p.72
3.4 Study Methods	p.79
3.5 Conclusion	p.84
Chapter Four. A Conversation Between Trees	p.88
4.1 Overview of A Conversation Between Trees	p.89
4.2 Technical Implementation	p.94
4.3 Marketing <i>ACBT</i>	p.95
4.4 Touring <i>ACBT</i>	p.96
Chapter Five. Analysis of A Conversation Between Trees	p.114
5.1 The Study	p.115
5.2 An Overview of the Participants' Perspectives	p.120
5.3 Thematic Analysis	p.126
5.4 Engagement and Disengagement	p.151
5.5 Conclusion	p.153
Chapter Six. The Relate Project	p.155
6.1 Overview of the Relate Project	p.156
6.2 The Design Process	p.159
6.3 Phases of Activity	p.161
6.4 The Platform	p.172
6.5 Technical Overview of the <i>Timestreams</i> Platform	p.173

6.6 Using *Timestreams* p.179

6.7 The Experimental Artworks p.187

Chapter Seven. Analysis of the Relate Project p.205

7.1 The Study p.206

7.2 Introducing the Participants p.208

7.3 Thematic Analysis p.214

7.4 Conclusion p.236

Chapter Eight. Extended Themes p.238

8.1 The Role of the Artist p.238

8.2 Provoking an Emotional Response to Climate Data p.239

8.3 The Role of Technology in the Artistic Process p.239

8.4 Scientific Authenticity vs Emotional Experience p.247

8.5 Dialogic Practice p.250

8.6 Conclusion p.253

Chapter Nine. Conclusion p.255

9.1 Discussion p.256

9.2 Answering the Research Questions p.258

9.3 Contributions Summary p.263

9.4 Future Work p.266

Figure Contents

Fig.1 Moon Radio WebTV and MakeTV

Fig.2 Heartlands ('Ere Be Dragons)

Fig.3 Love City

Fig.4 Exploding Places

Fig.5 Chemical Garden

Fig.6 Literature Overview Venn Diagram

Fig.7 An exhibition presenting methods of combining practice and research by the author

Fig.8 Thematic Data Maps

Fig.9 The practice research cycle

Fig.10 Points of conflict in the practice research cycle

Fig.11 Schematic sketch of the visitor experience during the *ACBT* exhibition

Fig.12 The two projection screens, the front screen visualising a tree in the UK and the back screen a tree in the Mata Atlantica, Brazil.

Fig.13 The sensor box in a Service Tree in Haldon Forest with CCANW in the background

Fig.14 Visualisations of a mango tree in the Atlantic Forest, Brazil (left) and Ash tree in the UK (right).

Fig.15 Visualisation screen showing a mango tree in the Mata Atlantica

Fig.16 The Climate Machine from above

Fig.17 The Climate Machine

Fig.18 Burning circular graphs onto recycled paper

Fig.19 Hanging sheets with heat drawings representing 52 years of carbon dioxide increases in the earth's atmosphere

Fig.20 Using the phone application in the forest

Fig.21 Visitor using the phone application in Tijuca Forest

Fig.22 Photographs captured by visitors whilst using the phone at CCANW, Haldon Forest, Devon, UK

Fig.23 Old sensor kit including: Sciencscope hub, Nokia N95, temperature, humidity, atmospheric pressure and decibel sensors

Fig.24 Sketches of the technical schema of *ACBT*

Fig.25 The new sensor kit including: CO2 monitor, decibel sensor, humidity sensor, temperature sensor, Arduino hub, Android phone and Power Gorilla Battery

Fig.26 The drawing arm and soldering iron

Fig.27 The Inflatibles fully inflated

Fig.28 Active Ingredient testing the concept of performing data

Fig.29 Building the Inflatibles at Barracao Maravilha

Fig.30 The Inflatibles exhibited at Barracao Maravilha

Fig.31 Visitors standing outside the exhibition preview

Fig.32 The Inflatibles exhibited at Primary, Nottingham, UK

Fig.33 Artists participating in the Hackday event, UK

Fig.34 Architecture of the *Timestreams* platform

Fig.35 Blum walking with the sensor kit in his bag through the forest to Vera Cruz

Fig.36 *Timestreams* plug-in

Fig.37 Drop down menu

Fig.38 Adding a new measurement container

Fig.39 List of Measurement Containers

Fig.40 List of Measurements

Fig.41 List of Image URLs

Fig.42 Creating a new Timestream

Fig.43 CO2 data on the timeline

Fig.44 Image data on the timeline

Fig.45 Zooming in on the timeline

Fig.46 Setting start and end times and rates

Fig.47 Setting up a *Timestreams* page

Fig.48 Inserting a *Timestreams* Visualisation

Fig.49 Selecting a *Timestreams* Visualisation

Fig.50 A simple Javascript visualisation

Fig.51 Multiple *Timestreams* embedded in a page

Fig.52 The same *Timestreams* images on the timeline

The Inflatibles exhibited at Primary, Nottingham, UK

Fig.53 Code for adding a *Timestreams* in processing

Fig.54 Screen capture of the video of Before Light

Fig.55 The Prediction Machine and Fortune Empadinhas

Fig.56 Watching Me, Watching You

Fig.57 Mini Apocalypse

Fig.58 Visitors listening to Alvorada Dawn

Fig.59 Thunder Drum

Fig.60 Interactive Visualisations of CO₂, light and colour data

Fig.61 Inflatibles exhibited at Barracao Maravilha alongside other work by Richards and Tublenchak

Fig.62 A member of the public listening to the Rite of Spring at Barracao Maravilha

Fig.63 *Timestreams* experiments with Locke's Hydrophonics

Fig.64 The Bulb Experiment

Fig.65 The Journey of an Apple

Publications

Jacobs, R., Benford, S., Selby, M., Golembewski, M., Price, D., & Giannachi, G. (2013, April). A conversation between trees: what data feels like in the forest. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 129-138). ACM.

Jacobs, R., Benford, S., Selby, M., Golembewski, M., Price, D., & Giannachi, G. (2013, April). A conversation between trees: what data feels like in the forest. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 129-138). ACM.

(Awarded Best Paper Honorary Mention)

Blum J. Flintham M. McAuley D. Jacobs R. Watkins M. Lee R. Shackford R. Selby M. Leal S. Giannachi G. *Timestreams: Supporting Community Engagement in the Climate Change Debate*, Digital Futures Conference (Awarded Best Paper)

Jacobs, R. Selby, M. Leal, R. Shackford, R. 2011. Material Conditions. Proboscis, Bookleteer, pp.1–18. Available at: <http://bkltr.it/rU4H1u>.

Jacobs R. Selby M. Benford S. Engaging With Slowness: A Temporal Experience of Climate Change, Workshop Position Paper Slow Technology DIS 2012

Flintham, M, Greenhalgh, C. Lodge, T. Chamberlain, A. Paxton, M. Jacobs, R. Watkins, M. and Shackford.R "A case study of exploding places, a mobile location-based game." In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, p. 30. ACM, 2011.

Giannachi, G., R Jacobs, S Benford, Performing Nature's Footprint, in Arbury SA (eds) *Visual and Performing Arts*, Athens: Atiner, 2011, 393-404

Table Contents

Table 1. Implementing the Performance-Led Research in the Wild Framework

Table 2. Key to the visualisations in *ACBT*

Table 3. Five Phases of *ACBT*

Table 4. Participants in the study of *ACBT*

Table 5. *ACBT* Themes

Table 6. *Relate Project* Stakeholders

Table 7. Phases of *Relate Project* activities

Table 8. Participants in the Study of the *Relate Project*

Table 9. Reframing the themes

1

Introduction

The Artists' Footprint investigates the distinctive role that artists play in engaging the public with climate data. It reveals the strategies that artists employ and the impact of these strategies on the disciplines of Contemporary Art, Human Computer Interaction (HCI) and Climate Science.

This thesis focuses on two studies of how an artist led collective - Active Ingredient – has been engaging the public with scientific climate data through the public exhibition of an interactive artwork; and the design of an online platform for capturing, authoring and *'performing'* climate data, that was then used in partnership with other artists to create experimental artworks.

This research argues that these *'environmentally engaged artists'* offer distinct approaches which create an emotional engagement with climate data, provoking an understanding of the often slow, global processes of climate change on a human scale and making them relevant to our everyday lives.

Climate Change is a deeply challenging, complex, and often politically charged issue. The global and long-term nature of climate change data defies easy or immediate comprehension within our day to day lives (Scannell & Gifford 2012). Thus, while some parties are still furiously discussing the veracity and meaning of the scientific data around carbon dioxide levels and temperature rises, there is a risk of the wider public becoming disenfranchised, unwilling or unable to engage with the underlying data, its meaning and impact on their local environment, therefore becoming increasingly distanced from the debate.

Both DiSalvo et al. (DiSalvo et al. 2009) and Polli (Polli 2011) have previously argued that artists have a role to play in engaging the public with issues of climate change and the capture and interpretation of climate data. Both call for further investigation into the strategies that artists employ to engage with climate data, a deeper understanding of the artists' role in interdisciplinary collaborations that engage the public with climate change and the implications of these artists' contributions.

This chapter introduces the terminology, motivations of this research, background of the artists' work, approach, research questions, the contributions of this research and thesis outline, as a roadmap to the thesis.

1.1 Terminology

This research encapsulates the three disciplines of Contemporary Art, HCI and Climate Science and will therefore at times employ language specific to these disciplines, therefore it is important to begin by defining the terminology used within this thesis.

Climate Change

For the purpose of this thesis the author is focusing on the issues of human induced climate change. Climate Change is the most commonly employed term across the related climate science literature in relation to human induced (anthropogenic) changes in the earth's climate (Norgaard 2011; Washington 2013; Wrigley 1999; O'Hare et al. 2005). Across the scientific community, the media, the political domain and education there is an ongoing debate on how these changes are framed for the public, how and when to use of the terms '*climate change*', '*global warming*' and more recently the terms '*global weirding*' (Boykoff 2011) and '*extreme weather*' (Schiermeier 2011). This debate will be discussed in more detail in Chapter 2.

Climate Data

In the context of this research the definition of '*climate data*' is based on the measurement, capture, dissemination and interpretation of data captured from the external environment, on local and global scales (Burke et al. 2006). Climate differs from weather in that it represents the pattern of variations in the measurements of a given region over a long period of time, whereas weather represents the present measurements over a shorter period. The two case study projects investigated in this thesis focus on the measurements of both scientific climate and weather data as part of a series of artistic activities, this is achieved using sensor technologies, tools and devices that have been developed across climate science and computer science.

Environmentally Engaged Art

This research explores how contemporary artists engage with climate data. The term the author is using for the purpose of this research - environmentally engaged art – defines the ways in which contemporary artists engage directly with environmental, climatic and ecological discourses. Other ways of defining this area that are used within contemporary art includes Polli's definition '*eco-media*' (Polli 2011), which relates more specifically to contemporary media traditions - as in 'digital media' and Malina's definition of '*climate art*' (Malina 2009), which defines art that specifically deals directly with the climate, not necessarily leaving space for art that also reflects on other environmental or socially engaged themes, as with the works studied in this thesis.

DiSalvo et al. and Demos refer to this genre of work as '*ecologically engaged art*' (DiSalvo et al. 2009; Demos 2013). In this context the author felt the emphasis on ecology was problematic, suggesting a more activist approach (Latour 2009), rather than encompassing how artists engage more broadly with the environment and climate change, in this case often beyond a specific '*ecological*' political perspective or agenda. This debate will also be discussed in more detail in the literature review in Chapter 2.

Conceptualising Climate Data

Giannachi offers up the notion that artists in this space are '*conceptualizing environmental data*' (Giannachi 2010) as opposed to the more limiting terms of data visualisation and interpretation that do not necessarily encompass the full scale of artistic approaches to working with data, including performance and embedding data into physical forms and immersive environments. Giannachi suggests that these artists are interpreting data in their practices through temporal and performative actions that go beyond visualisations (Giannachi 2010; Giannachi 2012).

1.2 Motivations

The author's motivations for this research have come directly from her own arts practice, as one of the lead artists within Active Ingredient, alongside a broader call for further research in this area, across each of the disciplines of Contemporary Art, HCI and Climate Science to be mapped out in Chapter 2.

This research is timely. Across the scientific community, the media, the political domain and education there are many controversies about the best way to communicate and engage the public with climate change, addressing issues of climate change skepticism, the difficulties of understanding climate change in context of our everyday lives and the wide scale denial of the risks and threats (Washington 2013; Norgaard 2011; Spence et al. 2011). As discussed in Chapter 2 much existing work looks at how to engage the public with climate change, yet there is still limited research that brings this knowledge together, exploring the overlap between disciplines, and even less that focuses on the contributions of artists within this interdisciplinary context.

Within HCI there is a body of work that engages with discourses around sustainability, ecology and the environment. It has been suggested that much of this work has been based on a top down modernist approach and there is an increasing call within this field, often defined as sustainable HCI, to explore the role of interdisciplinary collaborations, particularly involving the arts, as a means to enrich this research (Brynjarsdottir et al. 2012.; Aoki et al. 2009; Froehlich et al. 2010). This is supported by DiSalvo et al.'s proposition that the often dialogic (DiSalvo, et al. 2009; Miles 2006) approaches of environmentally engaged artists can broaden the domain of sustainable HCI, calling for new methods to address design challenges, alongside new metrics of value and success across the disciplines. This work echoes a growing interest in the broader HCI community in the value of collaborations with artists and creative producers where issues of engagement, interpretation and the production of public exhibition and performance are themes that are of growing interest within this community (Benford et al. 2011; England 2012; England et al. 2012; Sengers & Csikszentmihályi 2003; Benford & Giannachi 2011).

Within Contemporary Art, artists are found to be increasingly collaborating with scientists and HCI researchers [4], often working across genres, mediums and disciplines. Many of these artists are increasingly working with locative and environmental data as a tool or medium to trigger conceptualizations of the environment, in response to wider socio-political issues around urban environments, nature, sustainability, climate and environmental change. Giannachi et al. suggests that environmentally engaged artists are working increasingly with environmental data (Giannachi & Stewart 2005; Giannachi 2010) as both an artist's tool (to

draw, sculpt, make tangible and meaningful representations) and as a medium of interpretation - as the thread of a story or a narrative experience (Bindi 2011).

The artworks created by these artists can also be considered alongside a wider interest in infographics and data visualisation, occurring across broader arts, design and new media practices (McCandless 2009; Tufte 1998; Bateman et al. 2010). This research will map previous research into these environmentally engaged artworks and investigate the contributions of these practices to other disciplines, the strategies the artists use to engage the public through this practice, and the impact on the public's engagement with the climate data, through the study of two artist led projects by the author's own arts collective Active Ingredient.

This research is also reflected in the disciplines of Climate Science and Environmental Psychology. Climate scientists and institutions, such as the MET Office UK, are increasingly seeking novel ways to engage the public with environmental data, as part of their own communication of climate change. Research in this field shows that *'one of the reasons that people may not take action to mitigate climate change is that they lack first-hand experience of its potential consequences'* (Spence et al. 2011). Furthermore these findings show the growing need for scientific institutions and research bodies to increase levels of public trust in the data presented by scientists, in the light of very public media dialogues such as the debate around the University of East Anglia's so called *'Climategate'* and the role that the media plays in shaping public understandings of climate change (Boykoff 2011). These dialogues are likely to increase as the Intergovernmental Panel on Climate Change (IPCC) release a new report on the scientific, technical and socio-economic impacts of climate change in 2014 (IPCC 2013).

This research is also timely from a wider cultural perspective. Government departments such as the MET Office UK, Hadley Centre and many environmental campaign groups and organisations are attempting to engage the public with the complex issues of climate change in response to high profile events such as the Earth Summit in Brazil, 2012¹ and to disseminate research that reveals the potential impact of environmental and climate change. In support of this socio-political context there is a growing interest within the wider digital economy in the capture and visualisation of a wide scope of public data.

This research therefore brings together the existing knowledge from the three fields of Contemporary Art, HCI and Climate Science in order to explore artists' distinctive strategies

¹ <http://www.earthsummit2012.org>

and contributions - through the study of two artist-led projects, which engage the public with climate change.

1.3 Research Statement and Objectives

This thesis investigates the distinct contributions of artists engaging the public with climate data, proposing that by employing performative, temporal, sensory strategies within their artworks artists are able to engage the public in multiple interpretations of data, on a human-scale that provoke emotional responses to the issues of climate change.

The research objectives:

- An evaluation of the complex role and distinct contributions of environmentally engaged artists working with climate data
- A discussion of the design implications for the HCI community to support the future development of tools and systems for artists
- Highlighting the challenges, opportunities and further questions for future collaborations across the disciplines of Contemporary Art, HCI and Climate Science.

1.4 Research Questions

This thesis poses the key research question: what are the distinct contributions of artists who engage the public with climate data?

This question is investigated through the study of two artistic projects, alongside a review of the literature and related work across the three disciplines of Contemporary Art, HCI and Climate Science in Chapter 2. These key research questions respond directly to the research objectives outlined in the previous section:

1. What is the role of artists working with climate data in interdisciplinary collaborations?
2. What are the specific artistic strategies (including motivations, rationale, vision and approach) employed by these artists in order to engage the public with climate data?
3. How do the public perceive artists' work that employs these strategies?
4. How might these strategies be embedded into future practices and technologies within the fields of HCI and Climate Science?

1.5 Approach

Due to the complexity of the author taking on the role of both researcher and artist the voice of the researcher is referred to as '*the author*' throughout the thesis. This may at times appear artificial but this approach has been chosen to enable the author to shift between the perspectives of researcher and artist. When discussing the author's role in the artist-led projects she will be described as '*artist/author*'; this approach will be discussed in more detail in Chapter 3.

The research questions outlined in Section 1.4 will be investigated using a mixed method approach, reflecting the interdisciplinary nature of this research. This involves combining Benford et al.'s '*Performance-Led Research*' framework (Benford et al. 2013) with Taylor's self-situated and reflexive '*Designing from Within*' (Taylor et al. 2011), both of these frameworks will be described in more detail in Chapter 3.

This thesis describes the two artists-led projects studied as part of this research and then provides a separate analysis and discussion of the artists' motivations and rationale, the perspective of the climate scientist who advised on both projects, the public's response – in the case of the first study, and the HCI researchers – in the case of the second study.

The two artist-led projects that contribute to the studies in this thesis are described below. Both projects were developed by the author and her own artist collective, Active Ingredient, in collaboration with Horizon Digital Economy Research Institute; Dr Carlo Buontempo, climate scientist from the MET Office, UK; and British Brazilian artist Silvia Leal.

Study One – A Conversation Between Trees

The first study is of an artwork - *A Conversation Between Trees (ACBT)* – that toured to three forest venues in the UK and was presented in a forest (Tijuca Forest) in Rio de Janeiro, Brazil. The study of this artwork enabled the author to define the motivations, rationale and strategies that the artist group Active Ingredient employed in the making of this artwork. The study involved recording the artists' perspectives (including the artist/author's own perspective), alongside the perspective of the climate scientist, through audio interviews and access to documentation of blog posts, notes, photos and videos. These were combined with the perspectives of the public audiences who experienced the first artwork (*ACBT*), also captured through audio interviews alongside questionnaires and observations. A video of the artwork is provided on the DVD attached to the back page of this thesis or can be viewed online².

² <http://vimeo.com/35013316>

Study Two – The Relate Project

The second study of the *Relate Project* involved the development of an online environmental data capture system designed for artists and tested through a series of artist residencies and hackdays. This second in depth study provided an opportunity to broaden the artistic activities to gain the perspectives of the other artists who collaborated with Active Ingredient and participated in the project, acting as an impact study of the first artwork (*ACBT*). The findings from the first study informed the design of the blogging system – the *Timestreams* platform - to enable artists to ‘perform data’, a core concept that has resulted from this research and will be described in more detail later in this thesis. This study investigates how the artists used the platform, comparing the findings from *ACBT* against conversations with the other artist participants in the project and the wider perspectives of the HCI researchers and climate scientist who collaborated on the project. These perspectives were also captured through audio interviews, access to blog posts, notebooks, photos and videos. A video about this project is provided on the DVD attached to the back page of this thesis or can be viewed online³.

1.6 Background of the Work

Against the broad backdrop discussed in the previous sections, this thesis investigates the distinct roles played by the author, the author’s own arts collective, Active Ingredient, and other artists working in this domain.

The author has worked professionally as a practicing artist, researcher, lecturer and consultant since 1994. She is a co-founder of Active Ingredient, the artist collective that led the two artistic projects contributing to the studies within this thesis. She comes from a background of performing and visual art and has developed an arts practice that merges art, science and technology.

Active Ingredient has been making interactive artworks since 1996. Their work has been presented nationally and internationally in galleries, arts festivals and public spaces. Active Ingredient was an early producer of artists’ web streaming projects that explored notions of liveness and telepresence in the late 1990s and early 2000s. They created groundbreaking artist web TV projects, including *Moon Radio webTV* and the pre-YouTube flash streaming channel *MakeTV* (see Fig.1). Active Ingredient also pioneered some of the first locative artworks and mobile phone games, including the award winning mobile phone game *Heartlands* (*‘Ere Be Dragons*) that toured worldwide (Fig.2); *Love City*, a mobile phone

³ <http://vimeo.com/54275779#at=0>

game based in the East Midlands region of the UK (Fig.3); and *Exploding Places*, a mobile phone game based in the London area of Woolwich (Fig.4).

The collective has three core members, the author (Rachel Jacobs), Matt Watkins and Robin Shackford. They also employ a team of associate members who join the collective on a project-by-project basis. Active Ingredient is based in Nottingham, UK but has presented artworks nationally and internationally at galleries, arts festivals, conferences and in public spaces.

Active Ingredient has been collaborating with scientists, technologists and researchers since creating their first large tour of the interactive installation, *Chemical Garden* (Fig.5), in 1999.

Since 2005 Active Ingredient have developed seven artist-led projects in collaboration with HCI researchers at the University of Nottingham (Mixed Reality Lab and Horizon Digital Economy Research Institute). During this time Active Ingredient have worked with environmental and bio-sensors, creating a series of artistic and research projects using data to reveal invisible processes in our bodies and the environment. This work emerged from the mobile art game *Heartlands ('Ere Be Dragons)* project (see Fig. 2) in which the artists revealed invisible biological processes using heart rate sensors and GPS as participants in the game took journeys through a landscape. *Heartlands ('Ere Be Dragons)* explored the impact of the environment on our emotional and physical states (Davis et al. 2005; Davis et al. 2006; Marshall & Benford 2011). During an exhibition of this work in Brazil the artists became interested in turning this approach inside out, to explore how the human presence impacts on the environment by focusing on forests in the UK and Brazil, how our human presence in the forest creates changes in the environment and in turn how they could sense these changes.

This previous work has resulted in Active Ingredient's more recent projects, where the artists have used environmental sensors to reveal the hidden processes of climate change, particularly in forest environments in the UK and Brazil. These projects have involved artistic collaborations with scientists in both countries and HCI researchers (based at the University of Nottingham). This has resulted in the schools' exchange project, *The Dark Forest* (2008), and the two projects contained in this thesis: *A Conversation Between Trees* and the *Relate Project*.

1.7 Contributions

The key contribution of this work is the study of two distinct artistic projects. Both projects engaged the public in the UK and Brazil and contributed to research across Contemporary Art, HCI and Climate Science. As described in the previous section, the findings from the first study also directly informed the development of the *Timestreams* Platform, which is



Fig.1 Moon Radio webTV and MakeTV (1998 – 2004) – artist-led live web streaming channels developed for artists to experiment with live broadcast in the early days of the Internet



Fig.2 Heartlands ('Ere Be Dragons) (2005–2009) – a mobile phone game/mixed reality performance played on the streets, using heart rate and GPS



Fig.3 Love City (2007) – a mobile phone game / mixed reality performance that merged the three cities of Nottingham, Leicester and Derby into an augmented reality where players sent messages of love to each other in order to keep Love City thriving



Fig.4 Exploding Places (2009) – a mobile phone game for smart phones, creating communities that thrive or die over 100 years of history as players explore the streets of Woolwich, London



Fig.5 Chemical Garden (1999 – 2000) – an artwork of a post-apocalyptic world made from salt crystal trees, Lego robots, webcams and TVs connected to the internet, showing webcams around the world and messages sent from the project website

open source and now publicly available, providing an example of how artists can inform the future of systems for capturing, measuring and interpreting environmental data.

This research has also contributed to the field of Contemporary Arts through a rich analysis of artists' strategies for engaging the public with climate data, an investigation into the role of artists working in collaboration with scientists and technologists and in practical terms, the production of several new artworks that have been presented to the public in both the UK and Brazil. It reveals the challenges and opportunities for artist/researchers investigating their own practice in an interdisciplinary context and new methods for studying these practices from both a Contemporary Art and HCI perspective, discussed in more detail in Chapter 3.

Contributions to the field of Climate Science extend existing research into the challenges of engaging the public with climate data, by providing a detailed description of the strategies used by artists and the public response to these strategies.

Through the collaboration and dialogue with Dr Buontempo, Senior Climate Scientist at the MET Office UK, the findings from this research have also contributed to his work in communicating the impact of climate change. The collaborative nature of this research has also highlighted the need for further research into these collaborations between artists and climate scientists.

Additional to these direct contributions to the disciplines of Contemporary Art, HCI and Climate Science, the author and one of her colleagues in Active Ingredient is developing a new mobile game involving climate data - '*Cold Sun*', informed specifically by the findings from the *Relate Project*. Alongside this one of the prototype artworks developed during the *Relate Project – The Prediction Machine* – has also been commissioned to be exhibited in 2014 and is planned to be developed and toured by the author as a continuation of this research.

1.8 Thesis Outline

This thesis involves three parts. The first part reflects the theory and approach of the research. The second part describes the studies of the two artist led projects, and the final part provides a discussion of the role of the artist in reflection of both of the studies, the theory and literature.

Chapter Two investigates how the research questions have evolved in respect to the literature and related work. This research combines knowledge across the disciplines of Contemporary Art, HCI and Climate Science. These three fields and the overlaps between them are represented in the Venn Diagram (Fig.6).

Chapter Three describes the methodological approach of this thesis in reference to the interdisciplinary nature of the research outlined in the previous chapter and the mixed methods employed for the two studies of the artist-led projects. These approaches are described, alongside a reflection on the challenges and opportunities raised by the author taking on the role of both artist and researcher.

Chapter Four describes the first case study *A Conversation Between Trees*

Chapter Five provides a thematic analysis of the artists' motivations, strategies and rationale for making *A Conversation Between Trees*, public engagement through the visitors' experience, and the perspective of the climate scientist who collaborated with the artist.

Chapter Six describes the second study the *Relate Project* providing a technical description of the *Timestreams* Platform alongside the broader project activities and resulting experimental artworks.

Chapter Seven provides a thematic analysis of the *Relate Project* by combining the artists' motivations, strategies and rationale with those of the HCI researchers and climate scientist who collaborated on the project. This analysis extends the findings from *A Conversations Between Trees*.

Chapter Eight provides a broader discussion of the role of the artists and their contributions with respect to Contemporary Art, HCI and Climate Science.

Chapter Nine concludes the thesis by returning to the research questions, providing a summary of the findings in response to these questions, a discussion of the contributions this research makes to each of the fields of Contemporary Art, HCI and Climate Science and future work to be conducted in response to this research.

2

Literature Review and Related Work

The first step of the journey through this thesis is to undertake a literature review in order to establish a theoretical grounding of existing ideas and approaches and to identify the research gaps.

As introduced in Chapter 1, this research is a three-way '*conversation*' between the disciplines of Contemporary Art, Human Computer Interaction (HCI), and Climate Science, represented by the Venn diagram in Fig. 6. These disciplines represent the three core domains within the key research question: the artist practices that engage the public, the technology that enables the capture, mediation and representation of climate data, and supporting current scientific practices involving measurement and interpretation of the data.

This chapter provides a systematic look at existing literature across these three disciplines, providing a broad introduction to each of the disciplines, then digging deeper into the crossovers within the disciplines, finally presenting the small body of existing work that investigates artist's contributions to engaging the public with climate data within this interdisciplinary context.

Much work has already taken place exploring the broader role of artists within the sciences (Ede 2005; Arends & Thackara 2003) and HCI (Paulos 2007; England 2012), whereas in this case the focus of this thesis is to dig deeper into the related literature, to discover the gaps in understanding of the specific roles, strategies and contributions of artists who are working specifically with climate data.

It is at this convergence where old meets new, nature meets technology, art meets science, that the author seeks to explore how the distinctive traditions and approaches of artists can contribute to the discourses of climate change and the design of tools and systems that encourage public engagement with climate data.

2.1 Introducing The Venn Diagram

Relevant literature is spread across the three disciplines represented in the Venn Diagram in Fig.6. This review follows the headings outlined below, reflected by each set of the Venn Diagram.

It is a challenging task to provide a linear journey through each of these disciplines, and the author has attempted a reductionist approach in order to contain the core issues within each of the different sets, but there are many examples where the research bleeds across the boundaries of disciplines, particularly at the intersections of the sets. This will be discussed in more detail later in the chapter.

Due to the interdisciplinary nature of this work it was felt that a broad introduction to each of the disciplines was needed before a deeper review of the core literature could take place. Therefore the following sections investigate the intersections of the Venn Diagram by working from the outside in. This frames the context of each discipline and takes a brief journey through the broader related work. The review will then present the intersections in the literature within each of these disciplinary perspectives, working towards a review of the core literature, represented by the centre of the Venn diagram.

Sets 1 – 3 contain brief general introductions of each discipline, investigating the broader literature and how each of these disciplines inform the specific research focus of this thesis:

Set 1: Contemporary Art

Set 2: Human Computer Interaction (HCI)

Set 3: Climate Science

At the intersections of the Venn Diagram are sets 4 – 7. These sets highlight the overlap between the disciplines. The core themes within them are investigated in more detail, in order to reveal the core literature at the centre of the diagram in Set 7:

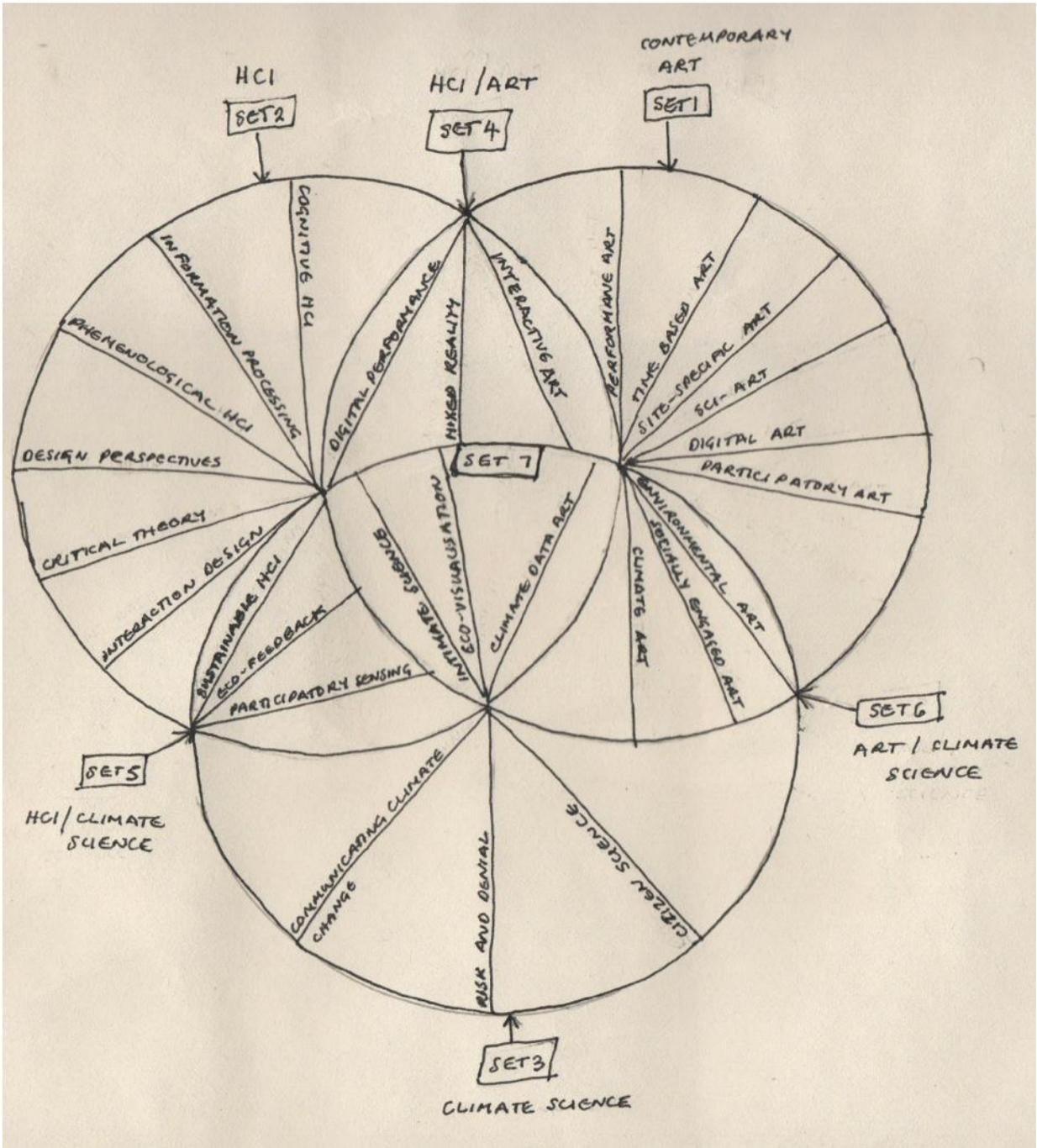


Fig.6 Literature Overview Venn Diagram

Set 4: HCI and Contemporary Art

Set 5: HCI and Climate Science

Set 6: Contemporary Art and Climate Science

Set 7: Environmentally Engaged Art and Climate Data

2.2 Set 1: Contemporary Art

Beginning at the outer sets of the diagram, Set 1 represents Contemporary Art, presented here as a short summary of related artistic practices and movements of the last century that are defined as '*contemporary*' within the context of Art History (Stiles & Selz 1996), and focusing predominantly on a Western perspective. This summary therefore attempts to provide a theoretical grounding in support of the studies of the artists to be undertaken in this thesis. For further reading about the background, context and historical perspective of these practices the author suggests two key works '*Theories and Documents of Contemporary Art*' (Stiles & Selz 1996) and '*Information Arts*' (Wilson 2002).

These key related art forms and movements emerged during the twentieth and twenty-first century in response to the industrial revolution; developments in science, technology and philosophy; the impact of the World Wars; and other cultural and social changes worldwide (Stiles & Selz 1996).

The following descriptions are of the art genres and movements that have informed many current environmentally engaged arts practices. A more detailed description of environmentally engaged art will be discussed later in Section 2.7, as this review digs deeper into the core literature. These broad summaries of related genres and movements are followed by a discussion that frames the context of the conditions of artists working within these practices.

2.2.1 Performance Art

Performance Art is seen as emerging almost simultaneously in Japan, Europe and the United States in response to modernism and industrialization, emerging from the Modernist Avant-Garde to include the Futurist, Dadaist, Bauhaus and Surrealist (Goldberg 1979) movements of the early twentieth century. Performance artists tend to be informed by a diversity of cultural, social and artistic influences unique to their location, environment and conditions of practice, (Stiles & Selz 1996): 679 using their bodies '*as the material of visual art*' by bringing art closer to their subjective, lived experience (Stiles & Selz 1996). Performance Art often reflects a social and political perspective, whilst deliberately attempting to avoid

commodification, and is often difficult to document and preserve because of its ethereal and immediate 'live' nature. The temporal, transgressive, disruptive and interventionist nature of the work is seen as a response to broader contemporary global, technological, market-led culture and society and has had a key influence on current environmentally engaged artists in terms of performativity and live experience of the artwork as a temporal often ethereal act and providing sensory experiences where the human presence is an important factor in the artists work.

2.2.2 Time Based Art/Live Art

Time Based Art, sometimes defined as Time Based Media or Live Art arose from the roots of Performance Art, specifically the Dadaists, the Situationists, the Happenings and Fluxus movements (Stiles & Selz 1996). With an emphasis on temporality, these works are often performative or film and video based and evolving over a long time scale, the temporal nature of this work is often an influence in current environmentally engaged arts practices.

2.2.3 Site-Specific Art

Western artists in particular began to investigate the importance of locality, place and space to their work also termed '*situatedness*' (Pink 2009). These artists take into account a sense of both human and non-human presence in time and space, in order to '*reassess the relationship between the art work and its site*' (Kwon 2004) this work emerged from performance art practices in the 1990s to explore the importance of place and time in the experience of artworks and these considerations have become a key factor in many environmentally engaged arts practices.

2.2.4 Information Arts / Sci-Art

Wilson describes Information Arts as the convergence of art, science and technology, responding to what social scientists call the '*information age*' (Wilson 2002). Within this domain sit many of the other classifications and genres discussed in this research, often involving collaboration across the disciplines of art, science and technology and the integration of research into art. This classification encompasses Science and Art projects, such as the Sci-Art programme that took place in the UK in the 1990s through support from the Arts Council of England (Arends & Thackara 2003), in partnership with the Wellcome Trust. This work sought to encourage and research the current practices of artists and scientists by specifically bringing these two disciplines together and have specifically informed environmentally engaged arts practices that combine elements of art, science and technology in their representations of the environment.

2.2.5 Digital /Interactive/Generative Arts

Emerging as a response to the '*computer revolution*', the term '*digital art*' evolved through artists working with technology as a medium within their practice to enable participation and interaction and/or ways to autonomously generate the work itself, as tools to enhance their practice. As technology has pervaded most of our lives, it has of course pervaded contemporary arts practices, where now even traditional fine artists such as Hockney are generating paintings on their ipads (Grant 2010).

2.2.6 Participatory Art

Participatory Art sits on the boundary between Public Art (where art occurs in the public domain outside the walls of the art institution), Community Art (where art is created for and within a particular community or communities) and Generative/Interactive Art (where art is generated by interactive, autonomous or technology driven systems). Participatory Art also has roots in Performance Art, shifting the emphasis from the Fine Art traditions of the object or artifact onto the body and lives of both the artist and audience, towards a socially engaged relationship between the subject(s) and the world.

Participatory Art enables the audience to have agency and participate in the creative process, as co-creators or collaborators within the artwork, this work has influenced many of the environmentally engaged arts practices investigated within this thesis through the emphasis on public engagement and participation.

2.2.7 Dialogic Art

Dialogical Aesthetics emerged from the work of Bahktin (Holquist 2002), revealing the relations between people and the world through dialogue. The dialogic aesthetic is a durational experience of negotiation and participation, whereby the dialogue or exchange is a focus of the arts practice. '*Dialogical Aesthetics*' suggest that an aesthetic experience does not need to be located solely in the experience of an object, artifact or physical condition. Kester (Kester 2004) suggests that in performative, participatory and collaborative arts practices the aesthetic experience can also exist in the process of communication. This work connects to Beuys' concepts of '*social sculpture*' (Beuys 2004) and the more recent work of Sacks (Giannachi & Stewart 2005) where performative dialogues and actions between the artists, environment, social space and audience becomes the artwork. Examples of contemporary dialogic practices also include '*The Battle of Orgreave*' (Deller, 2001).

Kester defines these dialogic practices as:

- Organized around a collaborative relationship

- The interactions require a discursive framework in order for participants to share insights, observations and reactions
- The interactions occur through a process of exchange and dialogue that is cumulative
- Involving a durational experience rather than an immediate experience (Kester 2004): 11-12

These dialogic arts practices are often at the heart of the environmental engaged practices investigated within this thesis. By combining *dialogic practices* with notions of *participatory art* many environmentally engaged artists are exploring how they can engage the public in a dialogue about the environment, place and identity within their work.

2.2.8 Conditions of Contemporary Visual and Performing Arts Practice

Having summarised these related artists' practices this author will provide a brief description of the context in which interdisciplinary contemporary artists tend to work.

The '*interdisciplinary*' contemporary artists investigated in this thesis often work in a professional environment that is separate from the commercial gallery system, although some of these artists' practices also cross over (Stiles & Selz 1996; Staines 2010) reflected in the sometimes interventionist and disruptive ways that they present and make their work. These artists tend to be defined as much by their processes and methods, which are predominantly collaborative, generative and participatory, as by the presentation of the artwork. Their work is often financed through public funding, commissions and research grants, and their audiences are often at public galleries, arts festivals, community spaces, in urban or rural public domains (such as in the '*natural*' landscape or on the city streets), or in non-commercial gallery spaces (that are often free and also publicly funded). The nature of their work tends towards social engagement through public participation, rather than based on the values of the commercial art market (Stiles & Selz 1996).

These artists' practices can crossover many classifications within the arts and design sector. It is not unusual for these artists to also work in the commercial arts market at times, in industry as designers and consultants, in education and in academia as researchers, as well as through publicly funded arts spaces. It should also be noted that these conditions are potentially different in countries where public funding for the arts and artist commissions are less available, such as Brazil and the US. At this time this is also a changing landscape in the UK due to on-going reduction in public funding through the Arts Council of England (Harrison 2013). As with science and research, a reduction in public funding may have impact on the future of this interdisciplinary work and the potential for collaborations in this domain (Staines 2010).

The conditions of practice for these artists, including environmentally engaged artists often involves working internationally. Many of the artists discussed in this thesis work across several countries and even continents, often within or similar to the academic model, based at several international institutions, galleries and working within many different communities at one time. This sector of artists is deliberately hard to define, their practices exploring mobility, crossing and disrupting boundaries, borders and locations and therefore challenging more traditional arts categorisation, notions of identity and the clearly defined peer review processes that are inherent to many other disciplines.

2.2.9 Brazilian Contemporary Art

As the research contained in this thesis takes place across the UK and Brazil - due to the nature of the artworks - most notably during the second study which investigates Brazilian artists working with climate data, it is most relevant to this thesis to address some of the differences in the way artists in Brazil and the UK generate practices around the environment and climate change. The artists represented in the second study have emerged from a Brazilian historical art tradition where the relationship between artists and the environment has been heavily influenced by the impact of the colonisation of the people and landscape of Brazil.

Distant from the World Wars and with industrial development not fully occurring until the late twentieth century, much of contemporary environmental arts practices in Brazil have been embedded in a combination of indigenous cultural perspectives, Afro-Brazilian emergence from slavery, and the concept of '*repersonalisation*' (Brett 2002). Alongside the complex cultural heritage that has informed contemporary Brazil, Brazilian art has evolved as a response to the relationship between the rural and urban, militarization, recent industrialization of the mega cities, the agricultural spread of the country and the fast consumption of Brazil's rich resources in support of arguments for social and economic change.

Out of this specific cultural heritage three distinct contemporary movements have evolved: *Tropicalia*, *Concretism* and *Anthropofago* (Amirsadeghi 2012). These movements continue to influence contemporary environmentally engaged arts practices in Brazil today, each of which supports a 'Brazilian specificity' a notion that is explored and questioned by Ferran and Fonseca (Ferran & Fonseca 2009) in their mapping of how contemporary Brazilian media artists are engaging with the environment. These artists have developed socially engaged practices '*which do not rest on technical or disciplinary criteria but are rather focused on the transformation of an aesthetic idea or model*' (Ferran & Fonseca 2009). In Brazil, technology and the environment tend to be represented in terms of scale, distance and

the plurality of multi-cultural differences; in a country so large and with such a diverse cultural heritage these issues are perceived very differently than in Europe or smaller, less culturally mixed societies (Ades et al. 1989; Amirsadeghi 2012).

Andrade's 1928 Manifesto introducing the concept of '*Anthropofago*' responds to a Brazilian concept of colonialism where the colonized '*accept and embrace (eat) the coloniers*'. This movement has in turn informed Brazilian hacking, open source and recycling culture and has greatly influenced contemporary media art and environmentally engaged Brazilian arts practices (Ferran & Fonseca 2009).

As highlighted in the brief summary of related Contemporary Arts practices within this section, the last 100 years in the West and Brazil have seen an evolution of art forms and movements, incorporating responses to technological innovations and the shifting cultural, social and political landscape of the times. Since the beginning of the twenty first century these art forms are increasingly embracing digital technologies and reflecting the concerns of our age, discussed in more detail in Section 2.5.

The next section will investigate how the discipline of HCI has evolved in parallel.

2.3 Set 2: Human Computer Interaction (HCI)

This section (corresponding to Set 2 of the Venn Diagram in Fig.6) reveals the evolution of Human Computer Interaction as a distinct research field within the broader discipline of Computer Science. As with the previous section, the author will briefly summarise the historical and theoretical background of this discipline, in order to contextualize and draw out how the emerging themes relate to the research within this thesis.

HCI is concerned with how people interact with computers, seeking to merge knowledge about people from various interdisciplinary perspectives with technology research into interfaces. Harrison et al. suggest that there are '*Three Paradigms*' of HCI, involving human factors, classical cognitivism/informational processing and phenomenologically-situated HCI (Harrison et al. 2007). A further discussion of these three paradigms of HCI suggests that they have each emerged from developments in computer science, psychology, ethnography, design and more recently art and critical theory (Jacko 2012).

HCI first emerged in the 1970s as an overlap between computer science and psychology, with a focus on ergonomics and usability. It was extended in the 1980s to encompass social perspectives as computers became tools for collaboration and began integrating perspectives from social science, such as ethnography, which has led to the emergence of the Computer Supported Cooperative Work (CSCW) Conference and community.

The 1990s saw the integration of design perspectives into HCI (Rogers et al. 2011), as computers became more of a commodity and were sold as products for everyday life, to include the rise of the home PC rather than just computers for work. A spin off of this was the conference '*Designing Interactive Systems*' (DIS) and interaction design emerged as a sub-discipline. Related research from this sub-field includes investigations into the roles of tangible computing, ambiguity and sense making in the design of interactive experiences. It draws on critical theory and other aspects of the humanities to understand further the role of computation in the context of the increasing ubiquity of computing in everyday lives, and the resulting interdisciplinarity in which HCI research is evolving (Rogers et al. 2011). Since 2000, HCI has seen a turn to the artistic, looking at more provocative, cultural, social, challenging experiences of HCI and the concepts that support them.

This progress, towards ubiquitous and pervasive computing, that occurs beyond the screen and in the world, has occurred in parallel to research that extends our understanding of technology - beyond issues of functionality and usability - towards the consideration of technologies in context of society, psychology, critical theory, design and interdisciplinary research practices.

More recently HCI research has begun to reflect on the crossovers between interactive arts and HCI, evaluating the collaborations and strategies artists and designers use to engage audiences in the '*spectacle*' of their work (Benford et al. 2011) and the trajectory of experience of those who interact with the work, particularly in terms of Mixed Reality Performance (Benford & Giannachi 2011).

DiSalvo et al. suggest that this new wave of HCI research is '*looking to the arts for enhancing, or in some cases transforming, our traditionally science-dominated practice*' (DiSalvo et al. 2009), this move towards the arts will be discussed in more detail in Section 2.5.

2.3.1 Design Perspectives

The most relevant of these phases of HCI to this thesis is the integration of design perspectives, interactive arts and critical theory. In the 1990s Ishii et al. (Ishii & Ullmer 1997) began to explore HCI in terms of these design implications, specifically '*tangible media*' and the physical embodiment of digital information. Their work combines strategies and ideas from artists and designers alongside more traditional scientific approaches:

'We are very eager to design a new medium for the representation of ideas. For landscape design it's not so much rigorous simple scientific work - it needs aesthetics, an 'artistic' point of view. This clay is both computational clay and physical clay. You can give it form and manipulate it while simultaneously the computer provides an analysis - a rigorous scientific

mathematical analysis. It is painting on top of the clay. This becomes a medium for not only artistic representation but also scientific reality.' (Ishii & Ullmer 1997)

Work by Dourish (Sengers et al. 2006), DiSalvo et al. (DiSalvo et al. 2012), and Gaver et al. (Gaver et al. 2003) has also opened up new approaches for design within HCI. They each call for HCI to absorb methods from critical and cultural theory and look beyond the traditional ethnographic methodologies used by HCI and human factors, in order to address the new challenges opened up by interaction design. Ishii et al. suggest it is through encompassing new design implications and artistic considerations that a '*new material*' for human computer interaction is evolving:

'taking advantage of multiple senses and the multimodality of human interactions with the real world.' (Ishii & Ullmer 1997).

This work has led to more in depth and rich understandings of the implications of design within interactive technologies and the emergence of '*Ubiquitous Computing*' (*Ubicomp*). Gaver et al. focus more specifically on an arts and design perspective (Gaver et al. 2003) suggesting new design strategies that can create a space for the participant and user to respond to their interaction with technology in indeterminate and multiple ways. DiSalvo et al. define this as the '*frustration of closure*' where these indeterminate interpretations or multiple levels of meaning (DiSalvo et al. 2010) are attached to an artwork or design experience. These concepts of '*ambiguity*' and '*multiple interpretations*' (Sengers & B. Gaver 2006) provide examples to HCI of the ways people interpret interactive experiences, where ambiguous designs and experiences that allow multiple interpretation create a focus on process and reflection rather than on the usability of the technology. This work creates frameworks for future HCI design, which in turn enables a better evaluation of existing HCI design and new understandings of the context of use of Ubicomp systems, tools and devices (Sengers et al. 2006; Dourish et al. 2004).

This recent work shows that through a greater understanding of design issues HCI is beginning to confront assumptions of the importance of usability versus usefulness, and raises critical questions around the role of technologies, also reflected within contemporary art theory and to be discussed in more detail at the overlap between Contemporary Art and HCI, in Section 2.5.

2.3.2 Designing for Interactive Experiences

The convergence of these design perspectives and HCI has resulted in more specific research into design for interactive experiences. McCarthy and Wright's work (McCarthy 2004) proposes a framework for evaluating interactive experiences through sensory engagement,

feltness (McCarthy & Wright 2005) and enchantment (McCarthy et al. 2005), addressing one of the key divergences between HCI and design - that of the functional vs. aesthetic experience.

McCarthy and Wright define this divergence in terms of '*emotive response*' and '*lived experience*', calling for a space for reflexivity within HCI where '*the quality of the experience is as much about the imagination of the consumers as it is about the product they are using*'.

As we have seen, HCI research tends to emphasize design implications, methods and features, as opposed to what McCarthy and Wright call '*feltness*' – aesthetic, emotional and sensual quality of experience (Wright & McCarthy 2010). Their work creates a framework for evaluating and considering interactive experiences that they call the '*Threads of Experience*'. This framework includes:

- The Sensual thread
- The Emotional thread
- The Spatio-temporal thread
- The Compositional thread

Alongside this framework, McCarthy and Wright have also begun to consider the role of dialogical aesthetics within HCI, also explored by DiSalvo et al. (DiSalvo et al. 2009). Both these perspectives suggest that introducing a dialogic approach within HCI can support multiple interpretations and heterogeneous approaches, taking on board issues of temporality and location in order to support our understandings of interactive experiences. DiSalvo et al. suggest that further research into dialogical approaches would have implications on the following questions:

- How does HCI engage the public and communities?
- How does HCI determine efficacy?
- How do we understand communication in relation to the technology developed within HCI?

Research into dialogical aesthetics within HCI remains limited as opposed to within contemporary art, yet this existing work suggests that these dialogic processes are significant to both disciplines and can be as much about encouraging communication between people, as engaging with the elements of the interactive experience.

This broad summary of HCI and the sub-theme of interaction design show how HCI has begun to consider interdisciplinary perspectives in the design of systems, experiences of

human computer interaction, which has led to the overlap between art and HCI, to be discussed in greater detail within Section 2.5.

The next section will jump to the field of climate science, continuing to follow a route around the outer sets of the Venn Diagram in Fig. 6.

2.4 Set 3: Climate Science

As with the previous two sections, Set 3 provides a summary of the related themes emerging from the discipline of Climate Science, providing a scientific grounding to the research within this thesis by defining the discipline and related research fields.

The discipline of Climate Science has arisen from the science of climatology, the atmospheric sciences (including atmospheric physics, dynamics and chemistry) and the Earth Sciences (including meteorology, oceanography and physical geography). (Robinson & Henderson-Sellers 1999; O'Hare et al. 2005)

As indicated in the introduction to this thesis, within the scientific community there are strict differences between the terms '*climate change*' and '*global warming*', with climate change relating to a broad definition of climate characteristics, whereas Boykoff (Boykoff 2011) suggests that '*global warming*' focuses on the '*increase of temperature over time*'. Wrigley et al. (Wrigley et al. 1999) propose global warming is the '*fingerprint*' for human induced climate change (anthropogenic climate change) and any changes in the climate can not be perceived in isolation from broader changes in climate (non-anthropogenic).

Norgaard (Norgaard 2011) suggests that there are two basic facts that the public need to be aware of in order to understand issues of anthropogenic (human induced) climate change:

'if global warming occurs it will be the result primarily of an increase in the concentration of carbon dioxide in the earth's atmosphere' and *'the single most important source of carbon dioxide is combustion of fossil fuels'*.

Noorgard suggests that despite data being increasingly available to the public that shows evidence of these statements, public response to these issues is declining, and in some areas becoming increasingly skeptical. Noorgard's study, alongside other similar studies that have taken place across Europe and North America suggest that the reasons for this decline are both complex and paradoxical (Norgaard 2011.; Scannell & Gifford 2012)

One of the key problems that is increasingly revealed by research across climate science, environmental psychology and social science, is that the global and long-term nature of

climate change data defies easy or immediate comprehension within our everyday lives (Scannell & Gifford 2012).

In order to understand the issues around public engagement with climate change, this research looks towards environmental psychology, which focuses on how the environment affects humans within different environmental factors. Core theoretical notions within environmental psychology connect directly to the research question, supporting existing literature in both HCI and Contemporary Art discussed throughout the rest of this chapter. These include notions of place identity, place attachment, environmental consciousness (Tuan 1977; Rodaway 2002) and how we perceive climate change in response to these factors.

Within this field there are growing concerns that address human perceptions of environmental risk, climate change and weather, and how our inability to engage with these issues is responsible for the decline in public engagement with issues of climate change. As a result, increasingly research is looking towards how scientists can communicate climate change in ways that more successfully engage the public.

2.4.1 Communicating Climate Change

It is recognized that although the risks are as great as ever, the factors that impact on societal interest in the issues related to climate change (Scruggs & Benegal 2012; Shum 2012) include:

- Cultural conformance (conforming one's beliefs to those prevalent in one's group), where people tend towards beliefs that maintain healthy peer relations over those that benefit the environment (Kahan et al. 2012)
- Low levels of scientific comprehension by the public (Kahan et al. 2012) of media reporting (Boykoff 2011)
- An emphasis on fear and threat (O'Neill & Nicholson-Cole 2009)
- A lack of access to information that explains the complexity of climate change and sustainability (Brynjarsdottir et al. n.d.)
- A broader need for a local and personal connection to scientific information (Scannell & Gifford 2012)
- Difficulties in understanding the abstract notions of global, long term, slow change (Spence et al. 2011)

Much of this work explores how these factors that cause disengagement can be addressed by new forms of '*climate change messaging*' (Boykoff 2011), and some of this work calls for

more research into the role that artists can play in engaging the public with climate change (Curtis et al. 2012; Gabrys & Yusoff 2012).

These discussions around public disengagement with climate change issues tend to be based on perceptions of risk and public denial (often seen as apathy). Previous research has taken place across social science, environmental psychology and environmental science, where investigations of communities that are increasingly affected and at risk through climate change have been studied (Norgaard 2011; Scannell & Gifford 2012), to explore how we as humans in the twenty first century deal with these global risks.

Increasingly research has revealed the importance of emotion, place and human perceptions of climate change in the way that scientists communicate about climate change to the public (Norgaard 2011; Spence et al. 2011; Scannell & Gifford 2012). Scannell's paper (Scannell & Gifford 2012) suggests the significance of these factors in enabling personally relevant engagement with climate data, by studying and comparing the responses of residents in British Columbia to both local and global climate change information.

In this study Scannell argues that issues which cause disengagement involve limited attentional resources where *'individuals are not always able to notice or further process all information in their environment'*; the impacts are often perceived as distant and uncertain and these perceptions or *'psychological distance'* exist for *'temporal, spatial, social, and hypothetical (i.e., real vs. imaginary) dimensions'*. This work particularly reveals the importance of *'place attachment'* in people's perception of climate change, which is also supported by Norgaard's studies in Norway (Norgaard 2011). Scannell proposes that *'individuals may be more willing to exert effort to protect their meaningful places'* and *suggests that 'local messages would be even more idiosyncratic to the particular region, and would be presented in more captivating media such as art and video'*.

These factors connect to the Contemporary Art themes of *locality, place* and *situatedness* (Pink 2009; Kwon 2004), to be discussed later in the chapter.

Other research in the field suggests that promoting fear of climate change can also act to disengage the public. O'Neill et al. propose that visual and iconic representations of fear *'is generally an ineffective tool for motivating genuine personal engagement'* (O'Neill & Nicholson-Cole 2009), whereas non-threatening imagery is proven to engage people more.

There is much controversy over the use of iconic images to depict climate change that challenges the often emotive and sometimes inauthentic representation of climate change by the media. Remillard (Remillard 2011) explores the role of visual interpretations and representations of climate change on the public's understanding of the risks and threats using a photo essay documenting the Canadian Oil Sands and the complexity of using these forms

of visual representations to communicate risk. This work suggests that different forms of visual framing (such as photography) can hinder the public's reading of the imagery and can often bolster the public's feelings of distance and sense of the '*overawing scale*' of climate change. Remillard proposes that '*there is a relative dearth of investigations into visual representations of risk*' and calls for further research into how environmentally engaged art and visual interpretations can communicate the risks of climate change to the public.

2.4.2 Risk and Denial

Much of this research addresses issues of risk perception. The psychologist Rowe investigates why humans are easily able to deny climate change is happening, and why we avoid thinking about and acting on the risks that occur on such a global scale (Rowe 2011) proposing that people tend to rely on myths to structure their ideas about climate change. These myths provide reassurance for when we encounter new stories that are difficult to comprehend and enable us to make sense of the threat, thereby rationalising our desire to remain safe in the face of adversity. Norgaard also explores issues around culture and risk perception in her study of the impact of climate change on a town in Norway, Norgaard (2011) describing the '*arc of power*' that contributes to the way people respond to climate change in their everyday life:

"I follow the arc of power that moves from the microlevel of emotions to the mesolevel of culture to the macrolevel of political economy and back again. According to my data both from Norway and the United States, thinking about global warming is difficult for community members because it raises troubling feelings that go against cultural norms. And these norms are in turn embedded in the particular social context and economic circumstances in which people live".

Norgaard suggests there are two types of denial in response to climate change, the first being the most discussed in the public domain which she describes as '*outright climate skepticism*', where in the United States 26% of the population are said to not believe the scientific consensus (Krosnick et al. 2006). The second state of denial that her research reveals is that although a large percentage of the population she studied in Norway and the United States were not skeptical, they were living in a paradoxical state that she calls the '*double life*' where they were concerned about climate change but rarely acted in response to these concerns. This is described as a disconnection between the abstract, global information about climate science and our everyday experiences, revealing our inability to integrate our understandings and the complexity of climate change, its global, slow and sometimes distant nature, into our lives.

Spence et al. (Spence et al. 2011) also suggest that issues of distance from the impact of climate change, a need for embodied social cognition and difficulties around media representation all contribute to the public's confusion around climate change.

Buontempo, the scientist who collaborated on the artworks studied in this research suggests that in order to communicate the risks and impact of climate change we need to create opportunities for analysis and debate, requiring narratives that engage us emotionally in order to bring into play our rational, cognitive and intuitive processes (Giannachi 2012).

Buontempo, along with an increasing number of climate scientists, are looking to art and citizen science to provide solutions to these issues.

2.4.3 Citizen Science

Citizen science is one of the ways in which scientists have traditionally engaged with the public. Examples of citizen science projects which relate to climate science include participatory and crowd sourcing activities such as the *The Urban Pollution Monitoring Project* (DiSalvo et al. 2009); *OPAL*⁴ a national survey on climate; and the *Old Weather Project*⁵ a crowd sourcing project that asks the public to transcribe archive weather observations from Royal Navy Ships.

Projects such as these provide opportunities for science to be seen as not separate from society but as an informant to a larger debate about how humans interact with and are responsible for their environment.

As Collingridge and Reeve suggest, (Collingridge & Reeve 1986) there are concerns within the scientific community of a '*shift of power*' within governance and policy making, emphasising that, as much as science needs to evolve within the public sphere governance, policy makers and citizens must also respect and allow the scientific community to continue to conduct research following known and agreed methodologies.

Gieryn also explores the boundaries between science and non-science, suggesting that the debate on epistemic authority lies not in labs and journals but in the social construct of science and the '*discursive interpretations as they make their way downstream to respectful waiting publics*' (Gieryn 1999). He suggests that it is essential to provide the right conditions to enable this '*downstream*' interpretation to occur without denying '*the value of scientific knowledge*'.

⁴ <http://www.opalexplorenature.org>

⁵ <http://www.oldweather.org/>

This broad summary of related research from a Climate Science perspective shows that communicating issues of climate change to the public remains a complex and challenging issue. As shown, public perception of the risks and threats continue to result in denial, misrepresentation and misconceptions. Important and interesting work emerging out of citizen science to environmental psychology has begun to explore ways to engage the public, revealing questions and challenges around epistemology and empirical knowledge. Much of this work provides a wider context for research into participatory sensing and public engagement that is occurring in the overlap between HCI, Climate Science and Contemporary Art, which will be discussed in the next three sections.

Having provided a general overview, the following sections investigate existing overlaps between the disciplines. Providing a route through the various intersections and moving closer the centre of the Venn Diagram in Fig.6.

2.5 Set 4: HCI and Contemporary Art

This section brings together research from Contemporary Art and HCI, exploring how contemporary art has addressed the technological developments of the twentieth and twenty-first centuries and in turn how HCI has begun to take a turn towards the arts.

Post World War II, as photography and cinema became increasingly part of mass culture artists and cultural theorists began to explore the impact of modern technology and the resulting opportunities for mass communication on society as a whole, and more specifically on art and culture. The critical theorist Adorno (Adorno 1982) is known for his criticism of technological determinism and mass culture, post World War Two. His contemporary Benjamin (Benjamin 2008) argued the other extreme, in the seminal work *'The Work of Art in the Age of Mechanical Production'* Benjamin proposed that through its own mechanism the influence of technology on the arts has the potential to be fundamentally progressive:

'From a photographic negative, for example, one can make any number of prints; to ask for the "authentic" print makes no sense. But the instant the criterion of authenticity ceases to be applicable to artistic production; the total function of art is reversed. Instead of being based on ritual, it begins to be based on another practice—politics.' (Benjamin 2008)

Adorno argued in response that the *'infiltration by technology into art'* brings about *'disillusionment and distrust of the obscuring quality of magic, and by the objective situation of art, which is that authoritative art works are becoming more and more difficult to bring off successfully'*. (Adorno 1982)

Thornton suggests that from the 1960s contemporary art practice has been heavily influenced by these discourses, and that they have remained relevant throughout the convergences of film and video, computation, broadcast media, telecommunication and gaming:

'...it is important to remember that what gives rise to that sense of déjà vu, that feeling that we have been here before, is not so much the actual historical repetition of technologies as the repetition of deeply ingrained ways in which we think, talk and write about new technologies.' (Thornton 2007)

2.5.1 Digital Performance, Presence and Locative Art

Since the 1990s new art forms have emerged in response to modern developments in technology, including digital art, interactive art, mixed reality and mediated performance. British artists have been investigating where the lines between art and technology are increasingly blurred (Giannachi 2004). These artists include Shinkhansen (now Body>Data>Space⁶) Christian Nold⁷, London Fieldworks⁸, Jane Prophet⁹ and Proboscis¹⁰, alongside Blast Theory¹¹, the Thrill Laboratory¹², and Active Ingredient¹³ - in collaboration with the Mixed Reality Lab and Horizon Hub at the University of Nottingham. Blast Theory and the author's own collective Active Ingredient embrace technology through locative art, pervasive gaming, Mixed Reality performance and data visualisations. This work has occurred predominantly through an emphasis on performance (Giannachi 2004) and notions of *'liveness'* and *'presence'* (Giannachi & Kaye 2011).

These artist practices ask questions particularly on how technology enables the performance of presence. What notions of *'live'* really means to our experience of self and identity, the importance of location and place, and how we create co-located, co-present experiences between performers and audiences. Some of this work from the 1990s/2000s was mapped and researched as part of the BBC Interactive report on locative media (Stynes & Woolard

⁶ <http://www.bodydataspace.net>

⁷ <http://www.christiannold.com>

⁸ <http://londonfieldworks.com>

⁹ <http://futureeverything.org>

¹⁰ <http://proboscis.org.uk>

¹¹ <http://www.blasttheory.co.uk>

¹² <http://www.blasttheory.co.uk>

¹³ <http://www.i-am-ai.net>

2006) and the Presence Project which focused on case studies of the artists Lynn Hershman Leeson; Gary Hill; The Builders Association; Blast Theory and Paul Sermon (Giannachi & Kaye 2011).

As a result of the Presence Project, a rich resource is now available on the role of liveness, presence and telepresence across contemporary art and HCI. This work also began to map the methodologies, techniques and questions that artists contribute to issues of 'liveness' and technology. It suggests that the role of presence across performance art and computer science is also *'further problematised by the layering of virtual with real phenomena.'*

Since the advances in networked, mobile and pervasive computing, and film and video that took place in the 1990s and early 2000s, artists continued to address issues of liveness as a temporal experience of the present, exploring how new technologies can inform audience and participants' engagement and interaction within the *'live experience'* (Jacobs et al. 2012). Much of this work has occurred as a direct collaboration between artists and the HCI community, where there has also been an interest in liveness, presence and engagement (Witchel 2013; Hook 2012).

2.5.2 HCI, Interactive Art and Mixed Reality Performance

As discussed, artists and HCI researchers have long been collaborating to develop new applications, systems, and design frameworks. This convergence goes back as far as the early experiments with Virtual Reality and the beginnings of Siggraph in the 1970s (Woolley 1993) and has impacted across the disciplines of interaction design, interactive art, HCI and beyond. It is increasingly common for HCI conferences such as CHI and ACM Multimedia, to have an interactive/digital art exhibition and strand, while equally it has become increasingly common for HCI research to be represented at festivals and conferences within the interactive arts sector, such as Future Everything, Ars Electronica¹⁴ and ISEA.

As described in the previous sub-section, research that has emerged from the Mixed Reality Lab, University of Nottingham (where the author is currently based) has explored the strategies that artists use within interactive arts, most specifically within mixed reality performance, through collaborations with artists such as Blast Theory, Active Ingredient and the Thrill Laboratory contributing to a broader interdisciplinary understanding of this work (Benford & Giannachi 2011; Benford et al. 2012). Benford et al. (Benford et al. 2009) have developed the *'trajectories'* framework that address notions of canonical, participant and historic trajectories within these forms of mixed reality performances, proposed as a way in

¹⁴<http://www.aec.at>

which HCI can begin to analyse how artists engage audiences in narrative driven and temporal interactive experiences.

Benford et al.'s research on trajectories has led to further research into how artists create 'spectacles' (Benford et al. 2011), developing a framework for understanding artists' rationale of production for interactive experiences (Benford & Giannachi 2011) and broader notions of temporality within HCI (Benford & Giannachi 2008). Alongside this work Taylor et al. propose the '*designing from within*' framework (Taylor et al. 2011) as an experience based design approach for interactive performance, that extends the work by McCarthy et al. on experience centred design (McCarthy 2010; McCarthy & Wright 2004). McCarthy and Wright suggest the significance of sensory and emotional experience, spatio-temporal factors and composition in the iterative processes of designing interactive performance. This research directly supports the methodologies used within this thesis, providing a framework for evaluating the distinct contributions, roles and strategies of environmentally engaged artists within the studies. These methods will be described in more detail in Chapter 3.

Within HCI the discourse on the role of the interactive arts has partly focused on the viability of usability and evaluation within HCI. This focus can create inherent conflicts with the paradigms and approaches of the arts (Sengers & Csikszentmihályi 2003; Paulos 2007), which will be discussed in more detail in Chapter 3.

This section has revealed how Contemporary Art and HCI research converges through interactive art and digital performance, and is a growing area of interdisciplinary research. Yet, this literature remains limited in its representations of the artist perspective and the impact of these collaborations on the artists' approaches, strategies and motivations. The '*designing from within*' approach lays the ground for providing an artist perspective within HCI, suggesting that much can be learnt by both disciplines from extending this approach.

This section sets up the core literature in Section 2.7, which digs deeper into how collaborations between HCI and Contemporary Art have occurred specifically in relation to sustainability and the environment, and begins to outline the role of technology within artists' work that specifically engages the public with climate data.

2.6 Set 5: HCI and Climate Science

This section explores Set 5 of the Venn Diagram in Fig.6, where the domain of HCI crosses with Climate Science and Environmental Psychology, focusing on relevant discourses within the research field of Sustainable HCI.

2.6.1 Sustainable HCI

Sustainable HCI is an emerging research field (DiSalvo et al. 2010; Brynjarsdottir et al. 2012; Nathan et al. 2008), encompassing environmental and sustainable discourses within the discipline of Human Computer Interaction (HCI). Within this field there are many discussions around the complexity of the subject, the value of sustainability as a separate research field within HCI.

Sustainable HCI is considered a growing research field within HCI. The key paper by DiSalvo et al. (DiSalvo et al. 2010) provides a methodological approach to mapping the landscape of this field raising issues around how to evaluate and create frameworks for addressing issues of sustainability and the environment in context of HCI's existing evaluation frameworks that often package a concept into relatively simple paradigms, suggesting that the *'packageable methods popular in HCI map poorly to sustainability because they fail to take into account the complexity of the problem'*.

Brynjarsdóttir et al. also propose that current methods within Sustainable HCI research often rely on designer's predetermining the *'success'* of their designs and that the current methods of usability studies do not support robust evaluations of long term behavior change that are necessary to evaluate sustainability. DiSalvo et al. (DiSalvo et al. 2009) also argue that assessments of sustainable technology design and applications should question the aims of the designers in terms of when, how, whom, and what is valued. These debates become even more valid in the context of interdisciplinary collaborations, where both works argue for a greater understanding of the designers and researchers' assumptions and the role, context and use of the tools that they are building, a broader understanding of the complexity and interdisciplinarity of the debates within HCI, and longer-term studies than tends to occur within HCI.

DiSalvo et al. and Brynjarsdóttir et al. call for further investigations into strategies and frameworks for engaging the public with the complex issues of sustainability, including sensing and interpreting climate data to find new approaches to encouraging action and behavioral change, some examples of these investigations with a specific emphasis on environmentally engaged artists have begun to be mapped by DiSalvo et al. (DiSalvo et al. 2009), to be discussed in more detail in Section 2.7.

As Brynjarsdóttir et al. suggest, the domain of sustainable HCI has traditionally been informed by Fogg's perspectives on changing people's behavior through *'persuasive'* engagement with computer technologies (Fogg 1998), particularly in the study of energy monitoring and environmental sensing (Foth et al. 2008; Froehlich et al. 2010).

This work raises questions about the intentions and integrity of HCI design for the public domain and is somewhat divergent to some of the critical and social considerations brought about by HCI research that has evolved from critical theory, design and art, discussed in Section 2.3. The difference between Fogg's persuasive computing and perspectives such as Gaver et al's understanding of the value of ambiguity (Gaver et al. 2003) and Sengers et al.'s work on multiple and alternative interpretations (Sengers & Gaver 2006) highlights a conflict in the discourse around increasingly pervasive and immersive technologies within HCI. Gaver et al. suggest this divergence lies in the interpretation of technology as '*evocative rather than didactic and mysterious rather than obvious*'.

Fogg's '*Persuasive Computing*' provides a simplistic approach to behavioral change, where questions remain to be answered around how HCI can engage users of their systems to act or change behavior in sustainable ways that have long term and meaningful impact. These questions are still being debated within this domain and there are increasing calls for further research into interdisciplinary strategies that build tools for participatory sensing and citizen science activities that can both change people's behavior and inform the public about issues of sustainability (DiSalvo et al). This debate suggests that there is a need for further research into the development of systems that remain open to multiple interpretations, and provide new models for users interaction, interpretation and engagement with issues of sustainability, the environment and climate change.

2.6.2 Participatory Sensing

A key sub-domain of sustainable HCI is participatory sensing, often involving the gathering, analysis and distribution of local knowledge (Goldman et al. 2009; Goodman 2009).

Goldman et al. have investigated the role of '*creative expression*' as part of these HCI led participatory sensing activities (Goldman et al. 2009). This work focuses on the functions and utility of sensing in the public sphere and also talks of the use of data to '*understand and persuade*'.

Despite this work research in this intersection shows that citizen science has been slow to use pervasive computing (Kim et al. 2013) with relatively few examples found that make use of mobile phones, let alone other non-phone based sensors and suggesting that users of citizen science platforms often don't have the technical skills required to get up and running with existing systems (Gaonkar et al. 2008; Burke et al. 2006).

Recent work has begun to extend the frameworks for designing participatory sensing services and systems, in order to connect to the citizen science concept of '*science that assists the needs and concerns of citizens*' (Irwin 1995: xi). Guidelines for the design of these systems

are emerging within the field of sustainable HCI but many gaps remain, particularly in terms of robust case studies of the application of these systems in the field.

Much of this research has occurred in urban environments and there is still very little research within sustainable HCI around participatory sensing that has occurred in rural and remote spaces - such as forests - where there is intermittent or no connectivity, issues of weather and sustainable power to contend with, as well as diverse cultural and social issues around the role and use of technology. This is in contrast to the work by environmentally engaged artists who are often working with capturing, sensing and interpreting climate data in extreme environments such as rainforests or at the Arctic and Antarctic (Bloom 2011; Polli 2011).

Much of the literature within the intersection between HCI and Climate Science shows that further research into sensing climate change is urgently required to address issues for diverse and remote environments and communities. Existing research also shows that robust ubiquitous computing platforms need to be developed that can facilitate communication between citizens through data collection, visualisation and interpretation (Knowles et al. 2013).

As a result of this work within Sustainable HCI, Froelich et al. (Froehlich et al. 2010) have begun to map how these new systems can facilitate communication, in support of sustainability and public interaction through the development of what they call '*eco-feedback technologies*'. As shown in Section 2.3 there is an increasing interest in the use of artifacts, visualisations and interaction design broadly within HCI Froelich et al. propose that the use of these novel interfaces and designs can reveal people's actions in terms of environmental change and sustainability. Froelich's research into '*eco-feedback technology*' arises from a combination of environmental psychology and interaction design, yet remains focused on behavioral change in order to bridge the '*environmental literacy gap*' (Froehlich et al. 2010). Again, little of this research has investigated using these artifacts in rural and outdoor environments.

This section has shown how environmental psychology is influencing discourses around sustainability within HCI, the challenges and opportunities raised by this emerging research field and the intersection between these HCI perspectives and the Climate Science research previously described.

This work also connects to the research that will be described in the following sections, and it is at this point in the Venn Diagram that the boundaries become increasingly fuzzy. Research within sustainable HCI described in this section directly connects to concepts of eco-visualisation to be explored in the following sections.

2.7 Set 6: Contemporary Art and Climate Science

This section continues to drill down into the overlaps of the three disciplines representing the final outer set of the Venn diagram, defining the intersection between Contemporary Art and Climate Science. It investigates how arts practices are engaging with issues of the environment and climate change, addressing the surrounding discourses of art activism and social engagement that are interwoven into the ways that artists intersect with climate science.

2.7.1 Environmental Art

Art historians have long explored how and why humans feel the need to express the world around them, and how humans through visual, tangible and performative expressions, have developed this into professional arts practices - which explore cultural, geographical and social understandings of our environment (rural, urban and the spaces in between). The history of these practices are also reflected in human geography, where our human presence and the expression of our landscape is implicit in the word '*geography*' - '*earth-drawing*' (Cosgrove 2008; Tuan 1977).

Most notably in Western Europe and North America art that engaged with the concept of 'nature' was connected with notions of nature as '*sublime*', '*spiritual*' and '*romantic*'. (Adorno 2004) Literature and the fine arts of painting and sculpture traditionally represented the landscape as pristine. This perspective remained predominant in Europe until the twentieth century wars and the impact of industrialisation – that Ede writes '*were to include the most annihilating means of clouding the night*' (Ede 2005) and caused a major shift in artists' relationship to nature and the environment.

In Europe, art that engages specifically with the environment and nature evolved from the Land Art movement of the 60s and 70s (Giannachi 2010), focusing on the materiality of nature. Giannachi et al. have mapped the influence of the Land Art movement on contemporary environmentally engaged art, suggesting that Land Art is '*the exhibition of nature as something constructed by humans, rather than a-priori, independent from humans*' (Giannachi 2010) Examples of the original Land Art movement include work such as Nash's '*Ash Dome*', a ring of trees planted near the artist's home (Grande 2001); Beuys' '*7000 Oaks*' (Beuys, 1982) and Goldsworthy's environmental sculptures such as '*Touching North*', an ice sculpture created in the North Pole (T. Friedman & Goldsworthy 2006).

Contemporary environmentally engaged artworks, such as Sacks' social sculpture '*The University of Trees*' (Giannachi 2010), are increasingly seeking new approaches to working with the environment and landscape and Wilson suggests that where Land Art focused on

artists sculpting living matter, the new aesthetics of these environmentally engaged artists tend towards a more conceptual '*syntheses of science, action and art*' (Wilson 2002). Giannachi et al. investigate this further, suggesting that this aesthetic embraces a '*performance of nature*' that is '*experienced by audiences as traces and footprint representations*' bringing together these scientific perspectives, critical theory and notions of artistic intervention (Giannachi & Stewart 2005; Giannachi 2010; Giannachi 2012).

In support of this, Miles outlines four categories of environmentally engaged art as:

1. Art that represents the natural world
2. Art that enters a discourse of the natural world and it's apprehension
3. Cultural production that tests methods of environmental salvage or contributes to sustainable forms of living
4. Dialogic interaction at the cusp of art and activism (Miles 2010)

Whilst much of this art history has been written with a European and Western emphasis, artists in other parts of the world and from non-western European cultural heritages have naturally, evolved their own culturally specific relationships to nature and the environment. In terms of art that engages with climate change, where there is an increasing international/global approach, it is vital to take into account the traditions of non-western arts, the Southern Hemisphere and indigenous communities, and the influences and divergences between our differing cultural understandings and relationships with the environment (Demos 2013).

2.7.2 Situatedness

The importance of locality and place is of increasing significance to contemporary artists, particularly in terms of engaging with issues of ecology, environmental and climate change. The intersection between Climate Science and environmentally engaged art practice occurs most significantly across sensory geography (Tuan 1977; Rodaway 2002) and contemporary art notions of place, locality and site-specificity (Pink 2009; Szerszynski et al. 2003; Kwon 2004). This work explores the importance of space, time and place to our sensory engagement with the environment, relating to research discussed in Section 2.4 around the importance of locality and personal experience to public engagement with climate change (Scannell & Gifford 2012; Spence et al. 2011).

Ferran suggests '*the significance of locality*' is a key factor that connects the '*poetics of place*' with broader environmental influences, raising concerns that are as equally relevant to Climate Science and Sustainable HCI around how to support multiple stakeholders, access to

infrastructures and participatory sensing opportunities in order to build tools for artists to use as part of environmentally engaged practices (Ferran 2012).

This work is also supported by research within sensory ethnography (Pink 2009) where ethnographic studies focus on sensory lived experience and perception Pink suggests that notions of '*situatedness*' provide opportunities for the analysis of people's sensory experience, suggesting methods for evaluating how we experience our environment, which have supported the analysis of the studies contained within this research, this will be explored in context of the methods used in this thesis in more detail in Chapter 3.

This work begins to dig deeper into how '*environmentally engaged art*' can be defined and understood within an interdisciplinary context. The following sub-section begins to explore some of the discourses within contemporary art around these practices and the historical context of artists responding to these complex issues within society.

2.7.3 Socially Engaged Art Practices and Art Activism

Notions of politics, action and revolution were embedded in the performance art and theatrical practices of the early to mid-twentieth century where the Situationists, Fluxus and Arte Povera artists saw revolutionary political actions, activism, as well as everyday life as inseparable from their art. Many of the art movements of this time wrote '*manifestos*' (Stiles & Selz 1996) as a way of defining their philosophy of how art, life, politics, society and the environment could be combined to create new ways of living and making art, in response to the social and cultural changes of the twentieth century.

New concepts of social action have emerged from this work that have influenced the environmentally engaged arts practices investigated within this thesis. These include Beuys' social sculpture that proposes '*society as artwork*' (Beuys 2004) seeing the act of sculpture as something that can happen as a social act as well as a manipulation of materials. Beuys was politically active through his work as one of the co-founders of the Green Movement in Germany in his relationships to arts and academic institutions, through his teaching and the '*transformative actions*' of his artworks that he viewed as the creation of '*new social models*'.

The Arte Povera movement also began to question the transformative effects of art and is a key contemporary art movement that began to engage with the environment and issues of ecology. (Giannachi 2012) Arte Povera started in central Europe in the 1960s and engaged with natural organic materials, objects, the environment and the body and remains a big influence on environmentally engaged arts practice and ecological activist art (Guattari 1996).

Third Text (Demos 2013) has recently published a dedicated edition under the theme of *'Contemporary Art and the Politics of Ecology'* this publication widens the discourse of environmentally engaged art and argues for an international view of art and ecology that encompasses non-western art traditions and practices beyond the traditional framing of Art History from a Western perspective (Demos 2013). These essays and articles address the themes of activism, ecology, colonialism, industrialization, globalization, indigenous representation, non-human experience of climate change, localization and nationalism from a contemporary perspective. This work is important in its representation of the scope of environmentally engaged practices and the political narratives that often underpins this work. Interestingly, few of these works discuss the politics of ecology within an interdisciplinary framework, and many are actively positioned as a critique of scientific and institutional approaches to ecology and climate change (Demos 2013 : 120).

This is not to suggest work isn't occurring in this area, as we can see from the core literature in Section 2.8, rather that these contrasting artistic practices are rarely discussed in relation to each other.

As seen in the summary of related Contemporary Art practices in Section 2.2, the artist movements of the twentieth century have evolved into these participatory, dialogic and activist arts practices. Kester (Kester 2004) proposes that social engagement through art is now occurring with an emphasis on dialogue, collaboration and locality (space, place and time), attempting to walk a line between art and activism, art and science, in order to go beyond the more traditional activist approaches as led by a specific *'cause'*, manifesto or philosophy. Within environmental arts practices this line between activism and dialogue is being played out by artists who are exploring how art and action can merge, how art can inspire new perspectives and dialogues, bring about new *'environmental knowing'* (Polli 2011) and provide new opportunities for action.

The previous discussion has investigated environmental art in a broad sense. Emerging from this is a body of work, which specifically focuses on issues of climate change. As with much of the discourse around artistic practice it is difficult to classify this work clearly as it often deals with layers of meaning and thinking that are not directly climate change related, yet is increasingly being recognized as an *'emerging trend'* within Contemporary Art (Bunting 2010).

2.7.4 Climate Art

Gabrys and Yusoff discuss this work as lying at the critical thresholds of science, art and politics, suggesting the significance of both environmental and cultural systems in this domain (Gabrys & Yusoff 2012) and proposing that these creative practices *'offer different*

ways to pose questions of – and possible responses to – climate change'. Alongside the work of Demos (Demos 2013) and Latour (Latour 2009) this work focuses on artists' distinct contributions to discourses of climate change in terms of politics, collective thinking and knowledge and less on the interdisciplinary nature and impact of this work.

In contrast, Curtis et al. (Curtis et al. 2012) have conducted a study into the role of the visual and performing arts in climate science communication and how scientists respond to this work, involving a study of performances and an exhibition as part of a national ecological conference in Australia. This work investigates whether scientists were entertained by the experience, whether the scientists believed the arts program would help the public to understand the science and if they would consider working in conjunction with artists in the future. The questions posed within the study were limited in that they did not dig deep either into the role of the artists, the nature of the existing or future collaborations, or any analysis of the distinct methods the artists used. Yet, there are few existing studies or papers from this perspective and this work marks the beginning of this discourse within the climate science community around the role of artists communicating scientific information.

Curtis et al. propose:

1. The capacity of both visual and performing arts to synthesize, simplify, and convey complex ecological or scientific ideas makes the information both more interesting and easier to remember
2. The arts can give a voice to marginalized or silenced perspectives and thus play an emancipative social role and contribute to progressive political change
3. One of the attributes of the arts is their ability to evoke emotions
4. The ability of the arts to create memorable moments and a celebratory atmosphere

This paper questions why so few scientists consider working with artists when they are struggling to communicate climate science to the public and calls for further research, suggesting that:

'the use of the arts to connect with people emotionally may indeed be an effective way to win support for actions to reverse problems like anthropogenic climate change and deserves further research effort.' (Curtis et al. 2012)

As shown by the intersection between contemporary art and climate science there is limited research, despite it being an emerging area of activity. Several key issues have been raised by previous research around the role of the artists, the nature of interdisciplinary collaborations, and the distance between art activism and dialogic socially engaged practices within environmentally engaged practices. These issues will be investigated further in the next

section (presenting Set 8 of the Venn Diagram in Fig.6) where the disciplines of Contemporary Art, HCI and Climate Science converge.

2.8 Set 7: Environmentally Engaged Art and Climate Data

The final set in the Venn diagram represents the intersection between each of the three disciplines and the core literature for this research. Work that brings together each of the disciplines remains limited and much of this published research has occurred from either the perspective of environmentally engaged arts practice or HCI, with very little work, as seen in the previous section, occurring from the perspective of Climate Science.

2.8.1 Environmentally Engaged Art within HCI

As shown in Section 2.6, previous work within sustainable HCI considers how communities have engaged with climate change, including the development of tools to support participatory sensing (DiSalvo et al. 2009; Aoki et al. 2009; Kuznetsov et al. 2011; Kim et al. 2013; Paxton & Benford 2009). The tools used in these studies have tended to be developed more specifically for citizen science activities, scientific analysis or physical system monitoring rather than for artistic performance and interpretation, despite the increasing interest in these tools by artists.

Previous works have suggested that artistic domains require alternative approaches to the design and deployment of pervasive or ubiquitous systems to the traditional ones previously described (Aoki et al. 2009; DiSalvo et al. 2009; DiSalvo et al. 2009). There are few examples of collaborations with artists that address issues of sustainable rural computing and rural environmental sensing, particularly in developing countries (Wyche & Murphy 2013; Paxton & Benford 2009) that reflect the research in this thesis that takes place in remote forest environments in the UK and Brazil. Previous HCI and arts collaborations have often taken place in urban localities where access to mobile connectivity, GPS and artists who work with technology tend to cluster (DiSalvo et al. 2009). Concurrent research across the eco-art networks (Fitzgerald 2013), also investigates how pervasive media and social networking can specifically support rural communities adding to a call for further cross-disciplinary research in this area to create new thinking and strategies, towards building innovative networks and tools in response to ecological concerns.

DiSalvo et al (DiSalvo et al. 2009a) and Brynjarsdóttir et al. (Brynjarsdottir et al. 2012) have specifically begun to research the role of artists within sustainable HCI, suggesting that artists have a distinct role to contribute to existing research. This work maps some of the ways that environmentally engaged artists are questioning traditional HCI knowledge, proposing areas of future investigation that encompass core differences between the disciplines:

1. The consideration within HCI of technology as an *'instrument'* as opposed to the arts perspective of technology as a *'prop'* (DiSalvo et al. 2009a)
2. The outcomes of expectation of behaviour change as opposed to facilitation of action and change

They discuss these differences in relation to three elements of sustainability within HCI (DiSalvo et al. 2010):

- The development of sustainable hardware and software
- Designing systems for energy efficiency
- The capturing and interpretation of environmental data

DiSalvo et al. suggest that alongside challenging traditional approaches to sustainability in HCI, environmentally engaged artists invoke a paradigm that involves *'discussion, action and transformation'* that has a role to play in informing the more empirical or persuasive approaches to sustainable HCI, and other scientific research around climate and environmental data.

Several key collaborations between environmentally engaged artists, the public (within specific communities) and HCI researchers have been mapped by DiSalvo et al. and others (DiSalvo et al. 2009a; DiSalvo et al. 2009b; Aoki et al. 2009; Kuznetsov et al. 2011) that begin to explore how these artists' strategies and contributions can raise questions around some of the key discourses within Sustainable HCI. A study of the artist led *'Neighbourhood Network Project'* (DiSalvo et al. 2009b) raised the following key issues:

- Authenticity of data in participatory sensing versus scientific sensing activities
- Public disinterest in the veracity and details of the data
- Showing that being more informed about data does not necessarily change people's beliefs and behaviour
- Questioning how the public are able to interpret the data *'responsibly'*

The findings of the study of the *Common Sense* project questions existing HCI assumptions of the value of scientific knowledge and *'the potential of new technology to make a difference'* (Brynjarsdottir et al. 2012). This study also raises interesting questions around how HCI can support public action and suggests that it is important to create experiences that engage the public, not only through interpretations of data but by providing opportunities to act in response to the data.

Issues around evaluation and the often deliberately disruptive and uncomfortable approaches that artists employ (Benford et al. 2012) can create an inherent incompatibility within these collaborations. These conflicts go beyond the wider debate about the role of artists, providing

scope for further work in this area to address the value and opportunities inherent in these collaborations across each of the disciplines of HCI, Contemporary Art and Climate Science.

2.8.2 The Role of Environmentally Engaged Artists Working With Climate Data

Demos proposes that a complex relationship exists between artists, empirical knowledge and the institutions of science in terms of environmental artists' practices (Demos 2013). In contrast to this, many environmentally engaged artists such as Kac (Ede 2005), Spitz (Rimmer et al. 2009), Polli (Polli 2011) and Jeremijenko (Weiner 2013) are confronting these assumptions by exploring how artists can interact with both science and technology through collaboration. In many of the works represented at ISEA 2011 artists are shown interacting with and exploring their own relationships to data and environmental science, in order to *'rethink our relationships to science and develop discussion around interdisciplinary art/science approaches to our changing environment'* (Aceti 2012).

The journalist and writer Bunting (Bunting 2010) argues for a clearer perspective on our expectations of the role of artists in terms of what she calls the *'environmental crisis'*, particularly in reference to these collaborations between artists and scientists. In discussing a series of exhibitions that focus specifically on climate change she suggests that artists are creating opportunities for powerful thematic narratives around climate change. In describing these narratives she questions whether it is the role of artists to simply inform the public about science - setting the stage for a debate around the role of artists as instruments of science. This work is also supported by Holmes' suggestion that artists are increasingly taking on the role of *'environmental stewards'* (Holmes 2007).

Gabrys et al. also questions the role of artists within these collaborations suggesting that: *'disruption can become a way to materialize and articulate what would otherwise be un-sayable and un-thinkable.'* (Gabrys & Yusoff 2012) Bindi digs further into this discourse, suggesting that artists' distinctive interpretations of scientific data can create *'new ways to communicate science'* and that artworks dealing with climate change often go beyond simply informing the public, towards offering new interpretations of the assumptions of scientific data. She suggests this opens up a perspective that looks out to the *'community and the future'* (Bindi 2011) rather than simply pointing back to knowledge held within the scientific community.

In a recent article, the artist Jeremijenko describes her practice as attempting to *'inspire an eco-mindshift'* portrayed as a reimagining of environmentalism, involving *'overtures to more engaged and imaginative participation'* (Weiner 2013). This view suggests, as with the work of Holmes (Holmes 2007) and Polli (Polli 2011), that new environmentally engaged arts practices are focusing on alternative interpretations of communications of science, scientific data and thinking around environmental change.

These artists are shifting beyond taking an instrumental role within their collaborations with scientists and moving away from the creation of *'infographics'* as representations of scientific data (Bloom 2011). These works reveal a growing community of environmentally engaged artists who are working with environmental data as a tool or medium to trigger conceptualizations of the environment and begins to define some of the strategies, motivations and approaches that the artists employ in response to socio-political issues around climate and environmental change (Ede 2005; Polli 2011; Demos 2013). This literature reveals how artists are increasingly using technology to reveal the invisible nature of data, using sensing technologies, data capture, visualisation and interpretation to create new environmentally engaged art forms that are reflected in the artists work studied within this thesis. Yet it should be noted that very little of the literature about these artists' works dig further into the public response to the work and the contributions of these artists to public engagement with climate data.

2.8.3 Eco-Visualisation

These representations of environmental and climate data (Giannachi 2010) are part of a wider interest in data visualisation that has grown within broader new media practices, responding to the increasing availability of public data and cheap mobile sensing devices. Holmes offers the term *'eco-visualisation'* as a response to these practices, defined as a *'new way to dynamically visualize invisible environmental data'* (Holmes 2007).

Much has been written in recent years about data representation, visualisation and infographics, including Tufte's research into design strategies for evidencing and creating narratives around data (Tufte 1998), also supported by research within HCI by Bateman et al. into *'visual embellishment'* (Bateman et al. 2010). Other literature presents graphically beautiful visualisations, as an aesthetic fetish of data visualisation whereby the data is often fetishized as a visual experience without a deeper reflection of the meaning, context or deeper discourses surrounding the data, which Tufte suggests can bring about increased *'disinformation'* (Tufte 1998). This world of infographics and data visualisation remains contentious, particularly from the perspective of Contemporary Art - raising questions around veracity, and the perspective and the subjectivity of the designer, questions that are integral to artists' thinking within Contemporary, particularly in reference to environmentally engaged arts practices (Demos 2013; Latour 2009). These discussions reveal three different ways of representing data as:

- Scientific representations of data as statistics, charts and tables
- Graphic designers' data visualisations as interpretations of science
- Artists' strategies that reveal invisible narratives and emotional resonance in response to the data, studied within this thesis.

The *'Making the Invisible Visible'* event (Hohl 2012) posed questions around this debate in order to understand the role of data visualisations specifically within the context of climate change, sustainability and ecological literacy. This work suggests that data visualisations can enable people to answer questions, inform and *'elucidate'*, as well as provide opportunities to reflect and explore (Hohl 2012), proposing that *'it often requires designers or artists to transform these conclusions into communicable formats that capture the public's imagination'*. This research raises questions around the methods that are being used and our assumptions around the role of data visualisation in our increasingly data informed society yet provides very few examples of what these methods or assumptions might be.

This existing research begins to define the strategies, motivations and approaches that artists are employing to engage the public with climate data, suggesting that designers and artists are employing two distinct approaches: abstract visualisations (tables, charts and infographics); and concrete visualisations (artifacts, objects and embodied experiences of data), arguing that concrete visualisations create more engaging experiences of data, by existing as *'objects in space'*. These strategies include:

- Using *'actual data'*
- Finding meaning within the process of making and not just the in resulting artifacts
- Using open-ended dialogue

This work also suggests *'the information visualisation community could learn to better communicate 'a particular point of view'* by studying how contemporary artists experiment with visualisation tools and methods and begins to address the question of what strategies and approaches are artists employing to engage the public with climate data. The next subsection presents examples of these *'concrete'* visualisations, digging deeper into the strategies, motivations and approaches of the artists who make them.

2.8.4 'Conceptualisations' of Climate Data

As discussed in the terminology in Chapter 1, Giannachi offers up term *'conceptualizing environmental data'* (Giannachi 2010) as opposed to the notion of eco-visualisation, proposed by Holmes. Giannachi suggests that the ways in which artists interpret data through temporal and performative actions offers further opportunities for engagement in reflection and dialogue (Giannachi 2010; Giannachi 2012).

Much of the work at the convergence between the three disciplines supports Giannachi's notions of these artists' conceptualisations of data. Research published by the Leonardo Journal and Electronic Almanac (Aceti 2012) provides the core literature by investigating the role of artists working with climate data and how artists are exploring *'The Data Landscapes of Climate Change'*. This core literature includes three papers from ISEA 2011 (Maun 1999)

begins to raise questions around how these collaborative projects occur, the challenges and discourses for artists working with climate data, and the strategies that they employ.

Bureaud (Bureaud 2011) suggests that in order for people to understand climate data beyond scientific graphs and infographics, new ways of interpreting data on a human scale need to be found that go beyond purely visual, 2D graphical and numerical interpretations, citing Leonardo's *'Lovely Weather project'* and artists who have worked in the North and South Poles, she suggests that artists are employing strategies to *'embody'* data as a physical and visceral experience, in order to contribute to public understanding in ways that go beyond the abstract.

Neiman (Gabrys & Yusoff 2012) suggests that scale is an important issue in the way that people interpret climate data, arguing that *'because the units are not intuitive, only those who are already numerically engaged with climate change can have any sense of scale for carbon statistics'*, opening a discussion for how artists create strategies for the public to engage with data on a *'human scale'*. Again, suggesting that by creating real world *'concrete'* experiences, people can begin to understand data on a human scale, reflecting the findings of Gabrys et al. (Gabrys & Yusoff 2012)

Corby and Cunningham suggest that art and science collaborations can support a new *'data aesthetic of climate change embracing both the convergences and divergences within art and science'*. Their visually powerful representations of the Antarctic suggest that data can have its own *'materiality'*, where the artists consider the data in the same way that they could consider paint or clay. (Aceti 2012)

The artist Spitz discusses the public's relationship with scientific knowledge, in particular reference to climate science, suggesting that the modern way of life has *'neutralized our experience of climate factors'* (Rimmer et al. 2009) and that art has an important role to play in responding to this, going beyond instrumentalism by encompassing human emotion and experience, that is:

"not only serving the illustration of scientific discoveries, but also making our feelings possible and revealing our subjectivity in relation to weather aspects, and letting us understand the meaning that we attribute to climate in our intimate world, subjective and individual."

Spitz and Malina's work calls for the creation of new collaborations between artists, communities, scientists and technologists towards public engagement. Their work involves the concept of open observatories, which is also reflected in the work of Polli (Polli 2011). They suggest that this concept can provide contributions to:

“artists collecting data for cultural and artistic purposes, as well as community leaders and researchers seeking ways to mediate personally meaningful access to scientific knowledge”
(Malina 2009)

Spitz and Malina have set up an open observatory that seeks to explore ecological social networks in line with many of the objectives and research questions posed in this thesis. Their work is also based in the Mata Atlantica, Brazil. Further research is yet to be published on the results of these collaborations, but Malina has presented widely on his concept of achieving an *‘intimate science’* as the result of these collaborations between scientists and artists (Malina 2009). This work calls for a *‘new sensuality’* that makes science *‘intimate’* by emphasising people and creating opportunities for open science, citizen science and crowdsourcing.

Polli’s work (Polli 2011) sits very much at this intersection between environmentally engaged art, HCI and Climate Science, yet orientated towards a media arts perspective. Her research is similar to this thesis in that it represents her artist practice, arguing for *‘greater public engagement’*, long-term collaborations between media art and climate science and increased public access to climate data. Coming from a background of sound art and focusing on data sonification – the interpretation of data through sound (that she describes as geosonification). This research also highlights the importance of *‘situated and embodied action’* as a strategy to engage the public with climate data. This work raises questions about the artists’ role in these collaborations, the role of technology and the importance of dialogue and participation in engaging the public with climate data, calling for further research into both the strategies that artists are using in their work with climate scientists and a greater understanding of the nature of these collaborations.

Bloom’s work (Bloom 2011) discusses climate change in reference to three artists attempting to re-visualise the Arctic and Antarctic. Again Bloom explores issues of human scale in terms of the *‘invisible’* nature of climate change and the controversies of environmental politics. She suggests that gender, race, emotion and perception each have a role to play in our interpretations of climate science, which is supported by the research emerging from climate science (Bloom 2011; Scannell & Gifford 2012) described in Section 2.4.

This core literature at the intersection between Contemporary Art, HCI and Climate Science reveals existing interdisciplinary thinking around engaging the public with climate data and shows that some initial work has been achieved to suggest strategies used by artists working with climate data, that include: issues of scale; emotion; situatedness; embodiment; community and dialogue. This existing literature contributes to the refining of the research questions within this thesis, and highlighting the research gaps as described in the next section.

2.9 Conclusion

As shown in this review, there is a large amount of activity across all three disciplines that investigate how to engage the public with sustainability and climate change. Each discipline has emerged with its own perspectives and key themes with each calling for an interdisciplinary approach, yet little research has been done to bring these perspectives together.

Key literature within Contemporary Art reveals that environmentally engaged artists are increasingly embracing digital technologies and scientific developments, often through interdisciplinary collaborations (Wilson 2002; Giannachi 2005). The role of contemporary artists both within these collaborations and across wider society is a debated and complex issue, particularly in reference to artists engaging with the environment and climate change. Raising issues around how artists take on the different roles of activists (Demos, 2013), interpreters of science (Ede 2005) and facilitators of social engagement and dialogue (Kester 2004) and the significance of these different approaches on the ways that the public engage with the artworks.

The disciplines of HCI and climate science are also beginning to explore the potential contributions of these environmentally engaged arts practices, alongside more traditional public engagement through citizen science activities, to engage the public with climate change (DiSalvo 2009; Curtis 2012). From an HCI perspective, DiSalvo and colleagues have presented a rallying cry for a deeper understanding of the relationships between '*ecologically engaged art*' and sustainable HCI, including a more nuanced treatment of arts and humanities perspectives. Yet few studies from either HCI or climate science investigate the impact of this work on either the design of participatory sensing systems or how the public engages with climate data within these interdisciplinary collaborations.

Discussions around the artists' role within these collaborations also remain limited and there is little in depth debate occurring around the contributions and impact of artists who are going beyond mere instrumentation of climate science, towards actively engaging the public with issues of sustainability and climate change.

Where this review helps to refine the research questions is in the definition of how artists are creating 'concrete' conceptualisations of climate data - by mapping some of the key artists working in this domain and the contributions and challenges arising from their practices. Beyond the work by Polli (Polli 2011; Bindi 2011) existing literature appears to fall short of a deeper discussion of how these artists navigate interdisciplinary collaborations across art, science and technology, suggesting a need for further research into how these artists engage with science and technology.

Related issues raised by art critics such as Bindi and Bunting (Bindi 2011; Bunting 2010) suggest that the context and conditions of artists' practices greatly influence the way in which these artists consider science and technology, where social engagement and dialogue plays an integral part. Further research is required to investigate how artists engage with science and technology, the significance of the roles that artists take on within their work, and the impact of these approaches on the public who experience the artworks.

Furthermore, existing literature reveals the importance of cultural specificity to how artists define their roles - as shown by some of the differences between British and Brazilian environmentally engaged arts practices (Ferran & Fonseca 2009; Ferran 2012). This literature is particularly relevant to the study of *the Relate Project* later in this thesis that takes place across the UK and Brazil.

At the intersection of the three disciplinary perspectives of Contemporary Art, HCI and Climate Science there is an increasing body of research that explores how artists are working specifically with climate data (Aceti 2012; Bloom 2011; Giannachi 2012). Existing literature begins to map some of the artists' strategies, motivations and approaches for working with climate data, of particular relevance is the work by Giannachi and Gabrys et al. (Giannachi 2005; Gabrys 2012) that define this work as '*conceptualisations*' of climate data in comparison to more traditional data visualisations, such as illustration and infographics. By digging deeper into how artists are creating these conceptualisations, existing literature from Contemporary Art and HCI suggests that artists are using strategies that embody data within their artworks, encourage human-scale, intimate, situated, emotional and sensory experiences of data, that often encourage dialogue around the socio-political issues of climate change as well as alternative interpretations of scientific climate data (Bureaud 2011; Bloom 2011; Malina 2009; DiSalvo 2009; Aoki 2009). The significance of these approaches are supported by literature within Climate Science and Environmental Psychology which emphasise the importance of personal and local perceptions of climate change, discussing issues around human's ability to perceive fear, risk and threats and the global and long term nature of climate change (Spence 2011; O'Neill 2009).

Polli's work (Polli 2011) creates a socio-political framing of this discussion by investigating the impact of these practices on the communities that participate in or experience the artworks. This research, alongside core literature from Leonardo (Aceti 2012) has begun to map these artists' strategies within an interdisciplinary context, laying the ground for a more refined thematic study of artists' strategies for engaging the public with climate change.

What is notable across this key literature is that very few of these works evaluate the public experiences of these artworks or provide frameworks for doing so.

Where there is a history of evaluating public experiences of interactive artworks is in the HCI literature, particularly the work of Benford et al and McCarthy and Wright (Benford et al. 2013; Benford et al. 2011; McCarthy et al 2004). Although this work looks at broader issues of interactive art, design interaction and mixed reality performance they provide frameworks for the capture of rich descriptions of the public experience and the way the public interact with and perceive interactive artworks. These frameworks and methods will be discussed further in the next chapter.

Finally, this review lays the ground for further research into how these strategies can be embedded into future practices and technologies. DiSalvo et al. (DiSalvo et al. 2009a) specifically call for greater understanding of artists' strategies within sustainable HCI, suggesting that environmentally engaged artists have the potential to question fundamental assumptions within this field. This is particularly significant in reference to participatory sensing in rural environments, where research remains limited from an HCI perspective, yet is much more common within Contemporary Art (Bloom 2011; Bureaud 2011; Ferran 2012).

What is most notable through the mapping of this literature is the limited research within the field of Climate Science around the impact of artists' practices that engage the public with climate data - despite an increasing interest in this work. Curtis (Curtis 2012) has begun to investigate climate scientists' perspectives on environmentally engaged art, yet provides no in depth account of the strategies the artists used within the case studies or the impact on future climate science research.

These research gaps suggest the following refinements to the research questions in this thesis:

1. An in depth understanding is required of the challenges and opportunities provided by collaborations between artists, climate scientists and HCI researchers in order to explore the roles of artists engaging the public with climate data
2. A discussion on artists' approaches to public engagement, activism and dialogue is needed to answer how artists are engaging the public with issues of sustainability and climate change
3. A more in depth thematic investigation and refinement of the strategies that artists are using to create these '*conceptualisations*' of scientific climate data and the implications for the public, climate scientists and HCI would support a greater understanding of artists' distinct contributions to engaging the public with climate data
4. A greater understanding is needed of how artists work with science and technology and how this impacts on future practices, collaborations and discussions relevant across the disciplines

The two case studies provided by the author's own artist company, Active Ingredient, provides an in depth investigation of their recent work with climate data, in order to extend the existing literature. These studies will provide opportunities to map out the role the artists take in each project, their rationale, motivations, strategies, and most significantly the implications of their distinct contributions on the public, climate scientists and HCI researchers. This will occur through three strands of investigations:

- A breakdown of the distinct thematic concerns and strategies employed by the artists to engage the public with climate data (Chapters 4 and 5)
- A set of design considerations for HCI to build a system that supports artistic practices, involving participatory sensing and 'conceptualisations' of climate data (Chapters 6 and 7)
- An in depth discussion of the role of artists working with climate data within interdisciplinary collaborations (Chapter 8)

3

Methodology

This chapter describes the interdisciplinary approach and methods employed within this research, in order to investigate the distinct contributions of artists engaging the public with climate data.

This chapter is separated into two parts, firstly describing how the methodology and theoretical context is informed by the academic disciplines of HCI and Arts and Humanities and how this has supported the study of the two artist-led projects - *A Conversation Between Trees* and the *Relate Project*. The second part of this chapter will describe the mixed methods employed across these studies, adapting and extending the *'Performance-Led Research in the Wild'* (Benford et al. 2013) by Benford et al.'s and Taylor's *'Designing from Within'* frameworks (Taylor 2012) and detailing the approach to the thematic analysis in Chapters 5 and 7.

The combination of methods employed in this research provides opportunities to find a route through the often-complex task of evaluating artists' strategies and contributions, to enable a rich reflection on the implications of this research for HCI, alongside a discussion of the broader implications across all three disciplines.

3.1 Overview

This research combines qualitative ethnographic methods with a self-situated practice-led approach most familiar to research within the Arts and Humanities. By employing this interdisciplinary approach it is the author's aim to make accessible the findings of this research across the three disciplines of HCI, Contemporary Art and Climate Science, with a particular focus on the HCI community where the core research is taking place.

This combination of methods supports the author to investigate the complex relations between her own artistic practice, and the audiences and collaborators within this practice, alongside the responses of how other artists working with climate data.

What is particularly unique about this research in comparison to most of the previous studies of environmentally engaged artists' work that have occurred in the HCI research community (DiSalvo et al. 2009b; DiSalvo et al. 2009a; Kuznetsov et al. 2011; Holmes 2007), is that it is conducted by one of the key artists and not by an outside researcher looking at an artist's practice. This research is therefore taking place from both a researcher and artists' perspective, drawing on the relations and prior *'insider'* knowledge of the author. Due to the challenges involved in acting as both artist and researcher within this context, the author has given a great deal of consideration to the way these different *'voices'* are represented within the studies. In response and so as to maintain a clear separation between the roles of *'self-situated'* artist and researcher within the following studies, the author will be referred to in the third person as *'artist/author'* when referring to any reflexive elements of the study that focus specifically on the author's artistic involvement. This may sound artificial at times, yet was seen as the most appropriate way to support the author to shift perspectives whilst maintaining a distinct voice throughout the thesis.

Additionally, in support of these shifts of perspective between reflexive and ethnographic methods the findings have been supported by external ethnographic research, involving several ethnographers interviewing and observing specific elements of both studies. This variety of methods provides both opportunities and challenges for the author, allowing for a subjective and reflexive voice, but one that is supported by other researchers and perspectives.

This thesis is therefore informed by research methods employed from the academic disciplines of Arts and Humanities and HCI, and less by Climate Science. The empirical methods of this discipline is less relevant to the qualitative, reflexive approaches required to understanding the impact of artist-led activities, where engagement and perception tend to involve subjective, complex discourses. The ethnographic and reflexive methods employed within this research enables an analysis of the strategies of engagement that occur through the

artists' practice and the public's interactions with the artworks studied within this thesis, (Pink 2009; Pink 2007; Benford et al. 2013; Taylor 2012).

In response to the challenges of this approach, this research extends to a study of other artists working with climate data in the second study within this thesis. Providing an opportunity for the author to reflect both on her own practice, the views of the other artists in the Active Ingredient collective, and test these findings and reflections with a wider community of artists, using the ethnographic methods traditionally used by HCI researchers to evaluate interactive art and interactive experiences (Rogers et al. 2011; Benford et al. 2013).

The author's decision to orient this research towards the HCI community responds to a call for greater understanding of these artistic contributions, particularly in the domain of sustainable HCI as discussed in the previous chapter. By combining reflexive methods with the more traditional ethnographic methods used by HCI researchers (Lazar et al. 2010; Rogers et al. 2011), the author seeks to provide new knowledge and insights to the HCI community.

This approach therefore calls for a combination of the following methods, which will be described in more detail later:

- Qualitative ethnographic methods including observation, semi-structured interviews and questionnaires
- Practice-led methods, including reflecting on the rationale and existing writing of the artist/author and the other artists in Active Ingredient about the work and documentation such as blogs, photography and video footage

3.2 Theoretical Context

The author comes from a tradition of knowledge that is sited at the boundaries and liminal spaces of theory, practice and research. As discussed in Chapter 1, the author's own arts practice is embedded in performance art, socially engaged public intervention, interaction and the dialogic arts practices described in the previous chapter. Both the artistic practice and resulting research contained in this thesis has taken place in public spaces and through interaction with the public.

In contrast, the author seeks to orient this research within HCI; where as already noted few artists have attempted to present their knowledge and experience in their own words to the HCI community. Benford et al. note (Benford et al. 2013) this has become an increasing area of interest as more interdisciplinary PhDs are made available, and particularly within the Mixed Reality Lab where the author is currently based - which has a long history of

collaboration with artist groups, including the art collective Active Ingredient (Benford et al. 2013).

Within the Arts and Humanities *'practice-led research'* is historically considered an acceptable approach for artists studying their own practice, (Niedderer & Roworth-Stokes 2007; Piccini 2002; Schön 1983) and is increasingly favored by artists taking on doctoral studies. Practice-led research methods have evolved from concepts within education studies, where research occurs through a subjective and reflexive qualitative analysis of experimental processes and lived experience (Kolb 1984; Whitehead & McNiff 2006).

Practice-led research has informed the work within this thesis but is not the approach directly taken by the author as it relies on the artistic practice being presented as the core research, acting as a reflection of the theory without or in combination with an additional theoretical analysis or written thesis. Where this approach informs this thesis is in consideration of how the methods used within practice-led research provides opportunities for reflexive analysis. As this thesis is orientated to the HCI community it can be seen as *'informed'* by a study of the author's artistic practice yet this practice does not contribute directly towards the doctorate credits.

Dourish et al. have previously explored possibilities for a reflective framework for HCI and the *'appropriation of a variety of disciplinary practices, concepts, and methodologies'* into an HCI context. This work recognizes the dangers and many challenges of building a conceptual framework or methodology around a theory appropriated from knowledge inherent in another discipline where *'their rich histories and the subtleties of their practices are lost'* (Dourish et al. 2004).

These questions around the nature of interdisciplinarity suggest that these approaches can often serve only to reveal incompetency and lack of knowledge across disciplines and this is one of the risks posed by the nature of this research and using a combination of mixed methods, to support communication across disciplines (Dourish et al. 2004).

By combining a traditional HCI ethnographic approach informed by a practice-led approach the author is able to employ both qualitative and reflexive methods to evaluate the two artist-led projects.

The author attempts to address some of the challenges of pulling together these two traditions of knowledge, by bringing her own understandings of the rich history and subtleties of Contemporary Art and her 20 years of practice in the field to the discipline of HCI. By offering the artists' perspective, the author aims towards a shared language, terminology and a deeper understanding of the divergences and distinctive contributions of the disciplines.

Where interdisciplinary collaborations occur, it is important to remember that this is a two way street, or in this case - where Climate Science is the third discipline in the collaboration - a three way street. Artists are not simply collaborating across disciplines in order to take from a different discipline, each discipline needs to have a desire to extend their knowledge, methods and perspective in order to feed each other. The following section reviews this approach.

3.3 Approach

As outlined in Chapter 1 the research objectives for this thesis are to evaluate the role and distinct contributions of artists working with climate data, discuss the design implications for the HCI community to support the future development of tools and systems for artists, and to highlight the challenges, opportunities and further questions for future interdisciplinary collaborations.

For the purpose of this thesis the author presents studies of two artistic projects, described in Chapters 4 and 6, in order to present a set of themes and discussions relevant across the disciplines of Contemporary Art, HCI and Climate Science.

Firstly, the artist projects will be described in terms of the background of the work, each of its elements, technical implementation and public activities (Chapters 4 and 6). These will then be followed by a rich description of the artists' motivations, strategies and rationale, as a thematic analysis of the findings from the studies (Chapters 5 and 7). In the first study this analysis is combined with the perspectives of the artists, public visitors and climate scientists, in the second study the artists' perspective is supported by the hackers who also participated in the project, and combined with the climate scientist and HCI researchers' perspectives.

The thematic analysis involves a mixed method approach. Most commonly within HCI, user studies of interactive experiences involve qualitative studies that tend to focus on usability and user experience goals. The paradigms and techniques of interaction design can vary from '*quick and dirty*' evaluations that provide user feedback at any stage of a design process; '*usability testing*' through the measurement of tasks that are controlled by the evaluator; '*field studies*' to increase the understanding of how users naturally respond to the impact of technology; and '*predictive evaluation*' that use heuristics to predict potential usability problems, where users are not necessarily present. (Rogers et al. 2011: 340-342)

As HCI has taken a turn towards the arts, debates have arisen over the validity of these HCI techniques for evaluating interactive artworks and the public's engagement in these works (Sengers & Csikszentmihályi 2003; Paulos 2007). New evaluation techniques are being explored (Höök et al. 2003) informed by McCarthy and Wright's *Threads of Experience*

(McCarthy & Wright 2004), Benford et al.'s *Trajectories of Experience* (Benford et al. 2011a) and *Performance Led Research in the Wild* (Benford et al. 2013) responding to these concerns. These techniques continue to be informed by ethnographic approaches, yet are beginning to widen HCI's approach to field studies and the line between the roles of researcher, participant, designer, performer and user. Taylor (Taylor 2012) also provides a framework for combining these methods with McCarthy and Wright's *Threads of Experience* and self-situated evaluation of her own performance led practices, leading the way for artists to begin to study own their practice within an HCI context.

The methods in the study are therefore derived from the following two methods:

3.3.1 Performance-Led Research In The Wild

Performance-Led Research In The Wild (Benford et al. 2013) provides a framework for HCI researchers evaluating artistic performance work occurring in public domains, such as galleries and public spaces - described as '*real settings*' - often involving tours or several iterations. This framework provides justification for the combination of mixed methods of interviews, observations and questionnaires employed by the author.

Benford et al. suggest that the triangulation of theory, practice and study is not a linear process but a loop that is '*interleaved*' and often iterative. The framework that Benford et al. propose takes into account the complex relationship between theory and practice, the context of research in the wild and the role of iteration within this process. This has significantly informed the methods employed in the study of the artistic practice, rationale, and public engagement across both studies. As described by Benford et al. in reflection of their previous work with Blast Theory, the Thrill Laboratory, and indeed the author's own arts collective Active Ingredient, practice and research is frequently drawing on the same data - captured by both the artists and researchers. Therefore the lines between practice, theory and study are increasingly blurred.

Benford et al. propose the challenges of this framework are:

1. Contrasting approaches to development between disciplines, artists and researchers
2. Demands of touring artworks
3. Documenting the ephemeral, complex nature of these artworks
4. Observing participants without compromising the experience of the artwork
5. Capturing the artists intentions and the audience experience
6. Archiving
7. Putting theory into practice
8. Balancing artistic and research interests
9. A flexible approach to building relationships and taking risks

10. The impact of ethical processes on arts-orientated research

These challenges reveal issues that have also arisen for the author during this research process. In response, the author has looked towards several other methods and frameworks to extend this work, combining the ethnographic methods and techniques discussed in Section 4, the frameworks proposed by Benford et al. and Taylor (Benford et al. 2013; Taylor 2012), and more reflexive approaches to documentation, discussed in Section 3.4.

The *Performance-led research in the wild* framework underpins the research in this thesis. The key difference to the overall approach suggested by Benford et al. is that in this case the author is both the artist and researcher for the first study, and extends the research to observe other artists' practices in the second study, creating yet another layer of complexity in the loop.

Benford et al. discuss how, as in the case of this thesis, one individual might move between perspectives throughout the process in order to combine these roles and encompass the full trajectory within their research, yet does not provide distinct examples of how this might work. Within this thesis the author has been required to make these shifts in perspectives throughout, not only moving between theory but jumping between ethnographic study of others and reflexive studies of her own artistic practice by shifting between reflexivity around her own role as an artist, observing other artists and studying the public, climate scientist and HCI researchers.

The author already had pre-existing relationships with all of the participants in the studies - obviously with the rest of the Active Ingredient team, and also with some of the participant artists who took part in the second study, the climate scientist and HCI researchers. These existing relationships provided a unique opportunity to enter into a dialogue with each of them, aiming to reveal insights into the rationale of production and the interdisciplinary nature of their collaborations that a more objective observer may not have achieved. Whilst creating challenges around bias, being too close to the work and split priorities within the quite opposing roles of artist and researcher, this also provided opportunities to both reveal processes from a unique insider perspective and translate between these disciplines.

Benford et al.'s framework highlights the importance of this research occurring *'in the wild'*, outside of the laboratory. This is particularly significant to the scale and public nature of the research in this thesis. Both studies occur in public spaces and galleries (as part of artists' residencies), and are concerned with the presentation of artistic practice outside of an academic environment, despite working in collaboration with academic researchers and partners. This research occurs also across the UK and Brazil, which in turn adds another

layer of complexity, taking into account changing cultural contexts alongside the shifting perspectives between practice, theory and studies addressed through the framework.

As a result of these adaptations, the author has summarized the way in which this thesis is informed by this framework in the table below.

Table 1. Implementing the Performance-Led Research in the Wild Framework

	Chapters	Framework	Activity	Method
Practice	Chapters 4 & 6	Co-creating novel experiences and concepts	Description of the case study projects, artists' motivations and design process	Reflexive written documentation inc. blogs, photography and video
Theory	Chapters 2, 5, 7 and 8	Abstracting concepts and frameworks	Mapping the research questions, methodology, landscape, literature and future implications	Venn Diagrams mapping literature and methodologies
Studies	Chapter 4 & 6	Understanding experience ' <i>in the wild</i> '	A summary of the data analysis and emerging themes	Audio interviews, written interviews, questionnaires, observations

This approach has brought about many new challenges and some conflicts in respect of the impact of the research on the author's own arts practice. Some of these challenges lie in the need not only to reflect on the discipline in which she is most familiar but also to translate the concepts and this historical context of this discipline for the HCI audience. The author was also required to learn some of the language and traditions of HCI in order to be able to communicate effectively and publish her findings within this community.

As Benford et al. have suggested it is not an easy job to discuss in a linear fashion, artist's strategies, methods and approaches. Artists rarely follow a distinct methodology in their practice or research. As can be seen from the literature review, artists' approaches and conditions of practice can be overlapping, layered, connected and interconnected process. Artists tend to weave their practices into research, commercial practices and across everyday life. They often make connections that defy categorization and deliberately inhabit the

boundaries of disciplines and knowledge, aiming to disrupt at the edges of these boundaries. Therefore they tend not to work within frameworks and under distinct themes and headings which is the tradition of HCI, supporting more generalized and empirical knowledge.

3.3.2 Designing From Within

Alongside Benford et al.'s framework, this research looks to Taylor's '*Designing from Within*' (Taylor et al. 2011; Taylor 2012) framework which proposes a '*holistic, immersive approach*'. Influenced by McCarthy and Wright (McCarthy & Wright 2004) and their concepts of dialogical design and threads of experience, this method was originally proposed by Taylor in context of designing immersive experiences as part of performance practice.

'*Designing from within*' is characterized by the qualities of a design process that is self-situated, involving the qualities of:

- The researchers taking 'active roles' in the projects that inform the research as designers and performers
- The studies involve a longitudinal, iterative process to facilitate sense making. The work is '*explicitly dialogical*' in its implementation of performance techniques to invite participation
- Open to '*participant-led interaction and the influence of place*', creating a situated, live experience where participants are able to have an open ended engagement with the artworks.

Where this approach is different to the author's research is again in the way the author shifts perspectives throughout the research, from ethnographic research of the public, to the study of other artists and collaborators, and then to '*designing from within*' as a way of studying the approach of the author and her artist collective in creating the artwork *A Conversation Between Trees*, the *Timestreams Platform* and resulting artistic experiments as part of the *Relate Project*.

Therefore, the author has adapted Taylor's immersive approach in order to support the reflexive elements of these studies as opposed to providing an overall framework for the thesis.

3.3.3 Extending The Methods

The two frameworks of *Performance-Led Research In The Wild* and *Designing From Within* provide existing methods to employ within the two studies. Yet this research also provides a unique opportunity to extend these methods, in order to reveal processes and thinking from the perspective of the author - acting as both artist and researcher.

Combining these frameworks and extending this existing work, in order to shift perspectives from artist, designer and researcher has brought about many challenges, opportunities and some conflicts. These are only partly resolved through Taylor's *'Designing from Within'* (Taylor 2012), where the study reflects on the design process but doesn't lead to the development of new processes and systems as a result of the findings.

Therefore there are some key differences within the author's approach to this research and the frameworks proposed by Taylor and Benford et al.:

1. *'Performance Led Research in the Wild'* has come out of research about other artists rather than a 'designing from within' approach
2. *'Performance Led Research in the Wild'* relies on an iterative loop between the states of practice, studies and theory which doesn't fully describe the more cyclical process that the author experienced within this research
3. Taylor's *'Designing from Within'* framework focused on self-situated design processes rather than an artist shifting perspectives between artist, researcher and designer to also include the artist taking on the role of ethnographic researcher
4. This research extends the *'Designing from Within'* framework to build an innovative, dialogic and experimental design process (building a new platform as described in Chapters 6 and 7) from the findings of the initial artist led process.

Within this extended approach, the author recognises moments of conflict and challenge, which have been mapped in three distinct ways. Firstly, the author has adapted the *'Performance Led Research in the Wild'* diagram by Benford et al. (Benford et al. 2013) in order to map the cyclical and dialogical process involved in shifting perspectives and creating a new experimental design process (see Fig.9). This diagram represents the artist/researcher's motivations, intentions and decisions alongside the cycle of combining practice, study and theory. This diagram is informed both by *Performance Led Research in the Wild* and the *'Ask, Observe, Perform'* cycle (Laurel 2003:41-48) which uses a combination of action research and performance theory to dig deeper into the dialogue between the artists' motivations, intentions and decisions and the trajectory of *'theory to practice'* that is suggested by Benford et al.

The author found that by mapping this cycle she was able to see where she was in the cycle and make decisions on which methods or approaches were required. This process often appeared to be instinctive, overlapping and random, but by digging deeper it becomes clear that this path involves a process of asking questions, observing the world, absorbing and reflecting on these observations, performing, acting and producing responses, refining and starting again. As highlighted by the diagram in Fig.10, the author was able to reveal two

points of personal conflict within this model, which appear at the most fundamental points of the cycle. The author reflects that these points of conflict arise between the need to investigate and study the work and a fear of exposure within the role of the artist.

Secondly, as discussed in Chapter 3 and 5 the author was invited to contribute to a publication in reflection of the creation of *ACBT*. These were published as a booklet after the tour of the exhibition (Jacobs et al 2011) including the following description of the conflicts she experienced whilst combining the roles of artist and researcher during the presentation and tour:

“The decisions that you make as the artist, that arise from previous experience, instinct, personal and individual reflection on the world and collaborative thinking and playing is hopefully what makes the work unique, that makes it art rather than purely science and technology – and yet, by opening up the process to an analytical methodology, by conducting an ethnographic study of the way audiences engage and interpret the work you need to open up to their questions and answers, their concerns, desires and expectations in a manner that doesn't break through the protective wall that enables you to commit to your own creative vision.

It is impossible to maintain objectivity in this context. This is the work that you have dedicated time, energy and vision to. It is part of you in a way that is totally beyond objectivity, the decisions you have made are often deeply personal, even if the work isn't self reflective, artists often dedicate huge amounts of their time and finance into their work, and very rarely is it 'a job' that is created within the financial restraints of artists fees and material budgets on a 9-5 schedule. The investment is often physical, financial and emotional.

You need a certain bloody mindedness, and for this you also need blinkers. You need to be able to say I made this like this, because of this and that is that. This is this.

I also on the other hand believe you should be able to justify your choices and that the reason to be an artist researcher and to conduct research around your own practice stems very much from a desire to understand, justify and value this process.

How do you deal with criticism and other people's ideas, how do you contextualise your work and reflect on it within the context of other work and practices and other disciplinary knowledge?”

Finally, the author was invited to contribute to an exhibition that explored practice and research, involving a presentation entitled '*Thinking to Making*', that was exhibited at

Primary Studios, Nottingham in July 2013 (see Fig. 7). This enabled the author to reflect on the process and approach within the context of contemporary art and the author's own arts community and to present this in the form of an exhibition as opposed to the theoretical written form of this thesis.

As shown by extending the frameworks of Benford et al. and Taylor, taking on the role of both artist and researcher is complex and at times a deeply conflicted experience. Yet, in taking on this challenge the author has had a unique opportunity to reveal artistic processes from both within the world of the artist and from the study of other perspectives, engaging with a broad set of discussions and themes that reflect the disciplines of Contemporary Art, HCI and Climate Science and their shared interest in engaging the public with climate data.

3.3.4 Capturing Participant Perspectives

In response to these challenges and the need to shift perspectives throughout the research the author captured their own perspective alongside the perspectives of the artists, public and collaborators, to enable a comparison between the artists' rationale, audience experiences, and the perspectives of the researchers and scientist who collaborated with the artists.

In the first study, this approach was also supported by an ethnographic study, conducted by an external ethnographer, who observed the visitors to the exhibition over several days, and also captured observations made by invigilators in the galleries where the artwork was exhibited.

The second study was supported by an additional ethnographic study conducted by other HCI researchers that observed the artists' participants during the UK Hackday event (described in Chapter 6).

3.4 Study Methods

A variety of ethnographic techniques have informed the methods used by the author in this thesis.

Firstly, the technique of user observation - supported by notes, audio, video and interaction logs - provides opportunities to investigate how users behave particularly in reference to field studies. The biggest challenge of this technique is the influence of the observer on the users and how to implement observation without disturbing people. (Rogers et al. 2011)

Other techniques for evaluation that have informed the studies in this thesis include asking users and experts, these often occur through audio and video interviews and questionnaires. Interviews can occur as open-ended, unstructured, structured or semi-structured, and as either

single or group interviews. In this thesis the author has chosen to follow a semi-structured interview technique, following a predetermined set of questions, leaving space for potential discussion and conversation around these questions. The challenges that are inherent in this approach involve taking care not to preempt participant responses in the way the questions are formed, and finding ways to ‘probe’ participants to reveal further information without creating a bias. (Rogers et al. 2011; Lazar et al. 2010) The key to these interviews is that they can support replication across a number of participants, enabling analysis of a collection of responses.

Further challenges will be discussed later in the chapter around the difficulties of implementing a semi-structured interview technique when the evaluator is also the designer or artist of the experience being evaluated, where an inherent bias and lack of objectivity needs to be taken into account Polli suggests an approach that can enable a ‘conversation’ to occur between the researcher/artist and the participants of the studies (Polli 2011).

Finally, implementing evaluation through questionnaires can provide demographic information and user opinions (Lazar et al. 2010). This technique is used in the first study of this thesis alongside the semi-structured interviews, to evaluate a broad range of visitors’ responses in the first study of the artwork *A Conversation Between Trees*. The questionnaires provide opportunities to clarify opinions drawn from the interviews across a larger participant group, including a combination of open and closed questions and quantitative evaluation techniques such as check boxes and the Likert Scales (Rogers et al. 2011: 401) that enable a more generalized measurement of opinions.

As described in Chapter 1, this research includes studies of two case studies:

1. *A Conversation Between Trees* (Active Ingredient 2011), a series of artist residencies and exhibitions that toured to forest venues in the UK and one in Brazil, between 2010-2011
2. *The Relate Project* (Active Ingredient 2012) involving the development of an online platform designed for artists to capture and play with climate and energy data and a series of artist residencies, exhibitions and Hackdays, which took place in Brazil and the UK between 2012-2013.

Both artist-led projects involved ambitious international art activities that engaged the public with environmental and climate data. They were both led by the author in collaboration with her arts collective Active Ingredient, funded externally from this research and occurred as stand alone projects in their own right, with their own separate aims and objectives.

At times the priorities of the artistic practice overtook the research methodology and at times the research informed the practice. The conflicts and challenges inherent in this method are discussed in Section 3.5.

The case studies provide an opportunity to do two things. Firstly, to investigate the ways in which Active Ingredient's distinctive strategies, rationale and approaches engaged the public with climate data. Secondly, to design a platform - *Timestreams* - that is informed by these practices, strategies and challenges. This online sensor blogging platform enabled the artists to make new work in response to the climate data they captured and aggregated, and to engage other artists to work with the platform, creating their own artistic responses to working with climate data. This involved an interesting overarching methodological feedback loop, whereby both the practice and studies support the creation of methods of evaluating and making.

The artist/research feedback loop enabled the author to explore the complex relationship between artistic practice and research and evaluate how this combination of methodologies can support and hinder both practices. This holistic approach is deeply rooted in artistic practice, and has been previously documented in reference to practice research (Piccini 2002). It has also been explored as an approach within sensory and visual ethnography, where *'lived'* visual and sensory experience informs ethnographic analysis (Pink 2009; Pink 2007), creating an opportunity for the lived experience to become intertwined with the analysis of the experience. As described by Leal, the British Brazilian artist who collaborated with Active Ingredient on both of the case study projects, it is hard to separate the actions of being an artist with lived experience:

"...being an artist is not a job... its an attitude, it's a posture in many ways its sort of putting into practice ideologies and thinking. It's a lot about thinking and incorporating that is exactly putting into practice what you are thinking and what you're questioning and realizing that in a number of situations"

3.4.1 Data Analysis

As already described, the author combined a variety of approaches to support the difficult task of conducting a qualitative thematic analysis of data.

Braun et al. (Braun et al. 2006) suggest thematic analysis is a method 'in it's own right' that provides a flexible approach to the coding and analysis of data. In the case of this thesis it has been used as an experimental method to provide rich, complex and detailed accounts of the different perspectives of the artists, public, HCI researchers and climate scientist who participated in the studies.

This experimental approach has been chosen as it is suited to the complex process of analysis of the experiences of creating artworks, and participating in or experiencing artworks.

Ethnographic content and observational analysis (Lazar et al. 2010), supported a first level analysis and categorisation of the findings, enabling the author to pull together the findings within a generalised thematic structure, which is more common to qualitative analysis of user experience within HCI. This process began with an overview based on the themes defined by McCarthy and Wright *Threads of Experience* framework, to explore how each participant in the study describes the following:

1. Sensory, emotional, spatio-temporal responses to each component
2. Composition
3. How they made sense of each component
4. The narrative and dialogic experience

In addition, Pink's classifications of sensory experience informed the analysis of the visitors' experience of the artwork (Pink 2009). She proposes that the use of metaphors to define sensory, lived experience can support a classification of these experiences including:

1. Embodied actions – enactment, touching, utterances and descriptions and facial descriptions
2. Categorisation of experience – mere experience, defined experience and reflected experience
3. Situated Experience – the importance of place, locality and cultural specific knowledge

Pink proposes that meaning making occurs through the way that people experience presence (being in a place in time) through sensory embodiment, and ambience (the ambient environment) as '*situatedness*'. This approach is particularly significant to a thematic analysis of visitors' experiences of performance art, her work is supported by more general theory within geography and environmental science, exploring how humans perceive environmental factors (Rodaway 2002; Tuan 1977).

The thematic coding was conducted through a novel approach, informed by the concept of 'data maps' that were an integral part of the artwork *A Conversation Between Trees*. This process of visual 'data mapping' enabled the author to develop her own mapping approach for the data analysis (Fig.8), directly influenced by the artistic processes of visualizing data in the artwork and other mind mapping approaches (Niedderer 2007). This visual technique for coding the data enabled the author to create 'thematic data maps' where quotes were physically cut and pasted on to the paper discs left over from the artwork, physically grouped

into sub-themes and lines were drawn to connect between individual quotes and sub-themes to bring out the trends, patterns and connections in the data.

These '*thematic data maps*' enabled the author to investigate common themes and layer the data in a visual way, which felt more instinctive to the author than a more linear approach, such as traditional coding, conversation analysis or using mind map software. This method of using artistic practice to inform ethnographic research methods is recognised by Pink (Pink 2009) and Benford et al. (Benford et al. 2013) as a significant way in which art practices inform research and vice-versa. In this way the author was able to map and categorise the comments and observations of the participants based on McCarthy and Wright's framework – creating separate discs to represent comments and observations that related to the themes of sensory, emotional, temporal, composition and narrative. The comments and observations were then cut out from print outs of each interview with the study participants, the comments book and observations notes. The author then honed these themes based on trends across each theme, revealing patterns and clusters of key words, appearing on each disc across each perspective - these emerged as sub themes. The author then contextualised these sub themes by relating them back to Pink's categorisations, grounding the patterns and themes in the literature related to analysis of interactive experiences and artworks and the author's own existing assumptions as an artist. The author then related each theme back to the research questions in order to focus on:

1. The role of the artist
2. The strategies that the artists' employed
3. The ways the public engaged with and perceived climate data
4. How these strategies were embedded into the artists' practices and the technology used within the work.

This approach was successful in visually highlighting emerging themes, supporting a rich coding of the data that took into account the sensory, emotional and aesthetic responses of the participants in the studies. Having created a variety of data maps as part of the artistic process of creating the artwork *ACBT* (using environmental data) it was interesting to explore how the data from the studies could then be re-interpreted and viewed as a visual experience of itself and how this method might present connections that may not have otherwise been revealed.

The author chose to focus the analysis on an overview of these emerging themes and subthemes rather than focusing on each data item (e.g. audio interview or visitor comment) as, already discussed, the data corpus encompassed a variety of perspectives from audio interviews, questionnaires, observations, artist documentation and comments. This thematic

overview was seen as the most effective method to create a picture of the experience of each project - across each perspective. This approach also enabled a comparison between the artists' motivations and rationale for creating the work, the public's experience of the work and the HCI researcher and climate scientist in response to the research questions.

In the second study (Chapter 7), a description of each participant interviewed was provided. This occurred to support more specific identification of the artists background and context of their motivations as it was seen important to contextualize their individual and historical perspectives, provide a broad description of these artists conditions of practice and go beyond assumptions of what types of artists are involved in interdisciplinary practices. This was particularly significant to the second study as many of the participants came from a Brazilian background and therefore a different cultural context from the author and the institution where the research is taking place. This was less important in the first study of the artists who created *ACBT*, as they were each part of the same arts collective and seen as coming from a similar cultural context.

3.5 Conclusion

In this research the author has a unique opportunity to take on reflexive interdisciplinary methods of research alongside more traditional ethnography, in order to reveal a rich exploration of her motivations and intentions as an artist. By entering into a dialogue with her colleagues and with other artists, and by combining the perspectives of the artists, public audiences and scientists (including HCI researchers) the author has been able to bring a broader understanding of the artist perspective to the HCI community.

This research provides a novel example of how these interdisciplinary methodologies can be combined in order to create new frameworks for evaluating artists' distinct contributions to interdisciplinary research, and specifically their distinctive contributions to engaging the public with climate data.

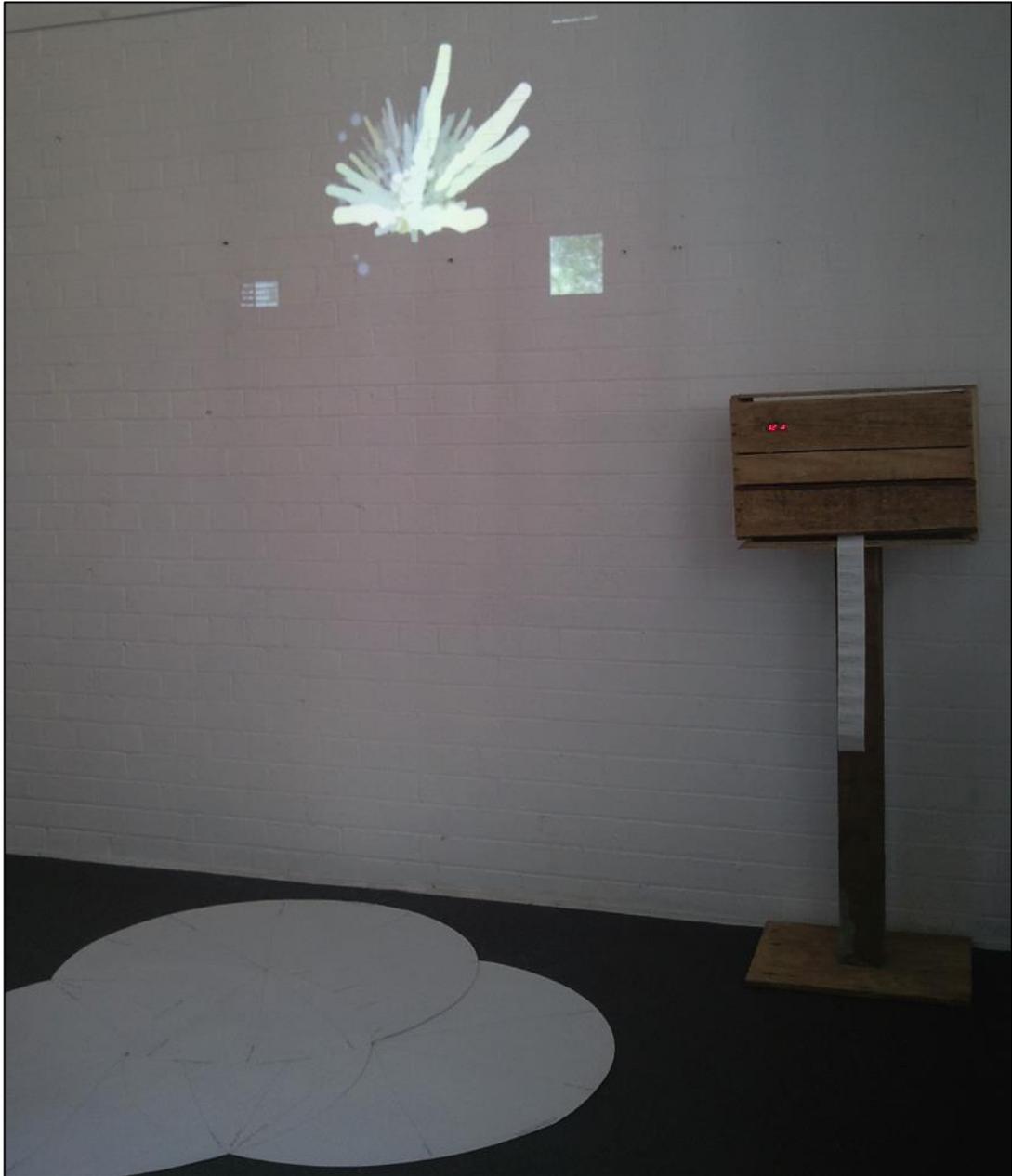


Fig.7 An exhibition presenting methods of combining practice and research by the author.

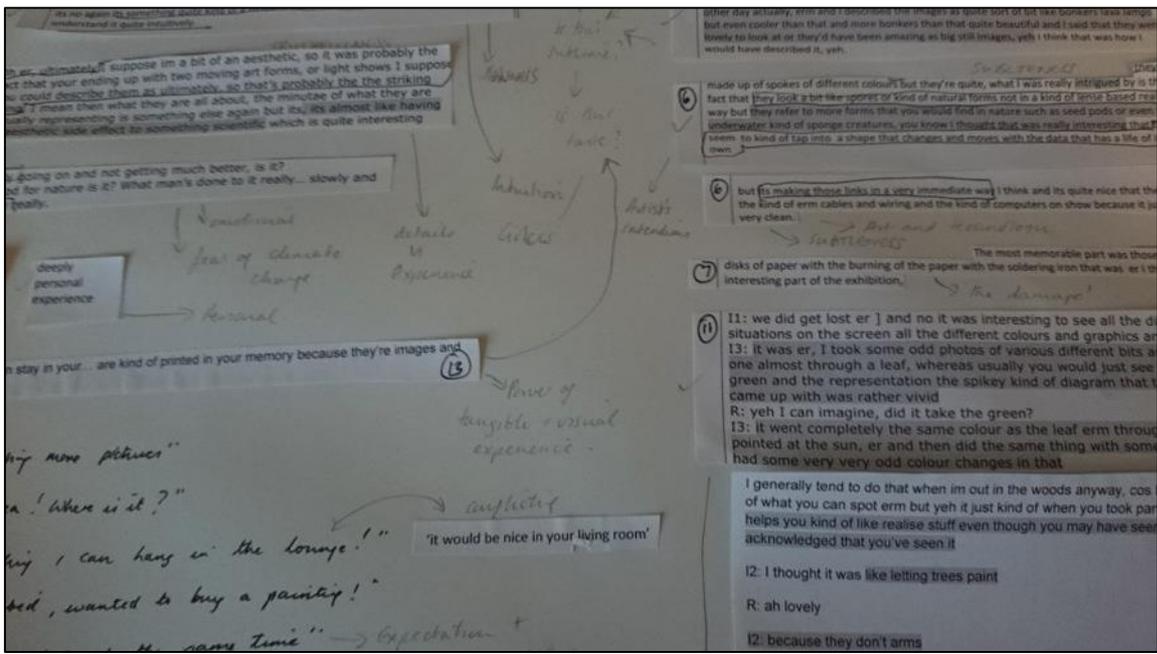
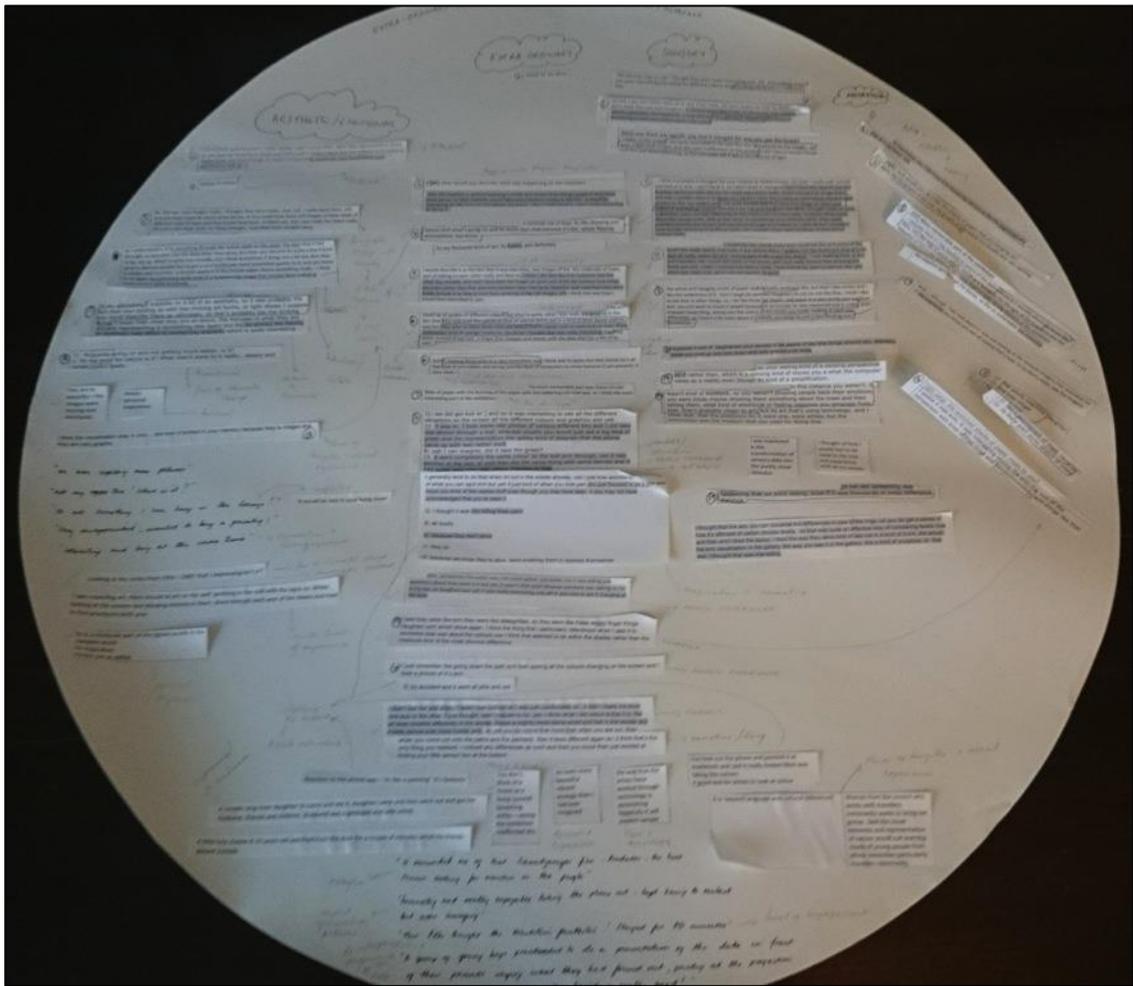


Fig.8 Thematic Data Maps

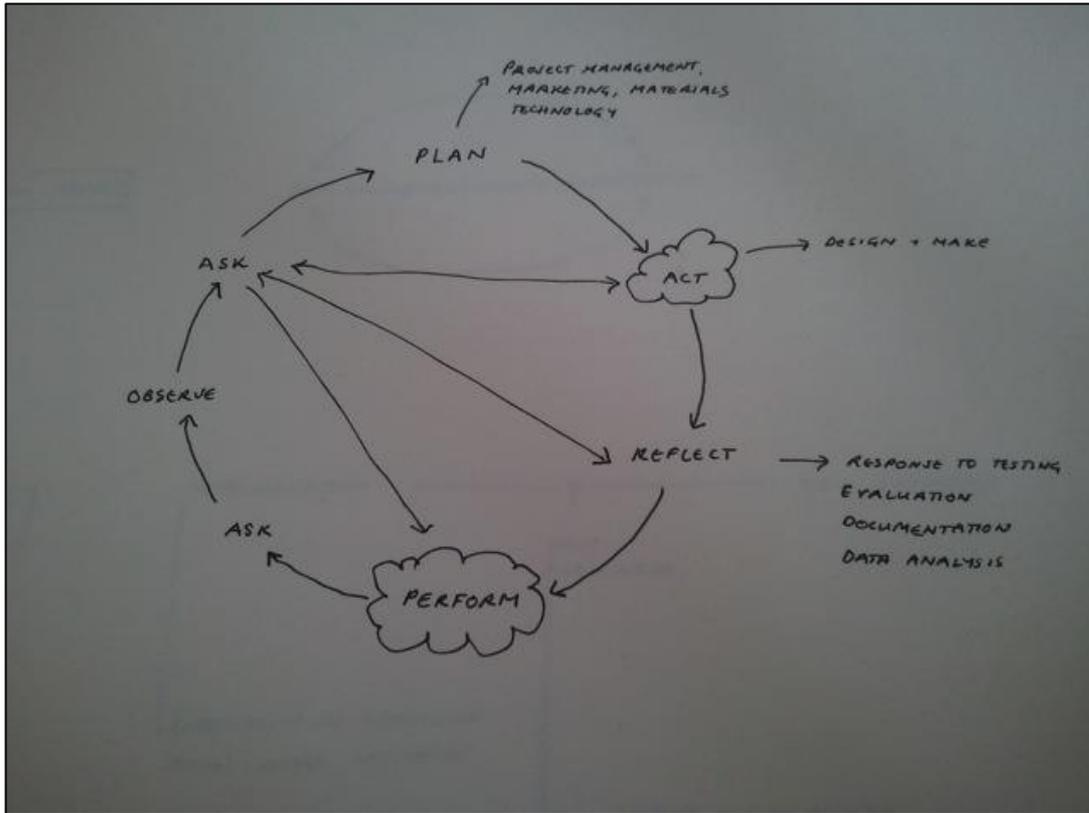


Fig.9 The practice research cycle

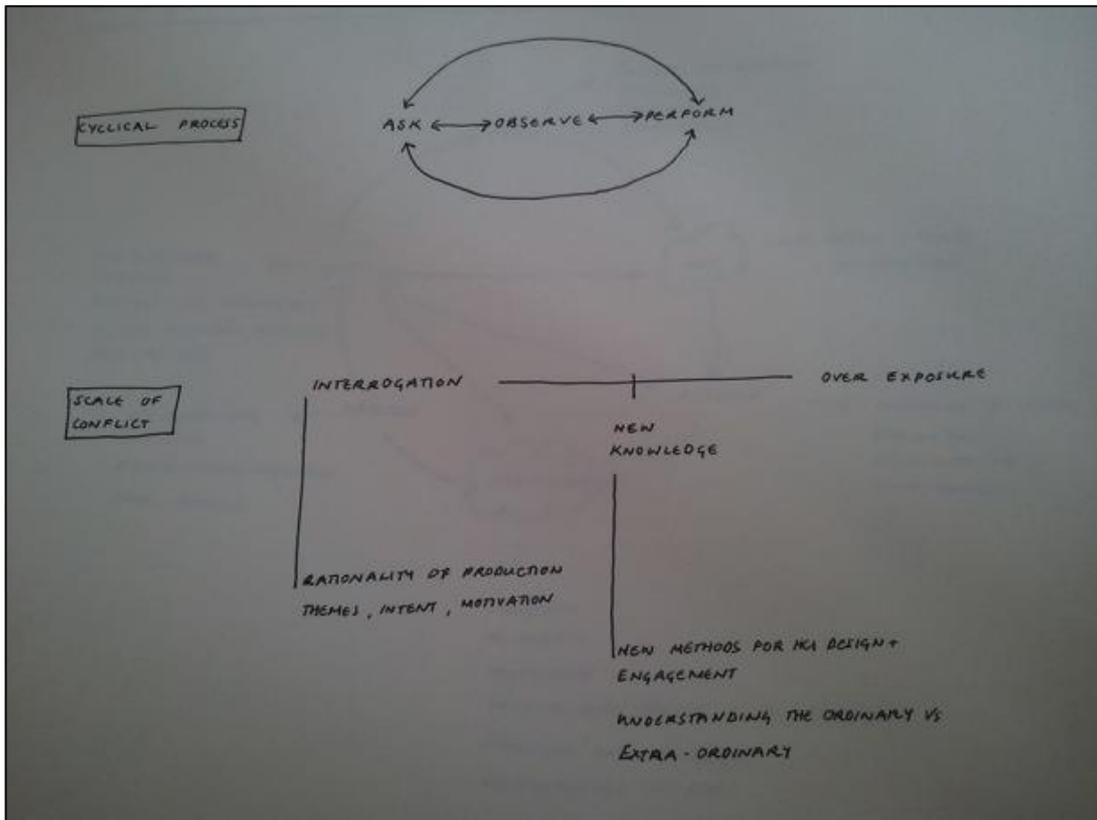


Fig.10 Points of conflict in the practice research cycle

4

A Conversation Between Trees

“There is a point where the clearing, the landscaped space inhabited by us humans stops and the boundary, a dark line of trees, appears in front of you. The edge of the forest. If you cross this line you become submerged. The light changes, shadows deepen, sounds are layered and you can breathe deeply. There are new rules.” (Active Ingredient)

This chapter describes the artwork ‘*A Conversation Between Trees*’ (*ACBT*) that took place in 2010/2011, involving an international collaboration between the artist collective Active Ingredient, Horizon Digital Economy Research Hub, Senior Climate Scientist Dr Carlo Buontempo and British Brazilian artist Silva Leal.

ACBT was an ambitious touring artwork that used sensing technology and environmental data to connect forests in the UK with forest regions in Brazil. *ACBT* involved five artist residencies, three exhibitions, and many more public interventions in forests in the UK and Brazil.

This chapter presents an overview of the final form of the exhibition, describing key aspects of the implementation of the exhibitions. The next chapter will present the artists' motivations, strategies and rationale in order to analyse the findings of a study of these exhibitions that combines the perspectives of the artists, public visitors and the scientist who collaborated on the creation of the artwork.

4.1 Overview of A Conversation Between Trees

ACBT was first inspired by a visit to the Atlantic Forest, Rio de Janeiro, Brazil as a part of research that took place during Active Ingredient's previous research project, the Dark Forest (Giannachi 2010), described in Chapter 1. *ACBT* was subsequently developed as part of a larger arts and schools exchange project. The project involved a combination of artists, scientists and researchers collaborating to visualise and interpret environmental data by exploring forests on either side of the world.

ACBT is a unique interaction between artists, scientists, audience and locations, described by the artists on their website as '*a playful conversation about forest environments*'¹⁵ building public understanding of climate science. The tour is documented online, including a documentary video: <http://hello-tree.com>.

The interactive artwork *A Conversation Between Trees* reveals unseen aspects of forest environments. Each element of the exhibition provides '*a clue for visitors to piece together an unfolding story of 70 years of climate change and our forests*'¹⁶. The public experience involved three exhibitions in public venues in or close to forests in the UK; a two-week live performance experience as part of the exhibition; an interactive mobile phone experience that audiences could take out into forests in both the UK and Brazil.

The artwork establishes a live connection – or conversation – between a distant tree in the Atlantic forest and a local tree at each venue in the UK. The artwork involves arranging three key elements within an overall exhibition, each of these elements are brought together as part of a coherent whole through the use of climate and environmental data, that joins each element of the exhibition into an overarching narrative around climate change.

Instrumented Trees and Visualisations - Environmental sensor data captured and streamed live from each tree and visualized on two large displays that face each other across the gallery.

¹⁵ www.hello-tree.com

¹⁶ <http://hello-tree.com/about/>

Climate Machine - Juxtaposed between these visualisations the '*climate machine*' is an unusual device that visualizes recorded and predicted global CO₂ levels by slowly burning circular graphs onto large circular disks of recycled paper. These are subsequently hung up and displayed in the gallery space.

The Forest Walk - Visitors can also elect to experience a walk in the local UK forest during which they enact being a sensor, using a mobile phone to capture and visualize images of the forest and answering questions about their sensation of being in the forest.

The resulting experience is therefore a complex juxtaposition of different locations (gallery, local forest and remote forest), datasets (live environmental data and aggregated scientific CO₂ data), and technologies (sensors, phones, projections and climate machine) that come together as one coherent artwork. The representations of environmental data were revealed by the artists through the visualisations and an enactment of drawing the data (using the Climate Machine) as a '*performance*' in the gallery space. This was also supported by on going dialogues with the audience about what the data means, where it is from and their experiences and understanding of the forest and climate change, throughout each exhibition.

The use of scientific climate and environmental data throughout the exhibition provided a narrative thread. By comparing the global historical CO₂ data embedded and visualised by the '*climate machine*' and resulting hanging discs to the live data from the forests in Brazil and the UK visitors were able to make comparisons between the data, unifying their experience of each of the elements of the artwork. An example of this was in the comparison between the global CO₂ shown by the climate machine and the live CO₂ data within the projected visualisations, and how the live data in the forests in both the UK and Brazil was in a similar range to the global CO₂ data for the same year.

The following sections describe the three components of the exhibition and how they came together to create a coherent experience for the public.

4.1.1 The instrumented trees and visualisations

In order to capture live environmental data from the chosen trees the team developed a bespoke Arduino sensor hub connected to an Android Nexus One phone via USB. This equipment was housed in a robust and waterproof wooden casing ready for mounting in a tree. Once a minute this sensor kit took a photograph looking up into the tree, simultaneously measuring local temperature, humidity, decibel and CO₂ levels, all of which were transmitted via 3G to a server in the UK. A wireless Internet connection to a computer in the gallery allowed an animated visualisation created in Unity software to call the data from the server once a minute, this data then transformed the visualisation as summarized in Table 2.

The climate scientist Buontempo advised the artists on which data to capture and sensors to use in the forest to support the concepts within the artwork, suggesting that the use of temperature, humidity and CO2 data was representative of localized weather and environmental conditions as well as more global climate conditions.

The exhibition involved projecting the animated visualisation on two opposite screens in the gallery (see Fig.12). These were each an abstract dynamic (moving) 3D image visualising photographic and sensor data captured in each of the forests in Brazil and the UK. Each visualisation responds dynamically to the light and colour content of the images captured by the mobile phone camera, and the temperature, humidity, decibels and CO2 levels captured by the sensors.

The colour and brightness in the image comes from each pixel of the photograph that is taken at the tree (this photograph also appears in the corner of the screen). An abstracted version of the photograph in the centre rotates and dynamically responds to changes in the data received from the sensors from the tree, updated once a minute in the gallery (see Fig. 13). The key to how this works is summarized in Table 2.

Table 2. Key to the visualisations in *ACBT*

Sensor	Data	Visualisation
Camera	Pixels	The image from the camera is transformed into a grid, spherised and animated to rotate
Camera	Colour	The average colour of each pixel in the image is calculated and visualized
Camera	Light	The light levels in each pixel of the image creates a 3D ' <i>tentacle</i> ', the brighter the pixel the longer the tentacle
Camera	Full Image	The full image is shown in the right hand corner of the screen and updated every minute
Temperature	Centigrade	The temperature creates random circles within the image that are coloured on a range of red (high temperature) to blue (lower temperature)
Microphone	Decibels	The tentacles are animated to ' <i>bounce</i> ' -, the higher the decibel level the more they are animated

Carbon Dioxide	Parts per million	The levels of C02 increase the size of the spherised image (the higher the C02 the smaller the image)
Humidity	Relative Humidity	The humidity levels blurs the image (the higher the relative humidity the more blurred the image becomes)
Temperature, Microphone, C02, humidity	C, DB, RH, PPM	The numeric data from the environmental sensors is shown in the top left hand side of the screen
	Location	The location appears at the top of the screen

The visualisations capture a sense of the environmental conditions around the instrumented trees at that specific time and location. One screen shows data from the tree in Brazil and is marked '*Looking Up Through the Branches of a Mango Tree, Mata Atlantica, Brazil*' (see Fig.14) and the other from a tree which varied with each exhibition, local to the forest wherever the exhibition was occurring and also marked with the details of the tree (the UK trees included an Oak Tree, A Wild Service Tree, A White Birch Tree and an ancient Ash Tree).

Many visitors searched for the instrumented tree, particularly in Fineshade Woods where the tree was a 500 year old Ash and visitors who took out the mobile phone experience were advised to start their walk at the tree. The artists also suggested to visitors (particularly with children) that they made noise and shouted at the tree to make the visualisations respond. This worked best at Centre for Contemporary Art and the Natural World (CCANW) in Haldon Forest (see Fig.13) as the tree was close enough to the gallery for people to run to the tree, make some noise and then run back to the exhibition and see how the visualisation responded to the change in decibel levels that had triggered with the noise.

4.1.2 The Climate Machine

In the centre of the gallery space a custom built machine, the '*Climate Machine*' draw live recorded data representing annual C02 levels in the Earth's atmosphere. This machine uses heat from a soldering iron to burn circular graphs onto discs of recycled paper. The data Manua Loa C02 data set¹⁷ is a measurement of monthly trends in carbon dioxide recorded at

¹⁷ Mauna Loa, Trends in Carbon Dioxide. esrl.noaa.gov

the Mauna Lao Observatory, Hawaii since 1958 to the present day. This data set is representative of global levels of carbon dioxide and is publicly available via the Internet, Buontempo advised the artists to use this data set as an important representation of the growth of carbon dioxide in the Earth's atmosphere (Thoning & Tans 1989).

The turntable rotates with a stack of paper; a drawing arm that holds a heating element moves in and out to burn a circular graph of recorded monthly CO₂ levels (see Fig.16 – 18).

It moves very slowly to scorch the paper effectively, so it takes about 25 minutes to complete a single drawing. The machine sits in the middle of the exhibition, between the two real time visualisations of environmental data; connecting the present experience of the forest with a more temporal scientific perspective of climate change. The artists facilitated this, layering the paper discs on the machine, pressing the button to start the machine, removing the discs, embossing and marking them with the date and hanging each paper disc containing a year's worth of data up in the gallery. This created a time-based *'performance of data'*. At the end of two weeks of performance a full set of annual CO₂ data from 1959 – 2010 filled the space.

Beginning in 1959 and continuing until mid-2011 each drawing represents a single year of monthly CO₂ readings and is labeled so that the series of data can be read collectively as an ongoing story of climate change. The further from the centre the line is drawn, the higher the amount of carbon dioxide measured at that time. A drawing of data from 1959 shows a very small circle close to the centre of the paper, while one from 2010 is close to the outside edge.

This element of the exhibition evolved throughout the two weeks that the artists were in residence in each of the venues in the forests. At the end of each residency the full set of heat drawings were hung from the ceiling, like a suspended tree trunk made of paper discs, each with a single circular ring representing the CO₂ levels of that specific year. This continued to be exhibited in the gallery as a representation of the scale of change in CO₂ levels from 1959 – 2011.

4.1.3 The Forest Walk

The third element of the exhibition involved visitors going out into the forest with a borrowed mobile phone. An application on the phone revealed both the live data captured by the sensor in the tree in the forests and photographs and user generated data captured by the audience as they explored the forest (see Fig.20 - 22).

Photographs are captured automatically using the camera on the back of the phone every ten seconds as the visitor walks through the forest. There is a countdown on the top left hand side of the screen to the next photograph being taken so that people can move the phone to frame the image themselves, within the time constraints set by the countdown. Temperature,

humidity, decibels and CO2 data being collected from the forest appears at the bottom of the screen and the same visualisation as projected in the gallery appears in the centre of the screen. People can move the visualisation around using the touch screen, zooming in and out to discover for themselves how the light, colour and data creates the abstracted image. The phone '*paints*' the image with the data from the photograph that the audience capture as they walk through the forest. The soundtrack is a dialogue between the artists Jacobs and Leal, a narrative describing a journey through the forest from the artists' perspectives.

The mobile phone application enables the audience to use their own bodies and sensory responses in order to act as '*human sensors*'. Text boxes appear on the screen asking people to choose on a scale of 1-10 what they think the temperature, humidity, light, sound, and air quality by moving a slider bar on the screen of the phone. Finally they are asked to input three words describing how they feel. This data is recorded and uploaded to an online server. The original idea was to upload it directly to a website but sadly the technology for this proved problematic, and wasn't realised in time for the exhibitions.

4.2 Technical Implementation

The development of the technology for *ACBT* was led by Horizon researchers in collaboration with Active Ingredient and artist and Horizon DTC student Mike Golembewski.

The core developments involved building the infrastructure and database to enable real time transmission of data from the trees in both forests and the development of the mobile sensor technology.

The sensors involved several iterations, based on an original sensor system originally developed for the Participate project (Paxton & Benford 2009) that worked with a Nokia N95, Sciencescope hub, temperature, humidity, decibel and carbon dioxide sensors. These were developed for a previous research project between MRL and AI called '*The Dark Forest*'.

Working with researchers at Horizon Digital Economy Research Institute and Golembewski, the artists developed a bespoke sensor, using the original Sciencescope sensors, but with an Arduino hub that works with Android smart phones. The Android phone application for the sensors takes a photograph every minute and collects data from the Arduino hub via USB. The application then sends the data using 3G to the server once a minute. The data was then pulled into a visual interface designed by Active Ingredient in Unity, interpreted as a 3D dynamic animation. The sketches in Fig.24 were made by the author to show how the technical architecture of *ACBT* was informed by the artists' design of the work.

Unfortunately the new sensor sent to Brazil got caught up in Brazilian customs and so the Mango Tree in Brazil (where the sensor was placed) was still being sensed using the old system. The artist Silvia Leal and Prof. Mario Jorge Ferreira de Oliveira in Brazil managed to collect live data using this system on and off throughout the project. Also due to the time difference between the two countries the Brazil sensors were only live for the second half of each day during the exhibition. If the new sensor had been available to be used then it would have been possible to keep the sensors live throughout the duration of the exhibition as the battery power lasted longer.

The Climate Machine was built out of experiments with heat, paper and climate data by the interaction designer and Horizon DTC student Mark Selby who worked as part of the Active Ingredient team. The paper was provided as sponsorship by a paper company who specialise in 100% recycled paper and local paper cutters that cut the paper to size with a central hole for the paper to sit on the turntable.

The Mauna Lao CO2 series data set was processed and translated into mechanical movement using open source hardware (Arduino) and software (Processing) via USB to the computer. When you press the button on the front of the machine a custom application written in Processing takes the data, breaks it up into months and years and translates the numbers into a set of basic direction commands. These commands are sent to an Arduino board which uses them to drive two stepper motors, one of which rotates the platform, while the other moves the drawing arm in and out.

4.3 Marketing *ACBT*

The website contains rich details about the project including: documentation of the process as part of a blog; the technology; participatory activities alongside the exhibitions; background and scientific information about the forests involved; videos of the machine and the exhibitions as they occurred. The website also presented weather forecasts for each forest region in the UK and Brazil with corresponding images taken by the artists of the forests they had visited during the project research, these photographs were selected from a FLICKR set (a web based image tool) based on a temperature range. The website¹⁸ also shows the project tweets updated by the artists throughout the exhibition to encourage visitors to engage in an ongoing discussion with the artists.

¹⁸ The website can be viewed at: www.hello-tree.com

The development of audiences for the exhibition was supported by an accessibility advisor who worked with the artists to explore ways to make the interactive elements more accessible, the aim was to ensure information on the website and other marketing would fit within accessibility guidelines and to explore how visitor experiences could be supported on many levels. This included designing and promoting a guided experience of the exhibition led by the artists throughout the exhibition, providing large print and additional descriptive texts to support the work and the phone experience.

A flyer (with a large print alternative) was provided as a hand out for visitors to the exhibition that explained the work in detail – also acting as a guide to the work. This also doubled up as a promotional flyer and therefore aimed to introduce audiences to the themes and ideas within the work before they arrived at the exhibition.

Signage throughout the exhibition space also aimed to support the audience along the trajectory of the experience. The artists spent some time iterating this ‘*journey*’ in each venue aiming to make the experience of exploring the exhibition as clear as possible given the complex nature of the work. Signs were displayed where people entered the main exhibition space and by each screen, the climate machine and the hanging sheets, to explain the context of each element.

4.4 Touring *ACBT*

Table 3. Five Phases of *ACBT*

	Making the artwork	Public Exhibition 1	Public Exhibition 2	Public Exhibition 3	Forest Walk
Study Location	Yorkshire Sculpture Park Estudio Movel Experimental / Rio de Janeiro	Fineshade Woods	Rufford Country Park and Broadway Media Centre	CCANW, Haldon Forest	Tijuca Forest, Brazil and at each UK forest
Study Participants	Artists	Visitors	Visitors Artists	Visitors Artists Scientist	Visitors
Study Methods	Blogs Video Photography	Audio interviews questionnaires observations	Audio interviews questionnaires observations	Audio interviews questionnaires observations	Audio interviews

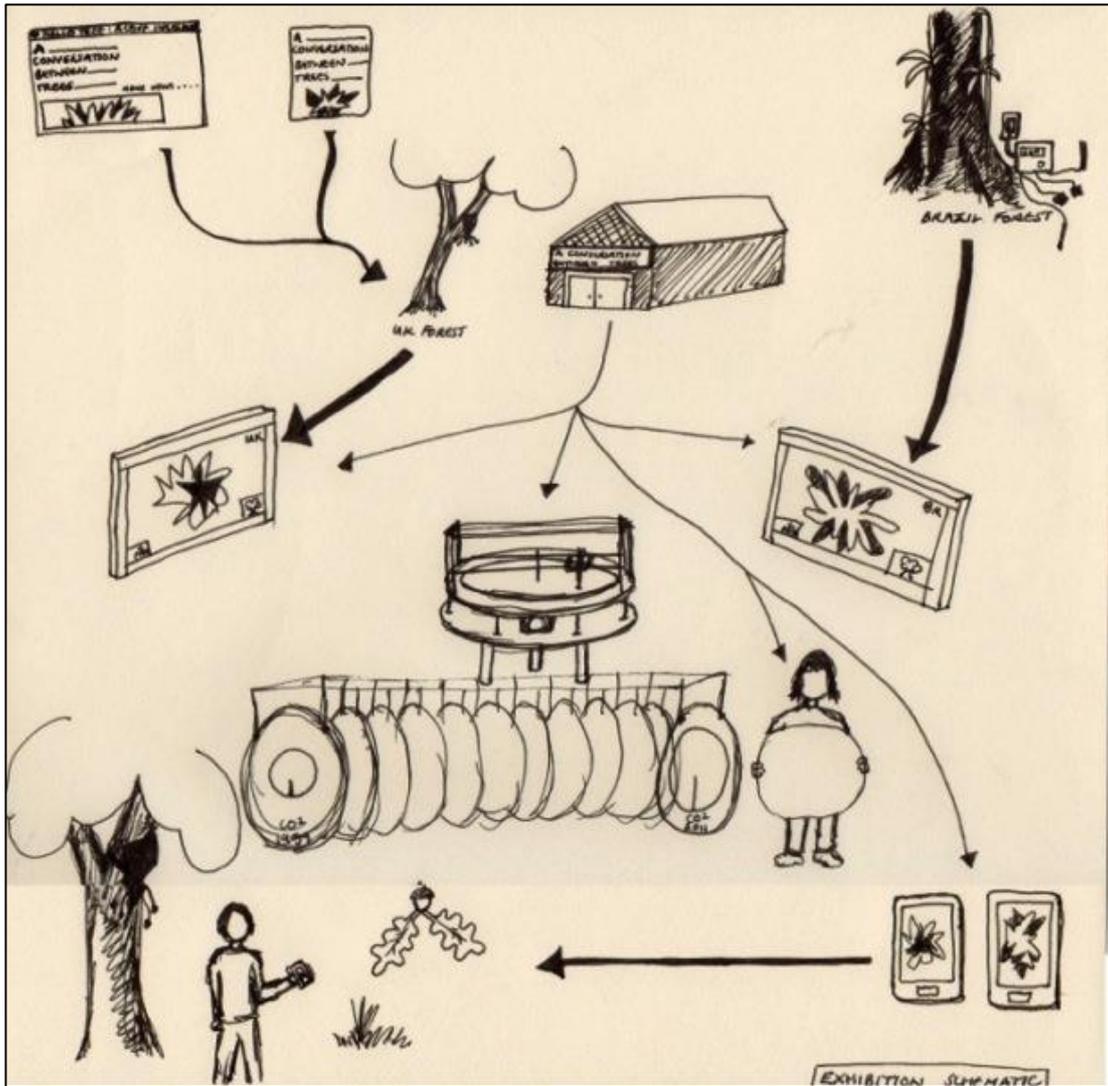


Fig.11 Schematic sketch of the visitor experience during the ACBT exhibition

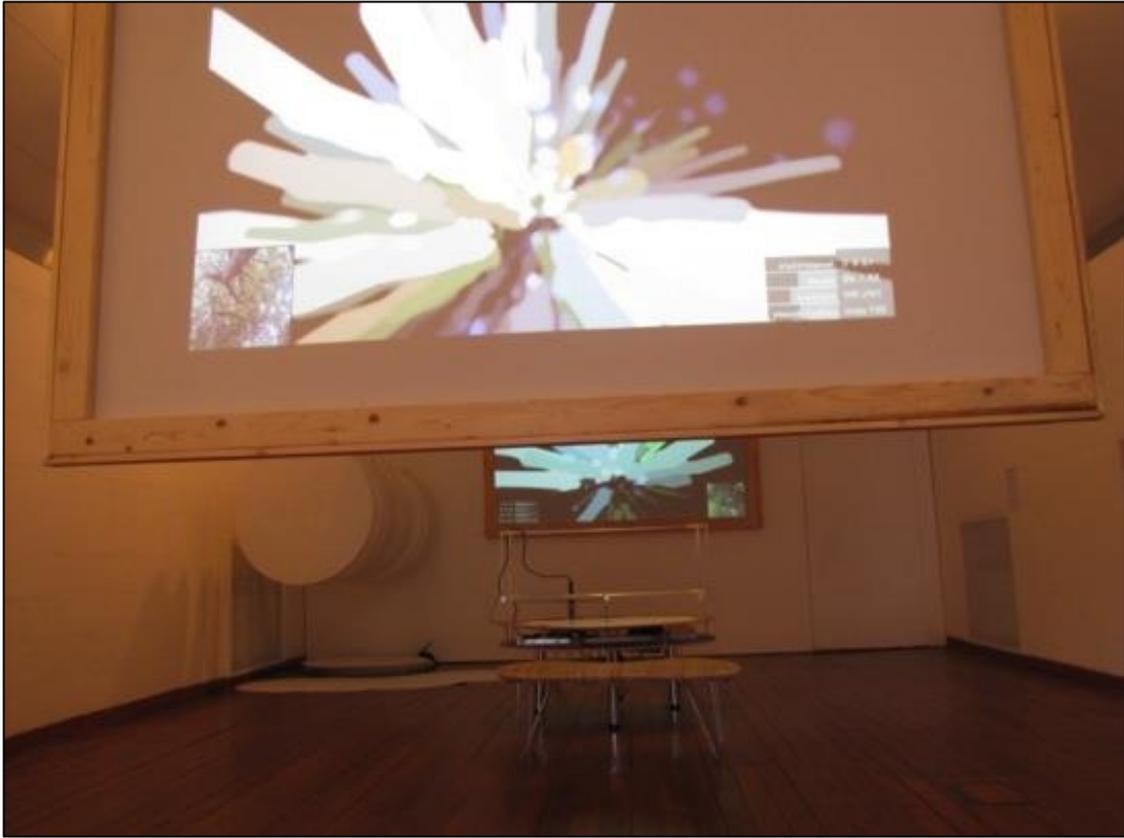


Fig.12 The two projection screens, the front screen visualising a tree in the UK and the back screen a tree in the Mata Atlantica, Brazil.



Fig.13 The sensor box in a Service Tree in Haldon Forest with the gallery in the background



Fig.14 Visualisations of a mango tree in the Atlantic Forest, Brazil (left) and Ash tree in the UK (right).

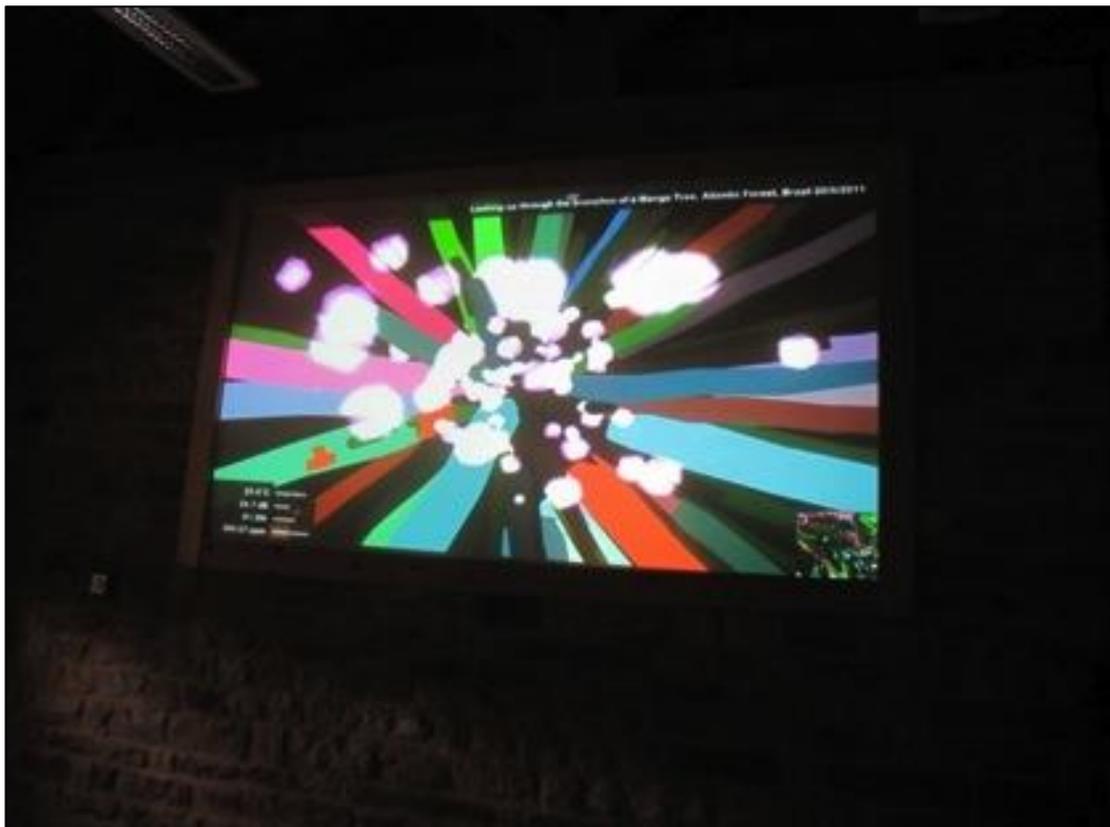


Fig.15 Visualization screen showing a mango tree in the Mata Atlantica

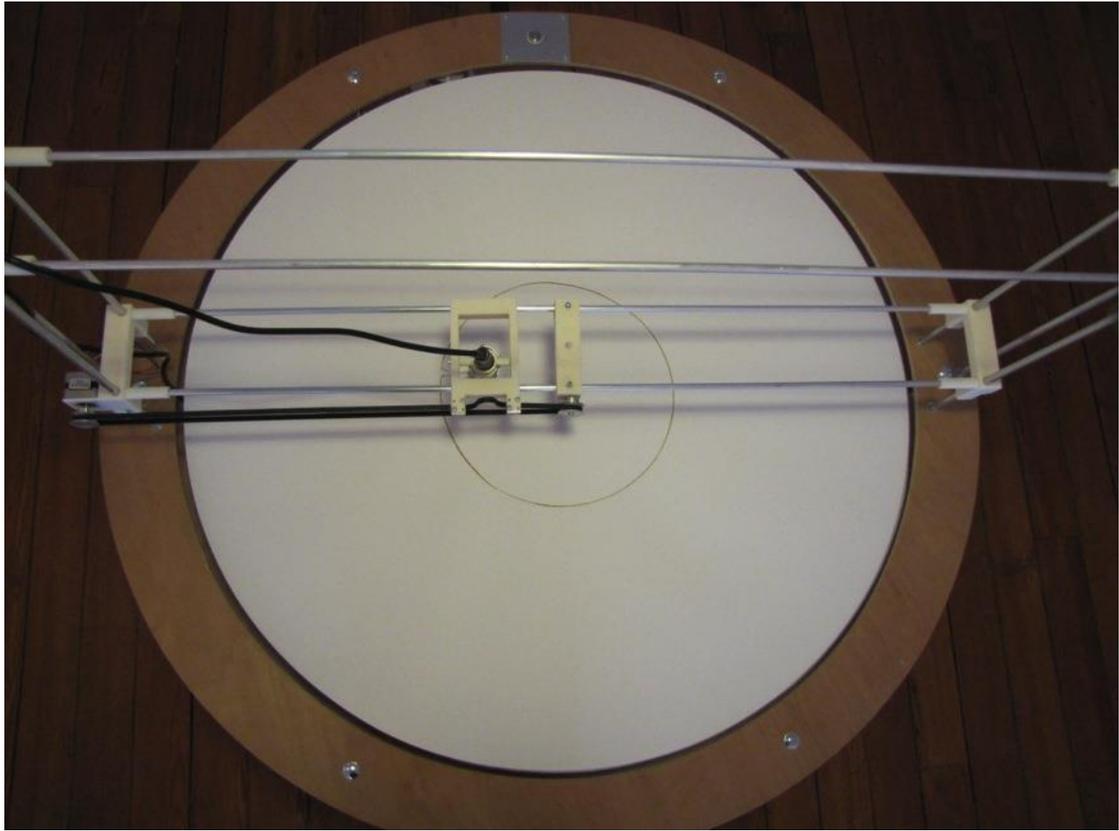


Fig.16 The Climate Machine from above

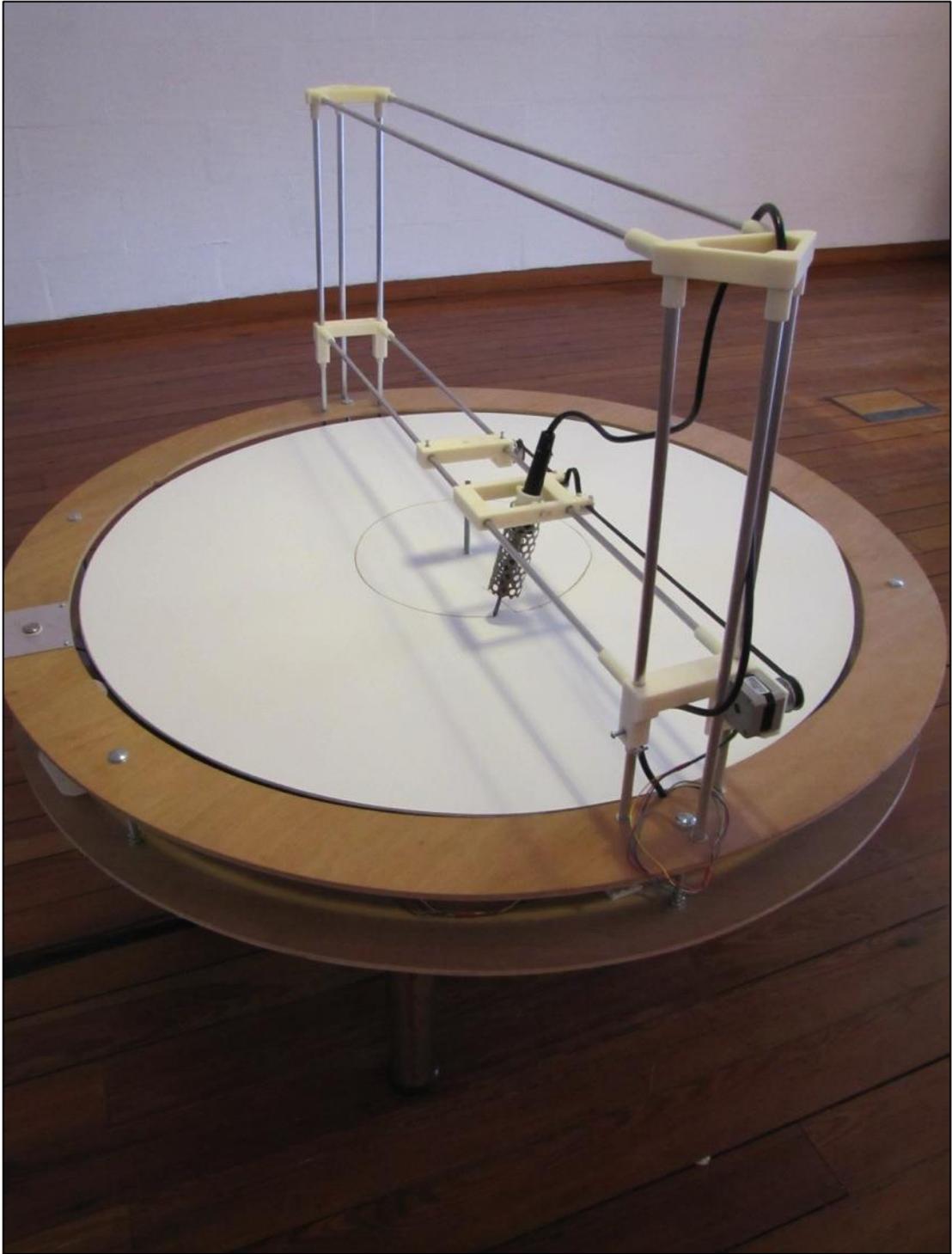


Fig.17 The Climate Machine

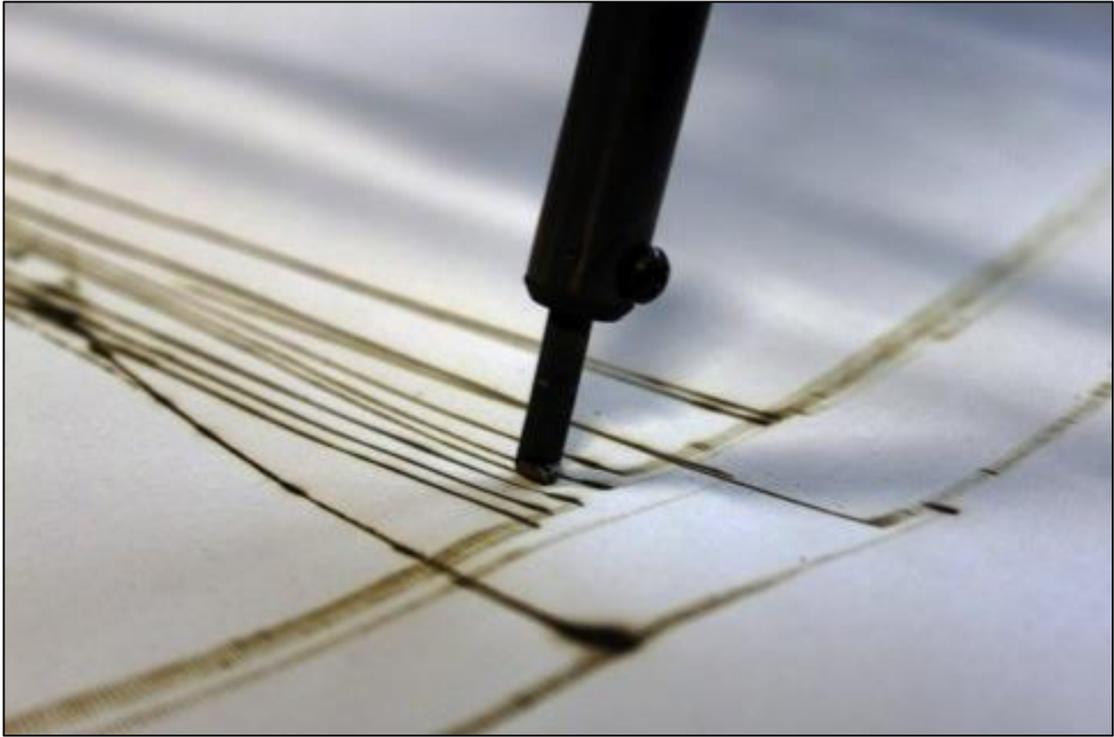


Fig.18 Burning circular graphs onto recycled paper



Fig.19 Hanging sheets with heat drawings representing 52 years of carbon dioxide increases in the earth's atmosphere



Fig.20 Using the phone application in the forest



Fig.21 Visitor using the phone application in Tijuca Forest



Fig.22 Photographs captured by visitors whilst using the phone at CCANW, Haldon Forest, Devon, UK



Fig.23 Old sensor kit including: Sciencescope hub, Nokia N95, temperature, humidity, atmospheric pressure and decibel sensors

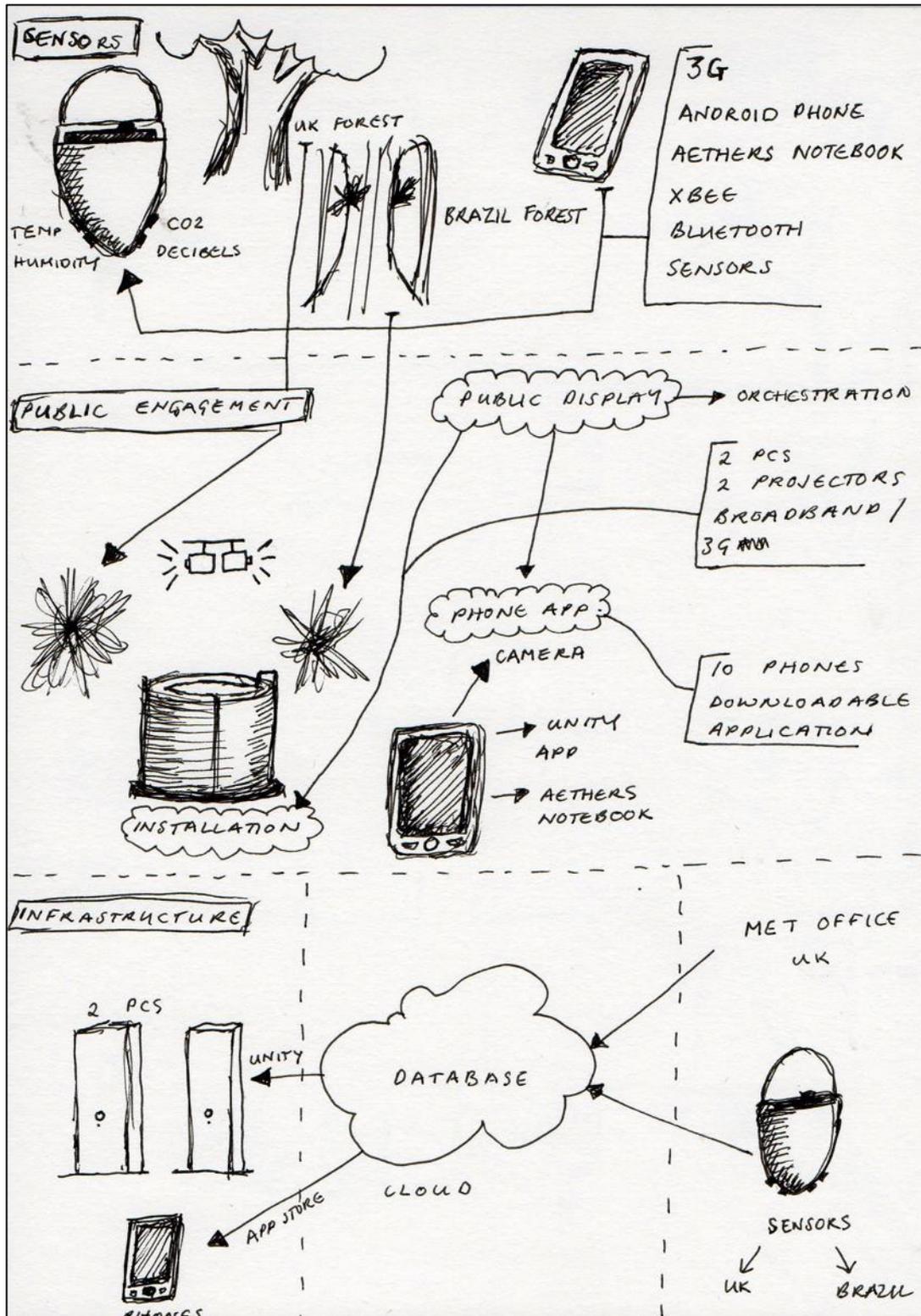


Fig.24 Sketches of the technical schema of ACBT



Fig.25 The new sensor kit including: C02 monitor, decibel sensor, humidity sensor, temperature sensor, Arduino hub, Android phone and Power Gorilla Battery

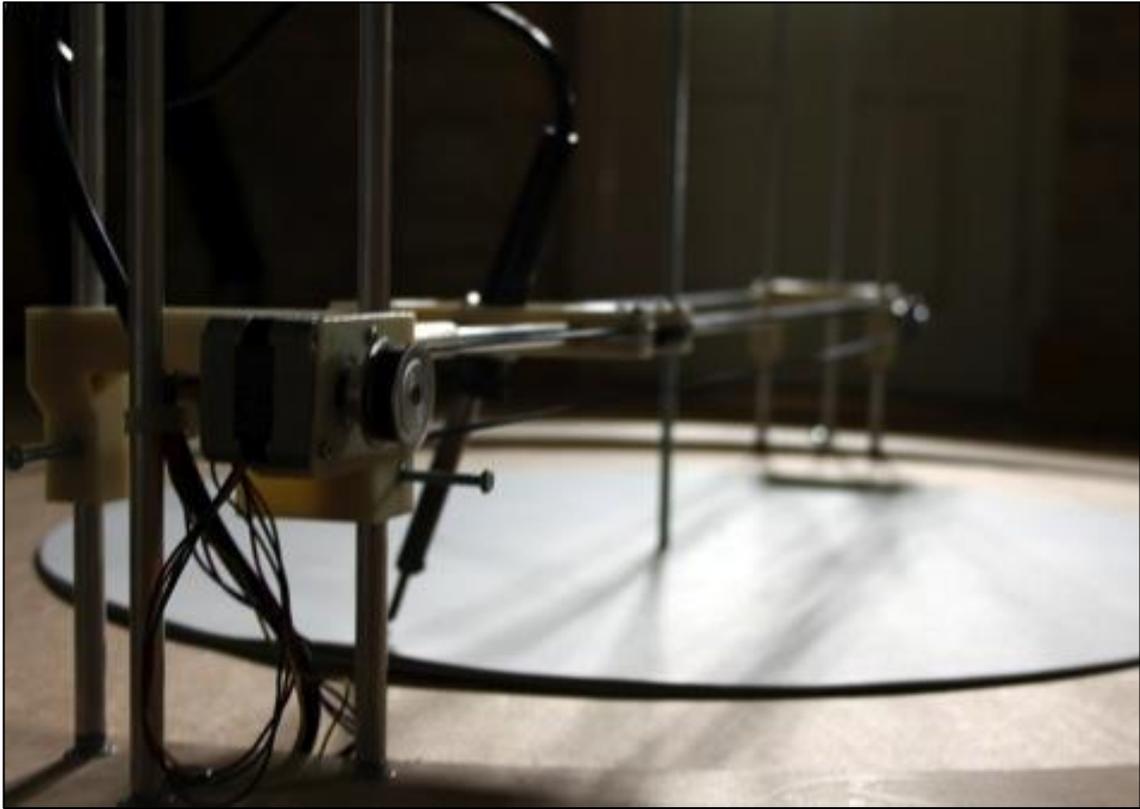


Fig.26 The drawing arm and soldering iron

4.4.1 Public Exhibition at Fineshade Woods

ACBT took place over five phases. The first phase involved developing the artwork and implementing the technology developed during a series of artist residencies in Brazil and the UK. *ACBT* then toured to three public arts venues that were located in different UK forests and the forest walk that was presented in Tijuca Forest on the outskirts of Rio de Janeiro, Brazil. These five phases that make up the overall tour are outlined in the table below.

An early pilot study took place at the first venue at Fineshade Woods, Northamptonshire. The exhibition was installed in a Forestry Commission site, in a barn converted originally for conferences, meetings and public workshops. This was the first art exhibition to be installed in this venue. Some of the comments and questionnaire responses from this pilot study were used to support the findings of the core study.

4.4.2 Public Exhibition at Rufford Country Park

The second exhibition in the tour took place over a period of two weeks at Rufford Country Park and Gallery, a traditional craft gallery that normally presents commercial craft exhibitions (where people can buy the exhibits) run by Nottinghamshire County Council. This was the first digital art exhibition that had been commissioned directly by the council leisure services. The audience was predominantly day-trippers to the Country Park, retired visitors and families visiting the park, walking their dogs or coming specifically to visit a craft exhibition. Some visitors came specifically because they had heard about the exhibition. There were some regular visitors interested in arts and crafts and there was a community of artists who visited the gallery through taking part in the gallery's predominantly craft orientated workshop/education programme.

Rufford Country Park is situated in the Sherwood Forest region and contains a woodland area, which is a mixture of Sherwood Forest's ancient woodland (Oak and Birch trees) mixed with imported trees and plants.

During the exhibition at Rufford Gallery a smaller exhibition of the project involving a dual screen projection of the visualisation took place in parallel, at Broadway Media Centre in Nottingham (the nearest city to Rufford). Information was made available about the exhibition in Rufford at Broadway, and it was observed that visitors travelled out from Nottingham to Rufford as a result of seeing this.

4.4.3 Public Exhibition at CCANW, Haldon Forest

The second study took place at the Centre for Contemporary Art and the Natural World (CCANW), a contemporary art gallery situated in Haldon Forest, Devon. This is a forest managed by the Forestry Commission, which is part commercial pine forest, part leisure

activities (including Cycling, Segway and Go Ape). There is a cafe and some sculptures in the forest.

The gallery (CCANW) traditionally shows a mixture of contemporary art that responds to the environment or nature, they conduct participatory projects involving nature and have hosted high profile Land Art exhibitions, such as Andy Goldsworthy (T. Friedman & Goldsworthy 2006) and David Nash (Grande 2001) with work placed out in the landscape of the forest.

The audience predominantly visit because they have an interest in art and the environment, or are visiting the forest and taking part in activities and pop into the gallery as part of their day out. There is a bookshop with books about art and the environment that also attracts people into the gallery. There is quite a high level of regular and local and recurring visitors and a strong education programme attached to the gallery that works with schools, local University students, teachers and specific community groups alongside the exhibitions.

An additional event took place as part of the project in Tijuca Forest, which is part of the Mata Atlantica Forest in Brazil, close to where the Brazilian sensor was placed. Members of the public were invited to take part in a workshop and take the phone experience out into the forest in parallel to the exhibition, taking place at CCANW in the UK. As a result of this event the artist Silvia Leal (Active Ingredient's collaborator in Brazil) interviewed these participants, these interviews are also included in the study of the forest walk mobile phone app.

5

Analysis of A Conversation Between Trees

Having described the artwork in the previous chapter, the author will now present the findings from a study of the artwork as it toured to the three forest venues in the UK and was presented in a forest in Brazil.

This study combines the perspectives of the artists who created *A Conversation Between Trees* with visitors who experienced it, and also the climate scientist who advised on the project. Firstly, each perspective is presented by an overview introducing the motivations of the artists, the general experience of the visitors and the scientists' reflections on collaborating with the artists.

This chapter begins with a description of the study methods described in Chapter 3, and a more detailed discussion of the approaches that informed the analysis of the data captured during this study.

This overview is then followed by a thematic analysis combining each of these perspectives in order to provide a detailed description of the emerging themes resulting from this analysis, that directly inform the next and final study which will be discussed in the following two chapters.

This study has so far contributed to the publication of one full paper at CHI 2013 (Jacobs et al. 2013) winning an Honorary Mention Best Paper Award and two workshop position papers at CHI 2012 and DIS 2012 (Jacobs et al. 2012; Jacobs et al. 2012)

5.1 The Study

The study focuses on the distinct role played by the artists in engaging the public with climate data and the visitors and scientists' experience of the artwork.

As discussed in Chapter 3, the author will be referred to as '*artist/author*' when referring to her specific artistic involvement in the artwork. Within this study the term '*artists*' will also be used to define the Active Ingredient team (as a collective).

The study presents an overview of each of the perspectives and the digs deeper into the data to investigate the emerging themes and sub-themes across each perspective in relation to the research questions and related literature.

5.1.1 Study Methods

The methods used in this study are described more broadly in Chapter 3, this section describes the specific methods employed to investigate each of the perspectives, centred on the following research questions:

- What did the artists set out to do?
- How was this made manifest in their design?
- How did visitors experience it?
- What were the challenges and tensions between the different perspectives involved in the work?

As described in Chapter 3, the study consisted of a mixed method approach, combining ethnography – semi-structured audio interviews, questionnaires and observation - and reflexive approaches that documented the artists' motivations and rationale in order to combine each of the following perspectives:

Studying the Visitors' Perspective

The study of the visitor's perspective posed the following questions:

- How did visitors engage with the experience/artwork?
- What were the visitor trajectories through the experience/artwork?
- Were there any extra-ordinary activities and responses to the artwork?
- In what ways did visitors interpret and understand the experience?

- How did the visitors experience compare to the motivations and rationale of the artists?
- How did the artist's motivations impact on the visitors experience?

This visitor study consisted of:

- 20 single and group interviews involving a total of 28 participants
- Comments and observations from 3 exhibitions
- An ethnographic study by a researcher from Mixed Reality Lab, University of Nottingham (Brundell)
- An audience evaluation report by an arts based researcher employed by the artists (Haines)
- Leal's interviews of participants at the forest walk event in Brazil

As a result of the research 20 semi-structured interviews were conducted with visitors to Rufford Park and CCANW and three at Tijuca Forest (Mata Atlantica), Rio de Janeiro, Brazil. The semi-structured audio interviews make up the core data of the public study.

7 questionnaires were filled in during a pilot study at Fineshade Woods and 30 questionnaires at Rufford Park. Comments and observations were recorded at all three venues.

The approximate total audience numbers and participants in *A Conversation Between Trees*, across all three exhibitions, between 2010 – 2011 were:

Gallery Visitors = 4946

Workshop Participants = 250

The author captured the visitors' perspective through semi-structured audio interviews that took place after their experience of the artwork. 20 semi-structured interviews were conducted, in a combination of single and group interviews, involving 28 participants in total. Feedback questionnaires were also made available to all visitors, as is common practice with public exhibitions and 37 of these were completed. The decision was made by the author not to record visitors via video or photograph, therefore audios interviews were used rather than a primarily observational approach in order to highlight visitors' feelings about the work and to avoid interfering with the experience (Rogers et al. 2011: 368-373).

As described in Chapter 3, this study was also supported by two additional reports. Firstly an ethnographer (Brundell) conducted a study that focused on the visitors who took part in the forest walk, contributing to the analysis of this element of the artwork. Additionally, the artist group Active Ingredient also employed an audience evaluator, which is encouraged by the Arts Council of England who funded the artwork. Some of the findings from these observations have contributed to the analysis, particularly in reference to the broader issues

of engagement and disengagement, discussed in the final section of this chapter.

Before presenting our findings from the visitors' perspective it is important to briefly clarify that the data reflected the views of visitors who engaged with the work in a serious way, that is who spent considerable time on one or more of its three elements and were willing to be interviewed afterwards. It should also be noted that not all of the interviewees fully viewed all the elements that constituted the entire artwork.

Another significant factor was that there were many visitors who entered the gallery who did not engage deeply, if at all. This is common with contemporary artworks, particularly when presented in venues that are not '*contemporary art galleries*'. These challenges will be discussed later in the chapter.

In order to provide a deeper understanding of this context the visitors who took part in the interviews are presented in Table 4, each participant is identified numerically. Participants who attended as a group are numbered and lettered. e.g. Participants 2a – 2c. Members of the public who were not interviewed but were observed or who filled out a questionnaire are identified simply as '*visitors*'.

Studying The Artists' Perspective

The author captured the artists' rationale by conducting three audio interviews with the artist team: the designer of the climate machine (Selby); the developer of the visualisations and mobile application (Shackford); and the collaborating artist in Brazil (Leal). The artist team also described their rationale, intentions and motivations for each element of the exhibition as part of a publication (Jacobs et al. 2011) that was written by Active Ingredient after the tour was over, some of this writing has been included in order to represent the artists' perspective in their own words. The artist/author also wrote a rationale of the exhibition in advance of studying the audience engagement with the work, so as to avoid as far as possible reconstructing her own rationale after hearing from the audience.

The artist's rationale was documented throughout the process of developing *ACBT*, on blogs, artist notebooks and press releases. The artists were invited to contribute to the Material Conditions publication (Jacobs et al. 2011) after the tour was over, these descriptions act as reflexive accounts and recorded dialogues between the artists.

The questions centred around each individual artist's role, motivations and intentions for their involvement in the artwork, what they perceived as the value of the artwork, the key challenges and opportunities of the work, how they conceptualised the environmental data and what they felt was memorable about the work.

The artists' rationale is separated into the following sections:

1. The personal motivations of the artists
2. The rationale of production based on Benford et al. (Benford et al. 2011b)
3. Conceptualisations of the experience based on McCarthy and Wright (McCarthy & Wright 2004)
4. Categorisation of sensory experience by Pink (Pink 2009)

Studying the Scientists' Perspective

Active Ingredient collaborated with a professional climate scientist from the UK's national meteorological centre (Met Office UK, Hadley Centre) to advise on the project, including recommending datasets. The scientist also visited the exhibition and was subsequently interviewed in order to capture their perspective of the work and their view of the role of the artists' engagements with climate change. An audio interview took place with the scientist, which has also informed this study. This interview followed the same semi-structured conversational methods applied to the artists and public interviews.

Table 4. Participants in the study of *ACBT*

ID	Age	Location	Additional Information
Participant 1	64	CCANW	first time to the gallery
Participant 2a	31	CCANW	On an organised group visit to specifically see the exhibition
Participant 2b	37	CCANW	On an organised group visit to specifically see the exhibition
Participant 2c	44	CCANW	On an organised group visit to specifically see the exhibition
Participant 3	41	CCANW	regular visitor to the gallery visiting with his elderly father, he explained the project to his father
Participant 4	52	CCANW	
Participant 5	36	CCANW	Interviewed a week after visiting the exhibition. Visited during the preview when the machine and sheets had only just began
Participant 6	52	CCANW	a regular visitor to the gallery and forest
Participant 7	38	CCANW	heard about it through a talk about the project at pervasive media studio and travelled from Bristol specifically to see it

Participant 8	50	CCANW	An art teacher, returned with one of her A level art students a week later
Participant 9a	11	Rufford	Two children came with one of their parents
Participant 9b	11	Rufford	Two children came with one of their parents
Participant 10a and 10b	39	Rufford	Couple who came with two children
Participant 10b	50	Rufford	Couple who came with two children
Participant 11	70	Rufford	A woman who complained about the exhibition to the invigilator and agreed to be interviewed
Participant 12a	40	Rufford	
Participant 12b	46	Rufford	
Participant 12c	36	Rufford	
Participant 13	42	Rufford	someone who came twice <i>“I came to the opening with my husband and my two children, including S who is here and today it is just S and I”</i>
Participant 14a	17	Rufford	art students from a local college visited in a large group with their teacher
Participant 14b	17	Rufford	art students from a local college visited in a large group with their teacher
Participant 15	39	Rufford	a friend of the artist who visited on the preview. Recorded a week after the visit to the exhibition,
Participant 16	65	Rufford	
Participant 17	27	Rufford	Recorded several days after the visit to the exhibition, (A colleague at the University)
Participant 18	63	Rufford	Interpreter at Rufford Abbey Country Park, after first viewing the exhibition he returned to do an interview
Participant 19a	35	Rufford	A family group, interviewed couple
Participant 19b	31	Rufford	A family group, interviewed couple
Participant 20	28	Rufford	Recorded a week after visiting the exhibition (A colleague at the University)

5.2 An Overview of the Participants' Perspectives

In order to lay the ground for a thematic analysis of the findings the next section provides an overview of the different perspectives of the artists, scientist and visitors, in order to present a rich overview of:

- The artists' motivations
- How the artists '*create the spectacle*' (Benford et al. 2011b) of the exhibition
- How the public experienced each of the elements of the exhibition
- The scientists' collaboration with the artists

5.2.1 The Artists' Perspective

Firstly, the artists describe how they composed the artwork. As discussed in the previous chapter, the exhibition was made up of three elements. The artists describe how a core component of creating a coherent exhibition, combining these elements was in the composition of the physical layout of the space in each of the galleries/forest venues and the presentation of the spectator interfaces. These were made up from the three elements of the work:

1. Projected interface - the visualisation
2. Artefacts - the climate machine and hanging discs
3. The mobile interface - the forest walk

The artists discussed their broad motivations around representations of climate change within the artwork. They made it clear that they did not want the presentation of the artwork to be politically explicit or express a clear position on climate change indicating that although they had considered their own political or personal understandings of the environment during the development of the artwork they made a decision not to present these positions directly or overtly within the aesthetic or narrative of its presentation. Shackford describes how he balanced these personal motivations:

"I've always had a massive interest in the environment since I was a teenager really and seen it as an important thing to talk about, and I think having that real, core simple goal really helped kinda push the whole thing forward" (Shackford)

As artists, not scientists they were also aware that in the act of making the artwork, through capturing and conceptualising the data, they were on their own trajectory of learning about climate change and going through their own process of questioning in parallel to the audience. They expressed a desire to be honest about this and not present themselves as

experts, despite grounding the work within a scientific perspective through their collaboration with Buontempo:

“I felt like I became a kind of instrument as well, and it made me much more aware of the environment here, you know it’s a huge learning curve, in terms of understanding what this data might be” (Leal)

In particular, Leal describes how her personal experiences as a British-Brazilian artist and relationship to the two forest environments in the UK and Brazil provided the artwork with an additional integrity and the significance of the collaboration to her personally:

“I think in terms of the bridge building, because I had lived in the UK and I was in Brazil I think my most precious sort of necessity was to work with you, not just a wish but it became almost a necessity of some of the bridge building... your commitment to communicating back with me and our commitment to work together over the distance and sharing your research and sharing your work being open to me to work with you here (in Rio), I think that was really beautiful.” (Leal)

Leal also describes how the iterative process of developing the artwork over time enabled a development of her understanding of the roles of science and technology, that the artists in turn aimed to engage the public in the same questioning process:

“It was an increasing opportunity to not represent, but to present again, to show a different way in which technology and science can be approached. In particular, for new generations who are I can’t imagine, who don’t know a time before technology, for them to be questioned about the extent of the potential of technology and science” (Leal)

Prior to the exhibition at Rufford Park, the artist/author adapted methods for describing how artists ‘create the spectacle’ proposed by Benford et al. (Benford et al. 2011b) to document a detailed description of her own rationale. This description focuses on the layout of the overall exhibition, the planned visitor’s trajectory through the work and how the author envisioned each element of the exhibition being brought together as a whole narrative experience.

Each interface or element of the artwork was designed by the artists to work independently from each other yet juxtaposed, in order to reveal different clues about the data within a broader narrative around forests and climate change. The different types of data used within each interface also informed the way they were designed, in order to connect the individual elements together as a coherent whole. The artist/author describing how she imagined the trajectory through the exhibition:

“You enter the gallery. It is not the normal type of exhibition to be expected in a craft centre, which normally has ceramics or prints. Here is a different kind of space. The first things you see is an area with books and a record player, with burnt paper and tree logs with tree rings. On the wall is pictures from the workshops we have done with The Dukeries College. A local school.

There is a table with computers and phones on it.

Straight in front a sign says the title of the work ‘A Conversation With Trees’ and a sign inviting you to explore and ‘join the conversation’.

You enter the main part of the gallery. Facing you is a bright coloured sometimes rotating, moving, jumping image. Like a sea anemone or a planet covered with strange alien plants. It has some scientific data on one side of the image. Telling you the temperature, humidity, sound and carbon dioxide levels of this strange planet. In the corner is a photograph and on the top of the image it says ‘looking up through the branches of a Mango Tree in the Mata Atlantica, Brazil’.”

The artist/author then describes each of the elements of the artwork:

‘The soldering iron draws a year’s worth of data onto a circular sheet of 100% recycled paper, the data is scaled to the paper so that each sheet of paper represents the increase in carbon dioxide levels that have occurred from 1959 to 2010. We place a new sheet of paper on the machine, press the button and let it draw, scorching the data into the paper. We then hang the sheet from metal cords from the ceiling of the gallery, slowly filling the room with circular sheets of paper, with ever increasing heat drawn circles, records of CO2 changes in our planet’s atmosphere. They look like tree rings and we see it as burning the rings back into a tree that has been turned into paper, as a performance of nature.’

The artist/author then described the forest walk, which was originally designed to occur after visitors view the exhibition in the main gallery space:

‘The phone guide is a bit like an audio guide, but with a difference. There are instructions and also descriptions of a journey into the forest, the things we have noticed in England and Brazil. A few stories, ways of looking. A conversation between Me and Silvia, the artist we are collaborating with in Brazil. On the screen is the same visualisation as projected on the wall of the gallery, but here the photograph is taken by the phone automatically every 10 seconds with a countdown to help you frame the image as you explore.’

The artist/author then discussed the conceptualisations of the data:

“In fact, the image is a 3D abstraction of the photograph. The predominant colour of each pixel of the image is extracted, the image is spherized and then the brightness of each pixel extrudes the pixel – creating long tentacles where there is light and smaller ones in the darker pixels. The colours, shape and brightness reflects directly the picture taken in the Mata Atlantica, in a tree, on the edge of Rio de Janeiro where city meets forest. The photo is updated every minute, live from the tree, via the Internet and so is the climate data. We hope it represents some of the feelings and senses of standing under a tree in the forest in Brazil.

On the opposite wall is a similar image, looking up through the branches of an old Oak tree in Sherwood Forest (Rufford Country Park). Often the colours are more muted, the temperature colder and the light changes faster. There is less movement as the sounds are often more ambient and sometimes when it rains it reaches the same or higher absolute humidity than the tropical forest in Brazil.

Both images blur as the humidity increases. Jumps about as the sound levels increase and glows red to blue as the temperature increases or decreases.

In the centre of the gallery is a circular machine. We call it the Climate Machine. It rotates slowly making clicking sounds as the motors turn. In the centre of the machine is a soldering iron that moves backwards and forwards like a scanner or printer, it interprets levels of Carbon Dioxide in the Earth’s atmosphere. Scorching circular graphs of data collected from an Observatory in Hawaii, the recorded levels of carbon Dioxide go back to 1959.”

The artist/author discussed the sensory experience of the work and how this is embedded in the design and conceptualisation of the experience:

‘We’re burning paper in reference to burning fossil fuels, as one of the possible causes of increased CO₂ in the atmosphere, as well as liking the effect on the paper, the smell of burning wood and the lingering trail of smoke.’

The artist/author also talks about how the forest walk also acts as a data collection tool for research, reflecting previous findings by Benford et al. (Benford et al. 2013) where the artists work creates a loop that can also provide data that can be used to evaluate the publics’ response to this work:

‘The phone itself could potentially become a sensory ethnographic tool as well as a way to capture the forest – to hand over the tools to the public, citizens, in order to interpret, visualise and express how they feel about the forest and share their interpretation with others via the website.’

The artist/author also describes in detail the role of the artist and of dialogue between the artist, the elements of the exhibition and the visitors within this process:

‘As artists we create the framework for this to happen, begin the dialogue by juxtaposing tangible and visual experience, digital and data driven texts as well as the words we speak in conversation with the public. The artists frame the dialogue by creating specific relations between these texts, informed by their own experience and interpretation of the data, their visual, sensory and physical response and their cultural perspectives from England and Brazil.

This frame creates a starting point. A space of reference that enables the public to continue the conversation and explore. As when I describe the work and what is happening to a woman and watch her say to her partner – you’ll like this and she goes on to describe it in her words. I take a step back and let them suggest reasons for the changing image, discuss together their own understanding of the science, climate change and the visual representations we have created in the exhibition. I return to hand them the flyer or add a new part of the story to explain that the movement could be caused by monkeys in the trees, and they stop to reflect and compare.’

5.2.2 The Visitors’ Perspective

The visitors who participated in the interviews at the exhibition locations in Rufford Park and Haldon Forest were asked to describe how they perceived the exhibition. These descriptions provided a detailed account of the visitors’ experience of the exhibition in terms of its’ composition, the trajectory through the exhibition and how each element came together as a complete artwork.

Many of the visitors often described their overall experience of the exhibition as a slow process, bringing together each individual element in order to understand the experience as a coherent whole:

“...when I first came in I had no idea, no clue, I didn’t read anything, I just walked in and I’m looking at the images and then I was given some idea, someone started talking to me about it and it went from there really. But first of all, it was the images and then slowly what it was all about started to come together, really.” (Participant 5)

Most participants said that they noticed one or both of the screens with the visualisations first, this occurred more frequently in CCANW where the screen could be seen through the windowed entrance. At Rufford Gallery visitors had to walk past a wall to get to the main exhibition and this layout appeared to impact on their trajectory. In this case there was also a

resource area as people entered the gallery and several participants described this area first as part of their experience of the exhibition, mistaking this as a core element.

The Climate Machine was predominantly considered as a secondary element of the exhibition, most visitors said they had looked at the visualisations first and sometimes didn't consider the machine until after they had looked at the hanging discs.

Not all of the visitors described the hanging paper discs when asked about their trajectory through the exhibition. Those that did appeared to notice them only after seeing the visualisations. As with the Climate Machine this element evolved over the period of time of the exhibition, so for some of the visitors who attended the preview or came at the beginning they would have not seen many paper discs being hung up and therefore would not have fully experienced this element of the exhibition.

12 out of the 28 participants in the study borrowed a phone to take out as part of the forest walk. Not all of the participants described this experience when they discussed their trajectory through the exhibition. Some participants described this element as completely separate to the exhibition, whereas others saw this as the main element of their experience of the artwork.

5.2.3 The Climate Scientist's Perspective

Buontempo describes his motivations for collaborating with the artists and how the iterative approach to collaborating with the artists created shared research agendas with his own work at the MET Office, UK:

"I think there were two (motivations), and they evolved quite dramatically in the course of the project. One was the possibility of working on the interaction with plants and the biosphere and this is something that is quite important in the (MET) office, there has been quite a lot of work on the carbon cycle many people are working on the die back of ah the Amazon rainforest and, and the how much carbon is fixed kind types of plants and so on, so there was an alignment between an active area of research in the Hadley centre and somehow your research agenda. There was also the interaction with the community... in the respect that in trying to understand the connection between the community and the forest was something interesting. And then, you know, quite rapidly it came out the idea of working on CO2 and the interaction with CO2 in the forest... I think was a very good idea, especially the part on the visualisation of CO2 the fact that you made the CO2 trend from Mauna Loa so evident in something people can relate to"

He also discussed his experience of visiting the exhibition, raising several questions around the metrics of the data used in terms of the live data capture from the forest as part of the forest walk:

“I wasn’t quite sure of the metrics that was used in the representation... I wasn’t quite sure if it was adding something to my experience of the forest, so it was interesting to have the (mobile phone) interface but I wasn’t quite sure, I mean for instance, having the sensor on the phone would have really helped because then it would have been at the same time. I see the image, I see a drop in temperature and everything becomes blue for instance. Or I see the sound and everything starts moving around, I don’t know what are the details of the algorithm but the fact that they were not really happening at the same time and same place, removes something from the experience”

Each of these perspectives will be investigated in more detail in the following thematic analysis.

5.3 Thematic Analysis

This section explores the emerging themes across all three perspectives, in order to dig deeper into the artists’ strategies, the resulting visitors engagement, and the scientists’ response. Finding ways to define artists’ strategies and audience engagement as a linear narrative can be very challenging, in response to this challenge the author has combined McCarthy and Wright’s *Threads of Experience* Framework (McCarthy & Wright 2004) and Pink’s sensory ethnography (Pink 2009) in response to emerging themes within the key literature discussed in the conclusion of Chapter 2. This process supports an analysis of the emerging themes across each perspective.

5.3.1 An Overview of the Themes

This thematic analysis brings to the fore the overarching theme of ‘provoking emotional response’ and then digs deeper into three additional sub-themes that emerged from the findings – embodying and embedding data, performativity and multiple interpretations and dialogue, as shown in the table below. Categorized within each of these three themes are additional sub-themes that dig into a deeper level of detail, although in reality many of these themes and the sub themes, described in the following analysis, cross over and are intertwined.

Table 5. *ACBT* Themes

Provoking an emotional response	
Embodying and embedding	<i>Sensory and aesthetic experiences of climate data</i>
Performativity	<i>Temporal structure including slowness and liveness</i>
Multiple interpretations and dialogue	<i>Comparing and juxtaposing different elements</i>

The top-level theme highlighted in Table 5 reflects how the artists adopted a distinctive perspective or ‘*voice*’ when engaging audiences with climate data by *provoking an emotional response*.

The following themes and sub-themes emerged from the coding of the data, reviewed in response to the related literature and refined through the thematic analysis involved how the artists:

- *Embedded data into an embodied experience*
- *Performed data* as a way of conveying the long timescales involved
- Juxtaposed different elements so as to enable *multiple interpretations and dialogue*

These themes also correspond with the core literature, across each of the disciplines of Contemporary Art, HCI and Climate Science, as already discussed in Chapter 2. This literature introduces the ways that artists embody data and temporality in their work with climate data (Aceti 2012; Aoki et al. 2009). The literature also highlights the importance of multiple interpretations (Sengers & Gaver 2006) and dialogue (DiSalvo et al. 2009a; McCarthy & Wright 2004; Kester 2004). The analysis below, investigates these themes further, across the perspectives of the artists, scientist and visitors.

5.3.2 Provoking an Emotional response

As discussed, the key way that the artists adopted a distinctive voice, flowing through all of the emerging themes, was to provoke an emotional response to data and themes within the artwork, this related to the core literature that introduced the concepts of human scale, emotional and intimate responses to data. This top level theme was particularly reflected across the questionnaires and comments books where visitors were asked to describe the

artwork in three words, examples of these responses include a variety of these responses from *'shocked and scary'* to *'peaceful, settled and relaxed'*, further descriptions stated:

"They are so beautiful – the images were moving and emotional"

These emotional and *'feeling'* words (based on Pink's categories described in the last section) were repeatedly used by visitors in the interviews and questionnaires, with the most common words being *'scary'*, *'emotional'*, *'alarmed'*, *'shocked'*, *'surprised'*, *'relaxed'*, *'sad'* and *"deeply personal experience"*.

The following sub-themes digs deeper into how these emotional responses were employed, perceived and experienced across each of the perspectives of the artists, visitors and climate scientist who took part in the study.

5.3.3 Embodied and Embedded Data

As seen in the core literature mapped in Chapter 2, Polli (Polli 2011) and Bureaud (Bureaud 2011) suggest that artists employ strategies to *'embody'* data as a physical experience, in order to contribute to public understanding of climate data. Malina (Malina 2009) calls for a *'new sensuality'* for engaging with climate science and Corby and Cunningham (Aceti 2012) propose that scientific data can provide a new material for artists to create intimate and sensory experiences for the public.

This is reflected in the findings from the study of *ACBT* that show how the artists embedded the data throughout the exhibition in order to build personal and emotive narratives around the data. This was particularly seen through the visitor responses to the circular hanging discs. Visitors were observed seeking out their birth year and built their own narratives around their memories of weather, climate and other events of the years represented by the discs. By creating these personalised, localized and everyday reflections in response to the global, slow, big datasets the public were able to embody the data, engaging on an individual, human scale.

This contrasts strongly with the more conventional disembodied projected visualisations within *ACBT* that encouraged a more rational, detached engagement, yet made connections between the remote spaces of a forest in the UK and a forest in Brazil. As shown by the visitor responses many people felt this more passive experience of the data still supported an immersive, reflective experience. Many of the visitors interviewed felt that they had somehow experienced *'another forest on the other side of the world'*, connecting space, place and time.

The artists describe in particular the way that the data was embedded in these visualisations, inspired by their own embodied sensory experiences of walking in forests in both the UK and

Brazil and the sensation of standing under the canopy of trees:

“What the data was and where it was from, you know often it had creative influences in the sense that you know we were thinking about things like pollen spores and forests and woods and trees and branches and leaves and all those sorts of things, and simple ways to visualise things like temperature.”(Shackford)

One of the participants in the forest walk in Brazil discusses how the mediation of the technology enhanced her relationship to the forest and specifically how the audio narrative of the experience guided her through a ‘physical’ experience of being in the forest:

“I thought it was really lovely the moment in which the narrator says that the rules here are different, this raised my expectations. It is interesting to think how little we pay attention to what is around us. I’m more attentive to people than to the natural environment, or even to the city. The environment which I entered through with the guidance of the narrator did not differ much from where I was, but I felt very strong separation. It was more mental than physical.” (Brazilian Participant, Tijuca Forest, Rio de Janeiro, Brazil).

Digging deeper into this theme reveals that the ways the artists embedded the data often enabled the visitors to engage in embodied sensory experiences through the use of metaphor and the distinctive aesthetics of the artwork.

Sensory Experience

ACBT highlighted the role of the technology in enabling the artists to engage with the data in these material and immersive forms. Shackford discusses how this became very interesting to the artists through the process of letting the data inform the aesthetics of artwork:

“looking at the unknown interactions between them... you can’t see it all and you can’t know that when two of those datas come together it’s going to have a particular effect.”(Shackford)

One visitor describes how the sensory experiences within the artwork enabled them to engage on an emotional level with the forest:

“... in this instance it wasn’t kind of feedback, so you weren’t showing people back their emotions, you were kinda maybe showing them something about the trees and then letting them, what kind of emotional or feeling response you generate from that, that’s probably closer to art, but it’s art that is using technology, and I think that, that the ambitions for it were artistic but the technology was the medium that you used for that”(Participant 20)

A woman from Nottinghamshire County Council who visited the exhibition said she felt the experience went *'beyond language and cultural references'* and somehow tapped into another type of sensory, visual or emotional language that would suit multiple learning needs.

It was in the design of the forest walk that the artists' commitment to a sensory aesthetic was perhaps most evident. The artists describe how the mobile phone experience was intended to enable visitors to re-enact and *'humanise'* their understanding of the data being captured by the sensors in the trees. For the artists, the mobile phone became a device that mediated a sensory experience of the forest in which visitors would directly embody and enact the sensor technology, moving through the environment and regularly sampling images, light levels, sound, temperature, humidity and air quality. The mobile phone experience was also designed to encourage visitors to comment on their feelings and emotional response to walking in the forest. The regular and enforced timing of taking photographs once every ten seconds (as described in the previous chapter) placed visitors in a position of being part of an automated embodied sensing system.

Some visitors described it as raising issues around the mediation of technology in a forest environment, whilst others discussed the experience as something that engaged them with seeing the forest in new ways, becoming immersed in a sensory and emotional experience:

"as I walked around, and I went through the recorded voice, the artists had recorded so I listened to all that... doing the little programs and little tasks which she set. Which I enjoyed and then they slowly like tuned me in really to the forest and and tuned me into the sort of the subtleties of it and the sounds and tuning out of the sort of hustle of Haldon and where we were in the art space with lots of people and walking away from that, so by the time I was finished that and then I was walking back to the gallery just on my own with the sounds and my own thoughts" (Participant 5)

This idea of *'tuning in'* to a sensory experience was repeated by several visitors who experienced the forest walk:

"I suppose it sort of heightened your senses to be aware of like little things around you, it definitely made you look up and look down and look around a bit more" (Participant 11)

One of the participants in Brazil who took the phone out into Tijuca Forest without the support of the whole exhibition also talked about an experience of *'tuning into'* the forest:

"I realized that my relationship with the forest had changed. I started to notice elements that I do not normally perceive, such as moisture and cold. Above all, the narrative inserted me into a poetic framework or Aura even. The relationship with the environment took place under the influence of this poetry, which encouraged me to open my eyes more, be more

susceptible to the details around me.” (Brazilian Participant, Tijuca Forest, Rio de Janeiro, Brazil)

Visitors were also encouraged to embody the data during the forest walk through a sensory experience that the artists called the ‘*human sensor activity*’ (sensing light, sound, temperature, humidity and air quality on a scale of 1 - 10):

“I could hear the sounds more and I could see the some of the forest like really clearly, and really it was almost like a I walked into the forest just kind of a bit shut off really, and in 2D and I walked back in 3D, it was like Avatar. I was walking back, it was quite bonkers, I could see some of the leaves, I just really noticed how amazing the forest was... I had shamefully been tuned out.” (Participant 5)

Aesthetic Experience

Many visitors discussed the role of the visual aesthetics in enabling them to make sense of what they were seeing, in order to reach a point where sense making could occur:

“Well firstly I just thought it was something like a pattern someone created on a camera, but when you look on the bottom right hand corner it is a picture of trees, looking up at trees... I didn’t know that until you look closely, sort of blobs in the corner and then you look and its almost like when someone hasn’t got their glasses on and everything’s blurred and you realise that your actually looking at trees in a different form” (Participant 14a)

Some participants appeared to respond simply to what they described as the ‘*beauty*’ of the visualisation, whether or not they had understood its relationship to the data, yet one participant suggests that through this aesthetic response a deeper engagement with the data was made possible:

“(the visualisations) are kind of printed in your memory because they’re images and they are very graphic” (Participant 13)

The connection between the sensory and visual aesthetics, and slow and subtle nature of the artwork was also picked up by several of the visitors:

“it has the two screens that mirror each other with the different projected information, animations, and then within that there’s like the complimentary machine, I think actually that, that the elements of the wood are really key, like there’s a visual kind of rhyme, it also reminds you that you are within a forest. So like the circumference of the machine is made of wood and then the frames have quite definite wooden structures and also the floor is made, and you can’t its not like a white cube gallery in that you forget about the outside, you are really aware of that you within a forest, when you’re in here” (Participant 7)

The temporal and reflective process of sense making described by these visitors was reflected in how some visitors related to the compositional experience of the visualisations and their trajectory through the exhibition (Benford et al.). Visitors describe how the combination of supplementary information including the statistical data, dialogue with the artists and/or gallery staff, and signage provided a type of key - or set of clues - for how the data affected the abstract and dynamic projected images:

“it worked quite well having the inset of what the image is in reality, so that you could see that it was the tree and referred to that and also the other side having the stats as well brought in the statistical sort of climate change and the fact that its data that you are looking at that makes is part of the image I think.” (Participant 2b)

Interestingly, some of the visitors indicate that the details of the data (understanding the numerical data from the live sensors in the trees) appears less important than people’s overall ability to engage meaningfully with the artwork:

“I found them quite beautiful, I didn’t know, I didn't know what, what they represented in terms of you look for meaning in shape and colour and I couldn't work that out without some external explanation, but even though, if I hadn't of had that I would have found them quite beautiful to look at” (Participant 1)

Some quite extra ordinary responses were also recorded, revealing how visitors engaged with the aesthetics of the experience, and how these often tap into the visitor’s imagination in unexpected ways. One visitor who went on the forest walk said she had pointed the mobile phone at toadstools and it looked like *‘it was taking the colours’*. Another visitor who was observed using the mobile experience found a beehive and also said that the imagery on the screen somehow *‘captured the essence of the movement and colour of the bees’*.

Some of the visitors responses suggest that the abstract nature of the visual aesthetics within the artwork inform a variety of unexpected and imaginative responses, such as:

“...it reminded me of that Swartzaneger film – Predator – the heat sensors looking for monsters in the jungle” (Comments observed by gallery staff at Rufford Gallery)

Several of the visitors who filled out questionnaires also noted that the visual and sensory aesthetics enable the forest to some how *‘come alive’*:

“You don’t think of a forest as a living (sound) breathing entity – seeing the exhibition reaffirmed this”

Visitors also described the Climate Machine mainly in terms of the *'aesthetic form'* of the machine reflecting on the craft and tangibility of the machine, this aesthetic response also appeared to lead them to become intrigued by the way it presented the data and to try and make sense of it:

"...you don't see the data other than wires, but then you see its quite a low fi kind of kit, set up, which is quite nice actually, 'cos I think sometimes if things are a bit too slick they tend to alienate people but its got a nice handmade hand assembled quality to it, and you know it rotates and scorches a circular pattern in the circular paper" (Participant 7)

Metaphor

Key to these sensory and aesthetic experiences were several metaphors that ran throughout the artwork. The artists describe how The Climate Machine was intended to make metaphorical connections between wood, burning, trees, paper and carbon dioxide, revealing layers of meaning embedded in the data and demanding questions of the viewer that pure statistics might not do on their own. They drew attention to the visual metaphor of burning the circular graphs as being *'tree rings'*:

"The paper discs created a tangible experience of data as ever increasing circles. The time based nature of how the machine scorched the circular graphs onto paper discs and the artists hung the paper discs, reflected the slow nature of change in the dataset - the recorded historical changes in CO2. The visual metaphor of the circular graphs as tree rings and the full set of hanging paper discs as a sliced tree trunk was a deliberate attempt to find personal and aesthetic meaning in the data." (Jacobs and Selby, from the *Material Conditions Publication*) (Jacobs et al. 2011)

Many visitors responded to this experience of watching the machine burn the CO2 data into paper and looking at the hanging heat drawings by expressing an emotional response to the metaphors:

"I just found the whole hanging circles of paper really visually exciting... but then I like circles and I like the orderliness of it... I think I like to see that in other things, so, I do like those big sheets, and paper is a very tactile medium and you just want to touch it as well because its so circular its very measured and in order, and I enjoyed researching, seeing into the centre of the circles you know, looking at each one differently, as I learnt a bit more about it." (Participant 8)

The artists' describe how the paper hanging from the ceiling also emphasises the metaphor of the tree rings:

"We then hang the sheet from metal cords from the ceiling of the gallery, slowly filling the

room with circular sheets of paper, with ever increasing heat drawn circles, records of CO2 changes in our planet's atmosphere. They look like tree rings and we see it as burning the rings back into a tree that has been turned into paper, as a performance of nature.”(Selby)

They referred to the general circular motif that was repeated throughout the artwork as being an organic shape linking to nature and natural forms (Jacobs et al. 2011; Tuan 1977) that was repeated throughout the artwork. The visualisations on both the projected screens and on the phone screen is also circular in shape and slowly turning.

They also discuss the importance of creating metaphors that can be experienced viscerally:

“Physicality is very important to this in a number of ways. Burning the data into paper takes something completely intangible and gives it a material form. The burning of the paper is a very physical process, much more so than if we just used a pen or printer to draw - the extent of the burn varies depending on the size of the circle, it produces heat and you can smell it. Although we're using recycled paper, the use of a destructive process on a material that is linked to deforestation is also very confrontational and was perceived as quite provocative to some of the audience.” (Jacobs and Selby, from the Material Conditions Publication) (Jacobs et al. 2011)

Visitors also referred back to these visual and conceptual metaphors suggesting that they had a level of universality or ability to connect with a wide variety of people. Visitor descriptions of the Climate Machine also often expressed similar metaphors, using terms such as:

“the tree ringer”, “like a seismograph of trees” and “it's like a giant etch-a- sketch of trees.”

The climate scientist also expressed excitement about how the artists' conceptualizations could engage the non-scientific public with climate data in metaphorical ways:

“The fact that you made the CO2 trend from Mauna Loa so evident in something people can relate to, I think was really exciting. I mean some of the comment of the people who came to the Haldon Hill (forest) exhibition about the fact that you know the dataset suddenly made sense to them, you know really, interesting to hear, because for me an x, y plot or some numbers are as exciting as your very nice plot but I thought totally acknowledge that for other people it can be totally different.”(Buontempo)

Another visitor refers to the metaphors and use of wood and circles as a ‘visual kind of rhyme’:

“it has the two screens that mirror each other with the different projected information, animations, and then within that there's like the complimentary machine, I think actually

that, that the elements of the wood are really key, like there's a visual kind of rhyme, it also reminds you that you are within a forest. So like the circumference of the machine is made of wood and then the frames have quite definite wooden structures and also the floor is made, and you can't its not like a white cube gallery in that you forget about the outside, you are really aware of that you within a forest, when you're in here" (Participant 7)

Selby describes how the artists created these metaphors to reflect an interpretation of the Mauna Loa data:

"You've got this data set that goes back like 60 years or whatever and then physicalising in a way that is meaningful I think is really interesting. So you know the stuff with the paper and kind of accumulation and like the way it marks the paper, the damage of it and then the kind of record of all these bits of paper, this was recorded as being both memorable and having conceptual and aesthetic impact on the participants. This creates tangible and sensory metaphor (it smelt of burning) for climate change and the increase in CO₂ in the earth's atmosphere that appeared to engage the visitors" (Selby, 2011)

By giving the data material form in terms of the burnt circular discs and the metaphors of burning through the Climate Machine and the tree rings, and by requiring visitors to take on the role of a sensor when walking through the forest, the artists were able to create deeply embodied sensory experiences of the data. As previously seen in the literature, McCarthy and Wright have identified the 'sensory' as being one of the four key threads of user experience (McCarthy & Wright 2004), a view that was clearly reflected in the artists' conception of ACBT and the visitors responses.

5.3.4 Performativity

As shown by the literature emerging around public engagement with climate data described in Chapter 2, one of the biggest challenges for communicating the impact of climate change is how to engage the public with the often-long timescales that are involved. Buontempo describes this challenge:

"Understanding how we behave or how we cope with slow processes is a very interesting question because it is the centre of the problem as well, so how should we shut down our emotional fear, response and let intervene another process that is based on something else, or develop an emotional response to something that is completely on a different time scale and it is interesting because strangely enough this is happening also on the, how do we deal with risk or how have we dealt with risk over the course of our existence as a species." (Buontempo)

The artists' response to this was to give the work a distinctive temporal structure, one that

they defined as a *'performance of data'*, combining *slowness* with *liveness* in an attempt to encourage visitors to relate their immediate experience of the forests represented in the visualisations to the Mauna Loa data series embedded in the Climate Machine. The artists discussed how this temporal structure informed their thinking specifically in terms of the visualisations:

"The visualisations provide a conversation not only metaphorically between the trees and locations, connected by the two sets of mobile sensors but also across different temporal zones, enabling the public to experience forest environments as an evolving, moving landscape that changes over time" (Jacobs et al. 2011)

Shackford also highlighted how the *'live'* nature of the data being captured in the forest environment in this way provided challenges to the technical development and the presentation of the interfaces:

"One of the most difficult things was to lose sight of what the code did. So you sometimes go in and it's really hard to connect what you see... There's a lot of layers to it and, and I do remember like little things creeping in... that might be a failing of mine but in other ways I think, it's just the nature of working in a kind of artistic iterative way... it's not like creating an application where you try and keep everything under control, what you do is try and let the control go, which is very dangerous in programming." (Shackford)

The artists discuss how the constraints of technology used to capture the live climate data also enabled them to create a distinct temporal structure within the artwork:

"The act of capturing data across Brazil and the UK gives a sense of the situated environmental conditions around those trees, within the temporal constraints set by the technology. These constraints add to the sense of distance and liveness, at times when they constrain the work (such as losing connectivity) the perception of liveness and distance for the spectators is increased." (Jacobs et al. 2011)

The artists discuss the significance of the temporal structure in the ways that they *'performed'* hanging the paper discs in the gallery:

"The drawings produced by the Climate Machine physically fill up the space as time passes, you wouldn't get this sense of accumulation through a scientific graph, a screen or projected image." (Jacobs et al. 2011)

Many visitors were observed sitting on benches placed in the gallery, watching the live visualisations and the machine whilst engaging in discussions about CO₂, deforestation and climate change. One stayed as long as eighty minutes. Several visitors indicated that the slow movement of The Climate Machine and slow changes over time of the dynamic

visualisations opened up these opportunities for reflection noting that the data represents changes in global CO₂ over the past, present and future:

“... it allows you to condense time and see what’s happening in the real world within a shorter space, that you could actually see what was, the change in CO₂ across years or either past or future.” (Participant 20)

Slowness

Key to the temporal structure of *ACBT* is the painstaking nature of the slow performance of the climate machine burning the data into paper, the circular discs filling the gallery over the duration of the exhibition and the slow rotation of the visualisations, changing every minute, directing attention to the temporal character of the data. This work demands an extended engagement from the viewer, which was seen as important to engaging their emotions by both the artists and the visitors themselves. Hallnas et al. (Hallnas et al. 2001) suggest that indeed one of the opportunities that these forms of slow technology can provide is the ability to enable experiences of reflection.

The artwork was intended to evolve over time to reflect the incremental nature of change in the datasets and engage visitors in a slow reflection. This slowness was most striking in the overall performance of burning the data into the discs. The forest walk also had an unusual temporal rhythm with photographs being captured every ten seconds.

As already discussed visitors were also observed searching through the hanging circular sheets for their birth year in order to establish a personal sense of the scale of climate change, in relation to their own lifespan. Some also related the slow movement of the visualisations back to their personal experiences of nature:

“... kind of slow abstract compositions that are, they’re kind of slowly spiraling or slowly turning, they’re made up of spokes of different colours ... what I was really intrigued by is the fact that they look a bit like spores or kind of natural forms not in a kind of lens based realistic way but they refer to more forms that you would find in nature.” (Participant 7)

One visitor suggests that the movement of the machine enabled this to occur:

“...because movement is continuous, there is a time magnifying sensation” (Questionnaire response, CCANW)

However, this unusual temporal structure also raised significant challenges for the artists. First, slowness demands an unusually high level of commitment from visitors; several minutes are needed to see changes in the projected visualisations, tens of minutes to see a cycle of operation of *The Climate Machine*, and the best part of an hour to engage in the

forest walk. Consequently, it was felt to be important that there were several different elements to the work, each requiring a different commitment of time from visitors. This flexible structure enabled visitors to engage at their own pace according to available time.

Many visitors discussed the effects of the slowness of the aesthetic experience, suggesting that the temporal *'performance of data'* encourages a deep level of engagement and occasionally strong emotional responses.

"I thought a really good visual way to see the changes over time... actually a bit shocking, it was really surprising. There's that small circle and then to where we are now, it's all a bit scary isn't it?" (Participant 10a)

It was also noted the temporal representations of the data also appeared to create an experience of climate change that wasn't reliant on encouraging people to feel fearful or guilty:

"I felt that this was more measured and let me you know derive other things from it not just to be frightened and put off by it but to actually to think a bit in a different kind of way" (Participant 2c)

Some visitors discussed the temporal experience of the automated images being captured as they walked. They highlighted how this enabled a certain amount of control for positioning the phone as well as indicating the pace of the photographic journey. Many visitors who took part in the mobile phone experience responded to this constraint with interest:

"I guess it took me a while to realise that the photos were being taken sort of every 10 secs I got quite a few of my feet on there and things like that but I think once I got the hang of that it was quite nice, it wasn't take a photo when you feel like it because it would be more posed and stuff it was more kind of, it was more consistent I suppose." (Participant 16)

It also reflected the timing of the camera connected to the sensors in the trees (which was automated to take photographs every minute) that controlled the visualisation in the gallery. Some of the visitor responses revealed an interesting tension between the improvised nature of the photographs taken by the phone and handing over of control to the machine. They talked about the imagery happening *'to them'*, often with an element of surprise:

"I suppose it was quite interesting holding this device in your hand because it was always changing so like if you have your finger in front of the camera and suddenly it would go bright pink or something but then when you kind of put it up it would change colours so it was just amazing, every time you looked at it was always changing" (Participant 1)

These responses reveal that often the slow conceptualisations of climate data enabled the

artists to go beyond visualising data, to a more human scale perspective that interpreted complex data sets covering broadly large periods of time.

Liveness

In contrast to slowness, the artists also emphasized how it was vital that the work should make a live connection between the two remote forests, in order to support a localized and viscerally real experience. Many visitors appreciated this aspect of the work:

“I think I will go away today with that feeling that I haven’t just been to Haldon today, I’ve experienced another forest, a very long way away. You know and the great similarities as well as the differences, and I am going away thinking why? I feel like it’s brought up a lot of questions, all this.” (Participant 4)

The live component of the exhibition revealed an interesting dialogue around how artists balance this desire for *suspension of disbelief* against strict accuracy of the scientific data in order to maintain the live experience. A ‘*suspension of disbelief*’ (Jacobs et al. 2011; Pfister 1991) in the live data was seen as a vital part of the audience’s engagement, in order to create a co-located temporal experience of the ‘*present*’ for audiences in both forests in the UK and Brazil as a seamless experience:

“If it hadn’t been live data then I think it would have been missing quite a lot”
(Questionnaire response, Rufford Gallery and Country Park)

The artists often had to improvise with the data and create a layer of ‘*smoke and mirrors*’, in order to produce this consistent sense of a live experience. For the artists these issues around the liveness of the data posed wider questions of how a performer improvises in a live public context around the types of challenges and seams that are inherent in the experimental sensor technology that underpins *ACBT*. The artists’ experience of orchestrating the sensors in Brazil and UK and the challenges of maintaining the sensors described in the previous chapter - including the time differences between the locations – raises questions of how technology has the potential to both support and disrupt audience engagement, when embedded in an artwork such as *ACBT*.

The artists discuss in detail how audience perception and the concept of ‘*suspension of disbelief*’ in performance are vital strategies that the artists employed to enable audiences to engage with the live data in the visualisations. The artists were able to encourage the audiences perception of a live experience by implementing various forms of ‘*smoke and mirrors*’ by improvising around the live presentation of the data, particularly in the face of the challenges posed by the technology, that can stop the live from being truly live (e.g. through the issues of disconnection described in the previous chapter).

The artists talked about times when they needed to make decisions over whether to prioritize the public experience of the artwork or strict accuracy of the data. At these times, the artists decided to replay prerecorded data as if it were live in order to maintain the experience of liveness, although at the expense of strict accuracy. The climate change scientist reflected on this tension and in doing so questioned some of the artists' decisions in response to these challenges:

"From my personal view its absolutely fundamental the data is live, it would actually alter my perception very significantly because while I do understand the reasons... it can be some sort of augmented or distorted reality, you take reality, you change it according to a metric, but it's an artistic metric somehow, but its related to reality... if you break that then what's the point." (Buontempo)

The artists recognized these tension between maintaining liveness versus accuracy, but on balance felt that, in this case, the occasional use of recorded data was sufficiently *'real'* and their presentation of it sufficiently ambiguous, to justify a degree of artistic license, certainly when the alternative was not to show any data at all. In short, it was felt appropriate to emotionally engage new visitors rather than adhering to the data being strictly live (in the sense of *'right now'*).

By prioritizing the *experience of liveness* as opposed to an *authentic live experience* visitors were able to engage in an immediate and personal experience, enabling a sense of presence in both forests whilst standing in the gallery or in the forest with the phone. The artists reported that they were required to improvise continuously throughout the exhibition in order to create these experience of liveness; they made choices about how they expressed these issues to the audience, whether to reveal the tensions between engagement in the live experience and maintaining the authenticity of the data or to create a *'smoke and mirrors'* effect to ensure the public's *'suspension of disbelief'* in the artwork (Pfister 1991; Jacobs et al. 2012).

Authenticity

Following on from the issues of working with live data, this study reveals that working with any scientific data can be challenging for artists. As seen, the artists often had to walk a line between the need to create an emotionally compelling experience for visitors and scientific authenticity. Buontempo describes this as a tension between the values of provoking an immediate *'gut'* reaction versus a desire for rational consideration of complex data:

"...it's a problem that is beyond human scale we do not perceive it, so you reach it only through rational thinking, you see the data you make your judgment and then you plan your

response based on your thinking” and “... feeling doesn't quite help, because it's not, you shouldn't base your response to your gut feeling.” (Buontempo)

This tension between accuracy and experience also extended to the choice of data to be used. At one point during development Buontempo had suggested working with a richer multi-dimensional dataset that was more representative of the way climate scientists interpret climate data:

“I would say from a scientific point of view it was quite an easy dataset, it was a monodimensional time series while in general climate data tend to be fairly complex, so I think it was central but out of many possible datasets we decided to go for relatively simple one and maybe because of that it was possible to build a nice interface.” (Buontempo)

One of the visitors who was herself an artist working with environmental data articulated some of these issues for artists working with scientific data:

“Well it's difficult because I'm aware that this, you know the scope of visualising data is quite, it's an odd space because in a way it's like all statistics... you can visualise it in anyway whatsoever so it's always got a slant on it, like how you choose to show it, so I would say there's a definite concern with environmental issues, the fact that what is of key importance here is the kind of growth of CO2 in the atmosphere and that the presentation of that in itself is quite alarming and also I guess the communication between forests that's just about nurturing the data... obviously there's a political edge to it cos everything does have but it's not focused on that, it's just focused on the sort of commonality between forests here and the forests in Brazil and the fact that their kind of eco systems are generative natural systems”(Participant 7)

Interestingly, other visitors reflected a similar response to the experience highlighting the sense that they often feel fearful of pure science and statistics, proposing that information in the public domain about climate change is often felt to be ‘inaccessible’:

“I think, you were trying to make visual some scientific data that's usually inaccessible to normal people (laugh). Which I think you've been really successful actually, you know because most people look at figures, I do, I look at figures and graphs and things and I just have a shut down... I do go on the visual impact first of all and start to investigate any ideas further from that and it is intriguing to see the imagery, get in to the ideas through the imagery.”(Participant 8)

In response another visitor explains how they engaged with the data differently:

“...data on a page or in an article only gets to so much of the population, if you can express that data in a way that is easily accessible, has a visual representation that sticks in your mind and you can sometimes interact with you’re going to get a lot bigger response of when you took part you just focused in on it and it helps you kind of like realise stuff even though you may have seen it you may not have acknowledged that you’ve seen it”(Participant 11c)

This suggests that many of the visitors had pre-existing feelings of disconnection and separateness from science and scientists, particularly in reference to climate change that was counteracted by the artists’ decision to provoke emotional engagement as opposed to focusing on the veracity and authenticity of the data:

“It’s good to see some actual data you know because you get such mixed messages in the media and it’s maybe good to actually see something that someone’s done independently from that”(Participant 11a)

One of the visitors suggests that they felt artists had a role to play in ‘*translating science*’:

“I think that the artist were, were kind of playing around with the idea of using very abstract things as a kind of tool so using very abstract things like gases, things that can’t see and trying to a use then as a tool... using forms that people could grasp more easily, so in a way it’s a kind of translation of one thing to another. Translating science into art... there is an environmental point, there is a message... how the climate data has changed over the years, over the past 20 years, for the worst. I certainly don’t feel like that the message was the overriding was rammed down my throat at all”(Participant 12)

The artists attempted to play off these tensions between the veracity of the scientific data and the importance of the audience being able to trust the source of the data they were seeing, against the desire for personal, emotional experiences that made sense on a human scale. It was important for the artists that the audience experience enabled personal meaning making on a ‘*human scale*’ that they could understand within their own temporal experiences and perspectives.

Buontempo suggests that this didn’t always work and suggested his experience of taking part in the forest walk was less successful in terms of suspending disbelief and the live connection between the data and his experience of the forest:

“I actually I was easily distracted by other things and I didn’t feel that sort of emotional link with the forest I would have had otherwise... I ended up having some other experiences that were not in, you know maybe I was not in the right place for doing the experience. But the idea I think was quite powerful. So probably having a tighter connection between what was

surrounding you in that specific moment and the comment, for instance a dynamic comment, so according to the information that the mobile phone is receiving, temperature, humidity.”

As shown through the discussions of the way the artists represented the live data, it was also important that adhering to veridical interpretations of the data did not break the suspension of disbelief in the overall experience of the artwork. It was the artist's intention that the visualisations of the live data were meaningful in respect to the visitor's experiences of the real forest (the current light, temperature, humidity, sound levels, air quality and the comparisons of CO₂ levels). This was reflected in the visitors' response:

“I think climate change is an interpretation of what you are seeing and not per se what you can see and I think if the machine, the discs, they demonstrate the growth of carbon dioxide then yes I would suggest erm, climate change. But I don't think necessarily looking at these pictures suggest that, they are what they are in their own right” (Participant 1)

This was also suggested by some of the participant's descriptions of the climate machine and the heat drawings:

“I saw the rings, so its got, those rings tell us that there is something going on cos, they're getting bigger aren't they (laughter) and bigger” (Participant 12a)

As these comments show many of the participants understood the fundamental scientific concept without necessarily focusing on the details of the statistical data. This view was supported by one of the visitors who were also another a climate scientist working at the Met Office UK:

“Thank you for doing this. I work with this data and it is really scary. We need more people explaining what is happening in a way that people understand” (Observed visitor comment at CCANW)

Throughout the exhibition there was an on going issue with the veracity and authenticity of the live carbon dioxide data, as part of the time the carbon dioxide monitor wasn't working properly and due to issues with Brazilian customs the replacement carbon dioxide monitor in Brazil never arrived. The artists made the decision at the time to replay previously recorded CO₂ data from the forests in order to not break the sense of liveness in the work. This created tensions for the artists and the inconsistency of the data was recognised by some of the scientific audience who questioned its authenticity, were reflected by comments from visitors:

“I don't think that the readings on the presentation are a true representation. Maybe it hasn't recorded properly” (Questionnaire response, Rufford Country Park)

“I would have thought that the CO2 emissions would have been higher in this forest and not in Brazil” (Questionnaire response, Rufford Country Park)

These responses suggest that, through the use of metaphors relating to commonly held concepts of time; visitors were better able to engage in a temporal experience of climate change and the forests. Similarly, allowing space for people to situate their own lifespan within the depicted timescales and as a live experience enabled them to engage in their own personal and emotional conceptualisations of the data. This combined with readily recognisable slow and crafted tangible and mechanical elements, allowed visitors to get a sense of the data’s meaning and significance.

5.3.5 Multiple Interpretations

A notable feature of *ACBT* is its complexity, apparent in the ways that the artists assembled a variety of contrasting elements into an overall experience. This juxtaposition of often contrasting elements was a key part of the artists’ strategy to provoke interpretation and dialogue. The visitors also reveal how they specifically made sense of the conceptualisations of the data within each element of the artwork, but also how this was supported by the overall composition of the work and possibilities for dialogue with the artists present at the exhibition.

Moreover, the gaps between the elements provided opportunities for dialogue between visitors, with the artists when present to perform the work, or with gallery assistants fulfilling one of the core intentions of the work – to facilitate conversation:

“When I first looked at them I could see that they represented something of the trees and I think you’d have to stand there and see the data and maybe you’d sort of get an idea of what’s going on but some explanation was really good, ‘cos that really brought it to life.”(Participant 2c)

The artists explain how the Climate Machine also creates a dialogue between the data and the space and time experienced by the visitors.

“It enables the data to become tangible, by drawing the data in real time onto the paper as circular graphs, representing tree rings... ever increasing circles, as the carbon dioxide in the atmosphere has increased. This recorded data is juxtaposed against the live, situated data coming from the trees in both forests, located in the here and now and that we collect from a tree that the audience can actually stand under and perceive for themselves” (Jacobs et al. 2011)

As already highlighted the artists’ motivations for the exhibition were to conceptualise the data in ways that enable the audience to have emotional and tangible responses to the

changes in the forest environment and climate. The artists' believe these intentions are at the core of what makes the experience of the exhibition an 'artwork', different from an empirical scientific interpretation, and equally different from an information based graphical visualisation of the same data. This is supported by Buontempo's description of what he sees as the benefit of working with artists.

"...why to work with artists? ahm the first one... is that they are not scientists so they provide a completely different take on reality and on, I mean the artistic sensitivity if you want is quite potentially complimentary to the scientific one so, im quite intrigued in the, interacting with artists to, to understand what's important for them and sort of questions they're asking" (Buontempo)

He also discusses how the comparison between the live data within the visualisations and the historical data within the climate machine was interesting to him, suggesting that it wasn't something he would have previously considered from a scientific perspective:

"...the comparison I thought as you say was very emotional, at the same time I would not really have tried to put the two on the same sort of axis so these are the historical observation and these are the observation that you see here, which have huge fluctuation because they are ... CO2 but if you do a long term average you realise that actually these value is not too dissimilar to the one you get from Mauna Loa" (Buontempo)

Dialogue

As part of the artists' strategies for creating multiple interpretations of data, the artwork combined opportunities for reflection, dialogue and conversation through the main exhibition, contrasting with quiet isolated or shared moments of interaction and reflection encouraged through the mobile phone experience:

"The dialogue that is created by these tangible interpretations of the two datasets intervenes with our preconceived ideas of what data is, how it should be represented, and how to understand data in meaningful ways, as metaphors, stories and aesthetic experience." (Jacobs et al. 2011)

The dialogic nature (Kester 2004) of the artwork was inherent in the name of the work '*Conversation Between Trees*'. The artists state that they did not see the work as just a metaphorical conversation between different trees and forest locations (which refers to the use of a mobile phone to communicate the data that is being captured in these locations, as if they were having a phone conversation). They state that it also works as a:

'a playful conversation about forest environments, building public understanding of climate science.' (Active Ingredient 2011)

This dialogue took place:

- Between the artists and visitors
- Between the visitors
- The visitors describing the exhibition to each other and other people who hadn't visited the exhibition

Visitors also describe the role of the dialogue with the artists as important to how they made sense of the exhibition, how they interpreted the data within each component of the exhibition and as a way to initiate further thinking and sense making around forests and climate change.

Many of the visitors discuss how they also engaged in dialogue with each other. Visitors were observed sitting and discussing with friends or other visitors what the data might mean. An older couple was observed watching the live visualisations of the forests change and the machine burning whilst having a discussion about CO₂ and one visitor was observed staying at the exhibition for 80 minutes

This ongoing dialogue and reflection was revealed through many observations of the visitors and how they involved other visitors within the exhibition.

One of the visitors who were interviewed (Participant 8), an art teacher, returned several weeks later to show one of her A Level students the mobile experience, saying it was '*inspirational*'. One couple rang their daughter whilst at the exhibition at CCANW and told her to come and see it. She arrived several hours later looked around and then when out to the forest to find her husband and friends who were on a walk in the forest, they then all stayed for some time, discussing the work with the artists and each other.

An interesting observation by one of the gallery staff at Rufford Country Park showed that not only did the exhibition encourage conversations and dialogue but also processes of direct and indirect learning as part of this dialogic engagement.

"A group of young boys pretended to do a presentation of the data in front of their parents, saying what they had found out, pointing at the projection while the parents sat on the bench – really good!" (Gallery Staff observation left in the comments book, Rufford Country Park)

In this instance the boys were enacting their own '*performance of the data*', leading to a '*re-interpretation*' of the data, that also became an embodied experience for the young boys.

One of the participants who was interviewed several days after their visit to the exhibition had attempted to describe the exhibition to other people after their visit:

“I did describe it to someone else the other day actually, erm and I described the images as quite sort of bit like bonkers lava lamps but even cooler than that and more bonkers than that quite beautiful and I said that they were lovely to look at or they’d have been amazing as big still images” (Participant 5)

Another participant reflected on how this process of questioning and dialogue might impact on the way they might think beyond the exhibition and provide opportunities to reflect on the conceptualisations of the environmental data:

“I don't know if I necessarily feel like I've come away with new knowledge but I do think it's a good way of sort of encouraging people to think about climate change locally and things like that in different ways so, what that means for different forests around the world and things like that” (Participant 16)

Many of the participants suggested that these opportunities for dialogue, re-interpretation and reflection were important to their engagement with the environmental data.

These types of reflexive, visual and sensory interactions arose from the artists’ intentions to frame a dialogue without being prescriptive or defining a specific political stance. Visitors’ responses also reflected how by engaging with the scientific data merged with slow, reflective conceptualisations they were able to enter into an open dialogue about the data.

“I knew that you wanted to show a representation of the trees through the visualisation and the machine, how kind of again a visualisation of change that you could show people in that space but I think, I felt very much that I was allowed to decide what I wanted. I didn't feel like I was being, none of the information around was very much telling me to think anything necessarily” (Participant 19)

Shared Vs Single Experience

Another strategy that enabled multiple interpretations involved the several ways that the visitors could participate in the exhibition, which varied across the different elements:

- The main exhibition - visitors were encouraged to participate in a dialogue with the artists follow a trajectory through the space and piece together the clues embedded in the artefacts and visualisations
- The forest walk - exploring outside in the forest where visitors were able to interact directly with and embody the sensing technology

Several participants who took part in the forest walk raised questions about taking part in an experience in a ‘*natural environment*’ such as a forest that was mediated by technology,

particularly in terms of participants who participated as a group either with several phones or by sharing a phone:

“I didn't use it but it's interesting to be with people that I've been, it's like walking around a stately home with an audio guide in someone's ears and cos it does disconnect them from you and disconnects them slightly from the landscape as well, so we had to warn you when bikes were coming and you know D said at one stage, oh there's no wildlife and I said well actually you can hear, the blue tits and coal tits calling quite close by and so, that's the technology separates you and so you can have an either or experience, it's difficult to combine the two” (Participant 2a)

One visitor refused to try the mobile experience because she found the idea of using a phone in the forest ‘too uncomfortable’. Many visitors who went on the forest walk felt that exploring the forest as a single user experience with one phone would work better, in order to be engaged in slow reflective interactions appropriate to the situated experience of being in a forest:

“I think that if I had gone by myself then I think it would have been a more pleasurable experience... it would have allowed me to kind of engage in the environment a bit more but I think because we were together, P was reading the map and he kept talking to me whilst I was trying to listen to the instructions.” (Participant 19a)

In contrast, a family group found that taking the phones out supported direct and indirect learning opportunities, suggesting that possibly the interaction was more successful within a cross-generational group:

“...we brought the kids along so, that I think being able to show them what's happening and then being able to talk them through it is a really good way of engaging them and get to them to kind of understand what it means” (Participant 9)

Bridging Hybrid Space

The artists reflected on the significance of the locations bridging the two forest environments:

“This begins to reveal the contextual importance of location and environment on environmental sensing technology. Understanding how technology can be used within ‘natural environments’ requires us to explore what and where these ‘spaces’ are, how we situate ourselves as humans within these spaces and how we capture the impact of these spaces on the tools that we use, the data we collect and our interpretation of this data.”

(Jacobs et al. 2011)

The artists' motivations to bridge the spatial and temporal experience of the forests, as hybrid spaces represented by the visualisations and the forest walk also contributed to the multiple interpretations of the experience. One visitor reflected on their excitement in considering the role of the artists in bringing about this activity:

"...the fact that it is a collective and you've got an artist in the (sigh) middle of nowhere somewhere else, that's linked to something here and the fact that it shows the world is actually quite small these days and you know but we've got this big issue we need to deal with" (Participant 2b)

Visitors appeared particularly interested in comparisons between the locations as a way of experiencing multiple yet meaningful connections between the forests.

"I suppose if you take both images there are many similarities between both images in terms of colour and shape and so it demonstrates a connection, erm, that will be the main thing I would take away. I mean the photographs themselves also have similarities, they're forests so I suppose I shouldn't be a surprise but it is a surprise because I haven't been to Brazil" (Participant 1)

Many showed surprise at how the imagery revealed a sense of a shared experience across these remote locations:

"Simultaneously I am, I mean I am experiencing what's going on at the same time in two places, two forests if you like, one side of the world to the other and er how similar it is, and you know the strange differences, fi you like, and it's just making me wanna ask a lot of questions, really" (Participant 4)

Other participants reflected on how the technology enabled them to make these emotional and sensory connections to both forests. Suggesting that the experience engaged visitors on multiple local and global levels with the data, creating a personalised, human scale experience of climate change:

"...it's nice to see an instant comparison of, sort of here and the other side of the world side by side, because that does it brings home the fact that there is another side of the world and you can actually stand here and sort of look at a tiny little bit of it. A lot of the technology you've got the communications side is worldwide, it is fairly instant so you do kinda get used to that but things on a smaller scale like that is its sort of more personal I guess in a way, its obviously, I suppose that gets back to the artist, this persons got a snapshot for himself, it is a quite a small thing to compare to the bigger picture being a finally balanced machine that we all work" (Participant 18)

Some of the visitors related the experience to how global climate change is represented in the media as a depersonalized and remote issue. Suggesting that the ways the artists presented the live data from both forests allowed a greater level of personal connection to the data to occur:

“...like I said in the beginning I didn’t know about the Atlantic forest... so that’s made me aware that there’s different parts of the world that there’s different things happening to and we all know about it in the news and everything but just to home it in and actually see it happen for yourself, I think really good” (Participant 15)

Visitors also discussed how the forest walk in the UK gave them the opportunity to reflect on the forest in Brazil and build a personal connection with this remote forest.

“...it just made you a bit more aware instead of just going for a walk your looking up at the trees and looking up into the canopy and maybe thinking, I had a thought of I wonder what it would be like walking finding the other sensor in Brazil and what the difference would be in my walk” (Participant 15)

It can be seen that in response to these multiple interpretations of the hybrid space, experience of the forests and through dialogues with each other and the artists, the visitors appreciated being given space and time to arrive at their own responses and interpretations. This resonates with previous research such as the *Shape* project that created a museum experience where visitors explored locations around an ancient castle that were juxtaposed with interactive installations inside (Fraser et al. 2003). However, *ACBT* is distinct in that it quite deliberately contrasts the different elements of the live visualisations from the climate machine, while the forest walk involves a very different experience again. On the one hand, the juxtaposition of different elements within one artwork involves deliberately creating contrasts between each of the elements. On the other hand commonalities between these elements encourage visitors to make comparisons, between them, further encouraged by various interrelated metaphors and themes. Thus the visualisations and phone experience draw on the same sensors and employ common visual techniques.

This study suggests that it is this arrangement of multiple elements that makes the design of *ACBT* open to multiple interpretations, the importance of which has also previously been discussed by Sengers and Gaver (Sengers & Gaver 2006). In turn, it is the interstitial gaps between these elements that provide the space for dialogue among visitors or with the artists and gallery staff.

5.4 Engagement and Disengagement

This study focuses on ways in which the artists engaged the visitors to the exhibition of *ACBT*. Observations revealed that visitors who engaged seriously with *ACBT* appeared to engage for a length of time, whereas those that didn't engage often left after several minutes. This section will briefly reflect on the challenges of engagement and disengagement, although this is part of a broader discussion within Contemporary Art and not the focus of this thesis.

Some of these experiences of '*disengagement*' were captured through observations and in the reports by Haines and Brundell and one interview was successfully conducted with a visitor who was very vocal about her lack of engagement with the exhibition, at Rufford Country Park agreeing to discuss her problems with the experience:

"...well as soon as I walked in, it just, I couldn't see the reasoning behind it, it did nothing for me visually, either of us, my friend as well, so you know, just didn't do anything for me, I couldn't see what it was all about" (Participant 11)

When asked to describe the exhibition in 3 words she said

"...can not understand" (Participant 11)

The artist present at the time offered to explain the thinking behind the work after the interview to see if a longer engagement and dialogue with the artist would support the experience. When re-questioned the woman responded:

"I see it better now you've explained it. But I still don't think it's designed simple enough for the everyday person to understand straight away, if you are not always there to explain it there's not enough information for people to look at and be able to understand it." (Participant 11)

In response to these issues Haines observed that:

"ACBT was a challenging work for audiences, who were often pushed outside their expectations of what they would find at a venue or what they might expect of an art exhibition. It was hosted by venues where visitors often had prior expectations of what they were there to do, and for all these reasons, some casual visitors found it difficult to make a real engagement with the work." (Haines, 2011)

Visitors that stayed for longer than 2-5 minutes tended to engage on some if not all levels, as Haines noted these visitors often "sat and watched the visualisations unfold for a very long time". Brundell and Haines studies both noted that at Rufford Park, specifically the galleries'

regular visitors tended to hold pre-existing expectations of seeing a craft exhibition and were often confused by the conceptual, digital, contemporary art work they were presented with when they walked in the door. These views were reflected by observed comments such as:

“We were expecting more pictures”

“Very disappointed, I wanted to buy a painting!”

“It’s not something I can hang in the lounge”

Yet, in contrast to this a visitor who did engage with the work for some time asked the artists how much it would cost to set up the sensors in their garden and the projection in their living room.

Brundell’s report also suggested that many of the visitors to the craft exhibitions found it difficult to reconcile the conceptual nature of contemporary art, recording one visitor as saying:

“I was intrigued but found it hard to think of a practical application... I suppose I’m not a very arts person”

Brundell also observed some visitors were confused by the complex trajectory of the exhibition, suggesting that the visitors were:

“...not sure where to go in the gallery, a preferred trajectory was unclear”.

It was impossible to quantify the percentage of visitors who did not engage with the work and the reasons why and it is not the author’s aim to focus the study on reasons for disengagement, but these comments and observances provide a qualitative picture of some of the contextual challenges of exhibiting these complex environmentally engaged artworks outside of contemporary arts venues, and to these diverse audiences.

5.5 Conclusion

As this analysis has shown *A Conversation Between Trees* created opportunities for public audiences to view representations of live and historical climate data, creating a narrative thread through the different elements of the artwork and the juxtaposition of the projected visual interfaces, the climate machine and hanging paper discs, and the forest walk.

The findings from both studies show that the artists set about provoking an emotional engagement with these representations of climate data through:

1. Encouraging a sensory engagement with data in support of McCarthy and Wright’s four

key threads of user experience (Wright & McCarthy 2010). By giving the data material form and by requiring visitors to take on the role of a sensor when walking through the forest, the artists created a deeply embodied experience of the data, contrasting strongly with the more conventional disembodied visualisations that suggest a rational but more detached engagement

2. Bringing a unique temporality to engagement with the climate data – including both slowness and liveness – which have previously emerged as an issue in the HCI literature (Friedman & Nathan 2010; Hallnäs & Redström 2001; Hook et al. 2012)
3. Juxtaposing different elements of the artwork that presented contrasting datasets – live, recorded and predicted – that provided multiple interpretations linked through a common narrative, metaphors and visual and sensory aesthetic

This study shows that the artists' role in engaging the public with climate data within *ACBT* was fundamentally about enabling visitors to observe the data for themselves and through this to provoke an *emotional* response.

A notable feature of *ACBT* was its complexity, the assembling of contrasting elements into an overall experience. This juxtaposition was a key part of the artists' strategy to provoke interpretation and dialogue through multiple interpretations. Perhaps the most striking feature of *ACBT* was the way in which visitors were invited to assemble their own experience and hence interpretation of scientific climate data.

However, this study also revealed that working with scientific data can be challenging for artists. Revealing how the artists had to walk a line between the need to create an emotionally compelling experience for visitors whilst considering scientific authenticity and veracity of the data.

This study builds a rich description of the rationale of the artists who created the artwork, the visitors experience and the scientist's response. In doing so, the findings have provided a set of themes that can inform future understandings of the strategies that artists use to engage the public with climate data.

ACBT also provided an opportunity to understand the collaborative process of artists, scientists and HCI researchers working together to produce an artwork that engages the public with climate data. The themes that emerged from this study directly informed the second study of the *Relate Project*.

This second study explores how reworking these themes through a collaborative processes between artists, scientists and HCI researchers can inform the conceptualization, building and testing of a tool kit and platform, that allows other artists and a wider community to engage with climate data. The following chapter describes the innovative process of designing a data

capture system in response to the findings from *ACBT*. This took place alongside a series of public engagement activities involving artist's residencies, hackdays and exhibitions. This project extends the framework of '*Designing From Within*' (Taylor 2012) to support an innovative iterative and collaborative process of artist led design, directly informed by the findings of the first study.

6

The Relate Project

The *Relate Project* explores the relationship between energy and climate change, developing a sensing platform with the aim of supporting a public programme of activities that encourage artists and communities to sense and interpret energy and climate data.

This chapter provides an overview of the innovative design process that resulted from the interdisciplinary collaboration between artists, scientists and HCI researchers and took place across four phases, the artistic engagement with the platform and the public and community engagement with the resulting artistic experiments. This chapter also provides a technical description of the *Timestreams* platform, revealing insights into how the design of the platform responded to and embedded these experimental processes.

The *Relate Project* provides a unique opportunity to investigate further the distinctive themes and contributions of artists working with climate data, across a broader community of artists in the UK and Brazil. Extending the findings of *A Conversation Between Trees* to encompass a broader group of artists, and an innovative design process.

A thematic analysis of the artists' motivations, strategies and contributions to the design of the *Timestreams* Platform and a series of artistic activities developed in response to this platform will be presented in Chapter 7.

This study has so far contributed to the publication of two full papers, at Ubicomp 2013 (Blum et al. 2013) and at Digital Futures 2012 (Blum et al. 2012) winning Best Regular Paper.

6.1 Overview of the Relate Project

Relate was a collaboration between RCUK's Horizon Digital Economy Research Institute, University of Nottingham and Active Ingredient to explore the relationships between energy and climate change.

The project occurred in partnership with Dr Carlo Buontempo the same senior climate scientist at the MET Office UK who worked with Active Ingredient on *ACBT*, Gabriella Giannachi, Professor of Performance and New Media at Exeter University and the British-Brazilian artist Silvia Leal who again joined the Active Ingredient team for the duration of the project.

The *Relate Project* followed on from *ACBT* providing the author with an opportunity to investigate the artists' contributions within the project in terms of how the themes revealed in the last chapter directly informed the design of a new system, investigating how the strategies used in *ACBT* could inform an HCI/artist co-designed system and the impact of this approach to on the other users of the platform.

The author took a lead role in setting up the *Relate Project*, defining the research objectives and co-designing the *Timestreams platform*, was a named investigator on the project and also contributed as one of the lead artists in Active Ingredient. As with the previous study this approach created many challenges, requiring regular shifts in perspective whilst also providing a distinct bridge between the artistic process. This phase of the research provides an opportunity to extend the frameworks of 'performance-led research in the wild' and 'designing from within' that informed the methods employed across both studies.

What is particularly unique about the *Relate Project* is that although the project is artist-led it was initiated by Horizon Digital Economy Research Institute as a follow up to *ACBT*. The artists from Active Ingredient were invited to contribute to the broader research as artist/consultants.

This chapter describes the platform that the artists and HCI researchers co-designed in response to the findings in the last chapter, the key concepts that emerged from this design process, the role of the artists, and a summary of the artistic activities that occurred in parallel to the system development.

6.1.1 Partners and Participants

The table below shows the different stakeholders in the project, including the author and their roles.

Table 6. *Relate Project* Stakeholders

Partners and Participants	Role
Active Ingredient	<ul style="list-style-type: none"> • Co-design of the platform and hardware set up • Creating prototype artworks by engaging with the platform • Creating an exhibition using the platform • Facilitating other artists to work with the platform
Horizon Researchers	<ul style="list-style-type: none"> • Investigators • Technical development of the platform • Research into sensor and power hardware • Facilitating the artists to engage with the platform
Artists/Hackers Brazil	<p>Engage with and test the platform</p> <p>Building prototype artworks using the platform</p>
Artists/Hackers UK	<p>Engage with and test the platform</p> <p>Building prototype artworks using the platform</p>
Climate Scientist	<ul style="list-style-type: none"> • Advising the artists and researchers on climate data • Advising on Citizen Science activities
Author	<ul style="list-style-type: none"> • Investigator • Facilitating the community engagement • Co-designing the platform • Creating artistic experiments by engaging with the platform
Lead Investigator	<ul style="list-style-type: none"> • Overseeing research

Each artist group was made up of 5 artists/hackers who either collaborated or worked individually; further information about these participants will be presented in Chapter 7. The artists were joined by a team of technology researchers from Horizon Digital Economy Research Institute and a climate scientist.

As already described, the author also played shifting roles within the project that involved co-designing the platform, acting as an investigator on the research and contributing as an artist.

6.1.2 Project Outline

The innovative design process embedded in the *Relate Project* involved the technical development of the *Timestreams* platform alongside four phases of artists' activity which

took place between January 2012 – March 2013, in locations in both the UK and Brazil. The four phases of activity are outlined in the table below.

Table 7. Phases of *Relate Project* activities

Phase One	Phase Two	Phase Three	Phase Four
Research / design across Nottingham and Rio	Forest Residency at Vera Cruz Farm (Brazil)	Rio Residency at Barracao Maravilha artists studio (Brazil)	Exhibition at Primary Studios and Hackday at Nottinghack (UK)

Alongside these four phases of artistic activity, Active Ingredient facilitated a series of wider public engagement activities involving:

1. Research and artistic enquiry around the relationship between energy and climate change
2. Supporting the Horizon researchers to develop the platform in response to their experience of data capture and conceptualisation during the *ACBT* project as described in Chapters 3 and 4
3. Creating a series of new artistic experiments/artworks in response to the *Timestreams* Platform
4. Facilitating other artists to work with the *Timestreams* Platform through an artist residency and a Hackday event.

The public engagement outcomes of the project focused on school children (aged 6-8 years), a public symposium and two public exhibitions, these are referred to in the findings but the study of the *Relate Project* focuses primarily on how the artists who participated in the project responded to the platform and the themes that arose from the previous study of *ACBT*. The author chose to focus less on public engagement and more on the artists' strategies of working with climate data, in order to answer a different set of questions than in the first study, this will be discussed in more detail in Chapter 7.

Due to this different emphasis the public were also much less involved in the *Relate Project* than in *ACBT*. In response, the artists chose to develop a series of artistic prototypes or experiments as opposed to creating a '*finished*' artwork for public exhibition, as was the case with *ACBT*.

6.2 The Design Process

The Relate Project was an opportunity to develop an innovative design process that emerged from collaborative research between artists, HCI researchers and climate scientists. The system involved conceptualizing, building and testing a tool kit that allows other artists and a wider community to capture, author and experiment with scientific data, alongside other more experiential data such as text, images and sound.

This process provides an interesting insight into how the design of the platform embedded the themes that emerged in the previous study of *ACBT* alongside the experimental artworks developed by the artists through four phases of development, described in Section 6.3.

The resulting *Timestreams* Platform also provides an example of the value and potential role of artist collaborations with HCI and a unique opportunity to research how artists' engagement with climate data can inform the design of a system.

6.2.1 How *ACBT* informed the *Timestreams* Platform

As already discussed, the design of the platform directly reflected the themes that emerged from the previous study, focusing on the following themes:

Sensory experience – creating a system that could both input environmental sensor data and output this data in order to create artworks/experiences that could be experienced in a variety of visual, physical and embodied, sensorial ways.

Embodied experience – creating a system where inputs can include users' experiential data as time series media (images, text, sound) alongside numerical, scientific data. Both types of data can be outputted to APIs that can be used with Arduino and other tools to enable artists to build immersive, sensory and embodied experiences of the data.

Performativity – The *Timestreams* Platform is based on the concept of '*performing data*' that was defined in the previous section, the data is based on a timeline and can be outputted as a '*live*' stream to enable data to be '*performed*' in real time and space.

Multiple Interpretations – The ability to author, juxtapose and compose data as if it was music or video informed the way '*Timestreams*' data feeds are managed on the WordPress dashboard. Based on video editing software such as Apple's Final Cut and multimedia editing software such as Adobe Flash (which many artists are familiar with) data can be attached to timelines that can be scaled, zoomed in and out, the rate reset and regions of data can be highlighted to be replayed. More than one '*Timestreams*' data feed can be juxtaposed together in order to be able to compare and contrast different sets of data. Any amount of

Timestreams can be outputted to the same API and replayed together in a visualisation, by an Arduino etc... This will be described in more detail later in the chapter.

Additional to these general themes Active Ingredient collaborated directly with the researchers on the technical specifications, which were also influenced by their experiences and the findings of the last case study (*ACBT*), these were implemented in the system design as:

- ***Liveness*** - The system is designed to support experiences of disconnection based on both the connection of live sensors or live interaction with the platform itself. Therefore if connectivity is lost during an exhibition, the concept of '*smoke and mirrors*' (Jacobs et al. 2012) that arose from *ACBT* can be supported through the replay of synched or pre-recorded data as if it was live data, using the API to mix and match *Timestreams* as required, or by setting up the WordPress server and local sensors on a local network
- ***Slowness*** - The system is designed to support the often slow capture of climate data by enabling users to scale data, or set the replay rate of the data, so that it can be replayed alongside other faster datasets (containing shorter timescales, media datasets) This enables longer timescale data (such as the Mauna Loa CO2 series from 1959 to the present day) to be zoomed out, authored and replayed on a more '*human scale*' as discussed in the findings from *ACBT*
- ***Temporality*** – As the name suggests *Timestreams* is based on time-series data, all data or multimedia is inputted and outputted as part of a timeseries. This can occur as either live data or historical, pre-recorded, modelled and aggregated data. The playback options within the *Timestreams* Platform are designed so that all *Timestreams* data feeds whatever the timescale of their source can be played back from a single play head – so it is played back *as if* it was live (see performing data).
- ***Authenticity*** – *Timestreams* enables artists to combine multiple scientific datasets, captured either by their own sensors and/or with aggregated pre-recorded and modelled datasets that are made available on the platform. This data can also be combined with live captured multimedia (through the *Timestreams* Phone App) to enable artists to continue to explore the line between experiential data and scientific data.

Having revealed how the findings from *ACBT* informed the design of the platform, the following sub-sections will present the technical architecture of the platform.

6.3 Phases of Activity

The iterative, phased approach that informed the design process is common to large artist-led projects that involve elements of public participation, exhibition and residencies. It is very much typical of Active Ingredient's approach, as can be seen by the description of *ACBT* in the previous chapters.

6.3.1 Phase One: Research

The first phase of the artistic activities involved research and a series of internal workshops between the partners collaborating on the project. The aim of this process was to share knowledge, ideas and thinking around the core elements of the project by:

- Researching the relationship between energy and climate change from the different disciplinary perspectives
- Developing the technical design and infrastructure for the development of the Platform

The Active Ingredient team conducted a series of artistic activities around '*performing data*' in Nottingham, UK that linked with the artist Silvia Leal in Brazil both via Skype and when she visited the UK for several months. This resulted in the design of a series of experiments that the artists explore in Phase Two and Three, described in Section 6.5.

An example of an early artistic experiment that took place before the platform was built includes Active Ingredient's experiment to re-enact global population increases (net population increases per minute) alongside deforestation in the Amazon rainforest (trees cut down per hectare per minute) as a performance see (Fig.47).

In this artistic experiment each of the artists '*performed the data*' in different ways in real time. In the image in Fig.47 you can see Lee with her eyes closed counting the time over one minute. In the background Watkins and Selby are drawing a series of circles and sticks (a simplified stickman), each of these symbols represent an increase in global population, where they are attempting to draw the net increase of population real time over one minute. In the foreground the author (Jacobs) and Shackford are attempting to cut out and place interlocking triangles (representing a simplified tree) that reflect the trees cut down per hectare in the same minute.

This physical re-enactment and embodied performance of data was not directly relevant to the development of the system, but was inspired by the data on the system (or in this case

data found online prior to the system being built). These enactments also enabled the artists to experiment with data prior to the platform being built and the results of these experiments contributed to the final design of the platform.

At this phase of the project the artists in the Active Ingredient team engaged with climate data through a process of playing with numerical data and then responding to it in these non-digital forms. The artists suggests that these non digital performances of data also informed the development of the later artwork experiments described in Section 6.5, suggesting it was an important part of their artistic process to be able to experiment with the data outside of the digital realm and unconnected to the platform to explore their own artistic vision away from the constraints of the technology. These reflections are discussed in more detail in following chapter.

6.3.2 Phase Two: Artist Residency at Vera Cruz, Miguel Pereira, Brazil

Active Ingredient and Blum from Horizon Digital Economy Research Institute spent eight days in residence at an arts centre and on a farm, in the mountains several hours from Rio de Janeiro. Zecura Ura, a British Brazilian Performance Group and contemporaries of Active Ingredient hosted this residency.

The farm was a bus ride and two hours walk from the road, up in the mountains, in a mixture of agricultural land and the Mata Atlantica (Atlantic Forest), it is a working farm and conservation area, managed by three farm managers. The residency was supported by two performers from Zecura Ura, who visited and took part in a '*show and tell*' session midway through the residency.

The Active Ingredient team spent 8 days at the farm capturing data, testing the platform in the forest environment and developing experiments. This work explored energy and climate change in response to the remote environment and the resulting experiments are described in the next section. Blum developed the platform to function in response to these experiments and the challenges and opportunities inherent in conducting research as this '*in the wild*'.

Developing technology in a farm in the middle of a forest in Brazil involved an interesting set of challenges that also enabled the team to '*embody*' the themes of the project, these included:

- Intermittent and slow internet connectivity caused by heat and remoteness
- Intermittent electricity caused by storms and heat
- A mixture of heat, storms and tropical rain that enabled the team to test their sensors in extreme climates
- Limited mobile phone signal

Some of the impacts of working in this environment are investigated in the findings in the next chapter. The residency was also meant to be viewable by an online public audience whilst the artists were at the farm, this was hindered by the problems of connectivity at the farm and therefore emphasis on the public outcomes were placed on the residency at the artist studio in Rio de Janeiro in the next phase as opposed to blogging during this remote residency.

6.3.3 Phase Three: Artist residency at Barracao Maravilha

Active Ingredient, Leal and Blum conducted their second residency in Brazil at Barracao Maravilha, an artist studio and gallery space at the heart of the bohemian area of Rio de Janeiro. Active Ingredient presented the *Relate Project* and *Timestreams* Platform on the first day of their residency and then set up in the studio to work towards an exhibition at the end of the week, inviting the resident artists from the studio to collaborate with them throughout the week.

The aims of this residency was to work with the artist community based at the studio, introducing the *Timestreams* Platform to these artists and work in collaboration with them to respond to the platform through a series of Hackdays. Many of these artists worked in more traditional visual art practices than Active Ingredient using sculpture and painting and would have not necessarily considered themselves as '*environmentally engaged artists*', as described in the participant case studies later in this chapter. These collaborations and the artistic experiments developed during the residency at Vera Cruz supported an exhibition that was launched on the last evening of the residency at Barracao Maravilha.

The exhibition at Barracao Maravilha was open to the public for 7 days, beginning with an opening evening event that had approximately 150 people attending. The studios have a shop front looking out to a very busy road in Lapa, which was opened up for the duration of the exhibition. The exhibition also showcased the work of Hugo Richards and Natali Tublenchak (artist participants) and the centrepiece was the *Inflatibles* collaborative work between Active Ingredient and the artists that was devised during the residency using the *Timestreams* Platform.

The other experiments devised by the team and in collaboration with the artists at Barracao Maravilha were placed around the building; these will be described later in the chapter. During the exhibition opening event Jesse Blum also presented the full set up of the platform including the sensors, the *Timestreams* online interface and the artistic presentations that responded to the data.



Fig.27 The Inflatibles fully inflated



Fig.28 Active Ingredient testing the concept of performing data



Fig.29 Building the Inflatibles at Barracao Maravilha



Fig.30 The Inflatibles exhibited at Barracao Maravilha



Fig.31 Visitors standing outside the exhibition preview



Fig.32 The Inflatibles exhibited at Primary, Nottingham, UK



Fig.33 Artists participating in the Hackday event, UK

6.3.4 Phase Four: Exhibition and Hackday in Nottingham, UK

A second public exhibition occurred at Active Ingredient's studios in Nottingham, UK where members of the public were invited into the studios (in an old Victorian Primary School in Nottingham) to visit the artists' studios and see curated exhibitions in the main spaces.

Active Ingredient showed the Inflatibles in the secondary main space, placing the inflatable objects where people were walking through. The inflatables responded to sound as people walked past and CO₂ in the room, representing the human presence in the environment. Each object responded to a different range – the two smaller inflatables reacted to low and medium range decibels and the larger inflatable to CO₂. Children were particularly intrigued by the installation, shouting loudly and jumping up and down to get the inflatables to respond.

In Active Ingredient's studio the artists presented their research, the sensor kit, the Prediction Machine and the Weather Fortune Empadinhas (see the next section). Each member of the team had filled in a notebook during the residencies in Brazil and this research was available for people to look through, seeing how the artists captured their own data, using the *Timestreams* Platform as well as by hand (writing numbers for temperature and humidity into a table with observances notated alongside) and through photographs displayed on the walls. The artists held discussions with visitors about the project and their research on how energy relates to climate change with visitors.

The final event within the *Relate Project* involved the Active Ingredient and Horizon team working with 5 participants throughout a weekend to hack the *Timestreams* Platform. The Hackday was a collaborative workshop that brought together artists, hackers and researchers to experiment with *Timestreams*, ideas at speed over two days. The participants were encouraged to make experimental projects using the platform and sensors in response to climate data under the Relate theme of the relationship between energy and climate change. During the weekend Active Ingredient and Horizon presented the *Timestreams* Platform, the sensor kit and the WordPress dashboard opening the system to the artists and hackers to build their own artworks, responses and tools to work with the system.

6.4 The Platform

The *Timestreams* Platform¹⁹ is a tool for gathering data from environmental sensors in real time to allow playback of the data in creative, performative ways and to better understand the relationship between energy and climate change.

The *Timestreams* Platform is an open source, online data management system that is integrated with the WordPress blogging platform²⁰ (Blum et al. 2013). It has four core functions:

- Inputting time series sensor data and multimedia using the *Timestreams* API
- The authoring and management of data and media along timelines called ‘*Timestreams*’,
- Outputting the ‘*Timestreams*’ data feeds using the *Timestreams* API to visualisations (created using Javascript or Unity), mobile phones and interactive machines, devices and environments (using Arduino, processing, Max MSP etc...)
- Sharing data between community members and artists

Alongside these core functions, the platform has been designed to provide the following services:

1. Online and offline data capture and storage, through the use of a mobile computer (such as a Dream-Plug or Raspberry Pi), laptop or other mobile computer device running an offline version of the WordPress blog, that can easily be synchronised and replicated to the online cloud version of the server
2. A ‘federation’ of blogs, with the ability to connect and share data stored on individual blogs, creating a social network of data sharing
3. Opportunities for individual, personal and local data capture, through the use of sensors, mobile apps and other media capture devices
4. Opportunities to aggregate open data that already exists online
5. A plug-in to connect the additional functionality of *Timestreams* to ‘Cosm’, an established online and publicly accessible data capture system
6. Opportunities to send ‘*Timestreams*’ data feeds to existing media and data authoring software and tools such as MaxMSP and Pure Data

¹⁹ The main website for Timestreams is: <http://timestreams.org>

²⁰ Active Ingredient’s Timestreams Blog can be found at: <http://activeingredient.timestreams.org>

6.4.1 Performing Data using *Timestreams*

The concept of performing data arose in the last chapter, through the discussions of ‘*performativity*’ and ‘*liveness*’. This concept of ‘*performing data*’ has been extended through the development of *Timestreams* and is defined here as:

- Data that can be replayed or experienced live in real time and real physical space
- Data that can be used to create and control sensory, embodied, immersive experiences and mechanical and electronic artefacts, in order to represent a meaningful narrative based experience (replayed or live) of the data
- Data that is remediated as sensory, embodied, immersive and mechanical time-based artworks.

Timestreams is also the name for live data feeds that can be interacted with, interpreted and authored. They provide opportunities for ‘*performances of data*’ that are created on the platform along a timeline. These ‘*Timestreams*’ or datasets can be authored through the *Timestreams Platform* and visualised, performed or interpreted through various outputs using the *Timestreams*’ APIs. To summarise the functions of the platform:

- *Timestreams* are live data feeds that you can play with, interpret and create.
- *Timestreams* enable ‘*performances of data*’ that are devised and shaped on a timeline on the WordPress dashboard and can be outputted to devices, visualisations, blogs and other data systems such as ‘*Cosm*’

6.5 Technical Overview of the *Timestreams* Platform

The following section provides a description of how *ACBT* informed the platform design, the technical implications and presents a walk through of the platform architecture.

6.5.1 The Platform Architecture

As already outlined (in Table 6) the researchers from Horizon Digital Economy Research Institute were responsible for the technical development of the Timestream Platform and the development of the sensor and power hardware. As shown in the diagram in Fig.27, the technical development consisted of the development of the following components:

- Sensor kit – a set of solar powered sensors, connected to a portable computer via bluetooth to a simple client designed by Horizon Digital Economy Research Institute to upload the data to *Timestreams*

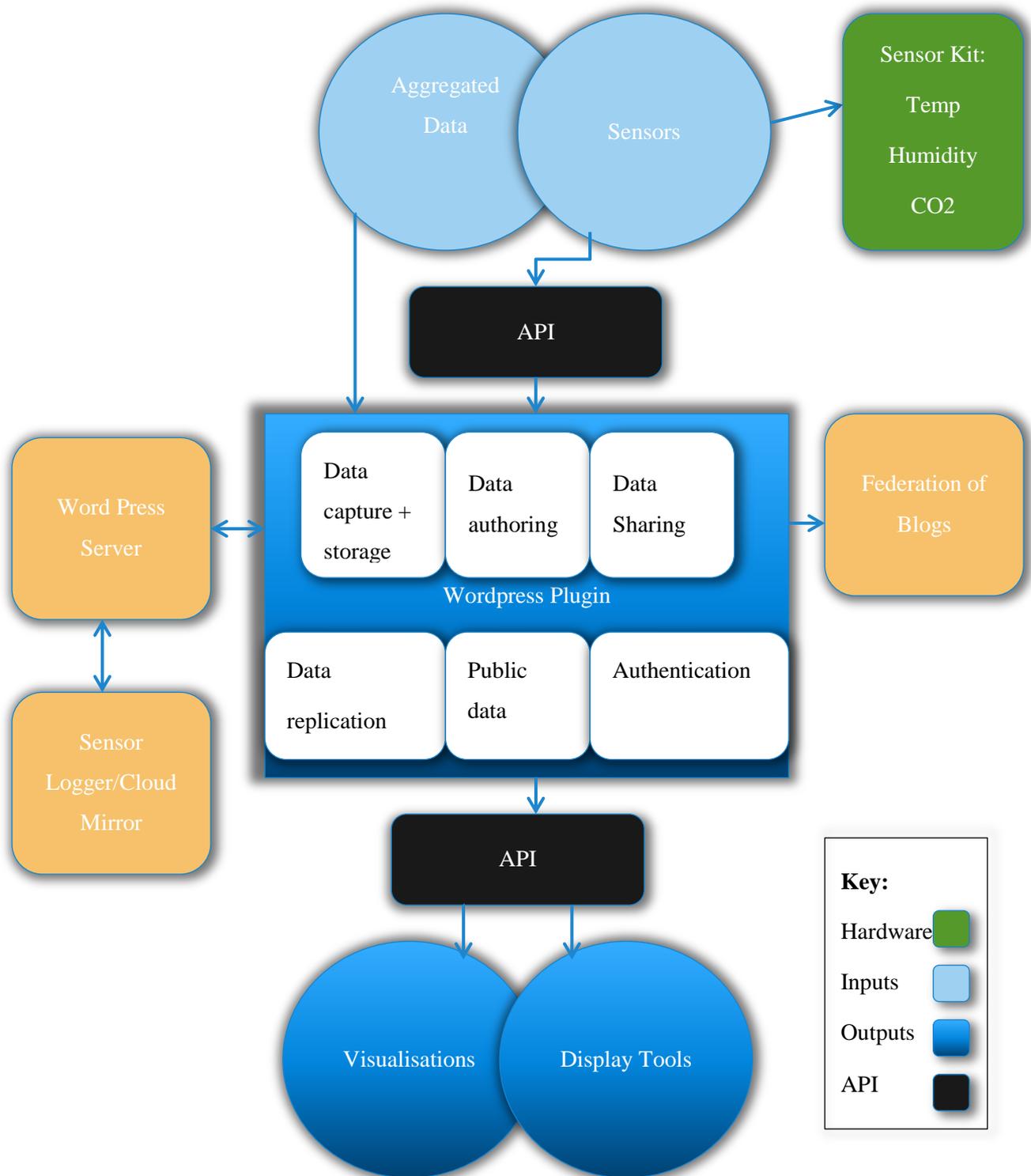


Fig.34 Architecture of the *Timestreams* platform

- Sensor logger – a portable computer (a Dreamplug) storing a local version of the WordPress server – online version of the WordPress server
- *Timestreams* WordPress plug-in – the plugin uploaded to the WordPress server and accessible via the WordPress administration dashboard
- *Timestreams* APIs – providing access to the *Timestreams* data for inputting and outputting data from the platform
- Visualisation and Display Tools – Active Ingredient and Horizon designed some visualisation tools for visualising the data in blog posts, stand alone visualisation using Unity software, and artworks that used Arduino to embed the data

The artists within the Active Ingredient team supported this design process through researching and testing the sensor kit, co-design of the *Timestreams* WordPress plug-in and dashboard interface, and testing the *Timestreams* APIs through the development of visualisation and display tools (as artwork prototypes).

As an additional element alongside the technical infrastructure of the platform, Active Ingredient built their own mobile phone app to enable easy and accessible capture of time-series multimedia and accelerometer data, using the *Timestreams* API.

6.5.2 Sensor Kit

The hardware developments involved developing an affordable mobile sensor kit that was powered by solar power (see Fig. 28) and that could be made available for the artists to use to capture live environmental data to the *Timestreams* Platform.

This contained:

- Temperature, Humidity, Decibels, and Nitrus Oxide sensors
- CO2 Bluetooth sensor
- Arduino board
- Power gorilla battery
- Solar Gorilla
- Dreamplug or laptop with the WordPress server installed

6.5.3 Sensor Logger/Cloud Mirror

A sensor logger, along with the offline version of the WordPress server (the cloud mirror), provided two options to support issues of disconnection and liveness, based on the findings from *ACBT*. The offline version of the platform enables both the sensing (input) and performing data (output) to occur without connectivity, particularly for artistic practices and



Fig. 35 Blum walking with the sensor kit in his bag through the forest to Vera Cruz

activities that occur in rural areas where connectivity is difficult (such as Phase Two at the farm in Brazil).

The researchers from Horizon Digital Economy Research Institute developed the prototype software for the Eco-sense sensors that were included in the mobile sensor kit. This could be supported by either a PC Laptop or a Dreamplug, or other small computational device such as Raspberry Pi.

The Dreamplug provided a mobile, robust and lightweight option for sensing which was particularly suitable for walking and remote activities, such as when the team walked through the Mata Atlantica (Atlantic Forest) to get to the farm where they were in residence for Phase Two of the project (see Fig.28) yet there were issues around accessibility for the artists using the Dreamplug and this solution didn't fully resolve issues of connectivity in practice. The Dreamplug relied mainly on WiFi and although some research took place to try and connect a 3G dongle this was not successful. The platform in its current state also worked too slowly on the Dreamplug to support more than one Timestream at a time.

Therefore the artists predominantly used a PC laptop to set up the sensor logger and offline WordPress Server to run the sensors and access their *Timestreams*. In this case a laptop was considered by the artists as a more familiar and accessible tool, even for the more technically literate artists, as the built in screens and familiar OS enabled them to troubleshoot as they worked.

6.5.4 APIs

The *Timestreams* API can be accessed through HTTP requests. These are designed to support the development of new visualisations within the *Timestreams* blog, visualisations that use software such as Unity or Open GL and computer electronics such as Arduino, to support '*physical actuators*'.

As *Timestreams* and WordPress is Open Source it is the hope that hackers, developers and technically skilled artists will be interested in developing their own tools to extend the usability and services within *Timestreams*, through access to the documentation at www.timestreams.org. This has already begun to occur from the *Timestreams* Hackday event (as shown in the findings of the study in the next chapter).

6.5.5 Visualisation and Display Tools

The developments of visualisations and Arduino controlled physical actuators require a certain level of technical knowledge in order to use the API into the development of Unity and Arduino and possibly other platforms. Within the Active Ingredient team there were the

skills to use the API, but not all artists (and as shown in the findings of the study) were able to use *Timestreams* at this level on their own.

There are some very basic visualisation tools built in Javascript by Horizon Digital Economy Research Institute researchers that can be used to add *Timestreams* data feeds to the WordPress blog posts and pages and it is hoped that other developers will refine the tools so that artists can easily adapt visualisations and Arduino either themselves or in collaboration with programmers, discussed further in the next chapter.

6.5.6 Federation of Blogs: Active Ingredient's Timestream

Additional to the visualisation and display tools the platform was designed to create a 'federation of blogs' that could be linked through the platform and share data.

In the case of this iteration of the project Active Ingredient published their own *Timestreams* Blog that consisted of blog entries based on each of the phases outlined above and the wider community engagement / schools exchange²¹. This was also linked into a blog developed for the UK Hackday event²² and a blog for the schools exchange element of the project²³.

Data sets and *Timestreams* were shared between the users of each of these blogs in order to test the concept of a social network of data blogs.

Alongside Active Ingredient's blog entries and discussions around each phase of the project, the artists also tested the *Timestreams* data blogging through the following experiments:

- *A Storm In Vera Cruz (Phase Two)* – a blog entry involving a *Timestreams* data feed of Temperature and Humidity and images taken using the Mobile Phone App during a storm
- *A Storm in Barracao Maravilha (Phase Three)* – a blog entry involving Temperature and Humidity and images
- *Autumn in Newstead* – a blog entry involving CO2, Decibels and images from the school in the UK

The Active Ingredient *Timestreams* Blog contains documentation of all the key artistic experiments that were created across the four phases of the project and the Mobile Phone App development.²⁴

²¹ www.ai.timestreams.org

²² www.hackday.timestreams.org

²³ www.schoolexchange.timestreams.org

²⁴ <http://activeingredient.timestreams.org/timestreams-app/>

The project is also supported online through a general project blog, which presents documentation of the research and technical designs.²⁵

The general website for the *Timestreams* Platform acts as an umbrella for the federation of blogs and is based at: <http://timestreams.org/> this provides potential users and developers with manuals, guides and project links.

6.6 Using *Timestreams*

The following description provides a basic example of end-to end use of the *Timestreams* Platform. This walkthrough presents a specific example of how the artists captured data during a storm when in residence at the farm in Brazil, showing examples of how this data can be authored and output as either a blog, a visualisation embedded in a web page or embedded in an artifact as part of an artwork.

6.6.1 The *Timestreams* Plug-in

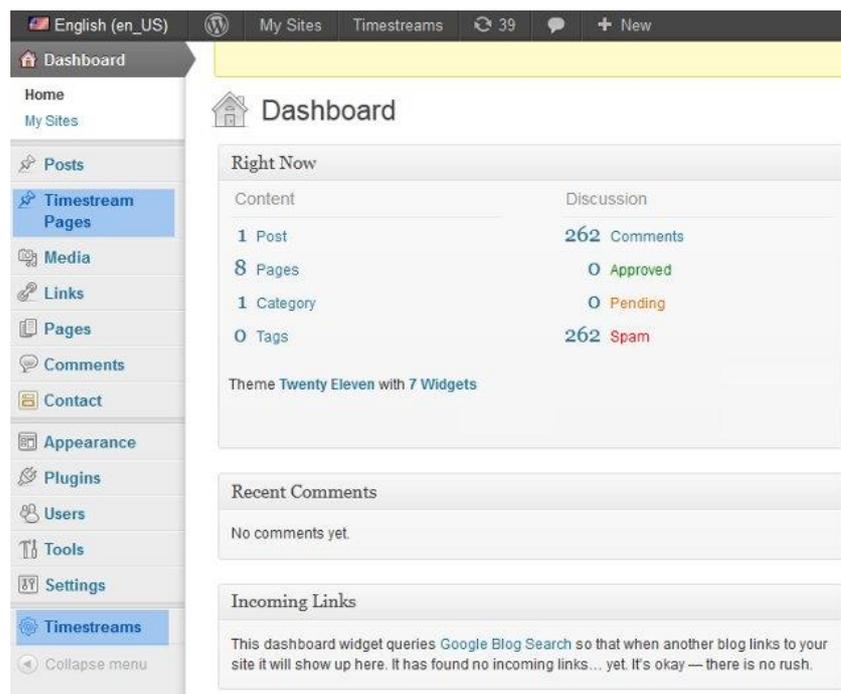


Fig.36 *Timestreams* plug-in

The *Timestreams* plug-in can be uploaded to an existing WordPress website or in the case of the Active Ingredient and Horizon blogs set up as part of a federation of Timestream blogs on the *Timestreams* server. Once the plug-in is uploaded it appears on the WordPress dashboard along with the rest of the WordPress settings. Two options are added to the menu, these are

²⁵ <http://horizab1.miniserver.com/relate/>

the *Timestreams* menu and sub-menus for creating *Timestreams* and the *Timestreams* pages for adding *Timestreams* to web pages.

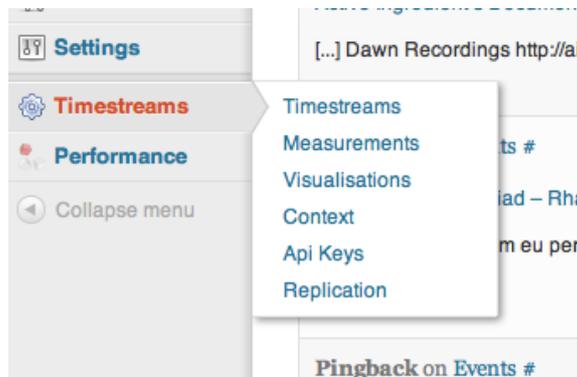


Fig.37 Drop down menu

The *Timestreams* plug-in sits in the WordPress menu, providing the user with 6 options:

1. *Timestreams* – instructions for using the platform, an interface that enables you to create a 'timestream', attach the timestream to the data or 'measurement container' and author the data along a timeline
2. Measurements – an interface where you can set up your data capture to the platform (create a new measurement container), view existing datasets (measurement containers) on the platform and chose to share your datasets with other Timestream users
3. Visualisations – A simple list of the visualisations that can be used to visualise the data through the WordPress blog
4. Context Record – An option to add context details to your datasets (measurement container) that can be used in visualisations, and support ways of ordering and managing the data
5. API keys – a list of keys to enable authentication of the datasets
6. Replication – A form to enable either discrete or continuous replication of the *Timestreams* Platform to another blog, for example from a local version of the platform to a remote server

6.6.2 Setting up a Sensor: Measurement Container

Data can be inputted into *Timestreams* as:

- Data captured through sensors
- Data shared by other '*Timestreamers*' (members of the Timestream community)
- Data aggregated as a resource available for the whole community

To capture data you need to fill in the form in the measurement section of the dashboard.

This sets up a new measurement container that holds each individual data source.

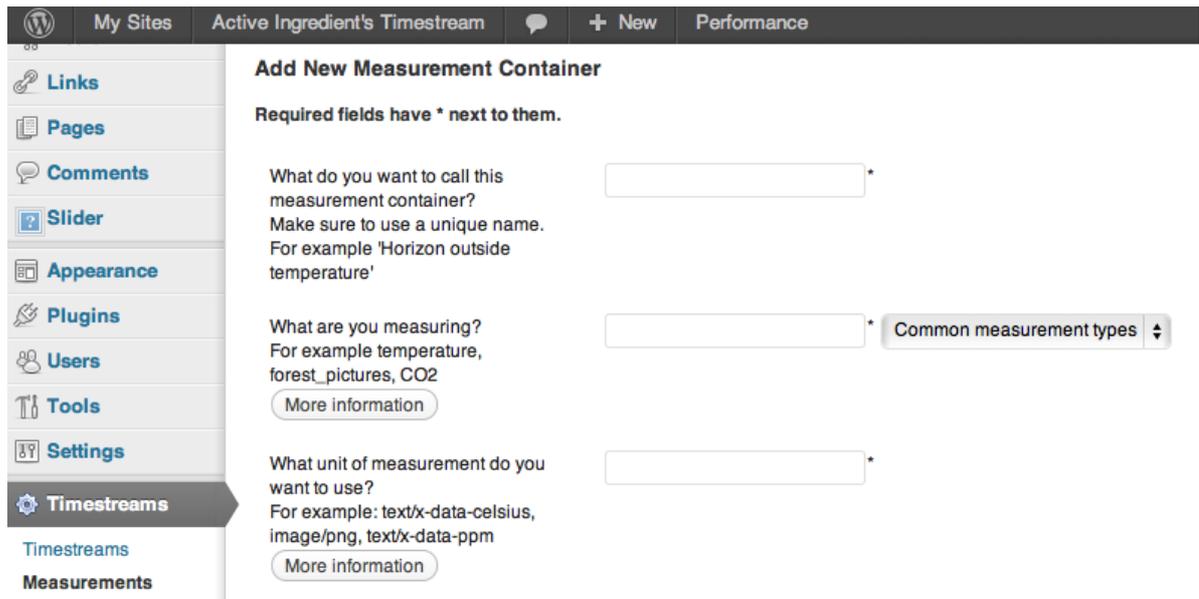


Fig.38 Adding a New Measurement Container

Once set up this allocates a unique measurement container ID to the data source (see Fig.31)

Measurement Container

id	view	share	table name	measurement type
66	View	Can't share.	wp_1_ts_CO2_66	ML CO2
122	View	Can't share.	wp_7_7_ts_street_decibels_122	street_decibels
156	View	Can't share.	wp_7_7_ts_Humidity_156	Humidity
170	View	Share	wp_1_ts_Test_170	Test

Fig.39 List of Measurement Containers

Data sources can be viewed in the table, which lists all the measurement containers and their properties, you can interrogate the content of the data by clicking on the view button and scroll through the data source.

Timestreams - Measurements: wp_1_ts_C02_66

Description

id	value	timestamp
2	325.68	1970-01-02 00:00:00
3	326.32	1971-01-01 00:00:00
4	327.45	1972-01-01 00:00:00
5	329.68	1973-01-01 00:00:00
6	330.18	1974-01-01 00:00:00
7	331.08	1975-01-01 00:00:00
8	332.05	1976-01-01 00:00:00
9	333.78	1977-01-01 00:00:00
10	335.41	1978-01-01 00:00:00
11	336.78	1979-01-01 00:00:00
12	338.68	1980-01-01 00:00:00
13	340.10	1981-01-01 00:00:00
14	341.44	1982-01-01 00:00:00

Fig.40 List of Measurements

It should be noted that at this stage datasets that include images, video and sound files are only viewable in this table as URLs. If users want to interrogate this further from this list they need to copy and paste the URLs into a separate webpage.

id	value
1	http://activeingredient.timestreams.org/files/2012/09/wp_7_7_ts_image_115_red
2	http://robin.timestreams.org/files/2012/09/wp_7_7_ts_image_115_img.png
3	http://robin.timestreams.org/files/2012/09/wp_7_7_ts_image_115_img1.png
id	value

Go To Add

Go To Add

Go To Add

Search in S

Search wit

Look Up ir

Copy

Fig.41 List of Image URLs

6.6.3 Creating a Timestream

To set up your *Timestreams* you need to create a new *Timestreams* in the *Timestreams* interface. Firstly you need to give it a name and attach a measurement container (data source) to the Timestream (see Fig.7)

Create a new Timestream

Timestream Name

Measurement Container

Create Timestream

Fig.42 Creating a new Timestream

The data will then appear on the Timeline with the name of your Timestream attached.

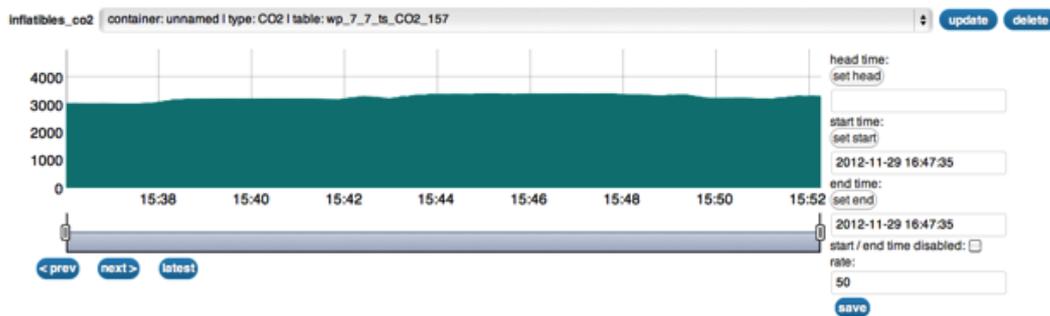


Fig.43 CO2 data on the timeline

Data that includes images will also show them on the timeline



Fig.44 Image data on the timeline

To view the full scale of the data you can zoom in and out of the data using the zoom bar below the timeline, or click on the 'prev' or 'back' buttons to jump through the data.

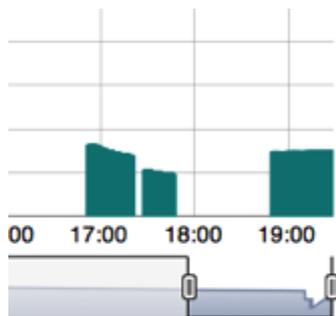


Fig.45 Zooming in on the timeline

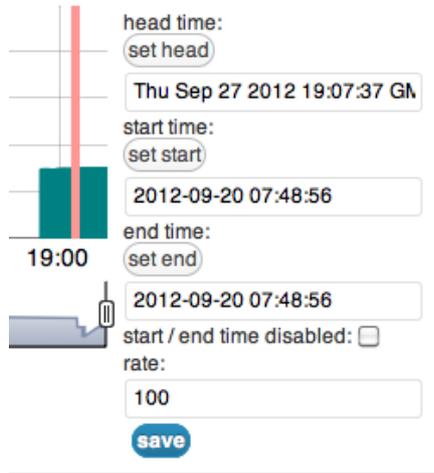
6.6.4 Authoring a Timestream

In order to 'author' the data within the Timestream interface you can change the playback rate of the data and set start times, end times, streaming live data or replaying pre-recorded data within the timeline.

Any changes made in the interface will control the output of the data to the API.

At the end of the timeline is a form with a list of settings to enable changes to the Timestream data. You have the following options:

- Set Head Time – set the *'play head'* to start to play out the data at a specific point on the timeline



The image shows a screenshot of a Timestream interface. On the left, there is a timeline with a vertical red line representing the play head. Below the timeline, there is a settings form with the following fields and values:

- head time:
-
- start time:
-
- end time:
-
- start / end time disabled:
- rate:
-

Fig.46 Setting start and end times and rates

By clicking on the timeline you can set the play head. When you set the play head to start at a particular place on the timeline the date and time appears in the form. You can also type this in manually and change the start and end time of the replay.

You can also change the following settings manually:

- Set Start Time – set a start time for replaying pre-recorded data
- Set End Time – set an end time for replaying pre-recorded data on the timeline
- Disable start / end time – disabling the start/end times enables the *'play head'* to play live data as it comes into the timeline, otherwise the playhead loops a replay of the data between the start and end times
- Rate – setting the rate the data

6.6.5 Embedding a Timestream into a webpage

There are three options for embedding a Timestream in a webpage:

1. Adding a Timestream to a stand alone webpage
2. Adding a Timestream to a WordPress page
3. Embedding a Timestream in a post within your existing WordPress blog

Firstly, users can view the list of visualisations available to embed into the page or post by clicking on the visualisations sub-menu. New visualisations can be created using javascript and the *Timestreams* API, but currently there is no online function to upload new visualisations to the blog via the web interface.

To embed a *Timestreams* visualisation in a web page you need to choose the *Timestreams* Pages option, which will then bring up a similar dashboard to creating a normal webpage in WordPress.



Fig.47 Setting up a *Timestreams* page

When you click on add a new *Timestreams* Page on the visual webpage editor will have an additional option of a smiley face button.

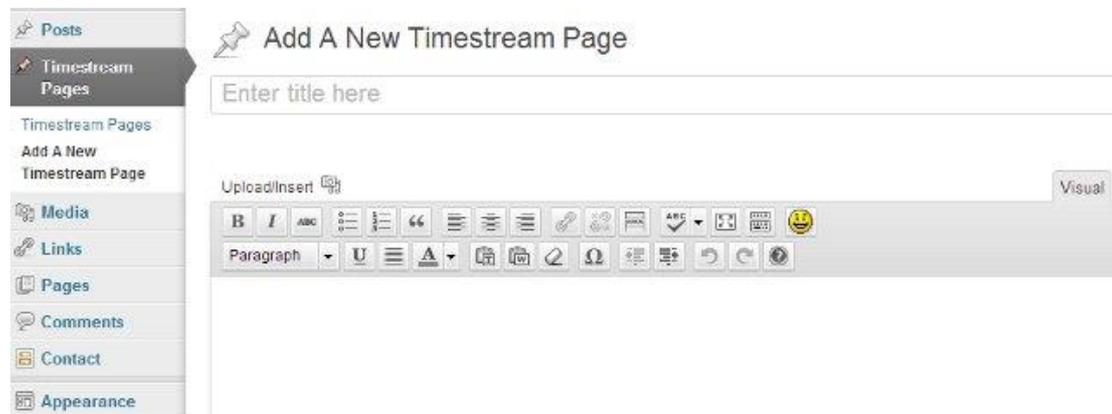


Fig.48 Inserting a *Timestreams* visualisation

This enables you to insert a *Timestreams* Visualisation and brings up a box, which enables you to choose your Timestream and visualisation to embed into the page.

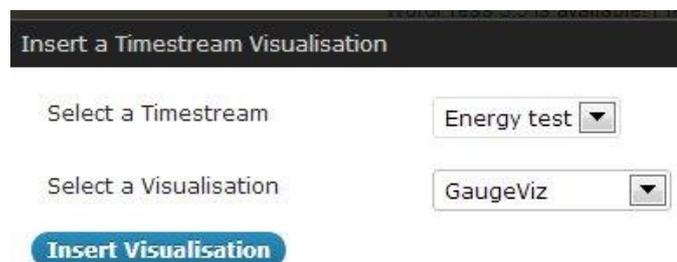


Fig.49 Selecting a *Timestreams* Visualisation

Within the page you can also add additional text and media (as you would normally to a web page) around the visualisation. You can also add multiple visualisations as a way of comparing and juxtaposing different datasets and building up narratives around the data.



Fig.50 A simple Javascript visualisation

See fig. 34 below as an example of a blog post containing multiple visualisations. This shows CO2 and Decibels in numerical form alongside a slideshow replaying time series images collected at the same time, each is replayed simultaneously as authored in the *Timestreams* interface.

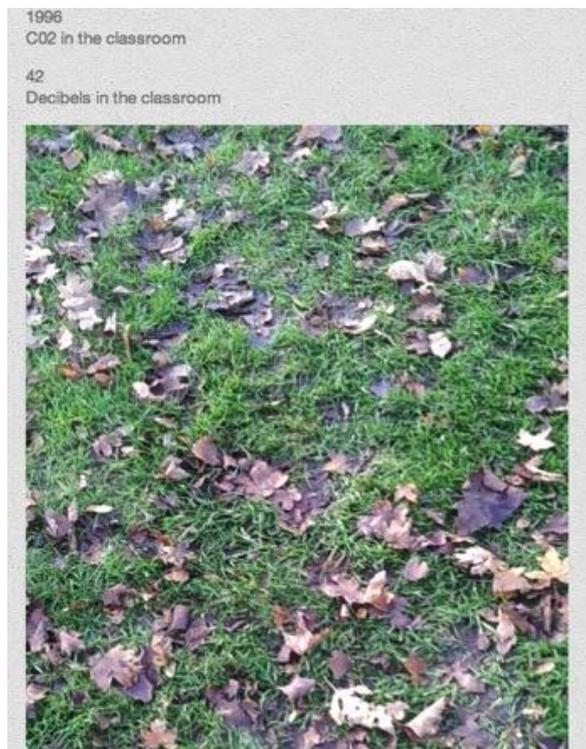


Fig.51 Multiple *Timestreams* embedded in a page

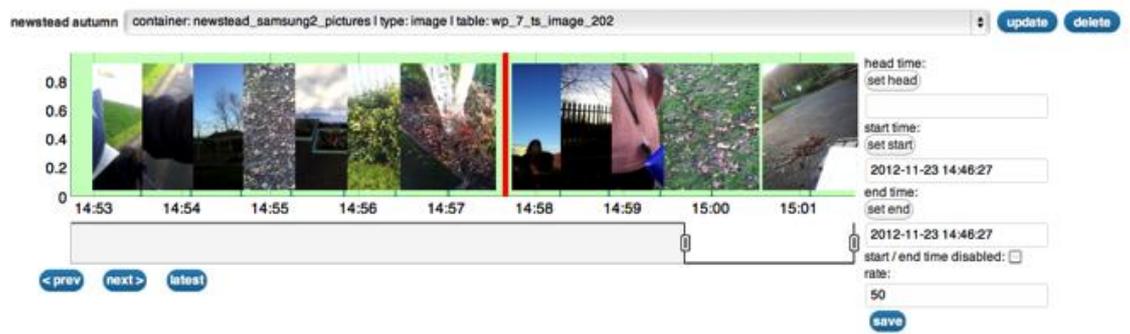


Fig.52 The same *Timestreams* images on the timeline

The *Timestreams* Visualisation button (the smiley face) will also appear in the WordPress blog post options and will work in the same way.

6.6.6 Embedding a Timestream using Arduino

As described, *Timestreams* can also be outputted to other software, data management systems and used to control electronic devices, using the *Timestreams* API. Within this example the data captured on *Timestreams* was used to control an artwork experiment 'The Inflatibles', developed by Active Ingredient in collaboration with the artists Richard and Tublenchak during the residency at Barracao Maravilha in Brazil. Below is an example of how the code for the Arduino requests the latest CO2 measurement on the specific Timestream being called through the API.

A screenshot of an Arduino IDE window titled 'Inflatibles_CO2_DECIBELS'. The code in the editor is as follows:

```
//  
String portName = Serial.list()[0];  
println ("port list: " + portName);  
myPort = new Serial(this, portName, 9600);  
//  
decibelRequest = "<?xml version='1.0' encoding='iso-8859-1'?><methodCall><methodName>timestreams.select_latest_measurement</methodName><parameters><parameter name='timestream_id' value='1' /></parameters></methodCall>";  
co2Request = "<?xml version='1.0' encoding='iso-8859-1'?><methodCall><methodName>timestreams.select_latest_measurement</methodName><parameters><parameter name='timestream_id' value='1' /></parameters></methodCall>";
```

Fig.53 Code for adding a *Timestreams* in processing

The code is set up to call the measurement and if it is within a certain range then the artwork responds accordingly.

In the case of the Inflatibles the measurement of CO2 decides the speed of the switch on the fan in the largest inflatable sculpture. The greater the CO2 measurement the faster the switch on the fan works and the more the inflatable sculpture appears to be breathing heavily (see Fig.46)

6.7 The Experimental Artworks

As a result of the activities in each of the phases described in the previous sections, Active Ingredient and the other participant artists created a series of experimental artworks that used or responded to the *Timestreams* Platform and were presented to public audiences during the exhibition at Barracao Maravilha, in Brazil and at Primary Studios, in the UK.

The artist motivations, strategies and rationale for these artworks will be discussed in more detail in Chapter 7 as part of a thematic analysis of the artists contributions to the *Relate Project*.

Due to some of the challenges of developing artworks in parallel to the technical development of the platform many of these artworks were created as prototypes and only a

few directly used the data on platform as part of their public presentation. The reasons for this are mainly due to issues of timing between the development of the platform and the activities planned within each phase of the project, and the challenges already described of working in a remote forest in Brazil.

Before Light (Fig.54)

Before Light, is a performance of lights turning on and off at dusk at the farm in the forest and mountains of the Mata Atlantica (Atlantic Forest), devised by Leal and Blum, with music composed by Lee.

Leal produced the video performance in six rooms in the farmhouse, photographed this performance as time lapse as dusk fell (which occurs very fast in Brazil as it is so near the equator). Inspired by the CO₂ data captured using the *Timestreams* Platform at the same location on a previous date, Leal calculated a binary representation of this for the purposes of the piece. The 6 other members of the team were given a print out of these numbers and using a metronome to keep in time they turned the lights on or off to represent the binary conversion of the data. To accompany the video music was created by transforming the binary numbers into a set of musical notes. This work provides an example of how an artist did not plug directly into the platform to present the work, yet the work was created using data captured on the platform and in collaboration with programmers. The video was presented at the exhibition at Barracao Maravilha.

The Prediction Machine and Weather Fortune Empadinhas (Fig.55)

The Prediction Machine is made of found objects, a printer, Arduino, digital display, temperature and humidity sensors and printed weather predictions based on interviews made at the farm and at the artists' studio in Brazil. This artwork was devised by the author (Jacobs) and Selby.

The print outs read like fortunes, predictions on the current weather data and people's observations of the weather, what they think might happen in the future and how this will impact on their lives. The artist/author also made handmade fortune cookies based on Empadinhas, a small handmade, sweet pasty-like cake common across South America, with a paper fortune hand written on the inside for people to eat, this enabled her to test the concept. The Weather Fortune Empadinhas were offered to visitors at the exhibitions at Barracao Maravilha and Primary Studios alongside a presentation of the Prediction Machine. Visitors could choose from four different plates, each plate was based on a different climate model,

predicting different future scenarios, based on IPCC climate model forecasts²⁶. Visitors had to choose the scenario and then choose a Fortune Empadinha. Each of the fortunes were based on interviews made with the artists and farm managers during the Brazilian residencies.

The Weather Fortune Empadinhas were made as a *'paper and cake'* concept test for the prediction machine as the machine wasn't set up to connect with the *Timestreams* Platform at this stage, testing the concept of choosing different datasets in order to get different predictions.

Watching Me Watching You (Fig.56)

Watkins and Shackford conducted a series of experiments capturing data and human presence in the forest around the farm. *'Watching Me Watching You'* involved capturing time-lapsed images using two mobile phones, running the Active Ingredient mobile phone app, as Watkins sat watching the forest on the edge of the farm change over several hours. The video was overlaid with animated dots visualising the invisible data in the atmosphere and he wrote his thoughts about the changes in the environment he perceived, drawn on a piece of card, which he held up at intervals to show to the camera.

Mini Apocalypse (Fig.57)

Watkins also conducted an experiment to see if he could create a mini apocalypse in a circle of grass on the farm by covering the area with a dome to increase the heat and humidity in the area under the dome. The concept was to create a miniature version of the earth heating up and to sense the outcomes using the *Timestreams* sensors. Watkins created a narrative piece of work around this, placing tiny figurines representing each of the team members inside the dome and writing a story around the characters experiencing the extreme climate of the dome. This experiment was then documented in photographs for the exhibition at Barracao Maravilha and for the project blog.

Alvorada Dawn (Fig.58)

Alvorada Dawn was devised by Rebecca Lee, created using audio collected at dawn across Brazil and UK. The two streams of audio data were then replayed at the exhibition at Barracao Maravilha and at Primary Studios.

²⁶https://www.ipcc.ch/publications_and_data/publications_and_data_figures_and_tables.shtml#Ugj2hODRe

Lee's artistic work in response to the platform involved setting up these dawn recordings over five days between the remote locations of Nottingham, UK and on the farm in Brazil. The process involved getting up at 5am during the residency at the farm, waiting for the dawn, recording it and collaborating with an artist back in the UK to do the same. Both sets of recordings were composed as a sound installation. The work did not connect directly to the *Timestreams* Platform, although the recordings and the final work were added to Active Ingredient's *Timestreams* blog via Sound Cloud, and can be viewed online.²⁷

Lee also conducted further research into how *Timestreams* could plug into existing sound software and online tools such as Sound Cloud, using the *Timestreams* data feeds, to enable *Timestreams* audio works to be created in the future.

Thunder Drum (Fig.59)

Devised by Mark Selby, a motor and Arduino were attached to a thunder drum and live humidity data was fed to the drum, causing the drum to respond to the data, replaying the humidity through the rumblings and cracklings of the drum. This was set up during a storm at Barracao Maravilha, playing out the storm.

Interactive Visualisations (Fig.60)

Shackford also devised a series of prototype visualisations that used CO₂; temperature and humidity data to create an abstract representation of the environment and human presence who walked through the environment captured using the webcam on a laptop. The image appeared and broke apart in response to live *Timestreams* of temperature, humidity and CO₂ data captured via the *Timestreams* Platform. These visualisations were created in Unity and developed as an offline visualisation interface and embedded into the blog as an interactive online visualisation.

The Inflatibles (Fig.61)

As a result of the residency at Barracao Maravilha, Active Ingredient worked with Hugo Richards and Natalie Tublenchak to create the Inflatible sculptures, responding to decibel levels from the very loud busy street of Barracao Maravilha. The three small inflatables 'breathed' in response to the sound, inflating and deflating as the data changed. An Arduino was connected to the three inflatable structures, which fed a Timestream of live decibel readings from the street outside. Each inflatable structure responded based on a different

²⁷ <http://ai.timestreams.org/2012/11/08/audio-dawns-and-sound-waves/>

range of levels (low, medium, high), creating a kind of graphical equalizer based on the sounds of the Rio streets.

For the exhibition at Primary Studios in Nottingham (Phase four) the Inflatibles were re-developed to respond to multiple *Timestreams*, the two smaller inflatable structures continued to respond to decibel levels and the larger structure responded to CO₂, beginning to explore ways to visualise energy and environmental, climatic changes in response to the artists' initial interest in capturing breath and wind.

The Rite of Spring (Fig.62)

The Rite of Spring was created by the Brazilian artist Bruno Jacamino, using the Mauna Loa CO₂ series [25] to control the speed of a record player that played Igor Stravinsky's *The Rite of Spring*.

Jacamino played the CO₂ data directly from *Timestreams* in order to control the *Rite of Spring*. This music was specifically chosen as the residency was taking place in springtime in Brazil, which was particularly meaningful in reference to the visiting team from the UK, where the difference in seasons also represented the distance in location between Brazil and the UK. The choice of record also resonated with a live experience for the audience listening to the record player, as in that particular week Rio had just experienced the hottest day of the year, which had been unusually hot for Springtime and then the weather changed to unusually strong storms, people were talking about the weather and how unusual it was.

Hydroponics (Fig.63)

The artists Caroline Locke and Noel Murphy brought elements of the British artist Locke's artwork Hydroponics²⁸ to the hackday to explore how *Timestreams* could be used in conjunction with the sounds fountains. In these experiments Locke and Murphy used live CO₂ data to create movement on the surface of the water of the sound fountains (see Fig.61) and images uploaded using the Active Ingredient mobile phone app to the Hackday blog to experiment with how the process could be revealed to an online audience.

The Bulb Experiment (Fig.64)

Matt Little and Michael Erskine collaborated to hack into an old style lightbulb, creating an actuator by *Timestreams* data that controlled a potentiometer connected to the incandescent light. The Timestream played out Mauna Loa CO₂ data set the measurements at a rate of approximately 1 year every 10 seconds.

²⁸ <http://www.carolinelocke.org/index.html>



Fig.54 Screen capture of the video of Before Light



Fig.55 The Prediction Machine and Fortune Empadinhas



Fig.56 Watching Me, Watching You



Fig.57 Mini Apocalypse



Fig.58 Visitors listening to Alvorada Dawn



Fig.59 Thunder Drum



Fig.60 Interactive Visualisations of CO2, light and colour data



Fig.61 Inflatibles exhibited at Barracao Maravilha alongside other work by Richards and Tublenchak



Fig.62 A member of the public listening to the Rite of Spring at Barracao Maravilha



Fig.63 *Timestreams* experiments with Locke's Hydroponics



Fig.64 The Bulb Experiment

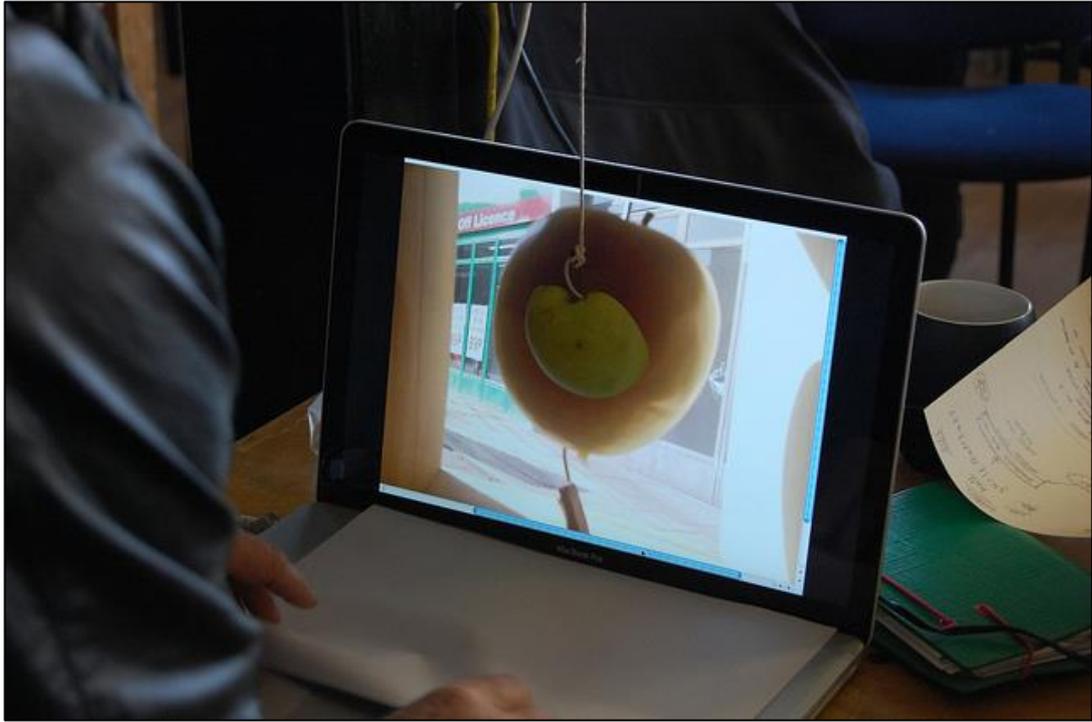


Fig.65 The Journey of an Apple

The Journey of an Apple (Fig.65)

The British artist Frank Abbott brought to the Hackday event a concept of a journey of an apple from one continent to the other, to track the impact of this journey in terms of the carbon footprint. This experiment took part as some initial reflections on an artwork Abbott was developing to be presented publicly at Nottingham Castle, Autumn 2013. To test his ideas Abbott conducted a simple experiment tracking a journey of an apple from one end of the street to another by creating a box in which to hold the apple and the sensors during its journey as the artist walked down the street with it, capturing images and decibel levels using the Active Ingredient mobile phone app, and CO₂ using the sensor kit.

Conclusion

As can be seen by this detailed description of each of the components, the *Relate Project* was a large ambitious project that took place across the UK and Brazil, involving the development of a novel sensor blogging platform, and a series of artistic experiments and activities that responded to the platform and the project themes.

This ambitious project was a unique opportunity to implement the findings of the previous study into the design of the platform and to observe and study how the other artist participants in the project approached working with climate data, comparing the strategies that they used with the findings from *ACBT*. This study and an analysis of the findings are investigated in the next chapter.

7

Analysis of the Relate Project

This chapter presents the findings from the study of the *Relate Project*, described in the previous chapter. The study presents the perspectives of the artists – in this case Active Ingredient’s team (including the artist/author) and participant artists, hackers and the HCI researchers and climate scientist.

This study provides the following opportunities for investigating artists’ contributions to public engagement with climate data:

1. Testing the themes that emerged from the earlier study of *ACBT* with a broader community of artists
2. Refining and extending the themes to present a final discussion that reveals how artists create emotional engagements with climate data
3. Exploring the impact of these contributions on the design of a sensor blogging platform - *Timestreams*
4. Providing a broader discussion of the role of the artists

This chapter begins by presenting the study methods employed during this study and a brief description of each of the study participants, their goals and resulting engagements, followed by an in depth thematic analysis reframing the themes presented in the first study, to

encompass the new perspectives of the artists, scientist and HCI researchers who participated in the *Relate Project*.

In the next chapter the author will presents a discussion of the role of the artists through a further analysis of the study and in reflection of related literature.

7.1 The Study

This second and final study involves presenting the perspectives of the artists, hackers, researchers and scientist involved in the *Relate Project*.

This study focused less on public engagement and more on the design and impact of the platform, the strategies employed by the various artists that used this platform for capturing and ‘performing’ climate data. In support of these objectives the following questions were included in the interviews:

- How did the artists who used the *Timestreams* platform respond to the system and its functionality?
- What were the challenges and opportunities created by their interactions with this system?
- Did participating in this project shift their perceptions of energy and climate change data within their arts practices?
- What was the impact of the artists’ distinct contributions on the scientists, technologists and educators involved in the *Relate project*?

This study focused on four elements of the *Relate Project*:

- Technical development of the *Timestreams* Platform
- Rationale of production for the ‘artists’ conceptualisations’ (as described in the previous chapter) created in response to the platform
- The ways that the artists and hackers engaged with and used the platform
- Collaboration between the artists, scientists and researchers
- Impact of the findings from *ACBT* on a wider group of artists and the design of the platform

7.1.1 Study Methods

As with the previous study of *ACBT* the author employed a mixed method approach involving semi-structured audio interviews conducted with the artist team (AI), researchers (Horizon Digital Economy Research Institute), a climate scientist (MET Office UK) and participant artists and hackers (Brazil and UK).

As in the previous study, the artist will refer to herself as '*artist/author*' when discussing her own artistic contributions. When referring to all of the artists (including Active Ingredient) she will use the term '*the artists*', and when referring solely to the other artists who participated in the project as '*artist participants*'. A more detailed explanation of these participants is provided in the next section, along with brief descriptions of each of the participants' background, goals and engagement.

The core study method involved using three different methods:

1. Interview/conversations with members of the Active Ingredient team, the Horizon team and collaborating scientists to investigate the rationale of production, system design and impact of the collaborations
2. Observations of the participant artists and hackers at the UK Hackday event (Phase Four) conducted by Horizon ethnographic researchers
3. Audio interviews conducted with the participant artists and hackers in Brazil and the UK

This analysis focuses primarily on the interviews but is supported by general documentation and additional research including:

- Blog posts by the Active Ingredient and Horizon teams and Silvia Leal
- Interviews by the Principle Investigator on the *Relate Project*, Gabriella Giannachi, including an interview with the artist/author
- Video footage combining self documentation by Active Ingredient, ethnographic documentation by researchers from Horizon Digital Economy Research Institute and video footage filmed by a professional film maker employed by Active Ingredient to document the artists work
- Photographic documentation of the artist team (AI), the artworks, participating artists and the technical development
- Sketches and notebooks provided by the artist team (AI)

The interviews were conducted using a set of pre-defined questions, with a view to create a conversation as discussed in Chapter 3, framed by the research questions of this thesis and the findings from the previous study. The interviews took place between the author and the participants during the relevant phase of the project (in Brazil) and post-participation in the Hackday event (in the UK).

An additional ethnographic study was also conducted by Horizon researchers that took place solely during Phase Four (the Hackday event) with the artist participants in the UK, this is referenced when appropriate within the analysis.

7.1.2 Aims of the Study

The interviews included an investigation into the following themes that were revealed in the first study:

- Sensory experience / sensing
- Embodied experience / embodying
- Performativity
- Composition and juxtaposition
- Temporality

Alongside extending the findings from *ACBT*, the interviews provided an opportunity to compare the artists' contributions to working with climate data with those of the technologists, hackers and engineers who also participated in the *Relate project*.

7.1.3 Study Questions

This study addresses the following top-level research questions, in order to understand the rationale of the artists and other partners, how they engaged with the platform and the data:

1. What was the rationale of production for the experiments that the artists developed as part of the *Relate Project*?
2. What was the artist participants' experience of using and engaging with the *Timestreams* platform?
3. What was the nature of the collaboration between the artists, climate scientists and HCI researchers?
4. How did the artists engaged with climate change and energy data through using the *Timestreams* platform?

7.2 Introducing the Participants

This section presents an overview of the participants who took part in the study, categorised into four groups, as outlined in Table 8. These brief description of each of the participant's background, as well as an overview of their motivations, role in the project and key activities are included in order to contextualize the following broader thematic analysis.

Table 8. Participants in the Study of the *Relate Project*

Participant Group	Key Interviews
HCI Researcher	Blum Flintham
Active Ingredient	Watkins* Lee* Jacobs* Selby Leal
Artist Participants and hackers (Hackday event in UK)	Little Abbott Murphy Erskine
Artist Participants (Barracao in Brazil)	Richards Tublenchak Jacimono
HCI Researcher	Blum Flintham
Climate Scientists	Buontempo

*Watkins, Lee and Jacobs (the artist/author) also took part in interviews by the principal investigator Giannachi that are also included in the analysis

The following descriptions are designed to provide a contextual insight into the range of participants, their backgrounds, goals and resulting engagement with the *Timestreams* platform.

7.2.1 Active Ingredient

Active Ingredient facilitated activities throughout the four phases of the project and devised a series of artistic experiments, outlined in detail in the previous chapter.

Matt Watkins - Watkins is one of the two remaining founder members of Active Ingredient coming from a performance and visual art background. Watkins describes his interest in working with the *Timestreams* platform as an opportunity to:

“...raise a conversation to create work that would that would make people think about the effects of climate change or make them aware of even the very small changes that are going on in and around them in their local area”

Watkins’ specific role involved co-designing the interface of the *Timestreams* Platform, as well as creating artistic experiments in response to the platform during the artists’ residencies (Phase Two and Three of the project).

Rebecca Lee - Lee is an associate member of the Active Ingredient collective, her key role was facilitating the community engagement and participating in the artist’s residencies. Her artistic practice involves music performance and composition, sound based installations, arts education and participatory arts. Lee reflected on what interested her about the *Relate Project* was how the artists could develop a language to access data that enabled a sense of personal connection:

“I think it is really important for people to be able to interact with the data that keeps that vocabulary they use, to keep that personal stuff and how you bring all that together”

Lee also conducted further research into how *Timestreams* could plug into existing sound software.

Mark Selby - Selby is an associate member of Active Ingredient who joined the collective as part of *ACBT* and remained an associate member for the duration of the *Relate Project*. His role is as an artist and interaction designer, his background is interaction design, visual art and research. Selby describes his interest in working with *Timestreams* as stemming from a broader interest in subjective experiences of data:

“...how we can kind of re-experience the data that is recorded about our experiences”

Selby’s role involved supporting the artist participants to create interactive works, particularly using the API to plug into Arduino, to enable real world, interactive, physical manifestations of the data. Selby also developed his own artistic experiments and worked with the other artists on the Active Ingredient team to support their artistic vision.

Silvia Leal - Leal is an associate member of Active Ingredient who has been collaborating with the collective from her base in Rio de Janeiro, Brazil, since 2010. Her role involved facilitating work across the UK and Brazil, connecting with schools, communities, art spaces and artists in Brazil. Her artistic practice involves socially engaged participatory, visual and performance art she also works as a curator of Contemporary Art in Brazil.

Leal talks about how her interest in the *Relate Project* and *Timestreams* Platform connects to a wider interest in ‘time and space’ within her arts practice, reflecting on the subjectivity of understanding broad concepts such as energy, environment and climate change:

“...you know this idea of people in a time and space, in a particular space and over a certain time... I think with the study that we did and the research we did, we realized all the time how broad that was and it only really started to make sense when we brought it back to our kind of experience and the presence of making work or thinking about collaborating together”

7.2.2 Participant Artists and Hackers, UK

This study focuses on four of the artist and hacker participants of the UK Hackday event all of whom engaged directly with the platform.

Michael Erskine - Erskine is an engineer and hacker and one of the founders of Nottingham Hackspace where the hackday took place. Although he doesn’t consider himself as an artist, much of his hacking is experimental and involves a creative process of production. Erskine works professionally developing systems that capture and manage data collection.

Erskine has a high level of technical expertise and appears to be interested in how the platform works, using the Hackday as an opportunity to play with some of the electronics he was currently hacking and connect them to the platform. Erskine created a variety of experiments during the Hackday and supported some of the other participants to develop their experiments.

Matt Little - Little is an electrical engineer with some programming experience, working in a multi-disciplinary capacity in the renewable energy field. He has a specific interest in revealing the physicality of energy in a variety of ways, including mechanical or pedal-powered devices, and integrating weather data.

Building on his existing experience and interests, Little wished to create an actuator that took *Timestreams* data and manifested the measurements physically in some way, with the aim of recreating the environment from a geographically remote area to give a sense of presence, by replaying measurements captured by environmental sensors. Little developed a visualisation using Arduino and Processing that connected to the *Timestreams* platform and made use of the same Mauna Loa data series as *ACBT*, in lieu of a significantly remote sensor, in order to control a potentiometer connected to an incandescent light.

Noel Murphy - Murphy is an artist with experience of programming for artistic projects. He often takes the role of a ‘creative programmer’ sitting between the tools, such as *Timestreams* and artists like Leal and Locke, who have less technical skills. He also makes his own artworks.

Murphy attended the Hackday as it offered an opportunity to apply his skills by using the *Timestreams* platform to transform data. In particular, Murphy was interested in integrating *Timestreams* data to enhance an existing artwork described in the previous chapter that he had previously worked on in collaboration with another artist (Locke). Murphy used *Timestreams* to access CO₂ data recorded from a sensor in the room. Murphy suggested that the *Timestreams* platform could support his own skills development and extend the way he works with live data.

Frank Abbott - Abbott is an artist who has collaborated with Active Ingredient in the past. He comes from a background of artist film and video and more recently has made performative artworks using interactive technologies, found objects and video that are often hacked and recycled. Abbott came to the Hackday event with a specific artwork in mind that he had discussed with members of the Active Ingredient team prior to the event. He was interested in how he could explore an emotional response to data collected through the journey of an apple by using the *Timestreams* platform.

7.2.3 Participant Artists, Brazil

Active Ingredient spent a day with each of the resident artists at Barracao Maravilha, Rio de Janeiro. Only the artists Richards, Tublenchak, and Jacamino have been included in the study, as they engaged directly with the *Timestreams* platform.

Hugo Richards and Natali Tublenchak - Richards and Tublenchak are artists based at Barracao Maravilha who work together to create inflatable sculptures. These sculptures are powered by electric fans using small generators and have been installed in public spaces in the 'natural' environment as well as galleries. The *Inflatibles* have toured in South America and were exhibited at Barracao Maravilha alongside the residency exhibition as described in the previous chapter.

Richards and Tublenchak suggested that working with Active Ingredient during the residency provided them with an opportunity to explore ideas that supported their own lines of enquiry and interests around the inflatable works. They were interested in how the *Relate Project* could support them to rethink the way they worked with the Inflatibles in the environments where they were installed, to expand their 'site specificity' (Kwon 2004).

Bruno Jacamino - Jacamino was introduced to Active ingredient as being the key artist at Barracao Maravilha who was likely to be interested in working with *Timestreams* as he already had an existing interest in data, the environment, technology and electronics. Jacamino's artistic background comes from studying sculpture but he describes his work as exploring 'sound and presence in 3D space'. Much of his work has involved hacking

electronics, he has some programming knowledge and experience of working with often recycled technologies.

Jacamino used *Timestreams* to access the Mauna Loa data set that was previously loaded onto the *Timestreams* Platform.

7.2.4 Horizon Researchers

The HCI researchers are based at Horizon Digital Economy Research Institute at the University of Nottingham, UK and were involved in all four phases of the *Relate Project*.

Jesse Blum - Blum was involved in the technical development of the *Timestreams* platform and supported all four phases of the artistic activity. Blum was present in Brazil for both the artists' residencies (Phase Two and Three) as well as co-facilitating the Hackday with the Active Ingredient team in the UK (Phase Four). Blum comes from a traditional Computer Science background and his previous research involved developing systems for data modeling. He has recently joined Horizon Digital Economy Research Institute and this project was the first time he worked directly with and developed technology for artists and communities. Blum saw his role as:

"...thinking about the research question and talking to the rest of the team and helping to do the systems analysis and architecture side and actually implement the vision that the team has kind of come up with and to do some field testing with it as part of the group in Brazil and at various events... I've also been involved a lot in the dissemination, going and giving talks about it, explaining and trying to get additional users"

Martin Flintham - Flintham was Principle Investigator on the *Relate Project*, he was involved in working with Active Ingredient during the research phase (Phase One), developing the technical infrastructure for the *Timestreams* Platform throughout the project and attended the Hackday event (Phase Four). Flintham has worked on previous collaborations between Active Ingredient and Horizon Digital Economy Research Institute as a researcher and technical developer as well as with other artists groups, and therefore has a wide range of previous experience of HCI/arts collaborations. Flintham suggests that the aim of the platform, from his perspective, was to create a system enabling the input and output of data:

"It's a very literal thing you know you are taking data and you are putting it into it and then the output"

Flintham was specifically interested in how the sensors and platform can enable people to relate to the environment, in order to encourage participation in 'citizen science' and to address who the potential user groups of the platform might be.

7.2.5 The Climate Scientist

Carlo Buontempo - Buontempo advised on the climate data and the relationships between energy and climate, supporting Active Ingredient's use of and access to climate data throughout all four phases of the artistic activity. Buontempo is a senior climate scientist at the MET Office UK, Hadley Centre where he has the position of Climate Hazards and Impact Processes Team Leader. He previously collaborated with Active Ingredient on the first case study *ACBT*. Buontempo suggests his motivations were an opportunity to create a follow on project to *ACBT* and to continue working with Active Ingredient to explore how the technical development of the platform could be useful across art, science and research.

These descriptions provide an introduction to the participants and their engagement in the *Relate Project*, these will be extended as part of a rich thematic analysis of how the artists used the *Timestreams* platform, their strategies for working with climate data and the impact of these contributions on the scientists and technologists.

7.3 Thematic Analysis

In Chapter 5, the study of *ACBT* mapped out how Active Ingredient engaged with the public in their work with climate data, the strategies used by the artists, and the themes that emerged from combining the perspectives of the artists, the visitors and the climate scientist.

In this study the themes from *ACBT* are again explored from the perspectives of the artists from Active Ingredient, alongside the other artists, hackers, HCI researchers and climate scientist who participated in the project, contributing to the following analysis and reframing of the themes to take into account these new perspectives.

Table 9 summarises how this study has resulted in the author renaming some of the key themes, bringing different themes to the fore and digging deeper into the sub-themes.

The top level theme that emerged from the study of *ACBT* – provoking an emotional response – remains an overarching theme in the case of the *Relate Project*, yet, it should be noted that this study doesn't include an analysis of the public's response to the artworks. Therefore the following thematic analysis focuses on refining and reviewing the emerging themes and sub-themes from *ACBT* refined as *performing data*, *sensory experience* and *multiple interpretations* (see Table 9). The distinct ways that the artists provoked an

emotional engagement with the data is reflected across all of these emerging themes, as opposed to being discussed as separate theme, as in the last study.

Table 9. Reframing the themes

<i>Key Themes from ACBT</i>	Key Themes from Relate	Refining the sub-themes
<i>Performativity</i>	Performing Data	Narrative Temporality
<i>Embodying and embedding</i>	Sensory Experience	Embodied and Embedded Materiality
<i>Multiple interpretations and dialogue</i>	Multiple interpretations	Dialogue Abstraction Juxtaposition

7.3.1 Performing Data

The key theme of performativity that emerged from the study of *ACBT* has been refined in response to the findings of the *Relate Project*, to focus more specifically on the strategies used by the artists to ‘perform data’. The artists describe the ways in which they created these performances of data to encompass narrative and temporality, which they considered as significant factor in the ways that the artists ‘performed’ the data within this study.

The notion of the artists ‘performing data’ is one of the most interesting and novel concepts to emerge from this research. This concept is based on a combination of literature that explores notions of ‘performing nature’, including Giannachi’s previous work looking at artist’s conceptualisations of climate change (Giannachi & Stewart 2005; Giannachi 2010; Szerszynski et al. 2003), Active Ingredient’s previous work with sensor data (Giannachi 2012; Flintham et al. 2011; Davis et al. 2005; Davis et al. 2006), and working in forests in Brazil and the UK (Flintham et al. 2011; Rimmer et al. 2009; Davis et al. 2005; Davis et al. 2006). Watkins reflected on this notion of performance and data after the *Relate Project* was over:

“...performance is there in terms of the way we make the data perform or that we create a situation where the audience can influence what’s going on... kind of feedback loops between the audience, the experience and back to them and so either they are actively taking part in it and they become active performers”

Findings from both studies suggest that this concept is not unique to Active Ingredient. Many of the artists who also participated in the *Relate Project* were informed by notions of liveness, presence and influenced by the traditions of performance art (Giannachi & Kaye 2011; Stiles & Selz 1996; Pfister 1991), social engagement and dialogic aesthetics outlined in the literature review in Chapter 2 (Kwon 2004; Kester 2004; Kester 1998). One of the UK participant artists Murphy makes reference to his background in theatre design when he talks about the notion of performing data:

“So maybe that kind of stagecraft is present and it lets you work, because that's kind of what you're doing with visualising data, you know, you're making a show out of something that's just there...”

The HCI researcher Flintham questions how the concept of ‘*performing data*’ could be perceived from an HCI perspective, suggesting within this context the notion of performance was more about the way that the artists mediated the data than it’s final presentation:

“I'd say that performance is one of the creative things where you add stuff, so when you perform a play you add extra stuff from what is actually in the text, you bring character to it in order to have additional stuff and that's what makes it performed rather than read so I'm not sure I've really understood how that directly is translated to an installation of data and so I think one working principle is that the performance of data was more manipulation, configuration, orchestration, of it, because I don't see how you could perform - its not like your voice where you can add extra emotion to a bunch of numeric data”

The other HCI researcher Blum also attempted to define the *Timestreams* Platform in terms of ‘*performing data*’, highlighting how this notion played an important role in the development of *Timestreams*:

“...the purpose of Timestreams is to make something to perform data and that the performing data maybe along with social connections between different communities, those two strands together form what I think the basis of the meaning behind Timestreams”

One of the hackers, Little, reflects on how by collaborating with Active Ingredient and the other artist participants he was able to consider his bulb experiment (described in the previous chapter) as a performative experience, more than the type of engineering experiment that he was used to conducting:

“I hadn't fully thought of it as a performance I mean I think it shows it kind of was a performance in the end, it was getting hotter, the bulb was getting brighter and it was an old incandescent bulb as well which I quite liked”

Murphy also talks about how the notion of performing data in reference to how he has worked in the past with artifacts, proposing that the artifacts he creates often develop their own characteristics and narratives as if they were actors on a stage:

“I think of HeliOscillator²⁹ ... it’s this weird personality... even now, I’ve got the little iPad version and I’ve been running it... I made both of them, I know how it sounds, why it sounds the way it does, but the fact that it sounds like the big one does, still kind of surprised me.”

The following sub-themes dig deeper into these strategies that the artists employed in order to create these ‘performances of data’.

Narrative

Watkins describes the role of narrative within the artists’ ‘performance of data’ and how a sense of the theatrical enables the data to tell a story:

“...when you’ve got like the Mauna Loa data you can clearly see these rings getting bigger and bigger and bigger, there’s a kind of drama in that, that’s kind of quite impressive that you can create a big emotional or emotive story... whereas the problem we’ve had with when you are working with locally and in a small time frames you have very little change”

Buontempo suggests that the way the artists engaged with narrative, through personal and emotional responses to the data, contributes to on going discussions within climate science around the use of storytelling to engage the public with the science:

“...you know its about fitting into a more general theme about storytelling and... we have had discussions a few months ago, we’ve had discussions about the fact that maybe we should be engaging storytellers and trying to find a narrative about climate change and it doesn’t mean, doesn’t need to be the narrative we had as a way of broadcasting information you know why not having, so yes very stimulating in terms of an artist response. As a science response well there wasn’t much there for me but as a starting point from a reflection that was great.”

Erskine talks about how he considers performance and narrative as the ‘long goal’ in his work as a hacker/engineer, suggesting that although he is interested in these notions he focused more on the functions of the work:

“If it has humanoid-type interactions then... you know, then I’ll definitely have a sort of script involved... it’s waiting to recognise something like hello, you know, but these things

²⁹ <http://www.visualdisplayunit.org/helioscillator-project>

rarely get very far – or I’ll get all the framework in place and then not really have time to develop it further. But performance, yes, performance could be... Like I say, it’s a long goal. It’s one of those great things that just you could get out of a piece of work if you have a bit of time.”

Lee explores how the artists begin to walk the line between the empirical, science based ‘*story of the data*’ and creating narratives as a subjective response, an issue that was also previously explored in the study of ABCT:

“...it’s really important to understand what it is representing properly... you never know what, what it came from, what the process is that made it happen, and how it was captured and what that instrument was, you know the story of the data, I suppose is really important to know that as well”

Buontempo suggests that these challenges around how to build narratives around the data can also exist for climate scientists. He tells a fascinating story about how a senior climate scientist dealt with a dilemma of representing the data around Hurricane Sandy (a hurricane that hit the Caribbean and east coast of North America in October 2012 with devastating effects):

“I think it is interesting for this discussion what she said cos when Cyclone Sandy I think it was hit in New York all the climate scientists received a number of phone calls saying ‘is this due to climate change?’ and 99% of climate scientists said ‘well no, we cannot attribute one event to climate change because its no. What you can say is that climate change will make this sort of event more likely so going forward it is possible... but I must admit there is some truth in what she is saying that the right answer would have been ‘yes it certainly has to do with climate change’ and then basically say the same thing after that, but you know... I think it is very dangerous approach but I do understand what she means, you need to engage with your audience, if you start with your caveats and you barricade yourselves in your ivory towers, then I think you are not necessarily do a good service”

This scientists’ perspective suggests that the artists’ interest in telling stories, building in drama and theatricality in response to scientific data, can respond to some of the challenges scientists encounter in order to find ways to tell complex stories about the data without disrupting the disciplinary boundaries and paradigms important to the scientific communication of climate change.

Temporality

Temporality is also revealed as a key strategy used by the artists to ‘*perform data*’ and provoke emotional engagement. Temporality is also seen as a significant element in the

design of the *Timestreams* platform – encompassing slowness, liveness, scale and speed. The temporal structures that informed the development of the platform also inspired its name and the way that users authored and played with the data along the ‘*Timestream*’ timelines (as described in the previous chapter).

Despite this the artists appeared to want the tools to be simple, familiar and accessible in order to release them to explore temporality through their own performative and narrative strategies, yet the HCI researchers who developed the platform were keen to explore other forms of representation of the timeline interface. Blum suggests that there may be better ways to represent time within the platform:

“...to paraphrase a Scottish doctor who said time is ‘wibbly wobbly’ I wonder if the timeline is the best metaphor... if there’s maybe other representations that, I won’t say better but different... what we could do to convey temporality a little bit more, in Timestreams, make time kind of come out of the wash.”

Flintham also proposes a different approach:

“Maybe a better metaphor would have been water, the time streams like having pipes connected pipes, you know sharing the flows, big flows, little flows, flows that go slower”

In response, in Giannachi’s interview (that took place at the beginning of the design phase) the artist/author discussed Active Ingredient’s rationale for the design of the timelines:

*“We have been looking at how we represent live experiences through sensor data and how the platform can help artists author or build live performances of this data, by re-enacting and re-interpreting the data as a live experience. As a response to this we have started to develop some ideas that we are calling ‘time streaming’, where the platform can provide a way to author live/recorded/historical data. Matt has designed a prototype dashboard (user interface) to do this. These discussions are helping us to make decisions on how we deal with gaps in connectivity, layering live data with recorded data and replaying data from the past, all issues we experienced whilst exhibiting *A Conversation Between Trees*.”*

Despite Blum's concerns around the interface, all of the artists chose to create artistic experiments that involved dynamic interpretations of the data, using time-series data, even when they made work in response to *Timestreams* but weren’t plugged directly into it, as with Leal, Lee and Watkins’ work.

Blum discusses how the platform was designed to deal with this time series data in novel ways, in response to the artists’ requirements and Active Ingredient’s experiences of working with sensors as part of *ACBT*:

“...normally with Timeseriesed data you have your sensor, you let it go, collect a whole bunch of data in a nice fixed metronomic kind of period, here things are quite often turned on and off again and then maybe there is a bit of dropped signal... so that the regularity is not quite as nicely manageable”

He also explains that by using historical data, across many decades, which is particularly relevant for aggregated climate data such as the Mauna Loa CO₂ series, he came across issues around how UNIX systems timestamp data. This form of time stamping data assumes that *“...the universe started in the year 1970 and the universe will finish in the year 2038”*. Although there are solutions to this particular problem it significantly revealed the complexity of developing systems to manage climate data that often encompasses long, slow datasets. Friedman et al (Friedman & Nathan 2010) discuss how these challenges of slow datasets and multi-lifespan design can require different approaches to designing information systems.

ACBT reflected these issues through the strategies for designing multiple interpretations of climate data. The findings from the study of the visitors' response to *ACBT* show that a more human scale perspective was made possible by shifting focus away from veridical representation and towards more emotional and personal engagements with the data. This directly informed the initial design of the *Timestreams* Platform in the way users could play with the scale of the data, as well as choose sections to highlight and replay, extending the slowness theme that emerged in the study of *ACBT*, to encompass a more general approach to the way artists mediated data, including different scales and speeds.

The way that the artists played with the scale of the data appeared to be particularly important within the *Relate Project*, reflecting the often slow nature of climate data (Thoning & Tans 1989). Buontempo describes how the effect of these slow timescales can affect our ability to perceive risk and the challenges of communicating this in an emotional way:

“We cannot have an emotional response to that sort of peril and that sort of hazard because we don't see it, its just happening on timescales that our brain is not designed to cope with you know we are very good at running away from a lion that is trying to eat us but absolutely incapable emotionally to react to an increase of hundred parts per million of CO₂, it doesn't mean anything to us, and it doesn't, you sit on the edge of the forest and you see nothing happening and it looks like the day before, the year before or the decade before and we are really bad in reacting to these hazards because we don't see them, so yes I think its, while I appreciate what you are saying, it makes a boring movie, the point though is a very important point”

Many of the artists responded to this notion by scaling the data, to support greater

engagement with these narratives of risk and threat. Jacamino also describes how he attempted to mediate and scale CO2 data using his record player, by speeding it up and slowing it down in response to the variations in order to find ways to discover emotional connections or meanings in the data:

“There is a significance in dealing with important data such as CO2 or Decibels or Humidity etc. How to articulate this thinking within the arts, it’s obvious, extreme, the work with the record player allows one to experience exactly that, the scientific data. There is an importance of the data and the opportunity here is to throw these into the campus of art as material. Provoking and perceived in some way, it points to the difficulty of the understanding of data, but transforming it into a poetic construction.”

Some of the artists and hackers decided to magnify or otherwise highlight aspects of their data in order to enable different types of sense making, as Murphy reflects:

“I think it’s important to be able to explore data in as many ways as possible, just to see if it makes a difference... people connect with things on different levels for different reasons and I think you need to explore all of those things, because there might just be something that we’re missing, that you can only tell in a certain way”

Little reflected on how the function of a ‘Timestream’ as a single authored dataset, in contrast to a more traditional query-able, static database of measurements, enabled him to play with the scale of the data in this way:

“You are just getting any data that that thing points to, which is actually quite a nice way of doing it”

As Little was already a skilled programmer and engineer he was able to bypass many of the technical issues involved with the platform still being in development which appeared to enable him to focus on these issues of scale, authenticity and sense making in relation to the tools available within the platform. He describes this process of experimentation:

“First of all I built a kind of [servo controlled] pointer which showed the carbon dioxide quantity in the air. If I just set it to show the data as a scale of 0 to 1000, or whatever it would have been, the arrow wouldn’t have moved so I had to expand the scale until it showed from 400, 420 massively expanding in that bit. It massively improves the visibility of it... It’s going too slowly; I need to make time go faster... now it’s going around at the rate that I’ve set”

He also describes how he walked the line between scaling data to give it clearer meaning for an audience, and maintaining scientific authenticity:

“...so I had to expand the scale until it showed from 400, 420 massively expanding in that bit which shows people, it massively improves the visibility of it but your not skewing the data because the data is still there, you can play the data, so you are just making it readable by someone in a more obvious way as long as the data isn't kind of messed around with in anyway that would be my one thing, so with climate change data, again you do need, not massage the data but scale it, make it obvious to people what it is”.

Selby also reflects on how the data was scaled and mediated in order to find interesting narratives, particularly when making the *'Inflatibles'* artwork:

“...with decibels we were constantly changing the thresholds that made the Inflatibles inflate (laugh) because the volume kept changing throughout the day... I think that's quite revealing... because it was incredibly heavily mediated by us”

Buontempo suggests that playing with this data in this way is not unethical and potentially useful for scientists:

“I don't think there is nothing unethical, and you do play a lot with the data and zoom in and out... on the first page of my PhD thesis I think I quoted, I cant remember the quote or who wrote that quote but the quote was something like 'what is noise for someone is signal for someone else.’”

Yet, he also describes his concerns around high levels of mediation of the data, particularly in reference to the *Inflatibles*:

“I found those very fascinating, very beautiful very nice optics in a sense, I couldn't immediately understand was this going up because the sound, was it a sound what was the delay between the sound and the inflate, and again, it's the scientist probably, as in anyone I don't think our brain is split in the way that the two do not talk with one another so I think my emotional response is also mediated by my rational thinking so... I would like to see how this information is fed into this prototypes... I couldn't relate as much as I would have liked to because I couldn't see the algorithms, I couldn't feel the algorithms”

Watkins also proposes that the way artists began to manipulate the data could create conflicts:

“...you're not cheating but you are kind of adjusting in order to show a kind of continuous experience you are showing data at different times even though you are telling the audience that”

Murphy suggests that despite these concerns around heavily mediating the data, *Timestreams* makes it possible to play with scaling data whilst maintaining scientific authenticity:

“...there'd be no point in making the platform not authentic, like true to the data, I mean that's why I think it's good that having the scaling in Timestream is quite important”

These examples of how the artists approached issues of temporality by scaling and mediating the data to encourage sense making and provoke emotional responses to the data. These findings also reveal how the scientist considered the opportunities for new thinking through the way that the artists played with data, despite his concerns around the authenticity of these heavily mediated interpretations by maintaining clear links between the data and these interpretations.

As seen through the artworks and experiments resulting from the *Relate Project* described in the previous chapter, the artists were also deeply concerned with notions of ‘liveness’. This preoccupation with how live interaction with data can enable personal experiences have been explored in previous literature, where studies show that by connecting climate change to our local and personal experience a deeper engagement and response can be provoked (Scannell & Gifford 2012; Spence et al. 2011).

The ethnographer, who supported the study during the UK Hackday event, was particularly intrigued by the emphasis on the ‘liveness’ of the data by the artists who participated. This was shown in the way that the artists Murphy and Watkins discussed the significance of live data capture and conceptualisation in creating opportunities for interaction with the data.

Murphy was interested in how the liveness of the data transforms people’s perception of it, enabling new forms of interpretation which he felt created stronger memories and consequently stronger attachments with the environment and the data itself, suggesting:

“...there are ways to harness the human mind’s ability to be able to cope with data better, like there are ways... some people are good at seeing patterns in numbers, some people are good at seeing contrasting colours. And you might as well utilize those abilities and think that they might mean something.”

According to Murphy, liveness is fundamental to creating enriched experiences of scientific data:

“I use live sensors more than captured data, which, you know, it’s just that feedback I think people love, love to see something happen that correlates with something they did gives people a strong memory of that thing... it allows them to live differently, or it allows them to take on an avatar, or something like... I think you’re always... with all interaction you’re doing that... Like you’re kind of creating a link between people and objects.”

The artists Abbott and Jacamino took a different approach to liveness, by taking the emphasis

away from live data. Abbott raised questions about the gap that often occurs between the artists' motivations to create these live feedback loops and whether audiences really perceive the data as live. The HCI researchers and the scientists' who questioned the often-ambiguous relationship between the data and the artworks also reflected these concerns.

In contrast to the other artists at the Hackday, Abbott began to question the artists pre-occupation with the authenticity and liveness of data and how this translates to the audience:

"I was thinking, oh, actually, that ought to be the apple which is carried on the journey, and the data should be the data which has done the journey with that apple... it's again this spiritual thing... You know, why? ...then I'd have to explain that this, somehow this is the apple. During an interview, or through the title let them know, and so they can say that's the actual apple, you know"

Jacamino explored liveness in terms of the 'situatedness' of the artwork, as opposed to the way that the data was captured. The way the music on the record responded to the data was what was specific to the time and place of how the artwork was presented to an audience, therefore the audience's understanding of the data used in the artwork would have had less meaning if shown elsewhere at a different time. He suggests that the historic element of his use of a record player (seen in this context as old technology) created another layer of meaning to the historic nature of the Mauna Loa data, and therefore the way the audience would have found meanings in the interpretation of this data.

These examples show how live feedback loops can embed understandings and experiences of the data into people's memories and everyday experiences, creating stronger attachments to the environment through providing opportunities for live interaction with the data. The artists responded to liveness in terms of the context of the time and space in which the data was both captured and presented. Yet these findings also reveal that there are challenges in focusing on live data capture, including how audiences perceive liveness and how clearly the relationship between the data and the interpretation of the data is presented.

Some of the issues of liveness and temporality highlighted by these findings have previously emerged in HCI literature. Di Salvo *et al* noted temporality as a key concern of many ecologically engaged artworks (DiSalvo *et al.* 2009a), whilst there is also a growing interest in both slowness (Hallnäs & Redström 2001) and liveness (Hook *et al.* 2012) in the HCI community. Both studies show how the artists responded to temporality in distinctive ways. In terms of how they reflected on their own and the audience's subjective experience of the data within time and space (situatedness), relating to previous work in sensory ethnography and geography (Tuan 1977; Rodaway 2002), by considering the context of the environment in which the data was captured. These temporal strategies also emerged in the way that the

artists presented the artworks, in reflection of the artwork's site specificity (Kwon 2004) as much as through the aesthetics and composition of the work.

This sub-theme also reveals the influence of the artists temporal strategies on the development of the *Timestreams* Platform, how their novel approach inspired the design of the timelines, revealing tensions between novel representations of temporality within the interface versus novel uses of temporality beyond the platform.

These examples reveal that the artists' scaled and mediated the data with the aim of provoking emotional meaningful responses to the data. Many of the artists created live feedback loops to encourage interaction and strong attachments to the data, and the environment in which it was captured. By employing these strategies the artists were able to weave stories around the data that enabled personalized narratives. The scientist was excited by the opportunities provided by these strategies to support communication with the public but raised concerns around the authenticity of the relationship between the artistic interpretations of the data and the science. The researchers were also interested in the challenges exposed by the artists' novel approaches to temporality, their focus on the liveness of the data and the impact of this on the design of the Platform interface, and decisions such as how to timestamp the data to encompass the multi lifespan and often slow processes of climate data.

7.3.2 Sensory Experience

The *Relate Project* brings the sensory experience of the artworks to the top level, revealing how the artists employed strategies of embedding and embodying data, alongside working with climate data as a new material.

In order to create these sensory experiences the artists' embedded distinct aesthetics into the artworks, and embodied the climate data in various material and sensory forms. These highlighted the ways in which the artists considered climate data as a *new material* to work with, which is also supported by the work of Polli (Polli 2011; Bindi 2011), Corby and Cunningham (Aceti 2012), and Bureaud (Bureaud 2011) who suggests that by exploring the notion of embodied data artists enable the public to understand climate data '*through creating graspable realities*'.

The artists in this study describe how data has it's own sensory aesthetics that can be embedded in reality, objects and the environment that were embodied through the creation of immersive, pervasive, dialogic, visual and sensory experiences. Jacamino describes how he considers this through the objects that he makes:

“...the objects in the work are things that go through our senses such as vision and sound, these perceptions and characteristics are integral to the experience of the piece. This approach to creating a conversation between senses was necessary, the relationship between objects and how they are transformed by the actual experience.”

Richards reveals how he sees the sensory experience as fundamental to audience’s interaction with his inflatable artworks:

“The sensorial experience is part of the work. It is the work. It is totally different from a painting, a drawing, or even a sculpture that you are not always allowed to interact with it, our work is based on the fact it relates to the audience; it does exist as ‘landscape’ but its foundation is the relationship with the spectator.”

All the artists appeared to approach their work with climate data through creating forms of sensory experience. This interplay between the senses often involved embodying and embedding the data as part of their experiments, and treating the data as a new material in which to work with.

Embodied and Embedded Experience

Many of the artists discussed their interest in creating visceral, embodied experiences of the data. Watkins suggests that he saw this role as fundamental to his role as an artist making work with climate data:

‘...to try and embody a sort of mixed experience which isn’t just purely digital’

He talks about these strategies for embodying and embedding the data in terms of the ‘soft machine’ of the body in comparison to *‘the hard surfaces’* of technology, describing how using sensing technologies can support the artists’ desire to provoke emotional responses to the data and present *data on a human scale*:

“...some of that has been in the use of particular types, of ways of capturing data so focusing on things that were, that are very kind of human level... things like trying to capture heart rate, using sensors that are attached to kind of very physical very kind of soft machinery of the human body and how that, how we can turn that into something a bit kind of emotive and sensuous in terms of an experience...there was always an interest in how to make these kind of seemingly very hard surfaces of digital technologies, these very kind of shiny boxes and all these kind of invisible digital processes finding ways to make that feel more sensuous or more the human interaction was that there was some way of sensing the, something in the space sensing something in the work that was going on that was, that felt quite a human level and that was a real kind of that’s kind of been an important factor”

Lee discusses how the *Timestreams* platform and increasing availability of sensing technologies for artists creates new opportunities for embodied experience and emotional engagements with data:

“...that kind of combination of data with sort of text, visual information that becomes more affective I suppose... certainly more affecting as well, rather than stuff that probably would have happened earlier in this sort of movement. Its just exciting and cool to interact with data and make things happen because of the data, we have the technology to do it now and actually its almost like we are maturing”

She suggests that the *Timestreams* platform specifically has the potential to empower artists, the public and communities who use it through a process of:

“...reflection about the world around you and creating different connections ... its about that awareness and sensing, one of the things we said a lot was you know making visible the invisible”

As seen through the temporal strategies employed by the artists, this study brings to the fore ways the artists captured and manipulated the data on the *Timestreams* platform. Having mediated the data on the platform, the artists then found ways to embed the data back into everyday experiences, artworks and material forms using tools such as Arduino, Unity and mobile devices. Watkins describes how the use of these technologies through the *Timestreams* Platform could then support the creation of sensory experiences:

“...that whole nature of things is very important and certainly with this work now this kind of an idea of trying to create a sensuous experience with the natural, the way that humans interface with the natural world and a meeting space with the changes that might be going on there and they have to use to technology to make that, a kind of more connecting experience.”

Leal discusses how her work with Active Ingredient has helped her to engage with technology in order to reveal sensory processes that are normally invisible:

“I think this whole experience of the sensorial particularly influenced by I think working with Active ingredient, having the technology that operated as one of the tools or being kind of there as a resource, the way you know the human sensing activity became part of the work it just brought an awareness of actually, it sort of it added to the experience of me in the city or in the forest as people, it sort of added an awareness, an antenna to what is possible with our bodies and our presence”

Buontempo suggests that climate scientists also consider the sensory experience of data in their work, proposing that scientists equally need to tap into a *'personal'* experience of what the data means:

"...in a sense I like to think that scientists are strongly using observations, temperatures and things, in that sense you can imagine scientists as responsive to a huge network of sensors... I mean it's a bit of a poetic view of our climate scientists, you can imagine as an image like a climate scientist as someone who directly connected with these networks of stations across the globe and have a personal feel for what it means"

Buontempo follows this with a reflection on the role of artists within this process:

"I do think there is a role for artists to play in the interaction with these data because while scientists have developed an understanding and interaction it doesn't mean that the same channels should work for others and artists can play a role in making these data acceptable, yeh actionable in some sense to a wider community... its such a very big role for us to play while the simple options is one of visualizing the data, but it doesn't need to be visual it can be something else ..."

As already described, Jacamino worked directly with the Mauna Loa data that Buontempo had introduced to Active Ingredient as part of the development of *ACBT*, and sought to re-visualise this data by embedding it physically in a record player, stating that having opportunities to access this data *'enriched'* his practice:

"...to work with such abundant and accessible data, to offer this to our group was very positive."

Buontempo believes that we are moving towards a future where data is increasingly embedded in the world, and proposes that artists such as Jacamino and Active Ingredient can provide valuable opportunities for finding ways to make this meaningful:

"...we are going towards this big data world where data will come, will be everywhere sensors will be everywhere... so you can imagine a situation where everything will be monitored and we will have an incredible density of information that we have ever had, it becomes even more important then to relate this huge amount of information in new and innovative ways because it becomes unbearable and indigestible."

Materiality

Several of the artists suggested that through these approaches of embodying and embedding the data they began to consider data as a type of new material, with it's own textures, nuances

and meanings, just as a fine artist would view the materials of clay, paint and paper. Abbott explains this notion of 'materiality' in terms of his practice:

"I kind of like the idea that second order materials, things which have been made out of other things, can also be used as materials. Cardboard boxes, you know, which are not first order. They're not like wood or stone, they're not pure, they're not spiritual in that sense but actually you can take them and take what characteristics are embodied in them and work with or against or through that in your work, well, second order work."

Watkins describes how the sensory experience of 'nature' has its own type of materiality:

"...that whole nature of things is very important and certainly with this work now, this kind of an idea of trying to create a kind of sensuous experience with the natural, the way that humans interface with the natural world and a meeting space with the changes that might be going on there and they have to use technology to make that a kind of more connecting experience."

Murphy talks in detail about his approach to understanding the materiality of the data in reflection of his notions that data performs as different characters:

"It's quite interesting because those datasets have different patterns to them and different movements in them. So that I think... you're often looking for an algorithm that makes something seem more like this, or like that... like, you know, some of the data is very lively and some of the data is quite calm and stuff that can... I don't know maybe there are data personalities."

Many of the artists discussed how they considered sensory experience within the making and presentation of their work, and how this influenced the way they worked with the *Timestreams* platform. This research adds to existing work around participatory sensing and eco-feedback technologies (Bureau 2001; Burke et al. 2006b; DiSalvo et al. 2009b; Aoki et al. 2009) suggesting that through using the *Timestreams* Platform artists were able to reveal the sensory and often invisible processes of climate change.

7.3.3 Multiple Interpretations

The author has reframed the final key theme that emerged from *ACBT* in respect of the findings from the *Relate Project*, which highlights the importance of multiple interpretations as a key strategy that is informed by dialogue, juxtaposition and abstraction.

As a result of the findings from *ACBT*, the *Timestreams* platform was designed with the ability to create multiple data streams and attach them to either single or multiple outputs.

The way that the artists then juxtaposed different elements to present contrasting datasets –

live, historical, pre-recorded and predicted – was seen as an intriguing and important part of the success of the work. Buontempo suggests:

“I found it sort of very fascinating, and very interesting, the way of using the data and as an outcome ... the fact that this infrastructure allowed for a number of possible outcomes, it was very stimulating and very stimulating for creativity and allow other people to work on that, it was really a very good, important outcome.”

In Giannachi’s interview, the artist/author describes how Buontempo’s role as an adviser was also an important factor in enabling the artists to work with the multiple data streams:

“We are working with Carlo [Buontempo] to explore how these different types of data can be merged, layered and understood within a scientific context. What datasets can compliment and support our understanding of the live moment in time, here in this place – with what is known by science of the changes that occur slowly around us, sometimes even over multi lifespans”

Yet, Buontempo also warns of what he sees as the dangers of artists interpreting climate data in multiple ways without the collaboration with scientists:

“I think we, you know going forward, we need to develop a sort of deeper understanding because that is the way we can build something that makes sense scientifically if you want, but is also something that can generate an emotional response, so mixing data from the past and from the future observation, that’s absolutely fine we do it all the time in our analysis and doing it in an artistic framework I don’t see anything wrong with that but... the potential risk there is that you put together all this data and generate meaning or you tweak your meaning and people smile but its not, they (the meanings) are not there in the data”

By working with multiple interpretations of the data the artists were able to explore some of the challenges described above by Buontempo, employing a variety of strategies including dialogue, abstraction, juxtaposition and situatedness.

Dialogue

Selby suggests that the *Timestreams* platform provided opportunities for a dialogue between multiple places, artifacts and datasets:

“...you can use it as a go-between, between remote data sets and kind of performance objects, you’ve got a sensor in Brazil and something here you can use. Timestreams is really good to sit between them”

Leal talks about how the platform also enables a level of ‘spontaneity’, which makes space for dialogic experiences within the artworks:

“...you know putting the composition together but allowing it to be something spontaneous so when it's actually happening you don't know what the results going to be. That is really interesting so its not a matter of making a work of art that you know I've pre-meditated and I'm trying to achieve, its really putting the pieces together, the people or places you know and I don't mean like orchestrating this in a kind of very authoritative way but in a way of seducing people like a conversation”

The artists focused on opportunities for enabling dialogue that they created by allowing for multiple interpretations of the data, which they suggest can support them to bridge different and often remote locations and create new narratives in response to the juxtaposition of different datasets. In contrast, Buontempo proposes that it is through a dialogue between the artists and scientists that the artworks can become more meaningful:

“...so you take the data, you've generated these beautiful inflatable things that are going up and down, I could not relate to those but if we start a dialogue then we can actually use this funny and interesting tool to make it into something that is interesting even to me as a scientist and by doing that actually I think I believe really will immediately will become more meaningful for a greater audience.”

Abstraction

This debate suggests that there is a conflict between the artists' emphasis on narrative and interpretation and the scientists' interest in maintaining the authenticity of the science, one of the issues Buontempo suggests that he found that too much abstraction of the data created confusion and disengagement, particularly in reference to ‘The Inflatibles’ artwork:

“I couldn't understand what was the algorithm, if you want translating the data into the action, so are you representing the trend, are you representing the seasonal cycle, why is it switching on and off, at which point, and why this maybe irrelevant for other people it is certainly relevant for me because I would have liked to say ok, this is switching on because we have exceeded 385 ppm and so the pattern is becoming more frequent now the CO2 is going up. While I couldn't make that translation so it wasn't necessarily easy for me to engage with that.”

Despite these concerns he also shows an eagerness for artists to play with data:

“...while I do work in climate change quite a lot I think there is, I really don't ever have an underlying agenda and I think the best way of showing something is interesting and strange”

In response, Watkins in his interview with Giannachi describes the role of abstraction in Active Ingredient's process of visualising and conceptualising climate data:

"The definition of visualisation is quite broad in the ways that we have been using it in this project to date. On the simplest level I have recorded CO₂ levels in the gallery that we were working in and then represented them in a blog post as the raw values that play back in a ticker within the web page. However we have spent some time abstracting the notion of visualisation ...we were looking at a way to give physical form to an invisible process. We used decibels in central Rio, because the rise and fall of sound levels reflected human activity. Humans are noisy especially when they are exploiting resources. The challenge with all visualisation is creating a meaningful feedback to the viewer. How does the viewer make a connection to the data being visualised?"

Abbott also talked in detail about the importance of ambiguity and abstraction in his response to working with the *Timestreams* platform and the data he collected during the Hackday event. He describes how the narrative of the journey of the apple that he wanted to represent became more important than focusing on the many layers of data he had hoped to capture, and how this abstraction of data enables a more emotional response to occur:

"...you can imagine the graph on the poster ... so what I thought was, well, let's take away most of the, turn it into a new sort of... What's the word? Emotional, rather than an informational thing"

Abbott describes how for him these considerations of aesthetics, meanings and composition of the work is something instinctive and subjective, based on his previous work and using these experiences to consider an audience perspective:

"...the process of composition is, you know, a combination of sort of hunches and guesses which then, you know, become confirmed in practice. If it goes on for too long and they don't become confirmed, then once starts to perhaps go back to original premise and say just a minute..."

He suggests that these considerations can also enable a longer-term engagement with the artworks:

"...the public can connect to, kind of, conceptual sort of... They can leave gaps with their mind, you know, which can sort of, be a lot richer and that's where the time thing comes in, so it's like, they might not... Then, you know, they might take two weeks to think"

Juxtaposition

The study of ACBT revealed that the ways the artists' juxtaposed different forms of data

enabled visitors to engage on a more emotional level, by making connections they may not have otherwise experienced. The artists who participated in the *Relate Project* supported this concept, discussing the opportunities and frustrations of using the multiple data streams on the *Timestreams* Platform. Blum discusses how the platform was designed to incorporate these opportunities to juxtapose different types of data:

“...we suggest to have multiple timestreams on a page or have different visualisations running at the time or machines or whatnot and to support people looking at two things at once or multiple things at once, although we aren't limited there, it is possible to grab data from two timestreams and in your client application, your visualisation or what not, in your machine, take those and merge the data use it or somehow, juxtapose it somehow”

Through his series of experiments at the farm in Brazil, Watkins explored how juxtaposing multiple interpretations of data could represent his experiences of being in the forest:

“I was very into this idea of taking a human doing an action and tracking that action and focusing on the action, focusing cameras, everything on this one thing that you can track over a period of time and really kind of throw lots of data, throw as many ways of sensing that moment and that experience and then seeing what comes out of that in terms of the data that you have collected.”

Selby digs deeper into how the composition of different artistic visions of the work and multiple interpretations can engage an audience with the complex nature of climate data:

“I think when we were talking about how all the different things like tied together a bit it does kind of begin to flesh out a wider area, discreet examples... individual bits that people can understand on their own and then I think that helps you build in a little bit of complexity”

In contrast Abbott questions whether juxtaposing layers of complexity and experiences together is always appropriate:

“...sound and image, plus data, plus objects, that's four things altogether in one space, and I don't know what it would do. I don't know what it would feel like.”

Murphy also describes how difficulties around representing and interpreting complex data can cause disengagement in the audience:

“...because that becomes so complex, that kind of feedback of the environment into how your work, works, because your brain can't understand how complex all that is you can't really make out the pattern.”

Murphy was very interested in how the *Timestreams* Platform enabled him to juxtapose different forms of data in order to add new narratives to his pre-existing work:

“It’s interesting having that list of all the different types of data in all the time streams and how... I love the idea of there being a library of data... that you can just go, oh, what is my simulation like if I seed it with storm data, or what is my simulation like if I seed it with CO2 emissions.”

As a result of working with the artists and seeing how they used the platform in this way, Blum noted:

“...there is a real need out there for people who replay data, compare data streams, look at live data and compare it to something else... and otherwise perform this stuff and I think it’s a very interesting term and I think its, I hope we are unique in doing it I certainly think its one of our USPs?”

The platform was therefore designed to enable the artists to link into existing software that they were already familiar with through the API, supporting multiple outputs to blogs, JavaScript visualisations, Unity visualisations and sonification software, other data management systems such as Xively (formerly COSM and Pachube)³⁰, and mobile and electronic devices (such as Arduino).

Situatedness

Many of the artists suggest these multiple interpretations took place in response to the way they negotiated space, time and place. The artist/author explores how this notion, which is described by the ethnographer Pink as ‘*situatedness*’ (Pink 2009), influenced both the development of the platform and Active Ingredient’s artistic response:

“I see the role of Active Ingredient as exploring both the personal non-scientific experience of energy, and the science in context of localities. Looking at where the communities we are working with live and how energy and climate change impacts on their lives, how they define and understand the way energy and climate change is transforming in their localities. How do we create a shared experience of this? How do we understand a drought when we are experiencing a storm and how can that transform our experience?”

Selby describes how important time and place became both to his own engagement with the data as well as his interest in engaging others:

³⁰ https://xively.com/?from_cosm=true

“I got quite interested in weather systems and storms and all that kind of and how that relates to climate as opposed to weather. I think I’m a bit more aware of that now. I’m quite interested in that and how, most of all how people to respond to it. You know like the recent storms and things and then doing stuff about, because I know that’s not ham, I’m not doing that from the environmental perspective I’m interested in how people respond to extreme situations and yeh like we’ve talked about it a few times since as well, the idea that those extreme situations might become more like frequent and that is actually manifested in weather I think is quite interesting.”

The artist/author also describes how local and personal narratives created around the data supported the artist to deal with the broader global themes within the project:

“It is important that through making artworks, performative experiences and public interventions that these experiences are cohesive, that they make sense to the audience or participant and remain engaging – not preaching, purely educational or too broad. So we are trying out different experiments to make these experiences and objects that might create small, meaningful and personal moments that reveal the relationship between energy, climate change and ourselves.”

Buontempo was also influenced by the way that these personal narratives and localized interpretations of the data could support scientists to engage with weather predictions and climate modeling in the future. He expressed his interest particularly in the idea of fortune telling (from *The Prediction Machine*) and how this might encourage engagement with the issues of risk and prediction within Climate Science:

“I like the idea of the fortune teller as a concept and I think quite an interesting one, so you made me think whether we should be doing something similar you know, as a way of dealing with, ah with predictions, so should we provide predictions as, like a Chinese fortune teller... it would, would that increase the likelihood for people to interact or engage or to react?”

These reflections support research within climate science about place identity and the importance of personal localized experience on the public’s understanding of climate change (Spence et al. 2011; Scannell & Gifford 2012) as well as literature discussing the role space, place and time on our understanding of the environment (Tuan 1977; Rodaway 2002).

These findings show that the artists, researchers and scientist were equally excited by the opportunities provided by these multiple outputs, how they provided opportunities for a variety of ‘performances of data’ and novel approaches to outputting data from the platform. These multiple interpretations involved a complex dialogue between multiple places, datasets and artifacts; abstraction and aesthetic interpretations that encourage sense making and

longer term engagement with the data; and the juxtaposition of different datasets to enable complex interpretations of the datasets.

This theme also reveals the tensions between the artists creating too much abstraction and complexity and representing authentic scientific interpretations of climate data. Buontempo suggests that these strategies should occur in parallel to a dialogue between artists and scientists to ensure that the relationship between the data and the algorithms used to interpret the data are not so abstracted that the meaning of the data is lost.

7.4 Conclusion

This study of the *Relate Project* enabled a more in depth analysis of the themes that emerged from the first study of the artwork *A Conversation Between Trees* and an extension of these themes in consideration of the different perspectives of the artists and hackers, the technology and the science.

This analysis reveals the ways in which the artists interpreted climate data as performative, temporal, embedded and embodied experiences. As can be seen, the findings largely support the experiences of the participants of the previous study. Some of the themes have been reorganised and renamed, explored in greater detail, or broadened. Yet overall it appears that the artists who participated within the *Relate Project* employed similar strategies to Active Ingredient in the study of *ACBT*.

The *Timestreams* Platform provides a significant example of how artists' can support the co-design and testing of new HCI systems and tools for capturing climate data. These findings reveal how the challenges and opportunities explored in the study of *ACBT* informed the development of the system, providing new perspectives on the capture, manipulation and interpretation of sensor data.

These observations reflect on the role of *Timestreams* Platform in enabling the artists to create performed temporal and dialogic artistic responses to climate data. What is most notable here is the feedback loop between the tools that capture and enable the artists to mediate the data and the strategies the artists use to create narratives, dialogues, aesthetic and subjective responses to the data. Benford et al. describe this feedback loop as common to artists developing mixed reality performances and interactive experiences, and trace several other examples of how these strategies can then be used to inform the future design of HCI systems (Benford et al. 2013). What is notable is how the artists provided novel challenges for the developers of the platform in terms of their approach to temporality, liveness and multiple data streams, yet required the technology to remain in the background of their processes and presentations of their artworks, which will be discussed further in the next chapter.

This analysis provides insights into the artists' practical strategies and contributions, highlighting how these artists' strategies can inform technologists and scientists, through an increased focus on emotional, situated, human-scale and narrative experiences of the data. Yet as was found in the study of the artwork *ACBT* this raises questions around issues of authenticity, abstraction and sense making when interpreting climate data. The implications of this will also be explored further in the next chapter in terms of the role of the artists, broadening out the discussion whilst remaining grounded in the data from both studies.

8

Extended Themes

The previous chapters have presented the studies of *A Conversation Between Trees* and the *Relate Project*, illustrating the strategies that the artists employed to engage the public with climate data within these projects. This chapter extends these themes to encompass a broader discussion of the artists' role, exploring why the artists employed these strategies and the impact of their contributions on the three disciplines of Contemporary Art, HCI and Climate Science.

These meta-level discussions are presented in reflection of both studies but with a greater emphasis on the *Relate Project*. This second study enabled the author to focus more broadly on the role of the artists and the implications of the artists' contributions. The resulting discussion of these broader themes also raises questions for future work, to be discussed further in the concluding chapter.

8.1 The Role of the Artist

As a result of the study of the *Relate Project*, the author had the unique opportunity to test the findings of the initial study within a broader context, providing the basis for a wider discussion of the role of artists engaging the public with climate data, highlighting these four broad themes:

- How the artists provoked an emotional response to climate data
- How the artists considered technology within their artistic practice
- How the artists considered authenticity versus emotional experience when working with climate data
- How the artists engaged in dialogic practices

These broader discussions have the potential to support new frameworks for evaluating the artists' role in engaging the public with climate data, building a greater understanding of artists' distinct contributions to discourses around climate change and informing future interdisciplinary collaborations between artists, scientists and technologists.

These broader discussions respond to existing work within HCI (Benford et al. 2013; Sengers & Csikszentmihályi 2003), the more extensive work on science and art collaborations coming from a Contemporary Arts perspective (Ede 2005; Giannachi 2012; Arends & Thackara 2003; Bureaud 2011; Bloom 2011; Aceti 2012) and the growing interest in artists working with climate data emerging from a Climate Science perspective (Curtis 2012).

8.2 Provoking an Emotional Response to Climate Data

Findings from both studies show that the artists' key contribution to engaging the public with climate data was through their approaches to creating an *emotional response* to the data.

Malina's concept of '*intimate science*' (Malina 2009) suggests that artists provide a '*new sensuality*' in their engagement with climate change. Other related work suggests that environmentally engaged artists are increasingly using data as a new material within their practice (Polli 2011; Aceti 2012; Bureaud 2011; Bloom 2011; Rimmer et al. 2009) in order to reveal new perspectives; evoke emotional responses; and encourage personalised sense making in relation to climate change. This has been supported by the reflections of the artists and visitors in the study of *A Conversation Between Trees* and the artists who participated in the Relate Project.

Holmes suggests that '*art should involve an aesthetic encounter that provokes emotion or feeling of some kind*' (Holmes 2007). As discussed in Chapter 5, *ACBT* enabled the public to engage with climate data by observing the data for themselves and through this to provoke an *emotional response*. The visitor responses to *ACBT*, along with the reflections of the artists and climate scientist in the *Relate Project* suggest that creating an emotional response is a first step towards enabling people to clarify their perspective on the data and the wider issues of climate change.

8.3 The Role of Technology in the Artistic Process

The second extended theme within this discussion focuses on how the artists responded to the technology that enabled them to capture, manipulate, interpret and conceptualise climate data.

Both studies – of *ACBT* and the *Relate Project* - provide significant examples of how artists respond to working with data capture systems, how they manipulate and interpret the data within these systems and how their experiences in the ‘wild’ (specifically remote forest environments) can inform the design of future systems. These findings are supported by other work within HCI that have studied the way artists and communities engage with environmental data systems (Aoki et al. 2009; Kuznetsov et al. 2011; DiSalvo et al. 2009b; DiSalvo et al. 2009a).

The findings from both studies suggest that the artists see the technology as something in the background of the artistic process that enables them to make the artwork and bring the data to the fore. Watkins describes why it was important that the work he did as an artist within the *Relate Project* focused on the artistic process and not the technology, despite being a co-designer on the *Timestreams* Platform:

“Timestreams was not really (about) the technology for me, Timestreams was the process and the process was about addressing, trying to find sensor interfaces with climate change, with the human in the environment in relation to climate change and how you can kind of start to engage in a process of generating data...”

Lee also questioned how and when she might use the platform as an instrumental part of an artwork:

“...it might be a good way of presenting something but its not something, I suppose it will be in there as a resource, I wouldn't go there to make a piece of work.”

In contrast, Jacamino reveals how the artists could also find their own personal meanings through the process of using *Timestreams*:

“There was a poetic reference relating to the old technologies and the bank of information which the Timestreams gives... creating a new code, associated to an older one. Being translated by the composition, becoming another set of data.”

In the *Relate Project* the artists played an important role in testing the platform and informing the design process, revealing the need to take into account the entry points of the artists and whether they had the skills, time and resources to work with the technology independently, or whether they needed technical support either in collaboration with artists with greater technical expertise or the HCI researchers (Blum et al. 2012). This highlighted the specific role of a ‘creative programmer’ in many of these artists’ practices where artists such as Murphy, Selby and Shackford who have existing programming expertise often collaborate with artists with less expertise to support their engagement with the technology.

As also seen in the study of the ‘*Neighbourhood Project*’ (DiSalvo et al. 2009b), accessibility

issues were revealed as an important factor in determining how artists and communities use technology and why they want the tools to remain in the background during the process of developing new artworks. During a system review, that took place at the end of Phase 4 in the *Relate Project* timeline, Leal discussed usability issues regarding the mapping between what she called the ‘*scientific*’ or ‘*technical*’ terminology of the system and her understanding of how to use it:

“What’s the symbol of your measurements?” That’s becoming like a test. Someone who doesn’t know perhaps or who has forgotten temporarily that temperature is Celsius or perhaps in fact they work in Fahrenheit, and don’t even know there’s Celsius. It starts becoming like aghh I’m not intelligent enough for this. It’s too scientific, delete or move on.”

She suggests that by using a ‘*programmers language*’ the technology becomes a hindrance and that she would need to use a programmer in order to incorporate the platform into her existing artistic practice:

“But the language isn’t an artist language at all. We’re having to use a programmer’s language to understand. There’s going to be some sort of handover to an artist, (to use) a programmers’ language to be able to engage with this.”

Challenges aside, Leal is interested in how other groups, with higher levels of technical expertise may be able to experiment with the platform:

“I’m interested in engaging with it but also kind of engaging people with it, you know, and experimenting with it that way. So like this group Nuvem³¹, there’s a bunch of artists there, you know, interested in the environment and climate change and data and I can’t see that they would have anything like Timestreams, you know, to play with. So these kinds of resources would be really wonderful to kind of open out to those people to then see what they kind of come up with.”

Selby also highlights issues around accessibility for artists without the appropriate expertise:

“...because it is or will be open source so its, in theory its infinitely expandable, but you obviously need the expertise to be able to do that.”

In contrast to the issues revealed by the artists, the hackers who took part in the Hackday event appeared to easily engage with the platform, the language of the interface and any technical issues they encountered. In Erskine’s case his existing expertise appeared to enable a much deeper engagement with the platform and some excitement around its’ functionality:

³¹ <http://nuvem.tk/>

“I was very wowed by the collection of images over time – that was great – and the replay of those (Timestreams) – that’s also very good”

As opposed to the majority of the artists, the hackers were able to engage with the technology and understand its full potential, despite the issues of it being still in development. This suggests that the hackers were happy to spend time working with technology and consider the technology in the foreground of their activity. In contrast the artists, particularly those with less technical expertise, were concerned about the impact of the technology on the creative process and the time and resources required to use the tools. Abbott suggests a tool such as *Timestreams* may not provide him with enough opportunities to warrant the time needed to learn how to use the technology:

“...whether it’s broad enough to be able to devote the amount of time needed to learn to use it? You know, it might be a lot better to work with an expert, you know, who works with a lot of artists, rather than... You know, because while I was learning video it was a massive sweat, but once you’ve learnt it you can do all the videos. You know, beyond, you know, lining up data, there’s not a lot else you can do with it.”

Jacamino exposes some of these issues around how artists approach using technology differently to programmers or hackers, suggesting that when the technology and tools are in the foreground of an artwork, art can become too *‘literal’* and leave no room for reflection:

“In art there is a repulsion to giving away the tools, it is a problem if it is too literal, a technical language, and just visualisations, not thinking, questioning.”

He suggests that bringing the technology to the foreground can also distance audiences from an artwork, by changing the focus of the experience:

“...distance is an issue which the technologies and techniques can only overcome in part. The visual language is challenged... exposing the way things are being created, the relationship between man and machine, returning to the public, bodies, perceptions”

Yet the findings also suggest that whilst requiring the technology to remain in the background, the artists are interested in exploring how the *‘data’* can be brought to the foreground. Murphy reveals the importance of bringing the data to *‘centre stage’* - as part of the notion of *performing data* discussed in the previous chapter:

“...that’s kind of what you’re doing with visualising data, you know, you’re making a show out of something that’s just there, in a way, but you’re making it into a show - you’re giving it centre stage”

Blum describes how the process of engaging with the artists changed his own expectations and assumptions of artistic practices around environmental data:

“...early on when we started there was a series of talks that AI did and I sat in on them and early on we kind of said, so what do you guys want to do - infographics? And it was clear that that was not what you guys wanted but it still wasn't clear what was wanted and there was occasional talk of machines ... usually the word that was being used was visualisation and so I was kind of stuck in thinking about visualisation and then so we got somewhat down the development road and machines started to come back into it, into vogue... I can kind of get visualisations and sonifications, I've done some of these before, but machinery or getting other kinds of outcomes you need to get some other way to get your data out and I guess that's when the API, the API manifested really”

He suggests that the *Relate Project* successfully created an equal collaborative process between HCI researchers and artists through iterative design, where both disciplines were invited into each other's worlds, creating a two way street. He calls this approach an 'iterative design feedback loop' and describes in detail how by sharing languages and understanding of each other's discipline he began to gain confidence in working across the two disciplines:

“I think because of spending time with Active Ingredient and Silvia and then in Barracao, I'm becoming more familiar with the language and then the thinking processes, and I hope then when I go to present it is making more sense, it seems to, I feel I'm involved in interesting conversation at the end of my talk, you know interesting questions... I'm speaking a language that is more meaningful than I would have six months ago or a year ago”

Selby also worked directly with Blum, integrating the artistic experiments created by the Active Ingredient team and the other artist participants with the *Timestreams* API - to work with Arduino and Processing, which in turn informed the development of the API. He notes these challenges from the artists' perspective:

“Timestreams was, well it was definitely useful but I think it suffered maybe because it's not necessarily appropriate to get involved right at the beginning of everything?”

Flintham also shows concern with the 'iterative design feedback loop' described by Blum:

“...we need a first prototype which is something that demonstrates this, lets work towards that prototype... no doubt you guys know that's the most chicken and egg problem... and its always why didn't we have the technology when we started”

In contrast, Richards and Tublenchak highlight the positive challenges and opportunities within the collaborative process.

“The impact from the collaboration is mainly about the communication involved in the work - we are very visual, you’re very technical”

They suggest that the interdisciplinary nature of the collaborative process enabled them to think about climate and the environment in new ways:

“I thought it was absolutely different of what we do – this interdisciplinary quality of crossing from one area to the other. It opened another window for experimenting; I have never looked at my work through this perspective, but I began to relate things and it can be very interesting, things that are relevant for my work, even the relationship with what we would need to approach, this relationship with the breathing and the connection with city’s air, the air pollution, all these subjects are related to the work”

This was also reflected by Jacamino, who suggests that a key part of his engagement with the technology was through *“...the technical knowledge and important tools and the individuals’ knowledge”* provided by Active Ingredient and Horizon’s residency at Barracao Maravilha and that he welcomed the challenges posed by combining these disciplines:

“...my practice lends itself to what is understood as scientific, perhaps by the tools and objects that I use. The distance feels more related to the technology, it points to the possibilities of articulating this conversation between practices.”

Buontempo talks about how systems such as the *Timestreams* Platform can enable a wider community to access and interpret climate data but argues that this is part of a broader process:

“...this is a positive initiative that will make data logging and data interaction simpler for users that I think is a great opportunity. Possibly one of the challenges, how this feeds into a broader context of initiatives going in the direction of interaction with network data... how to tap into existing networks of other sensors”

Likewise, Leal proposes that artists have an important role to play in supporting tools such as the *Timestreams* Platform and open them up to use by other communities:

“...it’s not exclusive to artists, you know. I think other disciplines as well, you know, I think, but artists, it’s almost a, it kind of opens a door to everyone else you know if artists can do it, so can everyone else...”

Existing research within HCI also reveals the impact of working in rural and remote environments where connectivity, extreme weather and limited access to electricity can often

hinder the use of technology that tends to be designed for urban environments (Burke et al. 2006a; Paxton & Benford 2009; Goldman et al. 2009; Cranston 2013; Wyche & Murphy 2013). This was reflected within *ACBT*, where the most significant issue for the artists was the difficulties of using sensors in the ‘wild’ in forests in Brazil and the UK, including issues of disconnection, and the robustness of the sensors and mobile phones that captured the data from the trees in both forests. Although problems with technology can clearly hinder artistic practice, in this case these constraints also led to the development of tools that supported artists to develop new performative and temporal strategies to working with the data and developing the concept of *performing data*. The artist/author discussed how previous experiences of working with *ACBT* informed the way these constraints were supported by the *Timestreams* Platform:

“The major constraint we have identified is that all data needs to be time streamed (part of a time series), which I think is an exciting constraint to work with as an artist. This means instead of free for all documentation of events and places we are looking very much at the data as a performance, that is captured along timelines and therefore can be represented or re-played with a sense of temporality. This is particularly interesting in terms of finding ways to capture slow processes”

Blum describes how he also attempted to design the Platform within these constraints, whilst keeping it generic enough to be useful to artists other than Active Ingredient:

“...the unity visualisation is exactly the same as for the Arduino, they both need to get Timestreams out of that and its really up to the third party client what they do with it... they are all interchangeable and so then it becomes the responsibility again of the artist to mangle stuff to, however you want.”

Possibly the most surprising way that the artists responded to the technology in the *Relate Project* was in the way they used the platform to inform their artworks without connecting directly to it, and how this work ‘*beyond the platform*’ then fed back into the development process.

These uses of technology to enable artworks to respond to climate data without plugging directly into the source of the data can be seen in the descriptions of the artworks by Watkins, Leal and Lee in Chapter 7. These artists chose not to work with the platform during the exhibition at Barracao Maravilha, instead they created artworks that simulated how they had hoped the platform would work, and fed the results of these experiments back into the design of the system. Selby discusses how these early simulations provided opportunities for different forms of artistic ‘*lines of enquiry*’ to occur, that were initiated by issues of the technology not being fully developed at the time of the artist residencies, suggesting that:

“...if we’d started with doing programming, and getting that all going, we wouldn’t have even had anything to show...”

Flintham in contrast questions why these artistic outputs didn’t engage directly with the platform:

“I think that was the weakest part of the project to be honest in that we focused on the middle and the input and didn’t build stuff with it... I didn’t want it to remain with that kind of base database experience which is that, here’s the data kind of in some fashion of a gauge, here is the numerical representation of it, here is showing you the pictures, rather than like more immersive sensory representation”

These experiments ‘*beyond the platform*’ also provided the biggest challenge for Blum:

“...how does I as a digital economy developer face that, feel that if you don’t want to use the offering, don’t necessarily want the vision of the digital economy and the way it seems to be going and so how do we build tools for this kind of group (laugh) there’s a bit of a paradox there, the tools are the things that they don’t want in some cases, so when we were in Brazil you made the empanadas and for me, or so there’s that when we were in Barracao there was the meeting of the hands, two people shaking hands. These things are entirely not digital technologies”

The artists suggest that these processes are not just in response to problems with the technology but they were also an important part of their creative use of the technology. This implies that in the process of developing future systems for artists developers should consider how to support opportunities for artists to experiment and develop ideas in parallel to their use of technology and how these might feed into their use of the technology, in order to allow space for new thinking that is not constrained by the technology.

This broad discussion of the way the artists engaged with technology within both studies suggests that although the technology played an important role in how the artists worked with climate data and in turn engaged the public through their artworks it was clearly important to the artists that the technology remained in the background of this process. In contrast the artists were interested in how the data was allowed to perform ‘*centre stage*’ - through the strategies discussed in previous chapters.

8.4 Scientific Authenticity vs Emotional Experience

Possibly the most significant topic to emerge from this research is the ways in which the artists considered scientific authenticity versus creating emotional experiences in their treatment of climate data within the artworks.

As highlighted in the analysis of the artists' strategies in previous chapters, the ways that the artists provoked an emotional engagement with climate data while remaining 'true' to the authenticity of the scientific data was not a simple matter, often requiring the artists to walk a line between artistic license and strict accuracy. In both *ACBT* and the *Relate Project* the artists were found to be experimenting with maintaining the veracity of the scientific-ness of the data, considering their responsibility to the science and expressing their own artistic integrity in order to create personal, local and emotional narratives.

As shown in the study of *ACBT*, these artists' experiments successfully provoked emotional and personal meanings for many of the visitors, yet raised some ethical challenges of interpreting scientific data in this way. Buontempo describes this line between engagement and authenticity from a scientist's perspective:

"I think its as well about finding the right balance between the interaction between the audience and the authenticity or the rigor... you don't want to distort the science, at the same time it cannot be dry, a dry speech or a dry presentation... because nobody will engage with that, so its being correct at the same time to inform enough to engage with the audience"

Each of the artists who participated in the *Relate Project* responded to how they walked this line in different ways. Lee describes the responsibility she felt to maintain a level of authenticity when working with the data:

"...that's the golden thread through it you know... I think the intentions of authenticity and then failing is better than not intending it to be authentic."

Murphy proposes that the level of responsibility he felt when working with climate data could be off putting and discourage the playfulness that he has when working with other types of less complex scientific data:

"...it seems like it's quite a serious subject, but you probably... you don't want to get it wrong, or, I don't know, maybe I just stay away from it, because it would be a bit too important"

Leal describes how through her process of working with Blum, turning CO₂ data into binary code helped her to understand the data whilst giving her the freedom to be playful:

“Scientifically it also could be tracked back and you know, it was almost, I was trying to validate the work scientifically as well, you know, at one point Jesse said, no that’s right, you know if you’ve got the key you just have to have got the key, then its right, its scientific, yes, it is that data, you are dealing with that data”

Yet, she also recognises the difficulty in passing any notion of scientific authenticity on to the audience once the data is abstracted:

“Well its just totally questionable... as you know the more that you transform a number into another number you’ve totally abstracted it ... each of those steps creates something new”

As already described, Abbott responded to these issues of scientific authenticity versus artistic integrity by questioning how to use data in his work:

“It’s not an artist saying, well, you don’t need the data, or I don’t bother about data, or whatever. It’s fine that it’s there. I’m going to refer to it. It’s symbols and signs, but I’m not going to necessarily, directly use it in a sort of slavish way, but that doesn’t mean I don’t respect it.”

He goes on to describe how narratives are more important to him than the numbers and data feeds provided by the *Timestreams* platform:

“...as an artist I’m not interested in it as data. I’m interested in it as a way of exploring how we think about climate, or exploring how things in our environment work together. It’s like this notion of a hidden world.”

Many of the artists discussed the role of science in their artists practice. Watkins highlights the conflicts experienced around his attempts to *enact* and understand the scientific processes required to capture and measure climate data:

“...it is very difficult to collect data... if you’re being an artist in that situation... you want data that is going to tell you a story or that you can tell a story to other people... the problem is that if you have got data that is all, a very small change over a period of time, say over three hours you’ve got a change of like one factor, one degree, you really, there is not much of a story in that and so, therefore you are kind of are with this situation of what do I do with this? And one of the answers is you just present it as it is and then you accept that, or most artists or visual designers they look for the data set that is exciting and then they visualize it”

Selby also talks about how he began to understand the complexity of dealing with climate data through his participation in the project:

“...if you are going to do a bunch of things under the same project then for me anyway they need to be related... you get a bit of the complexity which when we are talking about something like climate change its very, very complex”

The artists tended to see scientific authenticity and rigor in parallel to issues of artistic integrity as Richards and Tublenchak explain:

“Datas can be forged in the same way conceptual, artistic work can be forged. It is more relevant to count upon the honesty of what you believe is important for your work, for yourself.”

Yet, Buontempo questions the reasons why the artists didn't always reveal the algorithms and remain 'true' to the scientific interpretation of the data, suggesting that maintaining the veracity of the data was essential to his engagement with the artworks:

“...the artists doesn't necessarily be visualizer of data in a sense of scientific significance if you want, but at the same time for me being a scientist I would have liked to have an understanding, because it would have allowed me to have an emotional relationship with the data which I couldn't really have.”

Despite these apparent tensions between scientific authenticity and rigor and artistic integrity both studies reveal often-unexpected overlaps between the thinking of the artists and the scientist. Buontempo proposes that science should be open to embracing new perspectives and working in partnership with artists. Despite his concerns he appears to welcome the opportunities provided by artists playing with climate data, which is most clearly shown in his response to the artists' strategies of embodying and building narratives around the data, discussed in the previous chapter. He describes how scientists also respond to a 'personal feel for what it means', calling on artists to make this scientific sensory network 'actionable to a wider community'.

In previous writing, Active Ingredient suggests that 'artists are triggered by the value of a piece of data to frame it in a way that suits their poetic process' (Rimmer et al. 2009). Selby explains further that what is significant in the different approaches of artists and scientists in the case of ACBT and the *Relate Project* is that the artists attempted to negotiate when scientific authenticity and the veracity of the data became more or less important to engaging the public with the data:

“...with the climate machine it was illustrating to a sort of degree it was illustrating the C02 data, but it was also comparisons with illustrations of some other years with the Inflatibles, and with the thunder drum if it lies it's not compared to anything else so it's a bit de-contextualised... like in the case of the climate machine it was heavily mediated by us but it

was a sort of consistent illustration, whereas with the drum its just kind of ok so you've got a number, 72 and I decide that it means that that shakes this much"

This was also reflected in the tensions between maintaining *liveness* versus *accuracy*, particularly in *ACBT*, which resulted in the artists employing a strategy of '*smoke and mirrors*' (Jacobs et al. 2012) to encourage the audience's perception of the data as live in order to suspend their disbelief in the connection between the two forests, even when the data was heavily mediated to compensate for issues of disconnection.

As shown in Chapter 5, these findings from *ACBT* reveal that the visitors appeared to focus less on the detail of the statistics and more on the experience of interpreting the data in a broader sense. That the statistics were available as a trigger to raise questions and inform an aesthetic experience of sensing changes in light, temperature, humidity, CO₂ in both forests appeared to be often more important to the visitors' engagement than the actual numerical details of the data. Yet these findings also showed that this is difficult line to walk, and at times the artists' use of '*smoke and mirrors*' to improvise around issues with the data could break the visitors suspension of disbelief. This could occur when the data was too abstracted or heavily mediated by the artists and the relationship between the numerical data and the aesthetic experience was no longer perceptible.

This negotiation of when scientific authenticity is important to engaging the public with climate data, and when to mediate the data in order to provoke an emotional experience raises significant questions around collaboration between art and science, empirical knowledge versus sensory experience, and the value of emotive narratives, aesthetics and experiential knowledge. These issues raise questions around the role of the artist in contrast to the role of the scientist to be discussed further under the final theme.

These discussions suggests that further research is required around the space of collaboration between artists and scientists, how the disciplines can share knowledge in order to continue to explore the line between emotional and empirical interpretations of data, in order to engage the public with issues of climate change.

8.5 Dialogic Practice

Previous research has explored the role of environmentally engaged artists, considering artists as instruments of science (Bindi 2011; Bunting 2010; Arends & Thackara 2003) or at the other extreme as activists, often positioning themselves counter to scientific and technological thinking (Miles 2006; Guattari 1996). There is a limited body of literature that discusses the implications of these opposing perspectives on the future development of

collaborative work between climate scientists and environmentally engaged artists (Gabrys & Yusoff 2012; Giannachi 2012; Hemment et al. 2013; Minissale 2012), the values and contributions of these practices (Polli 2011), and the tools and systems that support them (Burke et al. 2006a; DiSalvo et al. 2009a).

This research reveals that the ways these particular artists engaged with political aspects of the environment and notions of ecology were rarely overt, often focusing on dialogue as opposed to activism. The new aesthetics of environmentally engaged artists (Giannachi & Stewart 2005; Giannachi 2010) presented in this thesis reveal a contrasting position to the work by Demos (Demos 2013) proposing paradigms that focus on a more ideological thinking about ecology. Increasingly, as shown by the studies in this thesis alongside the work by Polli (Polli 2011), Malina (Malina 2009) and Leonardo (Maun 1999) artists and scientists are presenting example of how new thinking can occur through dialogic and collaborative practices between artists and scientists.

DiSalvo et al. argue that what they term '*ecologically engaged art*' often aims to stimulate environmental debate rather than directly informing or persuading the public to change behavior [4]. They have proposed that, historically, environmentally engaged artworks have tried to bridge the artificial division between culture and nature, engaging the public with environmental concerns, whilst also engaging the political.

The research within this thesis extends the argument proposed by DiSalvo et al. whilst questioning the ways that artists are perceived to engage the political in their work. As shown here, the artists discuss their desire to reveal and reflect on the data, to bring it '*centre stage*' (Murphy) without dictating what the audience should think. This is supported by some of the concerns raised by Selby around who should be making the choice about when to mediate data, suggesting that by making the platform open source it opens up the opportunities for dialogue and new considerations of the data:

"...when you're using anything to kind of mediate data that is going to have an effect on it... yeh the data's open but it is still a bunch of like creative professionals making apps for people... all the data is still going through the same system, the same filter the same social, political filter, so I guess that is built into any tool, specially when it comes to the university but that's like, but that's the nice thing about it being open source, that anyone can take that on and build what they need from it"

Interestingly, Buontempo suggests that he is very much against artists becoming the instruments of science:

"...on one side I don't think that 'the artist' should be used to broadcast a message that's coming from science I think these are a rather dangerous approach, firstly because I don't

think there is a message (laughter).. I think there is a big role for artists to play in that interaction and I think there is space for interactions between artists and scientists there in a sense I think there needs to be a continuous dialogue... maybe something that is quite exciting and appealing to a scientist maybe doesn't look so exciting at the beginning to an artist... after a bit of interaction I think you can have a sort of the feel and the ability and the sensitivity of an artist working alongside your intimate understanding of the data the scientist may have, I think it takes time”

The space for ‘*continuous dialogue*’ between artists and scientists is contentious territory, not least in the art community where artists take political positions that reject what they see as ‘*technocratic prescriptions*’ of nature as separate to humans and culture, in support of more democratic and collective thinking around ecology (Demos 2013).

These contentions are mirrored in the science community, where despite acknowledgement of the increasing need to engage the public with climate communication in ways that ‘*touch peoples’ emotions*’ scientists remain skeptical about the role artists can fill and the role of the senses in our understanding of science (Curtis et al. 2012). Little research has taken place from the scientist perspective of the potential benefit of these artist’s contributions to scientific research and the impact of these interpretations on the authenticity and robustness of the science, in order to understand or resolve these concerns. Yet Buontempo proposes that the artists’ distinctive approach to working with science could contribute to his work in several ways:

“I think because actually in touch with you and Active Ingredient and all this projects, made me aware of a number of issues that are existing in the interaction with the wider public so in that sense ahm, so in that sense yes it has been very beneficial to engage with you... in a sense I feel that Timestreams somehow played a role an important role... going forward it will be a very good way of interacting between the general public and the data ... I think this is a piece of a wider discussion and discourse if you want on public engagement with data, big data and so on and in that sense I think this whole discourse is changing a bit the way we interact with the data”

The artists studied within this thesis reveal that they embraced opportunities to work with scientists and that these collaborations provided them with the opportunity to ‘*enact*’ science as part of their own subjective lines of enquiry. In doing so they attempted to move beyond merely instrumenting science towards engaging the public in an emotional, embodied, personal response to the scientific data. What is apparent across both studies is that the artists considered their role within the collaborations as part of a broader dialogic artistic practice, rather than acting as instruments of science or as political activists.

The findings from both studies suggest that this was a *three way street* involving ongoing dialogues between the artists, the scientists and technologists, that negotiated issues of authenticity, emotional experience and the political framing of the work. Buontempo explains why he finds this *three way street* potentially exciting:

“...it was an opportunity to keep in touch with a group of artists that I enjoy working with and the other side I think was interesting because there was an involvement of a more if you want technical component so that was exciting and I thought it was a good opportunity to develop something that could have been useful you know that could have had artistic value but also potentially a science-y or research-y”

These varying points of engagement with the science of climate change reveal some of the complex issues around collaborations between artists and scientists, including debates around artists becoming instruments of science versus dialogic approaches where both types of knowledge are able to inform each other.

This research shows that by collaborating with climate scientists and HCI researchers the artists were able to engage in a dialogic approach that moves beyond literal interpretations of science and technology towards new shared understandings relevant across the disciplines of Contemporary Art, HCI and Climate Science

8.6 Conclusion

These discussions reveal the significant role the artists played in the co-design of the *Timestreams* Platform, how the constraints, temporal structures and issues around liveness that were revealed through the study of *ACBT* informed the design of the platform. This research highlights the distinct ways that the artists considered technology within their work, by bringing the data ‘*centre stage*’ but requiring the technology to remain in the background.

An interesting point that emerged from this discussion was how the *Timestreams* platform supported artists who may not want to work directly with technology but whose practices are informed by technology, as in the case of Leal who captured data using the platform and then used this data to inform a performative video work, separate from the platform. This also raised questions around how the development of these tools can make space for artists to follow lines of enquiry that may involve paper testing or experimenting away from the technology, in order to inform their understandings of how they might use the tools in the future.

As Blum et al. notes (Blum et al. 2012; Blum et al. 2013) previous research into the context of use and the design of data capture systems for artists is limited, despite the increasing

collaborations between artists and HCI researchers in this field (Aoki et al. 2009; Kuznetsov et al. 2011; Polli 2011; DiSalvo et al. 2009b; DiSalvo et al. 2009a), highlighting the need for further research into artists' experiences of working with these systems. The role that the artists played in testing and using the platform indicated a need for the tools to remain simple, with clear constraints and accessible interfaces that provide space for the artistic process. Yet, this research also showed how by using the platform and responding to the constraints of the technology the artists were able to engage with new performative and temporal strategies in their response to working with scientific data.

The artistic practices investigated within this thesis are not without a political framing, yet this discussion reveals that the artists took a predominantly dialogic approach to engaging the public with climate data. As shown by the visitor's responses to *ACBT* in Chapter 5, the artwork enabled audiences to reflect and interpret the data for themselves, making space for sense making without promoting a specific political agenda. These practices are informed by Beuys and Sacks' concepts of social sculpture (Beuys 2004; Giannachi & Stewart 2005) as well as by emerging dialogic arts practices, dialogic aesthetics and participatory arts (Kester 2004).

As with the findings from the study of *ACBT*, how the artists provoked emotional responses to climate data raised issues around the authenticity of the scientific data within their work and how they walked the line between instrumenting science and creating evocative experiences triggered by the data.

These examples provide an insight into the subjective ways that artists make work and how at times the conflicting issues of artistic integrity, responsibility to the scientific nature of the data and equally a responsibility to the audiences that view the work can influence the artists' decision making.

Most significantly this discussion reveals the importance of *ongoing collaboration* between artists and scientists in creating these authentic yet meaningful artworks that engage the public with issues of climate change.

9

Conclusion

This thesis has described the ways in which artists are engaging the public with climate data; mapped the related literature in order to set up the research questions and highlight the research gap; defined the approach and methods of the research; and presented two studies – that of a touring artwork that engaged the public with climate data, and the design of a data blogging system that was developed alongside a series of artistic activities.

These studies highlight the distinct strategies of *performing data*, *sensory experience* and *multiple interpretations* that the artists used to engage the public with climate data. As can be seen in both studies, the artists employed a distinct voice in order to provoke emotional responses to the data that often resulted in issues around authenticity, how they mediated and scaled the data to tell a story whilst maintaining a grounded representation of the science.

This research also provides a broader discussion of the role of the artists in interdisciplinary collaborations and their contributions to Contemporary Art, HCI and Climate Science. The final discussion reveals the significance of *ongoing collaborations* between artist and scientists that enable the sharing of knowledge as a two, or in this case three way street.

This concluding chapter summarises these findings in response to the initial research questions, highlighting the contributions of this research in relation to the key literature and suggesting future work.

9.1 Discussion

In this current era of ‘big data’ and in the context of a growing digital economy in both the UK and Brazil (where this research takes place) this thesis provides a timely insight into alternative strategies for dealing with scientific data and engaging the public in a dialogue about meaning, sense making and humanizing our experiences of data. This work is also timely in the investigation of public understandings of the ongoing threat of climate change, highlighting the role that artists can play in providing new contexts and perspectives on public engagement with climate data.

Studies of both projects within this thesis support a broader discussion on the role of the artist within this process, resulting in a thematic enquiry into what can be specifically learnt from the two case studies - *A Conversation Between Trees* and the *Relate Project*.

Related literature reveals artists are increasingly creating personal, emotional and human-scale interpretations of climate data, highlighted by Malina and Spitz’s work around ‘intimate science’ (Malina 2009, Rimmer 2009) and the work that emerged from the interdisciplinary conference, ISEA 2011 (Aceti 2012). What is most notable through mapping of this literature is the limited research into the public’s experience of these artworks. Existing research across the related disciplines suggest the importance of environmentally engaged artists engaging the public with climate change, particularly within Climate Science (Curtis et al. 2012), but few studies have been done of the impact of these activities on public engagement with the data or changes in behavior in response.

The resulting thematic enquiry detailed in Chapters 5 and 7 investigates how artists develop strategies for creating ‘concrete’ and tangible conceptualisations of scientific climate data and most significantly a rich description of the public’s response to the artwork *ACBT*. This research suggests the artists provoke emotional engagement with data, rather than following an informative or persuasive approach - beyond ‘*environmental knowing*’ – enabling the public to engage in human-scale, embodied, localized and personalized sense making. Both studies within this research highlight the challenges and opportunities created by the distinct ways that the artists’ engaged with the key strategies of *performing data*, *sensory experience* and *multiple interpretations* - to provoke this emotional engagement with the data.

One of the most novel concepts arising from this research is the concept of artists’ ‘*performing data*’ – creating *temporal structures* and *narratives* that bringing the data *centre*

stage within their work. Examples include the ways in which the artists were present in the gallery during the exhibition of *ACBT*, hanging the discs from the ceiling and entering into dialogue with the public. The data was also '*performed*' through the artistic experiments that took place as part of the *Relate Project*, including the *Inflatable Sculptures* and the artist's performance of CO₂ data at the farmhouse in Brazil as part of the video '*Before Light*'.

Both studies reveal broader discussions around how these artists walk a line between *authenticity* and *emotional engagement* in these interpretations of scientific climate data, and the conflicts and opportunities presented by this approach. Significant to this is an ongoing dialogic collaboration between the artists, the public, HCI researchers and scientists - in order to support authentic and meaningful engagements with the data.

Existing research by Polli (Polli 2011) highlights the importance of collaboration within these practices. This thesis begins to unravel these collaborations further, by exploring the conflicts and opportunities provided by both the use of technology within these artworks, the tensions between scientific authenticity and artistic integrity, and issues around the role of artists as facilitators of dialogue.

The research within this thesis extends existing HCI methods for the design of systems and their evaluation by revealing the innovative process involved in the design and experience of firstly *ACBT* and then how this informed the *Relate Project*. The studies of both projects specifically extends Taylor's '*designing from within*' (Taylor 2012) and Benford et al.'s '*Performance-Led Research in the Wild*' framework (Benford et al. 2013) by presenting an iterative process of research and design this provided opportunities for the author to shift perspective between artist and researcher and reflecting on the points of conflict created by taking on the role of ethnographer within a wider cycle of artistic production, public exhibition and system design.

This thesis reveals that artists can have a distinctive and powerful role to play in relation to climate change and sustainability; one that supports Sustainable HCI research in particular as HCI research continues to move into this territory, where HCI might ultimately learn about how to bring an emotional treatment to many other forms of data. This work supports the call by DiSalvo et al. for Sustainable HCI to take these artists strategies into account (DiSalvo et al. 2009). This thesis also presents concrete examples of how the artists' strategies revealed within the studies can be embedded into future practices and technologies within HCI and Climate Science - towards the design of new participatory sensing and systems for capturing and interpreting climate data in remote rural places, as well as for the production and study of new artworks that use these systems.

9.2 Answering the Research Questions

What is the role of artists working with climate data?

This research reveals that artists have a distinctive and powerful role to play in relation to climate change and sustainability.

These findings suggest artists contribute to HCI in particular, as HCI researchers are increasingly exploring the role of artists within the research field of Sustainable HCI, by providing new strategies and thinking around the treatment of environmental and scientific data in order to provoke an emotional response.

These findings also suggest that through working in collaboration with HCI artists have a distinct role to play as co-designers of new systems. In this case by providing novel thinking around the design of temporal structures, the manipulation and the mediation of data on a temporal scale including new approaches to slowness and liveness. This research also presents examples of how artists can support the design of multiple ways to output and *'perform'* data as part of the design of a system for the capture and interpretation of data.

Buontempo proposes that artists can play an important role in translating climate data and providing new narratives around climate change through ongoing collaboration and dialogue between artists and scientists, towards the creation of authentic yet meaningful artworks that engage the public with climate change. As climate scientists continue to address the complex issues of engaging the public with issues of climate data, the strategies of *performing data*, *sensory experience* and *multiple interpretations* can inform climate scientists in their quest to communicate climate change to the public.

This research suggests that through ongoing collaborations, artists and climate scientists can begin to tell meaningful stories of climate change. The findings from these studies suggest this can occur through considering the role of temporality (including slowness and liveness) and narrative; exploring the data as a new sensory material in which to create embodied and embedded experiences of climate data; and by abstracting and juxtaposing multiple, contrasting and yet related datasets.

This research also discusses the need to build a process of iterative design around the needs of the artists to keep the technology in the background within their artistic process and engagements with the public, raising questions for future research around interdisciplinary collaborations.

Finally the research provides an insight into the impact of working with science and technology on the artistic process. How at times the conflicting need of artistic integrity, responsibility to the scientific nature of the data and engaging the audiences can provide

tensions, discussing the role of the artist within these interdisciplinary collaborations. This research suggests the artists' role goes beyond merely instrumenting science and technology towards presenting new strategies for the treatment of climate data, providing a distinctive voice that provokes emotional engagement with climate data and novel approaches to the design of systems for sustainable HCI.

What are the specific strategies that these artists employ to engage the public with climate data?

This research presents three distinct strategies used by the artists to engage the public with climate data:

Performing data

The artists adopted a *performative temporal structure* that combines human-scale interpretations along with *slowness* with *liveness*. The artists created dynamic experiences of climate data that enabled visitors to the artwork, *ACBT*, to reflect on the data, encouraging dialogue with others about the meaning of the data and creating a longer-term engagement with the data that resulted in visitors continuing to think about and discuss the data after their experience of the artwork. These temporal structures also informed the design of the *Timestream* Platform, the novel design of multiple data streams along a timeline within the platform interface that enabled the artists to scale, replay and re-present live, recorded and modeled data.

Sensory Experience

By *creating sensory experiences* the artists were able to embody and embed climate data in various material and aesthetic ways, treating the data as a new material with its own aesthetics, set of metaphors and characteristics. These sensory engagements enabled the artists to create human scale, meaningful representations of data.

Multiple Interpretations

The artists *juxtaposed multiple interpretations* of the data, so as to invite comparisons and open up spaces between them for interpretation and dialogue. These multiple interpretations also informed the design of the multiple data streams on the *Timestream* Platform that could also be outputted in many forms and to multiple devices, enabling the artists to present complex and contrasting data. The artists created multiple interpretations of the data through the strategies of abstraction, juxtaposition and dialogue that were often situated by the capture of the data in a specific space and time and reflected the complex nature of climate data. It was these multiple interpretations of the data that most interested the climate scientist Buontempo, suggesting that by providing opportunities for the public to engage on multiple

levels with the data can enable new interpretations that open up opportunities for understanding that go beyond the statistics in order to engage in more personal, emotional ways on a human scale.

These strategies extend HCI's existing interest in the role of *performance*, *sensory experience* and *multiple interpretations*, proposing that these strategies can provide new ways to approach the capture, measurement and interpretation of many forms of data and the design of technologies to support these activities.

These strategies also support future collaborations between artists and climate scientists, providing examples of how artists walk a line between their desire to create an emotionally compelling experience for visitors and scientific authenticity. As the findings from the research suggest, by engaging in a dialogic approach ongoing collaborations between artists and climate scientists can enable new understandings and shared knowledge between the disciplines that can support public engagement with climate data through authentic and meaningful experiences.

How do the public perceive artists' work that employs these strategies?

The artworks appeared to provoke an emotional response in the visitors to the artwork *ACBT* and the artistic experiments that resulted from the *Relate Project* were able to engage the public in multiple ways.

The key implications of the public's perceptions of these works to the disciplines of Contemporary Art, HCI and Climate Science was in the ways the public were able to observe the data for themselves, which provoked a variety of emotional responses. As seen in the study of the artwork *ACBT*, people began to feel sufficiently strongly about the data that they wanted to reflect on it afterwards or to discuss it with others. It also reached out to an audience that might not normally engage with scientific data when presented in more traditional ways. This was evidenced by the comments and the demographic of the audiences, where the visitors tended to come across the artwork whilst going for a walk, visiting the gallery or forest where the work was situated, rather than deliberately seeking out a '*climate change related experience*'.

It appeared to be important to the public that these artworks provided multiple interpretations of the data. These experiences of the data were sensory and embodied, relying on distinct visual aesthetics, metaphors and narratives, yet were grounded in science and often experienced live. The visitors suggest that these strategies provided opportunities to reflect on and experience climate data in ways that didn't focus on the statistics or numerical data that were without an overtly political agenda and didn't make them feel fearful, proposing

that this approach enabled the public to engage in emotional and meaningful ways with the data.

The climate scientist proposes that the artworks provided important opportunities to engage the public with climate data in new ways and this has implications for the communication of climate change within Climate science. Of particular interest was the ways in which the artists embedded data into elements of the artworks and the narratives that were used to connect the public to the data in personal ways (such as visitors to *ACBT* looking for their birth year on the hanging discs, and the weather predictions printed as fortunes with *The Prediction Machine*). This research shows that by creating an emotional response to climate data the artists were able to reach a wide and diverse audience that could inform climate scientists and HCI researchers in their future practices, providing a first step towards enabling people to clarify their perspective on climate data and the wider issues of climate change.

These issues have implications for sustainable HCI and the design of future technologies for sensing, visualizing and interpreting environmental and potentially other forms of data.

Firstly, the ways in which the artists employed the strategies of performing data, created sensory experiences and multiple interpretations of the data suggest that these sustainability tools and systems should encourage new forms of manipulating and interpreting data to enable the public to engage with data on more personal and emotional levels. This research also suggests that employing these strategies within systems for the capture, manipulation and interpretation of data could potentially support new understandings and longer-term engagement with the data, which previous research shows (Giannachi 2012) is the first step towards action and behavioral change.

How might these strategies be embedded into future practices and technologies?

The strategies and discussions presented in this research have implications across the disciplines of Contemporary Art, HCI and Climate Science.

The opportunities provided by this research to the future practices of Contemporary Art are through the mapping of this interdisciplinary space, highlighting the significance of ongoing collaborations between artists, HCI researchers and climate scientists and the importance of the dialogic practices that support these collaborations. The findings from this research also suggests that the use of performance including human-scale representations of climate data and sensory experiences of data - significantly ones that enable the public to embody the data and create personalized experiences - and the use of data as a new material are important strategies used by artists within this domain. These findings extend previous research, to provide a rich description of how the artists in the studies employed these strategies.

Where this research most informs the discipline of Contemporary Art is in the rich description of the public's response to the artwork, considering their perspectives alongside the artists' strategies, motivations and rationale and the responses of the collaborating climate scientist and HCI researchers. These perspectives have the potential to enrich artists' understanding of their practice and their understanding of the impact of these practices on other disciplines and the public.

The implications of these findings for HCI supports the growing interest in the role of artists in engaging the public with issues of sustainability, participatory sensing activities and climate change. This research specifically extends the work by DiSalvo et al. (DiSalvo et al. 2009a) that suggests artists can contribute to sustainable HCI through their questioning of the ontologies of sustainability, embracing politics and reimagining the relationships between technology, people and culture. By focusing on two artist-led projects this research digs deeper into these discussions, suggesting that environmentally engaged artists provide distinct strategies that can support both the design of systems within sustainable HCI and considerations of the issues of sustainability, and climate change in particular. This research reflects on the complex issues of how artists go beyond instrumenting science in order to provoke emotional and meaningful responses, how artists employ dialogic approaches that are not necessarily overtly political, in order to walk a line between empirical knowledge, scientific authenticity and the creation of evocative emotional experiences.

This research also reveals the implications of artists co-designing a new system and how these artists' strategies informed the design of the *Timestreams* Platform by suggesting the capture of both offline and online data through a simple WordPress site; providing opportunities to author data along a timeline, playing with scale, speed and liveness in order to access multiple data streams; as well as creating different temporal representations of the data. These can then each be outputted in multiple ways using the *Timestreams* API, to be embedded in artifacts, immersive experiences, mobile applications, visualisations and a WordPress Blog, allowing the artists to create *performances of data* as part of their artistic practices.

The *Timestreams* Platform not only provides an example of how artists' strategies can inform the design of a platform but also how HCI can design tools and technologies for future artistic practices. This research highlights the importance of accessibility and the need to consider artists' existing expertise in the future design of artists' tools, suggesting there is often a need to provide technical support to artists alongside access to tools and technology. Some of these concerns have been reported in previous HCI literature (Benford et al. 2013; Hallnäs & Redström 2002) yet Blum et al. (Blum et al. 2013) suggest this work reveals a

need for further research into the development of tools specifically for artists, particularly for systems that involve the capture and interpretation of data.

This research also argues for further research into developing tools for remote environmental and climate data capture, revealing the implications of creating personal and local, situated experiences of climate data. This research exposes issues around liveness, temporality including slowness and scale, and the robustness of the technology in the design of these systems. The studies reveal how these issues informed the ways the artists presented the live data as visualisations and the forest walk, through an improvised process of '*smoke and mirrors*' as described in Chapter 5 and how the *Timestreams* Platform provided opportunities to respond to problems with situating the technology in remote places by playing with notions of liveness.

Finally, this research provides an example of how the author shifts perspectives between artist and researcher in order to conduct studies of her own practice and the practices of other artists, alongside the perspectives of HCI researchers and a climate scientist. The author's reflections on this mixed method approach extends the frameworks proposed by Benford et al. (Benford et al. 2013) and Taylor (Taylor 2012) for evaluating artists' practices from an HCI perspective. In this case the author proposes an approach that combines perspectives - between the artists, scientists and the public - providing an example for future artists/researchers working within this context.

9.3 Contributions Summary

This thesis has contributed to the following research across the disciplines of Contemporary Art, HCI and Climate Science:

- Mapping and defining the notion of environmentally engaged art that engages the public with climate data through a review of existing literature and a study of the motivations and rationale of the artists who engaged with climate data as part of the artwork *ACBT* and the *Relate Project*
- Identification of the three key strategies employed by the artists including the notion of *performing data* as a way of creating performative temporal structures and narratives, that combine human scale interpretations with slowness and liveness; *sensory experiences* that embody and embed scientific data in material and aesthetic ways; and juxtaposing *multiple interpretations* of data in abstract and situated forms that encourage dialogue and reflection

- Defining the concept of '*performing data*' as a response to the ways that the artists brought data '*centre stage*' within their artworks and employed performative and temporal strategies to provoke emotional responses to the data
- Providing insights into the response of the public who visited the artwork *ACBT* and a rich description of how they engaged with the climate data embedded in the work
- Providing an insight into the response of a climate scientist working with the artists, discussing the conflicts and tensions between the artists and scientist, raising issues of artists *instrumenting science* and how the artists walk the line between scientific authenticity and rigor and emotional engagement
- A study of how the artists' strategies informed the design of the *Timestreams* Platform, the artists role in this design and a discussion of how the artists perceived technology within their artistic process, often requiring the technology to remain in the background
- This research also extends existing HCI approaches for evaluating interactive artworks and artistic practices, providing a reflexive account of the authors role as researcher, artist and co-designer of the *Timestreams* Platform that required the author to shift between the different perspectives of artist and researcher in order to study the artists, scientist, public and HCI researchers

This research has contributed to mapping out the approaches of the three disciplines of Contemporary Art, HCI and Climate Science, as shown by the Venn Diagram in Chapter 2.

The thesis extends the growing body of work within broader HCI research that looks towards artistic practice, and within the sub-field of Sustainable HCI in relation to climate change, participatory sensing and sustainability. The core contribution of this research to HCI has been the development and testing of the *Timestreams* Platform as part of the wider *Relate Project*.

This research has also resulted in the following HCI publications:

- A workshop position paper at CHI 2012 (Jacobs et al. 2012)
- A workshop position paper at DIS 2012 (Jacobs, Selby, et al. 2012)
- Best Paper Honorary Mention Award at CHI 2013 (Jacobs et al. 2013)
- Best Regular Paper at Digital Futures Conference 2012 (Blum et al. 2012)
- Paper accepted at Ubicomp 2013 (Blum et al. 2013)

Other interdisciplinary contributions have involved:

- A paper presented at Atenir Conference 2011 (Giannachi 2010)

- A symposium event (organized by the author as part of the *Relate Project*) at Arts Catalyst, London discussing the intersection between arts, media and ecological/environmental issues, including a range of speakers working in interdisciplinary fields across art, science, technology and media³²

The artist-led projects studied within this thesis have contributed to the following public outcomes in both the UK and Brazil, with each of these contributions taking place within the public domain:

- A touring artwork *A Conversation Between Trees* (ACBT) that has taken place in 3 forest venues across the UK and in the Mata Atlantica, Rio de Janeiro, Brazil (2009-2011)³³
- An artist residency in a farm in the Mata Atlantica, Miguel Pereira, Brazil (2012)³⁴
- An artist and an exhibition of resulting artworks as part of the *Relate Project* in Rio de Janeiro, Brazil (2012)
- An exhibition and Hackday event in the UK as part of the *Relate Project*
- The development of the *Timestreams* Platform, an online sensing and blogging system designed to enable artists to ‘perform data’³⁵
- The *Timestreams* Platform has also been adapted for use in two further HCI data blogging projects Bee Lab³⁶ and Energy for Change³⁷

Finally this work has contributed to discourses on evaluating artists practices within HCI, providing a unique example of how the author was able to shift perspectives between artist, researcher and co-designer during the study of the two artist-led projects. Combining the mixed method approach informed by the *Performance-led Research in the Wild* (Benford et al. 2013) and the *Designing from Within* frameworks (Taylor 2011). This approach has revealed many of the challenges, conflicts and opportunities for taking on a role of artist/researcher that merges ethnography with a reflexive practice-led approach.

³² <http://ai.timestreams.org/events/>

³³ www.hello-tree.com

³⁴ www.ai.timestreams.org

³⁵ www.timestreams.org

³⁶ <http://beelab.org>

³⁷ <http://energyforchange.ac.uk>

9.4 Future Work

This research covers a broad range of activities. The inherently ambitious and interdisciplinary nature of the artist-led projects and the complex nature of the author taking on a mixed method approach to conducting these studies have revealed many further questions in support of future work.

By extending the work by Taylor and Benford et al. the author's experiences as artist/researcher looks towards future research into how self-situated research could be of benefit to the academic study of both HCI and Contemporary Art and collaborations between the two.

The extended themes, discussed in the previous chapter, lays the ground for further research that engages more deeply with these themes. The area least explored in this work was the challenges and opportunities for encouraging behavior change and social action as part of artists' strategies for engaging the public with climate data. These extended themes provide the author with a set of questions for both her future artistic practice and further research.

As can be seen by the discussion of the distinct strategies that the artists used, the artists focused on ways that engaged the public with data on an emotional level that enabled the public to feel something rather than trying to inform or persuade. Where this research remains limited is in its discussion of changing behaviors and supporting action in response to these experiences – raising questions as to how the strategies used to engage the public on an emotional level can also support action in response. This provides opportunities for future research to investigate political and socially engaged agendas, in reflection of the wide ranging existing work within HCI on sustainability and behavioral change (Bird & Rogers 2010; Brynjarsdottir et al. 2012) and the growing research area within HCI that looks at the role of technology in enabling and inspiring social action (Busse et al. 2013; Wulf et al. 2013).

Due to the orientation of this thesis to an HCI audience, the area that is least covered within these studies is that of the collaboration between Contemporary Art and Climate Science, and the role of HCI within these collaborations. As the literature review in Chapter 2 suggests, there is limited research occurring within this area, particularly into the impact of the artists' strategies and contributions that have been revealed within this thesis. Therefore, one of the next steps for this research is to explore this impact, finding ways to present the findings of this research back to a scientific community, potentially through presentations at science festivals, Hackdays, and through ongoing collaborations between artists and climate scientists.

Two future projects have already been confirmed as a result of this research. Firstly the author has been commissioned to develop a new artwork as a development of *'The Prediction Machine'* - one of the experimental artworks that emerged from the *Relate Project* - due to be publicly exhibited at Loughborough University in 2014. Additional to this, the author has been employed to act as a consultant on the development of a mobile phone game – Cold Sun - as part of a research project that looks at how game mechanics can engage the public with climate data, funded by Creative Exchange³⁸ as a collaboration between Mudlark Productions, Lancaster University and Anglia Ruskin University.

Finally, the author has also been invited to be an advisor to the MET office UK on a series of Hackdays engaging artists and designers with climate data, and to present the findings of this research as part of the UK Technology Strategy Board Data Visualisation Workshop in October 2013.

³⁸ <http://thecreativeexchange.org>

Bibliography

- Aceti, L., Sahin, O. Ackerman A, 2012. Uncontainable. 17th International Symposium on Electronic Art ISEA Istanbul, Leonardo/ISAT, ISEA Foundation, Sabanci University and Goldsmiths, London
- Ades, D., 1989. Latin America: The Modern Era 1820-1980. New Haven - London: Yale University Press.
- Adorno, T.W., 2004. Aesthetic Theory, Continuum.
- Adorno, T. W. (1982). *Prisms*. Mit Press.
- Amirsadeghi, H. ed, Petitgas, C. 2012. *Contemporary Art Brazil*, London: Thames and Hudson.
- Mauna Loa, Trends in Carbon Dioxide. *esrl.noaa.gov*. Available at: <http://www.esrl.noaa.gov/gmd/ccgg/trends/> [Accessed August 16, 2013].
- Relate Research Project, 2012. Horizon, digital economy research. Available at: http://horizab1.miniserver.com/relate/?page_id=709 [Accessed July 23, 2013].
- Aoki, P. M., Honicky, R. J., Mainwaring, A., Myers, C., Paulos, E., Subramanian, S., & Woodruff, A. (2009, April). A vehicle for research: using street sweepers to explore the landscape of environmental community action. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 375-384). ACM.
- Arends, B. & Thackara, D., 2003. *Experiment: conversations in art and science*, London: Wellcome Trust.
- Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010, April). Useful junk?: the effects of visual embellishment on comprehension and memorability of charts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2573-2582). ACM.
- Benford, S., & Giannachi, G. (2011). *Performing mixed reality*. The MIT Press.
- Benford, S., Giannachi, G., Koleva, B., & Rodden, T. (2009, April). From interaction to trajectories: designing coherent journeys through user experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 709-718). ACM.
- Benford, S., Greenhalgh, C., Giannachi, G., Walker, B., Marshall, J., & Rodden, T. (2012, May). Uncomfortable interactions. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems* (pp. 2005-2014). ACM.

- Benford, S., Greenhalgh, C., Crabtree, A., Flintham, M., Walker, B., Marshall, J., & Row Farr, J. (2013). Performance-Led Research in the Wild. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 20(3), 14.
- Benford, S., Crabtree, A., Flintham, M., Greenhalgh, C., Koleva, B., Adams, M., & Lindt, I. (2011). Creating the spectacle: Designing interactional trajectories through spectator interfaces. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 18(3), 11.
- Benjamin, W. (2008). *The work of art in the age of mechanical reproduction*. Penguin UK.
- Beuys, J. (2004). *What is art?: conversation with Joseph Beuys*. Clairview Books.
- Bindi G., (2011) *Man at the Centre of the Climate, Parco Arte Vivente*, Centro de Arte Contemporanea Torino
- Bird, J., & Rogers, Y. (2010). The pulse of tidy street: Measuring and publicly displaying domestic electricity consumption. In *Workshop on Energy Awareness and Conservation through Pervasive Applications (Pervasive 2010)*.
- Bloom, L., 2011. Contemporary Art and Climate Change: The Aesthetics of Disappearance at the Poles. *isea2011.sabanciuniv.edu*. Available at: <http://isea2011.sabanciuniv.edu/paper/aesthetics-disappearance-climate-change-antarctica-and-contemporary-sublime-work-anne-noble-co> [Accessed August 6, 2013].
- Blum, J., Flintham, M., McAuley, D., Jacobs, R., Watkins, M., Lee, R., ... & Giannachi, G. (2012). Timestreams: Supporting Community Engagement in the Climate Change Debate.
- Blum, J., Flintham, M. & Jacobs, R., 2013. *The Timestreams Platform*, Ubicomp 2013.
- Blum, J., Flintham, M., Jacobs, R., Shipp, V., Kefalidou, G., Brown, M., & McAuley, D. (2013, September). The timestreams platform: artist mediated participatory sensing for environmental discourse. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing* (pp. 285-294). ACM.
- Boykoff, M. T. (2011). *Who speaks for the climate?: Making sense of media reporting on climate change*. Cambridge University Press.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.
- Brett, G., 2002. *Art in the Plural*, Novas Direções, Museu de Arte Moderna, Rio de Janeiro Available at: http://www.nbp.pro.br/doc/art_in_the_plural_guy_brett_1162.pdf [Accessed August 6, 2013].
- Brynjarsdottir, H., Håkansson, M., Pierce, J., Baumer, E., DiSalvo, C., & Sengers, P. (2012, May). Sustainably unpersuaded: how persuasion narrows our vision of sustainability. In

Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems (pp. 947-956). ACM.

Bunting M., (2008) Art and Climate An Essay: does the art stop when the persuasion starts?, *RSA Arts and Ecology Magazine*, RSA

Bureaud, A., (2011) Climate Change: Embodying the Data. *www.leoalmanac.org*. Available at: <http://www.leoalmanac.org/isea2011-panel-farfield2-the-data-landscapes-of-climate-change/> [Accessed July 26, 2013].

Burke, J., Friedman, J., Mendelowitz, E., Park, H., & Srivastava, M. B. (2006). Embedding expression: Pervasive computing architecture for art and entertainment. *Pervasive and Mobile Computing*, 2(1), 1-36.

Burke, J. A., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., & Srivastava, M. B. (2006). Participatory sensing.

Busse, D. K., Borning, A., Mann, S., Hirsch, T., Nathan, L. P., Grimes Parker, A., ... & Nunez, B. (2013, April). CHI at the barricades: an activist agenda?. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 2407-2412). ACM.

Collingridge, D., & Reeve, C. (1986). Science speaks to power: the role of experts in policy making. London: Pinter.

Cosgrove, D. E. (2008). Geography and vision: seeing, imagining and representing the world (Vol. 12). London: IB Tauris.

Cranston, P. (2009). The potential of mobile devices in wireless environments to provide e-services for positive social and economic change in rural communities. *ICT Observatory on ICTs, ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA)*, Wageningen, October.

Curtis, D. J., Reid, N., & Ballard, G. (2012). Communicating Ecology Through Art: What Scientists Think. *Ecology & Society*, 17(2).

Davis, S. B., Moar, M., Cox, J., Riddoch, C., Cooke, K., Jacobs, R., ... & Melamed, T. (2005, November). 'Ere be dragons: an interactive artwork. In *Proceedings of the 13th annual ACM international conference on Multimedia* (pp. 1059-1060). ACM.

Davis, S. B., Moar, M., Jacobs, R., Watkins, M., Riddoch, C., & Cooke, K. (2006). 'Ere be dragons: heartfelt gaming. *Digital Creativity*, 17(3), 157-162.

Deller, J, 2001. Jeremy Deller. *jeremydeller.org*. Available at: <http://jeremydeller.org/> [Accessed September 8, 2013].

Demos, T. J. (2013). Contemporary Art and the Politics of Ecology: An Introduction. *Third Text*, 27(1), 1-9.

- DiSalvo, C., Nourbakhsh, I., Holstius, D., Akin, A., & Louw, M. (2008). The Neighborhood Networks project: a case study of critical engagement and creative expression through participatory design. In *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008* (pp. 41-50). Indiana University.
- DiSalvo, C., Boehner, K., et al., (2009a) Nourishing the ground for sustainable HCI: DiSalvo, C., Boehner, K., Knouf, N. A., and Sengers, P. 2009. Nourishing the ground for sustainable HCI: considerations from ecologically engaged art. *Proc CHI '09*. ACM, 385-394.
- DiSalvo, C., Louw, M., Coupland, J., & Steiner, M. (2009b). Local issues, local uses: tools for robotics and sensing in community contexts. In *Proceedings of the seventh ACM conference on Creativity and cognition* (pp. 245-254). ACM.
- DiSalvo, C., Sengers, P., & Brynjarsdóttir, H. (2010, April). Mapping the landscape of sustainable HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1975-1984). ACM.
- Dourish, P. (1999). Embodied interaction: Exploring the foundations of a new approach to HCI. *Unpublished paper, on-line: <http://www.ics.uci.edu/~jpd/publications/misc/embodied.pdf>*.
- Dourish, P., Finlay, J., Sengers, P., & Wright, P. (2004, April). Reflective HCI: Towards a critical technical practice. In *CHI'04 extended abstracts on Human factors in computing systems* (pp. 1727-1728). ACM.
- Ede, S. (2005). *Art and science*. IB Tauris Publishers.
- England, D. (2012, May). Digital art and interaction: lessons in collaboration. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems* (pp. 703-712). ACM.
- England, D., Fantauzzacoffin, J., Bryan-Kinns, N., Latulipe, C., Candy, L., & Sheridan, J. (2012, May). Digital art: evaluation, appreciation, critique (invited SIG). In *CHI'12 Extended Abstracts on Human Factors in Computing Systems* (pp. 1213-1216). ACM.
- Ferran, B. (2012). Sheltering from the Storm—Artistic Residencies and Environmental Crisis. *Leonardo*, 45(2), 194-195.
- Ferran, B. & Fonseca, F., (2009) E-Culture. *www.sica.nl*. Available at: http://www.sica.nl/sites/default/files/3R_E-Culture.pdf [Accessed August 6, 2013].
- Fitzgerald, C., (2013) *Networking the arts to save the earth*, ecoartnetworkjournal.com
- Flintham, M., Greenhalgh, C., Lodge, T., Chamberlain, A., Paxton, M., Jacobs, R., & Shackford, R. (2011, November). A case study of exploding places, a mobile location-based game. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology* (p. 30). ACM.

- Fogg, B. J. (1998, January). Persuasive computers: perspectives and research directions. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 225-232). ACM Press/Addison-Wesley Publishing Co.
- Foth, M., Satchell, C., Paulos, E., Igoe, T., & Ratti, C. (2008). Pervasive persuasive technology and environmental sustainability. In *Proc Pervasive '08 Workshops*.
- Friedman, B., & Nathan, L. P. (2010, April). Multi-lifespan information system design: a research initiative for the hci community. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2243-2246). ACM.
- Friedman, T. & Goldsworthy, A., (1990) *Hand to Earth*, Andy Goldsworthy Sculpture 1976 - 1990, W.S. Maney & Son Ltd in association with The Henry Moore Centre for the Study of Sculpture 1991
- Froehlich, J., Findlater, L., & Landay, J. (2010, April). The design of eco-feedback technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1999-2008). ACM.
- Gabrys, J., & Yusoff, K. (2012). Arts, sciences and climate change: practices and politics at the threshold. *Science as culture*, 21(1), 1-24.
- Gaonkar, S., Li, J., Choudhury, R. R., Cox, L., & Schmidt, A. (2008, June). Micro-blog: sharing and querying content through mobile phones and social participation. In *Proceedings of the 6th international conference on Mobile systems, applications, and services* (pp. 174-186). ACM.
- Gaver, W. W., Beaver, J., & Benford, S. (2003, April). Ambiguity as a resource for design. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 233-240). ACM.
- Giannachi, G., 2012. Energy in art, Relate A. Ingredient & H. D. E. Research, eds. *horizab1.miniserver.com*. Available at: http://horizab1.miniserver.com/relate/?page_id=304 [Accessed August 6, 2013].
- Giannachi, G., R Jacobs, S Benford, (2011) Performing Nature's Footprint, in Arbury SA (eds) *Visual and Performing Arts*, Athens: Atiner, 393-404
- Giannachi, G. (2012). Representing, Performing and Mitigating Climate Change in Contemporary Art Practice. *Leonardo*, 45(2), 124-131.
- Giannachi, G., 2004. *Virtual Theatres*
- Giannachi, G. & Kaye, N., (2011) *Performing Presence: Between the Live and the Simulated*, Manchester, Manchester University Press,

- Giannachi, G., & Stewart, N. (Eds.). (2005). *Performing Nature: Explorations in ecology and the arts*. Peter Lang.
- Gieryn, T. F. (1999). *Cultural boundaries of science: Credibility on the line*. University of Chicago Press.
- Goldberg, R. (1979). *Performance: live art 1909 to the present*. London: Thames and Hudson.
- Goldman, J., Shilton, K., Burke, J., Estrin, D., Hansen, M., Ramanathan, N., ... & West, R. (2009). Participatory Sensing: A citizen-powered approach to illuminating the patterns that shape our world. *Foresight & Governance Project, White Paper*, 1-15.
- Goodman, E. (2009, April). Three environmental discourses in human-computer interaction. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems* (pp. 2535-2544). ACM.
- Grande, J. (2001). Real Living Art: A Conversation with David Nash. *Sculpture*, 20 (10), 24-31.
- Grant, C., 2010. BBC News - David Hockney's instant iPad art. [bbc.co.uk](http://www.bbc.co.uk/news/technology-11666162). Available at: <http://www.bbc.co.uk/news/technology-11666162> [Accessed August 6, 2013].
- Guattari, F. (1996). *Remaking Social Practices*1.
- Hallnäs, L., & Redström, J. (2002). From use to presence: on the expressions and aesthetics of everyday computational things. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 9(2), 106-124.
- Hallnäs, L., & Redström, J. (2001). Slow technology—designing for reflection. *Personal and ubiquitous computing*, 5(3), 201-212.
- Harrison, E., (2013) *The Redistribution of Wealth* (animation) on Vimeo. [vimeo.com](http://vimeo.com/71129124). Available at: <https://vimeo.com/71129124> [Accessed September 23, 2013].
- Harrison, S., Tatar, D., & Sengers, P. (2007, April). The three paradigms of HCI. In *Alt. Chi. Session at the SIGCHI Conference on Human Factors in Computing Systems San Jose, California, USA* (pp. 1-18).
- Hemment, D., Buontempo, C., & Dennon, A. (2009). *Climate Bubbles: Artwork and Design Prototype*.
- Hohl, M. (2012). *Making visible the invisible: art, design and science in data visualisation* University of Huddersfield, Huddersfield
- Holmes, T. G. (2007, June). Eco-visualization: combining art and technology to reduce energy consumption. In *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition* (pp. 153-162). ACM.

- Holquist, M. (2002). *Dialogism: Bakhtin and his world*. Routledge.
- Hook, J., Schofield, G., Taylor, R., Bartindale, T., McCarthy, J., & Wright, P. (2012, May). Exploring HCI's relationship with liveness. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems* (pp. 2771-2774). ACM.
- Höök, K., Sengers, P., & Andersson, G. (2003, April). Sense and sensibility: evaluation and interactive art. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 241-248). ACM.
- Irwin, A. (1995). *Citizen science: A study of people, expertise and sustainable development*. Psychology Press.
- Ishii, H., & Ullmer, B. (1997, March). Tangible bits: towards seamless interfaces between people, bits and atoms. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems* (pp. 234-241). ACM.
- Jacko, J.A., (2012) *The Human-Computer Interaction Handbook*,: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition (Human Factors and Ergonomics) CRC Press. Taylor & Francis Group
- Jacobs, R., Benford, S., Selby, M., Golembewski, M., Price, D., & Giannachi, G. (2013, April). A conversation between trees: what data feels like in the forest. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 129-138). ACM.
- Jacobs, R. Selby, M. Leal, R. Shackford, R. (2011) *Material Conditions*. Proboscis, Bookleteer, pp.1–18. Available at: <http://bkltr.it/rU4H1u>.
- Jacobs, R., Selby, M., & Benford, S. (2012) *Engaging With Slowness: A Temporal Experience of Climate Change*.
- Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*, 2(10), 732-735.
- Kester, G.H., (1998) *Arts, Activism, and Oppositionality: Essays from Afterimage*, Duke University Press.
- Kester, G. H. (2004). *Conversation pieces: Community and communication in modern art*. University of California Pr.
- Kim, S., Mankoff, J., & Paulos, E. (2013, February). Sensr: evaluating a flexible framework for authoring mobile data-collection tools for citizen science. In *Proceedings of the 2013 conference on Computer supported cooperative work* (pp. 1453-1462). ACM.

- Knowles, B., Blair, L., Hazas, M., & Walker, S. (2013, September). Exploring sustainability research in computing: where we are and where we go next. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing* (pp. 305-314). ACM.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall..
- Krosnick, J. A., Holbrook, A. L., Lowe, L., & Visser, P. S. (2006). The origins and consequences of democratic citizens' policy agendas: A study of popular concern about global warming. *Climatic change*, 77(1-2), 7-43.
- Kuznetsov, S., Davis, G. N., Paulos, E., Gross, M. D., & Cheung, J. C. (2011, September). Red balloon, green balloon, sensors in the sky. In *Proceedings of the 13th international conference on Ubiquitous computing* (pp. 237-246). ACM.
- Kwon, M. (2004). *One place after another: Site-specific art and locational identity*. MIT press.
- Latour, B. (2009). *Politics of nature*. Harvard University Press.
- Laurel, B. (Ed.). (2003). *Design research: Methods and perspectives*. the MIT Press.
- Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research methods in human-computer interaction*. Wiley. com..
- Lynch, M. (2000). Against reflexivity as an academic virtue and source of privileged knowledge. *Theory, Culture & Society*, 17(3), 26-54.
- Malina, R., (2009) Rethinking Art as Intimate Science: Climate Art as a Hard Humanity. *diatropes.com*. Available at: http://www.diatropes.com/rfm/docs/Art_Intimate_Science.pdf [Accessed July 22, 2013].
- Marshall, J., & Benford, S. (2011, May). Using fast interaction to create intense experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1255-1264). ACM.
- McCandless, D. (2009). *Information is beautiful*. HarperCollins UK.
- McCarthy, J., & Wright, P. (2005). Putting 'felt-life' at the centre of human-computer interaction (HCI). *Cognition, Technology & Work*, 7(4), 262-271.
- McCarthy, J., Wright, P., Wallace, J., & Dearden, A. (2006). The experience of enchantment in human-computer interaction. *Personal and Ubiquitous Computing*, 10(6), 369-378.
- McCarthy, J., & Wright, P. (2004). Technology as experience. *interactions*, 11(5), 42-43.
- Miles, M., (2006) *Postmodern Aesthetics and Environmentalism*, University of Northampton: Culture, Environment and Eco-Politics Conference.

- Miles, M., (2010) Representing nature: art and climate change. *Cultural Geographies*, 17(1), pp.19–35.
- Minissale, G. (2012). Conceptual Art: A Blind Spot for Neuroaesthetics?. *Leonardo*, 45(1), 43-48.
- Mirzoeff, N. (Ed.). (2002). *The visual culture reader*. Psychology Press.
- Nathan, L. P., Blevis, E., Friedman, B., Hasbrouck, J., & Sengers, P. (2008, April). Beyond the hype: sustainability & HCI. In *CHI'08 extended abstracts on Human factors in computing systems* (pp. 2273-2276). ACM.
- Niedderer, K. (2007). Designing mindful interaction: the category of performative object. *Design issues*, 23(1), 3-17.
- Niedderer, K., Roworth-Stokes, S., & Rochester, U. K. (2007). The role and use of creative practice in research and its contribution to knowledge. In *IASDR International Conference*.
- Norgaard, K. M. (2011). *Living in denial: Climate change, emotions, and everyday life*. The MIT Press.
- O'Hare, G., Sweeney, J. C., & Wilby, R. L. (2005). *Weather, climate and climate change: Human perspectives*. Pearson Education.
- O'Neill, S., & Nicholson-Cole, S. (2009). “Fear Won't Do It” Promoting Positive Engagement With Climate Change Through Visual and Iconic Representations. *Science Communication*, 30(3), 355-379.
- Paulos, E. (2007). HCI Cannot Be Used To Evaluate Art. *Human-Computer Interaction Institute*, 209.
- Paxton, M., & Benford, S. (2009, September). Experiences of participatory sensing in the wild. In *Proceedings of the 11th international conference on Ubiquitous computing* (pp. 265-274). ACM.
- Pfister, M. (1991). *The theory and analysis of drama*. Cambridge University Press.
- Piccini, A. (2003). An historiographic perspective on practice as research. *Studies in Theatre and Performance*, 23(3), 191-207.
- Pink, S. (2009). *Doing sensory ethnography*. Sage.
- Pink, S., (2007). *Doing Visual Ethnography*, SAGE.
- Polli, A. (2011). Communicating Air: Alternative Pathways to Environmental Knowing through Computational Ecomedia.
- Remillard, C. (2011). Picturing environmental risk: The Canadian oil sands and the National Geographic. *International Communication Gazette*, 73(1-2), 127-143.

- Rimmer, S. et al., (2009) *Paralelo - Unfolding Narratives: in art, technology and Environment*, Sao Paulo: MIS and Imprensaoficial.
- Robinson, P. J., & Henderson-Sellers, A. (1999). *Contemporary climatology* (Vol. 2). Harlow: Longman.
- Rodaway, P. (2002). *Sensuous geographies: body, sense and place*. Routledge.
- Rogers, Y., Sharp, H., & Preece, J. (2011). *Interaction design: beyond human-computer interaction*. John Wiley & Sons.
- Rowe, D., (2011) *Why We Lie*, HarperCollins UK.
- Scannell, L., & Gifford, R. (2013). Personally Relevant Climate Change The Role of Place Attachment and Local Versus Global Message Framing in Engagement. *Environment and Behavior*, 45(1), 60-85.
- Schiermeier, Q. (2011). Extreme measures. *Nature*, 477(7363), 148-149.
- Schön, D. A. (1983). *The reflective practitioner: How professionals think in action* (Vol. 5126). Basic books.
- Scruggs, L., Benegal, S. (2012). Declining public concern about climate change: Can we blame the great recession?. *Global Environmental Change*, 22(2), 505-515.
- Sengers, P., Csikszentmihályi, C. (2003, April). HCI and the arts: a conflicted convergence?. In *CHI'03 extended abstracts on Human factors in computing systems* (pp. 876-877). ACM.
- Sengers, P., & Gaver, B. (2006, June). Staying open to interpretation: engaging multiple meanings in design and evaluation. In *Proceedings of the 6th conference on Designing Interactive systems* (pp. 99-108). ACM.
- Sengers, P., McCarthy, J., & Dourish, P. (2006, April). Reflective HCI: articulating an agenda for critical practice. In *CHI'06 extended abstracts on Human factors in computing systems* (pp. 1683-1686). ACM.
- Shum, R. Y. (2012). Effects of economic recession and local weather on climate change attitudes. *Climate Policy*, 12(1), 38-49.
- Spence, A., Poortinga, W., Butler, C., & Pidgeon, N. F. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change*, 1(1), 46-49.
- Staines, J., A. (2010) *Desire for a Conversation. a paper commissioned by the Creativity and Creation Working Group Access to Culture Platform*, Structured dialogue EU – Cultural Sector (May 2010), pp.1–31.

- Stiles, K., & Selz, P. H. (Eds.). (1996). *Theories and documents of contemporary art: a sourcebook of artists' writings* (Vol. 35). Univ of California Press.
- Stynes, K. & Woolard, A., (2006) Participate_WP2.2. Available at: http://www.participateonline.info/downloads/Participate_WP2.2_Picture%20of%20Now_Appendix_2006.pdf [Accessed August 6, 2013].
- Szszynski, B., Heim, W., & Waterton, C. (2003). *Nature performed: Environment, Culture and Performance*. Blackwell.
- Thornton, T. A. (2007). When old media were new: Revisiting the Benjamin-Adorno exchange. *kamome.lib.ynu.ac.jp*. Available at: http://kamome.lib.ynu.ac.jp/dspace/bitstream/10131/6638/1/208_04.pdf [Accessed August 6, 2013].
- Taylor, R., & Adviser-Boulanger, P. (2012). Designing from within: exploring experience through interactive performance. University of Alberta..
- Taylor, R., Schofield, G., Shearer, J., Wallace, J., Wright, P., Boulanger, P., & Olivier, P. (2011, May). Designing from within: humanaquarium. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1855-1864). ACM.
- Thoning, K. W., Tans, P. P., & Komhyr, W. D. (1989). Atmospheric carbon dioxide at Mauna Loa Observatory: 2. Analysis of the NOAA GMCC data, 1974–1985. *Journal of Geophysical Research: Atmospheres (1984–2012)*, 94(D6), 8549-8565.
- Tuan, Y. F. (1977). *Space and place: The perspective of experience*. U of Minnesota Press.
- Tufte, E. R., (1997). *Visual explanations: images and quantities, evidence and narrative* . Cheshire, CT: Graphics Press.
- Washington, H. (2013). *Climate change denial: Heads in the sand*. Routledge.
- Weiner, J., (2013) The Artist Who Talks With the Fishes - NYTimes.com. *nytimes.com*. Available at: http://www.nytimes.com/2013/06/30/magazine/the-artist-who-talks-with-the-fishes.html?_r=0 [Accessed August 6, 2013]
- Whitehead, J., & McNiff, J. (2006). *Action research: Living theory*. Sage.
- Wilson, S. (2002). *Information arts: intersections of art, science, and technology*. The MIT Press.
- Witchel, H. ed., (2013) *Inputs/Outputs Conference*, Brighton. Available at: <http://www.inputs-outputs.org/>.
- Woolley, B. (1993). *Virtual worlds: A journey in hype and hyperreality*. Benjamin Woolley.
- Wright, P., & McCarthy, J. (2010). Experience-centered design: designers, users, and communities in dialogue. *Synthesis Lectures on Human-Centered Informatics*, 3(1), 1-123.

Wigley, T. M. (2000). *The Science of climate change* (pp. 6-24). Brill Publishing, Cambridge, UK.

Wulf, V., Aal, K., Abu Kteish, I., Atam, M., Schubert, K., Rohde, M., & Randall, D. (2013, April). Fighting against the wall: social media use by political activists in a Palestinian village. In Proceedings of the 2013 ACM annual conference on Human factors in computing systems (pp. 1979-1988). ACM.

Wyche, S. P., Murphy, L. L. (2013, April). Powering the cellphone revolution: findings from mobile phone charging trials in off-grid Kenya. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1959-1968). ACM.