IdIoT:

Second-order cybernetics in the ‘smart’ home

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Contents

Chapter 3: The Algorithmic Paradigm v. second-order cybernetics p.78

Chapter 4: Methodology: The IdIoT proposition p.110

Chapter 5: IoTivity: ‘SMART’ fridge projects p.126

Chapter 6: Discussion p.234

Chapter 7: Conclusion p.253

References p.264

List of Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Appendix

List of Tables

Chapter 5

Appendix

Abstract

During thesis brings second-order cybernetics into design research, in the context of the Internet of Things (IoT) and 'smart' homes. My main proposition is to question and critically analyse the embedded epistemology in IoT technology in relation to human centred activities.

I examine how human lives are represented within the quantified approaches inherent in current notions of 'smart' technology, derived from Artificial Intelligence (AI), and characterise this as the *Algorithmic Paradigm*. I explore questions of how complex, lived, human experience is oversimplified in the IoT. By adopting an epistemology derived from second-order cybernetics — acknowledging the importance of the *observer* — combined with my 'IdIoT Proposition', a way of 'slowing down' research on a fast-paced topic, I explore designing reflectively.

The IdIoT is a methodological framework characterised by the process of slowing down and asking 'What are we busy doing?' in order to become aware of algorithmic oversimplifications. This methodological approach provides self-awareness and self-reflection on 'the way of knowing the world' to the researcher and to the participants, in the context of the *Algorithmic Paradigm* applied in IoT.

Through a series of practice-based projects, I use the figure of the 'SMART' fridge to examine the implications of the Algorithmic Paradigm in the 'smart' home. The consideration that 'smartness' is relational is investigated in *Becoming Your 'SMART' Fridge*, in which I position myself as the algorithm behind a 'smart' fridge, using quantitative and qualitative data to make sense and 'nonsense' outcomes, and exploring householders' interpretations. In the *'SMART' Fridge Session*, I developed scripted dialogues characterised by active, reflective users, and assigned roles in which the 'smartness' of the algorithms is explored via professional performances and fictitious roles taken on by members of the public. The findings reveal the value of second-order cybernetics, acknowledging an unpredictable observer and embracing 'smart' as relational in interaction with IoT technology. They suggest that a shift in perspective is required to create more meaningful interactions with devices in the 'smart' home, questioning the current technological path, challenging the dominant epistemology and proposing alternatives. My methodological approach demonstrates how design research and

second-order considerations can work together, asking novel questions to inform disciplines with an interest in the IoT, both from a design perspective and in terms of broader implications for society. The work has value for design, HCI, Critical Algorithm Studies, and for technical developers involved in the creation of IoT systems.

Preface

A good way to introduce my PhD is an exploration of my background, and the reasons I ended up writing *this* thesis.

Before university I was interested in art and architecture. When I was 18 I asked myself: 'how do abstract thoughts emerge from cells?' As I felt studying biology might help me find the answer, I took a BA in Biological Sciences at the Universidad Católica de Chile. After 5 years of studies I realised that my original question was silly and impossible for me, at least, to answer: the phenomenon of 'thinking' was simply too complex, yet, the years of my BA were not lost, giving me an understanding of systems and an appreciation of the brain's complexity, interrelations and scales. Needless to say, the mystery remains.

While studying biology I concentrated on neuroscience; however, because of the scientific method's dominance, and the specificity that contemporary high impact journals require, it was very difficult to link the different domains and scales of the phenomenon of 'thinking' (e.g. molecular, cellular, cognitive, psychological etc.), being 'neuronal physiology' (which is mostly focused on the electrical properties) the closest that I got into the cognitive complexities.

My undergraduate dissertation was on the neurobiology of emotion. The experiments I conducted for it employed an event-related potential EEG study, which measures the brain activity of a specific event. Experiments were conducted while patients (smokers and non-smokers) were watching images in a computer at the laboratory, and attempted to ascertain how the modulation of emotional context affects the attentional processes of observing related nicotine-cues.

Sometime after, I began to doubt the reductionism of such an approach, and became aware of the conditions in which the experiments were made. Though I did not pursue a scientific career, during my studies I was able to see the complexities and the interrelations of various systems with different scales (from genetics to ecology, from animals to bacteria).

After finishing my BA, I went to Stockholm to study an MFA. It was an interesting base on which to land after biology and as I was the only scientist I had the chance of meeting students from disciplines like architecture, landscape architecture, product design and graphic design. The context of Sweden in 2010 was also interesting: this was the time when Apple's iPhone was gaining popularity, and nowhere was this more pronounced than Sweden which had the highest adoption and implementation of advances in Information and Communications Technology (Global Information Technology Report, 2011).

Spurred on by curiosity about this technological landscape, I presented a paper at a conference called 'Fragile' at Sint-Lucas University's architecture faculty in Belgium. After the conference, I considered taking a PhD at Sint Lucas University; I was still interested in architecture, and while considering this I met Dr. Ranulph Glanville who encouraged me to go to the RCA. I was encouraged to develop a second-order cybernetics approach, at first by Dr Ranulph Glanville, and later, by the constant conversational input of Dr Paul Pangaro, who became my external supervisor after Ranulph passed away, in late December 2014.

My involvement with Dr Ranulph Glanville led me to become a member of the American Society for Cybernetics (ASC), which was very important to the direction of my study and this PhD. The ASC's intellectual environment changed the way I view the world and led to my interest in the 'observer'. This field, especially second-order cybernetics, influenced the main theoretical and practical framework of this PhD.

At the RCA I joined the Innovation Design Engineering department, which I hoped would help me move beyond my scientific training by throwing me into practice-based design research, an area where the criteria of repeatability and objectivity had no place. During the first year, my first experience of the field of design, I joined several courses with MA students, which aided my exploration of the 3D world.

The challenges I faced in my design-practice research were not limited to working with the physical space through projects, but also negotiating the ways in which theory informs practice and vice versa. As new knowledge had to emerge from the design research practice, in conversation with theory, I spent a lot of time in a state of confused paralysis during my PhD, unable to act, lost as I was between the poles of practice and theory.

This conversation for a long time, made no clear sense. My survival in this episodic process was made possible by the constant presence of Dr Ranulph Glanville who never gave up encouraging me to "start doing!" as "the knowledge will emerge from there!"

In relation to my PhD subject, I arrived to the RCA with an interest in Ubiquitous Computing and the complexities of 'computing being in the background'. During my PhD, beginning in 2012, the Internet of Things (IoT) became a very popular subject. With concerns about the IoT's algorithmic logic, against the rapid growth of products claiming to be 'smart' when dealing with central human activities, I decided to concentrate my analysis of the IoT in the 'smart' home specifically when it related to central human activities.

There is a connection between my concerns about the reductionism of the scientific method and my examination of the 'smart' home. In my investigations, I was concerned with the technology's design and the possible repercussions of the (over)simplification of human nature, inherent within IoT technology. In response to this, I employed the theory of second order cybernetics, which provides me with tools for investigating the subject while observing *my own* investigation.

Throughout in this thesis I will often refer to the appendix 'IdIoTivity' such as interviews and dialogues.

I also feel it is important to tell you, as the reader, that the constraints of the RCA's practice-based design PhD format have presented me with further challenges and endless dilemmas as I have written up my work. This experimental PhD practice is something new for me and has been something I have used to explore and build theory rather than an end in itself. As such, I have not been able to cover everything I would like to have done in this thesis, within the word limit, and there are many areas which I believe deserve a much more detailed treatment in the future, in another format or venue.

Acknowledgements

During process of this PhD has been a very important experience in my life; much has happened and changed in the process. In this PhD journey, which is characterised by being on your own a lot of time, I was not lonely. Many times I was lost and paralyzed, but I always had someone who motivated and encouraged me to have the mental and physical strength to keep going, and also by many others who contributed important and unexpected pieces.

Navigation and encouragements of explorations

First and foremost I want to thank my supervisor, Professor Ranulph Glanville who brought me to the UK to do the PhD – wherever you are Ranulph, thank you for opening for me this research door. I would like to express my profound gratitude, as I had the delight to 'sit in the shoulders of a giant' for a good couple of years, where I had the chance to directly experience some fragments not only of his impressive mind on multiple subjects (he had an extensive repertoire), but also his warm heart. For me Ranulph was a model as a man and as an academic, and this PhD is a tribute to him.

Ranulph was a truly dedicated tutor – until the very end he inspired me, kept revealing insightful knowledge, helped me to knit my loose ideas and took them for a trip to meet his many stories, characters and myths. Across the expedition, Ranulph constantly pushed me to remove myself from the scientific world, to widen my perspective, and to give a space to the 'I', that has made all the difference. As a tutor he also helped me understand the bigger picture not only of the subject, but also of education and the academic world – as a good cybernetician, Ranulph understood the importance of the system.

Ranulph never gave me straight answers. He wanted his students to find their own ways, and for that he provided direct guidance and indirect feedback. Always reinforcing the delight of what you do. He never forgot to ask me, "Are you enjoying this?" Very sadly, Ranulph was not able to see this thesis to the end. Nevertheless, until the end he was present with his legacy in my endless memories of him. Even if he was not here to see this thesis, along all the way I kept having imaginary conversations, which were very important for the outcome—but of course I lack his brilliance and his non-linear, adventurous life.

Here, I also want to thank Ranulph's wife Aartje Hulstein for the continuous conversations while Ranulph was here, and now that he is not here anymore. Aartje and Ranulph were both extremely generous with their time and care, they constantly provided me a homely feeling and affection.

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The comrades

This PhD would not have been possible without the everyday presence of my PhD colleagues and friends Helga Schmid, Claudia Dutson and Bruna Petreca. I want to thank them for their invaluable advice, constant feedback, stimulating discussions, honesty, friendship, encouragement and support across this adventure.

I want to particularly thank Helga Schmid not only for her reliability, warmth and sense of humour, but also for her feedback; her German clarity and honesty was very insightful. Helga who often referred to my design outcomes as “so bad that is good”, was essential to manage most of the graphical elements in this PhD. Helga’s aid and margins were essential for this thesis submission.

With Claudia and Bruna we had our PhD triangulations, where we triangulated (rather than forming a rigid triangle) around different subjects. In this process there was a continuous flow of affection and humour to overcome all a PhD means. I want to thank them individually; I learned a lot from Claudia from her amusing theoretical world and practical insights (Claudia spend a decade inside the RCA), and also from her passionate criticality. During these years with Claudia, we attended endless lectures all across London institutions, and this was a very important part of my process, not only to situate my research, but also to position myself and develop my critical understanding of a broad range of subjects. I want to thank Bruna for her acute comments, reliability, and especially for providing that Brazilian warmth and smiles that were so much needed.

I would like to extend my sincerest thanks to my close RCA friends Florian Kräutli, Daisy Ginsberg, Yen-Ting Cho, Jae-Seung Roe, David Pao, Louis Buckley and Austin Houldsworth, not only for their constant support, but also for so many good times. Special thanks to Sheila Clark for her advice and care during all these years. Here I would also like to thank people that contributed in my projects: Caroline Claisse from IED and Mike Kann from IDE.

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In my Boolean 3D printing incursion I want to thank Tibor Balint and also Neil Shepherd. In my entrance to the graphical 2D world, I want to thank Yoon Bahk for her remarkable drawing skills. Moving to the coding missions, I would like to thank Jeff Gough who very patiently dealt with my metaphors in the learning process of Arduino.

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The heart

I want to thank very much my non-academic family, most of them without a clue what I was doing, they were nonetheless believing and caring about me all the way through. My deepest gratitude goes to my grandmother Susana Hollmann who cared so profoundly about my professional development, and to my parents who raised me with so much affection. They taught me a very important thing: 'enjoy life'. This advice was essential to survive this intense phase. Their input was not necessarily academic, nevertheless they supported me in all my pursuits and in my rebellious academic journey ("Delfina until when are you going to keep studying?" "You are going to die in the British weather...Are you sure you want to spend your twenties there?") I would like to thank my sisters Clarita, Mia and also to Maggie Dias for always being there.

On the Chilean side I would like to thank my grandfather Fernando Fantini for his endless love and Italian 'Godfather' role, and Maria Luisa Braun for who knows how many prayers that I never asked. Special thanks to Gregorio Amunategui for his life experiences and all of those 'conferences' as my non-academic family called, in which we spoke about academic perspectives and third world duties.

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Homes

The series of spaces and the inhabitants that held me these four years have been very important. In the West I would like to thank my housemates from 'the bush' – the Bradburys and the inventor Robin Reeve, for their wisdom and their incredible parallel reality. As they would say in their language "Ram Ram Ram...Ram".

In the East I would like to thank Jago Rackham and Lo Svh who fed me and gave me a techno refuge.[1] Finally in the North, the home that I spent my writing-up period, I want to thank John, Gloria and Susan who made me feel at home. Special thanks to my housemate Hugo Cerqueira for feeding me, for his slow Portuguese pace and for some necessary punk and rock and roll.

Here I want to thank the staff of the Belle Epoque Cafe for their kindness and hospitality. It was in that 'afternoon-sun table' in which most of this thesis was written. Thanks Rita, Camelia, Martina, Marek and Axelle for predicting my coffee.

Things

Three objects were central for this journey. Firstly my loyal bike 'Peugotina' who almost daily crossed London safely the 16.2 miles of journey, often in deep rain. Peugotina was always there waiting for me. Secondly, my waterproof backpack that made it possible to transport so many things during these years, protecting my back so well. Finally I would like to thank my reliable 7-year-old white Mac laptop, which after several battery changes is still here loyally providing me access to years of files.

[1] My sincere apologies if some bits of the thesis are a bit loopy.

In this section I also feel the need to thank Neil Young, 10cc, Arthur Russell, Roy Orbison, Bryan Ferry, David Bowie and Prince, among other fundamental melodies that were with me in the loneliest moments of the journey. This thesis wouldn't be the same without the soundtracks.

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It is to Ranulph Glanville and to my grandmother Susana Hollmann that I dedicate this PhD thesis, both of them taught me essential things for life and believed in me. I thank Ranulph here, but hopefully the insights gained in this process will flourish through my future work.

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Author's declaration

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification.
The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

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Publication

I have previously published outcomes of the presented research in the following publications and conference contributions

van Ditmar Fantini, D and Lockton, D., 2015. Taking the code for a walk. *Interactions*, 23 (1), pp. 68-71.Available at: http://interactions.acm.org/archive/view/january-february-2016/taking-the-code-for-a-walk

Glossary

Smart:

Throughout this thesis I question the word *smart*; here I contest the definition from being defined as a commodity stored in a computer versus *smart* as a relational concept (both human and algorithm are responsible for the *smartness* of the interaction). For this reason 'smart' is being used in quotation marks in order to reinforce and highlight the complexity of the word. I will also characterise the word by using lower and upper case—upper case 'SMART' meaning that the word is being contested in my research projects (when I am questioning the term). The discussion of the term 'smart' can be seen throughout Chapters 3 and 6.

IdIoT:

The'figure of the IdIoT' refers to the role of a self-aware researcher (or participant) where the researcher slows down and asks 'What are we busy doing?' in relation to the *Algorithmic Paradigm* involved in IoT technology. By bringing 'the figure of the IdIoT' into design research, the IdIoT is used as an instrument for revealing algorithmic oversimplifications and to see nuances of the algorithmic processes involved in the algorithmic decision-making. The IdIoT's methodological approach provides self-awareness and self-reflection of 'the way of knowing the world' to the researcher in the context of the *Algorithmic Paradigm* applied in IoT; this results in the creation of a new set of questions. The description and origins of 'the IdIoT' can bee seen in Chapter 4.

User:

In this thesis, the term 'user' is used to describe the human component in a human-IoT interaction. In my research, it has no commercial bias. I am aware that the term 'user' is a problematic term; while in my research I have not directly discussed approaches such as Woolgar's (1990) notion that 'the user is configured by the technology', I want to make clear that in my research the 'user' is interpreted as a complex human instead of a passive consumer. In Chapter 3, I also discuss the use of the word *observer* as a synonym for *user* in a second-order cybernetics context.

Observer:

This concept, derived from second order cybernetics, refers to the active presence of the provider of the information. As Glanville (2003, p22) notes, “second order cybernetics considers (rather than ignores) the observer, studying observing as opposed to observed systems, insisting the observer takes centre stage”. He goes on: “The observer contributes and, since it is impossible to access what we observe without being an observer, that which is observed is unclear. Is there an object in an external reality? If so, what can we know of it, since our knowing always depends on us, and we can never subtract our presence?”

Human central activities:

In this thesis I consider ‘central human activities’ as a range of actions (behaviours) which embrace biological activities (e.g. sleeping, eating, physical activities) which are related to more ineffable psychological activities such as feelings, motivations, the idea of caring, and so on.

Chapter 1

Introduction

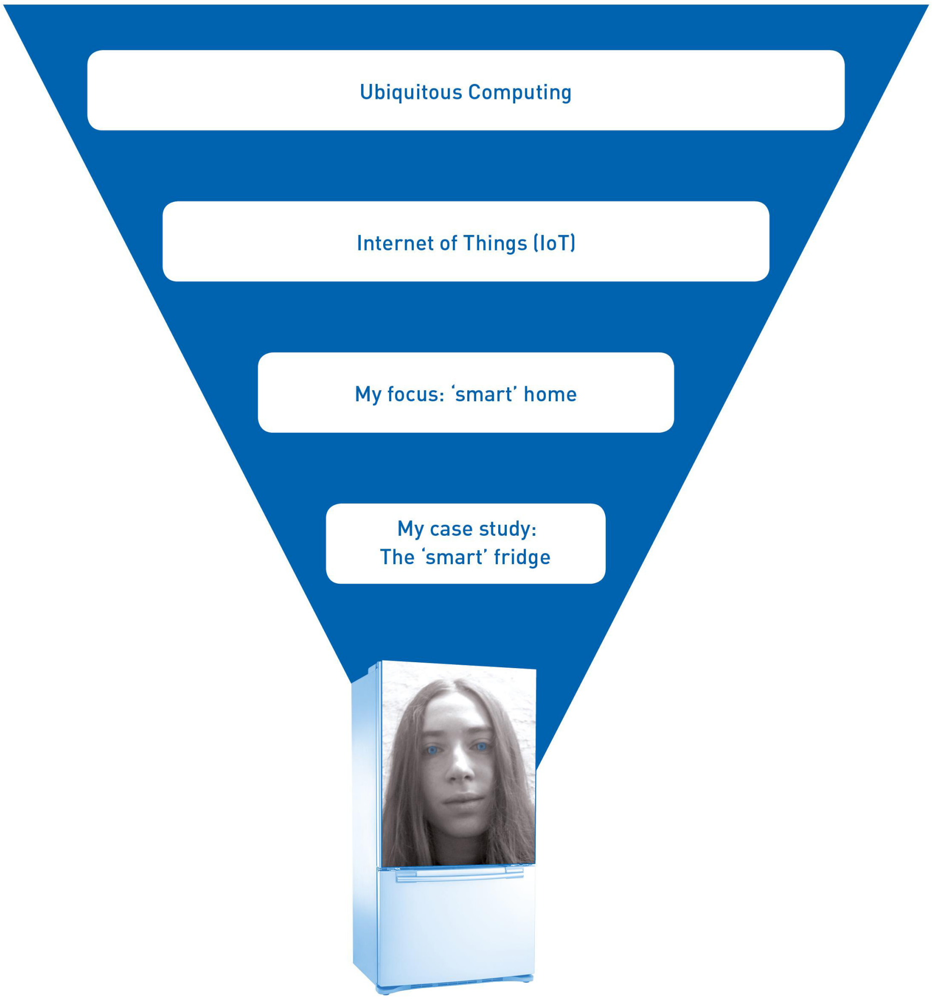

Figure 1.1: The context of my PhD. Over the course of my research, I progressively narrowed my scope from ubiquitous computing, through the Internet of Things, to focus on 'smart' homes, specifically adopting the 'smart' fridge as a case study.

Chapter 1: Introduction

In this chapter I situate my research context. Firstly, I describe the background to the Internet of Things (IoT)—Ubiquitous Computing. Secondly, I outline IoT technology with a historical approach rather than a technical description, and I focus the discussion onto the specific subject of my research: IoT in the domestic space. Finally, I situate my research in academic design research.

Throughout this thesis, it is important to note that I do not approach the subject in computer science or engineering terms; instead I focus on conceptual (theoretical) operations, the general logic and practical repercussions, from the perspective of design research.

This thesis will not offer design or technology ‘solutions’, but instead my proposition is to question and think critically about the embedded epistemology in IoT technology in relation to human centred activities. It is also important to note the constraints of the design practice-based PhD format: this is a relatively short thesis, and that limit imposes restrictions on the level of detail I have been able to go into with certain subjects.

1.1 Precedent of the IoT: The Age of Calm Technology

Ubiquitous Computing (UbiComp) is an important precedent for the emergence of the Internet of Things (IoT). Figure 1.1 shows how UbiComp provides a background context for my research. UbiComp emerged at Xerox PARC, a Silicon Valley research centre, in the late 1980s when Mark Weiser (1991) introduced the concept, describing it as the next era of personal computing.

Weiser (1991) defined UbiComp as a post-desktop model of human-computer interaction (HCI), in which information processing is integrated into everyday objects and activities. As Weiser (1991) noted in the early 1990s, “we are trying to conceive a new way of thinking about computers in the world, one that takes into account the natural human environment and allows the computers themselves to vanish into the background”. Weiser and Seely Brown (1996) described this scenario – of technology receding into the background of our lives – as ‘The Age of Calm Technology’.[1]

Weiser (1991) indicated in ‘The Computer for the 21st Century’ that UbiComp required “cheap, low-power computers that include equally convenient displays, a network that ties them all together, and software systems implementing ubiquitous applications”. Nowadays, more than two decades after Weiser wrote the above, Internet connectivity can be seen as a network between computers and people and everything else that is connected, including sensors and devices. Tiny, cheap microprocessors are indeed embedded in various spaces and objects. In 2015 the International Telecommunications Union declared a ‘new era of ubiquity’, characterised by connections between humans and things, and between things and other things (ITU, 2015)— the ‘Internet of Things’ (IoT) had arrived, and had begun to permeate many aspects of daily life.

The impact the advancement of IoT technologies will have on our lives should not be underestimated, it may bring bring potential benefits and, inevitably, challenges. In this context, it is important to note that even in the late 1990s, Weiser and Seely Brown (1997, p.75) had already noticed that importance lay not in the technology itself, but its relationship with humans.

[1] Case (2016) notes how the ‘continuous alerts’ of today’s world of smartphones and much

1.2 The Internet of Things (IoT)

The term ‘Internet of Things’ was coined in 1999 by MIT researcher Kevin Ashton. According to Ashton (2009), it started life as the title of his presentation made at US consumer products company Procter & Gamble in 1999, describing how wireless (RFID) tags could link products in P&G’s supply chain to the Internet. In statistical terms, Gartner (2014) has estimated that 25 billion connected ‘things’ will be in use by 2020, while Cisco projected that in 2020, 50 billion objects would be connected (Evans, 2011). The disparity in the figures does not necessarily reflect a downward revision after a three-year gap; it signifies how quickly the field is emerging, and the uncertainty that comes with that speed.

The IoT can be defined as a system in which everyday objects are digitally identifiable and programmable, and connected to the Internet. These connected objects are able to send (and often, but not always, receive) data, connect to other devices, and respond to the algorithms that govern them, often acting without human intervention. Since the late 1990s, and the incorporation of precise sensors and processors into objects, IoT technology has started to permeate our immediate surroundings and, even, our bodies.

An example of an IoT application in the body is the ‘Quantified Self’, a movement formed in 2007 by *Wired* magazine's Gary Wolf and Kevin Kelly, which started as a blog called “Quantified Self: Self knowledge through numbers”. Its aim was ‘tracking the self’ and, consequently, ‘developing self-knowledge’ (Wolf & Kelly, 2007).[2]

The Quantified Self is characterised by the adoption of wearable, connected devices in which, through sensors, a constant measurement and monitoring of several aspects of human life takes place, with online data analysis, aggregation and sharing (with companies as well as other users). Examples include fitness trackers, ‘smart’ watches and other health monitoring devices. While from a consumer perspective, the Quantified Self may be differentiated from the IoT in general, the networked dimension, with online analysis and the aggregation of individual users’ data into ‘Big Data’ sets, places the Quantified Self largely within the IoT domain.

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[2] The purpose, as described in the ‘quantified-self’ blog: “our mission is to support new discoveries about ourselves and our communities that are grounded in accurate observation and enlivened by a spirit of friendship”.

Applications of IoT in our surroundings include the monitoring of environmental variables (e.g. pollution), the optimisation of urban functions, like waste collection (e.g. 'smart' bins notifying municipal services when a bin needs emptying), and are often incorporated into the wider idea of 'smart' cities. Successful IoT applications can also be seen in industry, due to advantages for optimisation, efficiency, tracking (e.g. via RFID), managing resources and reducing costs.

However, in our domestic lives, the vision of the 'smart' home, in which IoT technology enables both data collection and automation in relation to many aspects of everyday life, has not, so far, received widespread adoption or acceptance; the emergent market at present is characterised by a piecemeal array of gadgets, some incompatible, some apparently unnecessary, and many arguably over-complicated. In Chapter 5, I compare some of the features of 'smart' fridges currently on the market, and some that are discontinued, showing how complicated and feature-laden some of these are. As Arieff (2015) points out, "in the smart home the tendency has been to throw excess technological capability at every possible gadget without giving any thought to whether it's really necessary".

As the IoT starts to permeate many important aspects of our lives, from quantification of our health to monitoring of our homes, it is potentially leading to a different relationship with computation and our surroundings. This aspect of IoT is ripe for investigation; as Nicol and Bremner (2014, p.68) note:

> most scenarios for domestic life have not factored in the advent of digital technologies, other than operationally (connection and bandwidth). This is an important omission because the digital has no respect for
> inside or outside, private or public, work or leisure, night or day, normal behavior or abnormal behavior, and so on.

In this context, from a sociological perspective, Wajcman (2015, p.131), explains the difference between domestic and industrial efficiency by their differing optimisation ideals:

> domestic spaces are subject to a quite different set of considerations than those governing the offices, factory floors and workplaces, within which information technologies have conventionally been deployed… while the dominant logic of capitalist workplaces is that of efficiency and profitability, a different logic governs the domestic life, one that is emotional and moral rather than quantitative.

This suggests the importance of research into the ‘smart’ home, considering the systemic implications beyond the primarily technical domain of efficiency and problem-solving. There is a need for an understanding of the implications of the presence of IoT technology within our lives and homes. In the next section, I explore the context of the ‘digitalisation’ of the domestic space and characterise the current technology market.

THIS IS MY HOME

No doubt. This is my home
I happen here, here
I cheat immensely
This is my home stopped in time.
Autumn arrives and defends me,
Spring comes and condemns me.

I have one million guests
They laugh and eat,
copulate and sleep,
play and think,
million guests who are bored
and they have nightmares and nervous breakdowns.

No doubt. This is my home.
All dogs and steeples
pass in front of it.
But my house is hit by rays
and one day it will break in two.
And I do not know where to take shelter
because all doors lead to the outside world.

Mario Benedetti, 1998

Translated by Delfina Fantini van Ditmar[3]

[3] None of the English translations that I found represented my understanding of the poem in Spanish.

1.3 Digitalisation of our lives: IoT in the Domestic Space

In my research I explore IoT technology in the context of the connected home, often referred to as to the 'smart' home. Early attempts at home automation includes the self-cleaning 'GABe house' (Figure 1.2), created in 1984 by Francis Gabe (Leigh, 2002).

The development of 'smart' home appliances started with several initiatives developing connected objects, such as John Romkey's 1989 'Internet Toaster' (Figure 1.3) or the first online refrigerator (Figure 1.4) a decade later in 1998 (Rees, 2015, p.104).

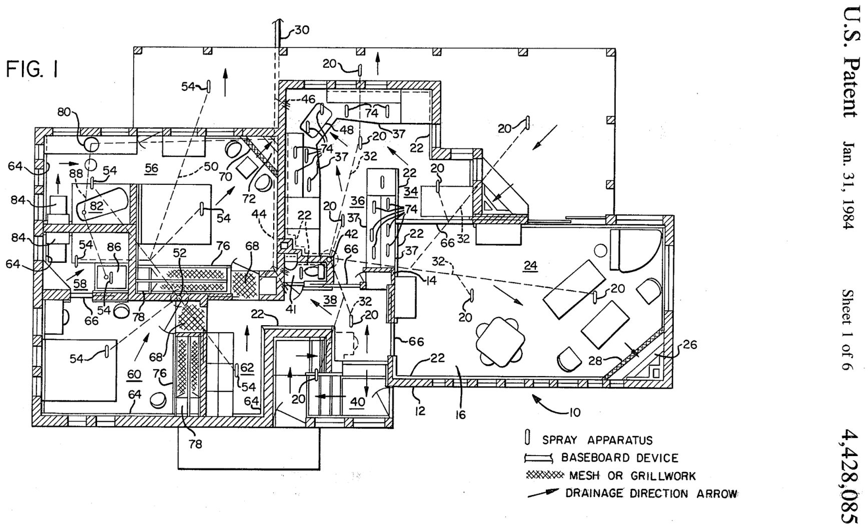

Figure 1.2: Francis Gabe's 'self cleaning house' (1984). "The self-cleaning building construction comprises apparatus for applying a fine spray or mist of water and/or water and detergent to wall, floor and ceiling surfaces, followed by warm air drying. Floors slope in a direction for removing excess moisture via a drain. Also included are closet apparatus for cleaning clothing, cupboard-dishwasher apparatus for cleaning stored dishes, self-cleaning bathtub apparatus, and self-cleaning washbasin apparatus" (Glink, 2014). Source: US Patent Office.

Figure 1.4: In 1989, using TCP/IP networking John Romkey connected a Sunbeam Toaster to the Internet.

Figure 1.4: LG Internet Digital DIOS internet refrigerator.[4] *"You probably didn't own it, not because of the $20,000 price tag, but because, well, who in their right minds needed a $20,000 refrigerator that was internet-enabled? That was then, this is now. The "Internet of Things" is making devices like internet refrigerators more mainstream today because consumers are hyper-adopting new technology and marketers are engaging in digital disruption" (Parry, 2015). Source: Lgblog.lt*

With technological advancement and reductions in the cost of processors, network capability and sensors, there has been rapid expansion in the development of IoT devices. These connected devices, brought into our intimate space, constantly sense data. The objects often have 'smart' features, ranging from automating, controlling, and monitoring the device itself, to learning users' behaviour and making suggestions.

Nowadays the 'smart' home market is a fast growing industry: major retail companies are getting into the business by releasing 'smart' objects. This is reflected by a boost in 'smart' home advertising. In his book *The Epic Struggle of the Internet of Things*, Bruce Sterling (2014, p.11) refers to the 'Big Five'

[4] *Dios* in Spanish means 'God'

companies in the IoT business: Google, Apple, Facebook, Amazon and Microsoft, who, despite their core business not apparently being in this space, have significant influence over the ways in which the IoT is being enacted from the consumer perspective. The 'smart' home marketplace is showcased annually at the Consumer Electronic Show (CES) in Las Vegas (Figure 1.5).

Figure 1.5: Samsung Electronics booth at CES 2015. "What does the Internet of Things mean for daily living? The main attraction at this year's CES booth is The Possibilities of IoT. A central smart hub shows visitors what a future home would act like – it is responsive, protective, flexible and innovative." Source: MDlab.com

Examples include areas such as home security (e.g. the Dropcam 'smart' camera, owned by Google), heating control (e.g. Nest thermostat, also owned by Google) (Figure 1.6 and 1.7), lighting automation (e.g. Philips Hue, part of Apple, Figure 1.8) and various 'smart' household appliances.

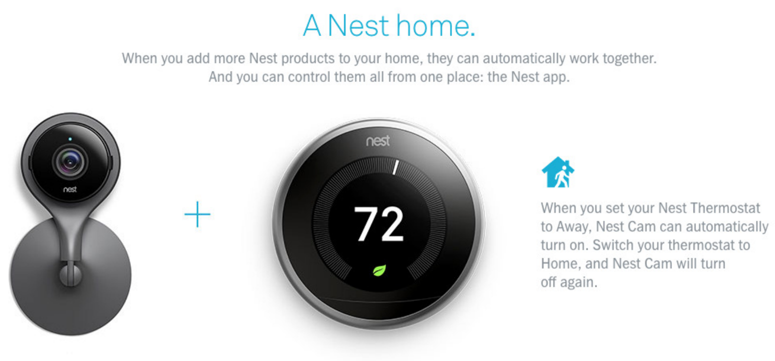

Figure 1.6: A Nest home. Nest Learning Thermostat and Nest Cam Video Monitoring Camera. Source: Nest.com

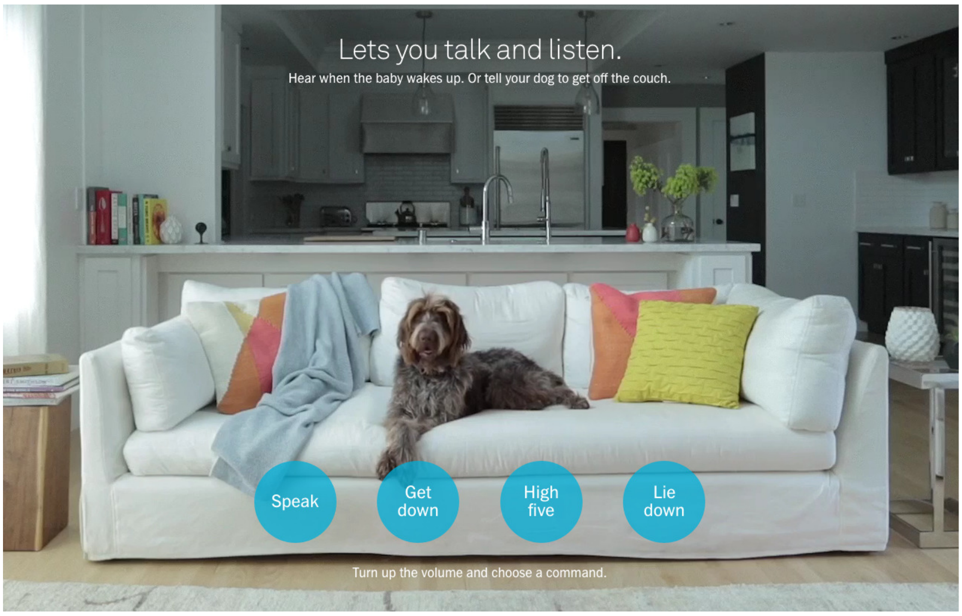

Figure 1.7:Dropcam advertisement. Source: Nest.com.

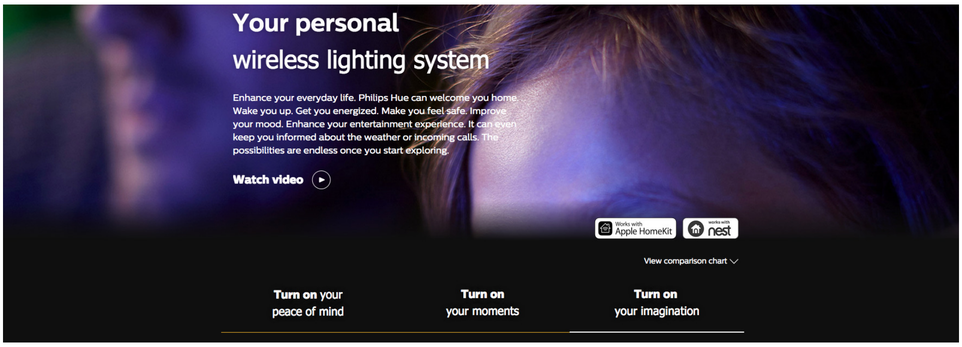

Figure 1.8: Philips Hue. "Philips Hue can welcome you home. Wake you up. Get you energized. Make you feel safe. Improve your mood. Enhance your entertainment experience. It can even keep you informed about the weather or incoming calls. The possibilities are endless once you start exploring." Source: Meethue.com

'Smart' household appliances constitute a large market, characterised by products like 'smart' fridges, washing machines, ovens, kettles and toilets (e.g. Satis, Figure 1.9). Included in the home objects category are 'smart' toothbrushes (e.g. Kolibree, Figure 1.10), vacuum cleaners (e.g. Roomba) and even rubbish bins (e.g. Bruno, Figure 1.11).

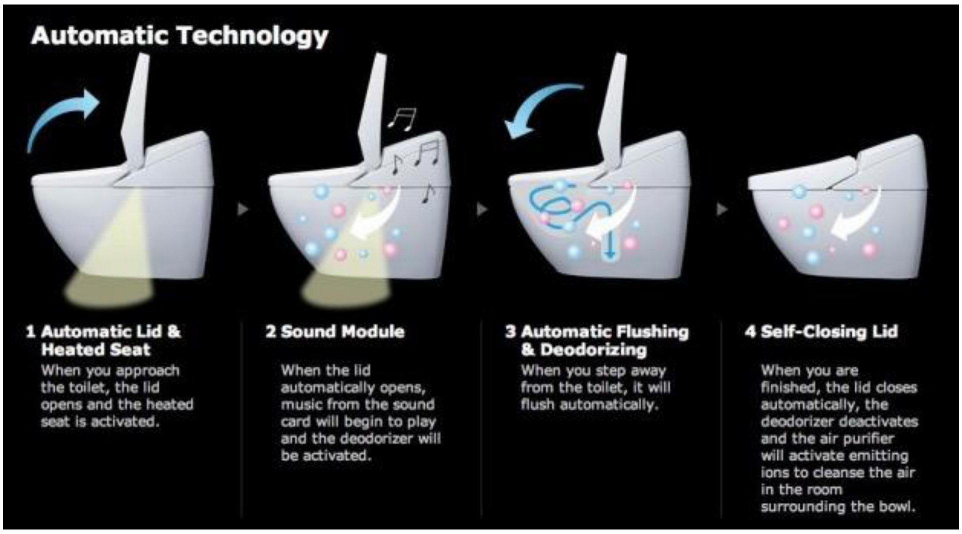

Figure 1.9: Satis toilet. The Satis Android app allows you to raise and lower the lid, operate the bidet function, play music, deodorise and flush the toilet. Source: Digitaltrends.com

Figure 1.10: Kolibree "The Fun, Intelligent & Beautiful Toothbrush". The app interprets qualitative & quantitative information about the kids' and their brushing habits. Source: Kolibree.com

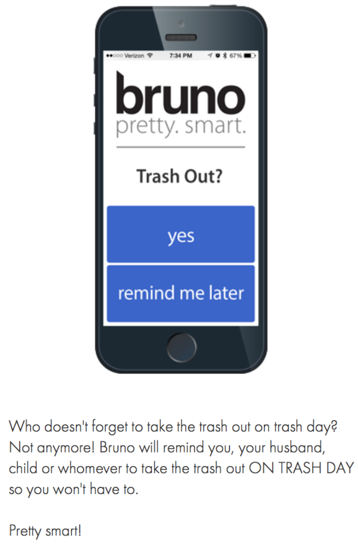

Figure 1.11: The app accompanying Bruno, a 'smart' bin. "Bruno can also be opened hands free - even when yours aren't. Simply motion your hands across the top to open the stainless lid." Bruno uses sensors to detect when dust is brushed close to it and sucks it up. Note the assumptions about household gender roles. Image: Source: Brunosmartcan.com

The IoT market also features 'smart' home hubs, such as 'Mother', intended to link data from multiple devices and provide central control. In the shape of a Russian *matryoshka*, this IoT life-coach is characterised by the tagline "Mother knows everything" and by its brand motto "the meaning of life" (Figure 1.12). Mother's sensors allow the user to monitor whatever they want and visualise the resulting data. Mother also reminds users about their activities (Figures 1.13).

sen.se The meaning of life®

Figure 1.12: The motto of Sen.se, the company behind Mother: "the meaning of life" Source: sen.se/mother/

Figure 1.13: Mother's examples of "smartifying everything" marketing campaign. Source:sen.se/mother/

Other IoT innovations include Amazon's Dash Buttons: WiFi-enabled buttons that the user can place around the house to automatically re-order household products (e.g. on the washing machine, to reorder detergent) (Figure 1.14).

Figure 1.14: Amazon's Dash Buttons. "Amazon's Dash buttons help you order items the moment you run out so that you're not forced to make a second trip. Heck, you don't even have to make a first trip… They are easy to use and they quickly become a no-brainer for any [Amazon] Prime member." When the Dash button is pressed the order is placed via the Amazon App (Steele, 2015). Doritos have recently been added, presumably through consumer demand. Source: Washingtonpost.com and Time.com

In recent years, big technology companies have released home automation platforms to monitor and control the surroundings, such as Samsung's SmartThings (Figure 1.15) and Apple's HomeKit. In 2015 Google announced the IoT operating systems Brillo and Weave. These systems promise to control any device with a wireless connection.

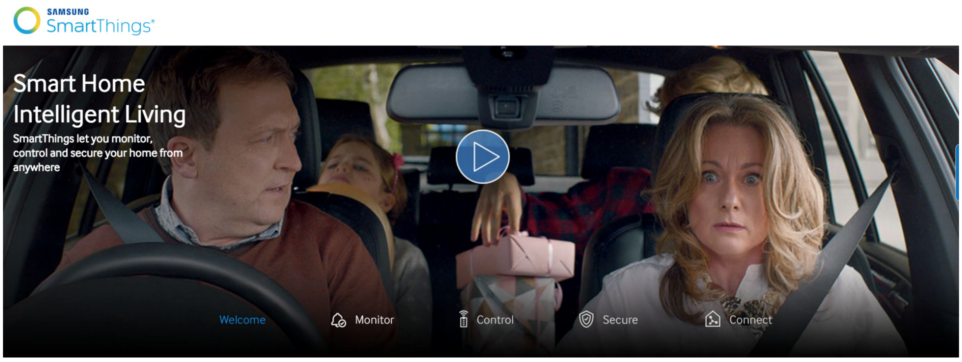

Figure 1.15: Samsung's SmartThings: "The SmartThings Hub is the heart of your smart home. It connects wirelessly with hundreds of compatible smart devices, allowing you to monitor, control and secure your home from anywhere." Source: Samsung.com

There is also a market comprised of object communication systems, such as LG's HomeChat, which allows one to communicate with smart appliances (Figure 1.16), and 'smart' assistants, like Amazon's internet-connected speaker Echo (Figure 1.17).

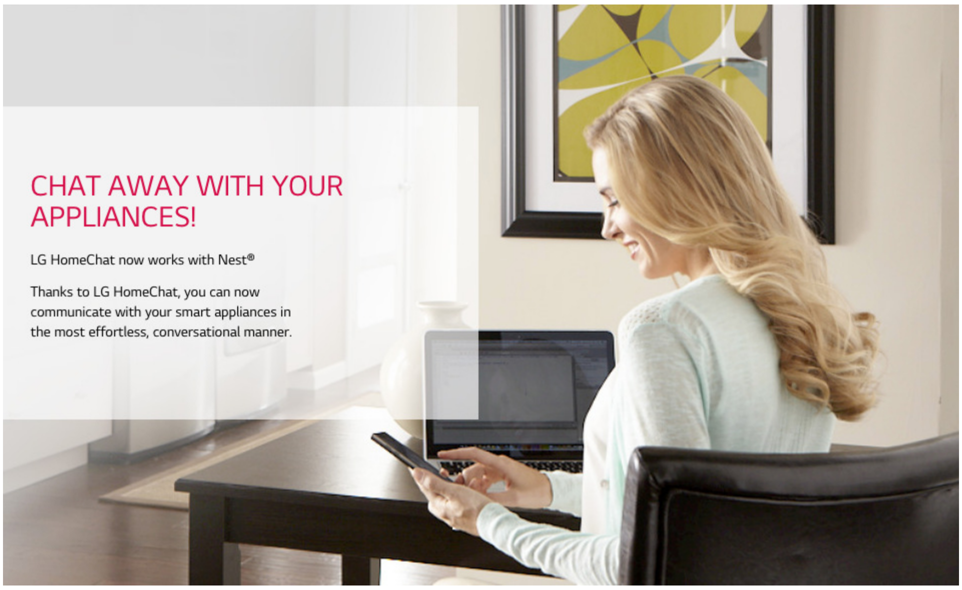

Figure 1.16: LG's SMART THINQ™. "With LG HomeChat, you can now communicate with your smart appliances in the most effortless, conversational manner. Simply send an instant message to LG HomeChat via smart phone messenger app LINE to control and communicate with your appliances remotely. Download family-pleasing recipes from your range, turn on your washer/update cycles, and even command your robot vacuum to clean your living room carpet and kitchen floor. And all this can be accomplished whether you're entertaining in the backyard". Source: Lg.com

Figure 1.17: Amazon's internet-connected speaker Echo.

"Alexa—the brain behind Echo—is built in the cloud, so it is always getting smarter. The more you use Echo, the more it adapts to your speech patterns, vocabulary, and personal preferences. And because Echo is always connected, updates are delivered automatically".

"Skills add even more capabilities like ordering a pizza from Domino's, requesting a ride from Uber, opening your garage with Garageio, and more. Enabling skills lets your Echo do even more—simply discover and enable the skills you want to use in the Alexa App." Source: Amazon.com

As can be seen from the above descriptions of 'state of the art' IoT technology, there have been several changes in the way the technology operates in relation to its surroundings and users since its origins in the 1990s, when it was characterised by adding information into RFID tags and in automating mechanical functions. Behind 'smart' objects there are companies and software with algorithmic strategies. In Chapter 3, I describe the main shift in IoT interaction and its algorithmic logic, and introduce what I call the Algorithmic Paradigm.[5]

[5] The depiction of the technology in the early 1990s mainly considered the idea of a tractable object, that memory and the possibility of information of an object to be stored in the RFID. Weiser was seemingly far from imagining the emergent fields of Big Data, machine learning or Behavioural Analytics within the scope of his Ubiquitous Computing.

Since the IoT home automation market is expected to witness significant growth, it is important to understand how the technology functions; yet many users do not understand how ‘smart’ devices operate, where the data they harvest is processed or stored, or who is behind their ‘smart’ outcomes (see Rowland et al, 2015).

The climate of technological advancement of IoT thus raises new challenges in our relations with technology, which are important to investigate.

1.4 Situating the research

The Internet permeates many aspects of our lives. The interrelation of humans and technologies, as well as the impact and implications of new technologies on our surroundings, suggests the need for new conceptual frameworks. As such, there is value in examining these relationships beyond merely the technical aspects, and this is the way I approach the field in my research.

This penetration of networked technologies into our environment and culture is part of the discussions in several fields such as the digital humanities, media theory, critical studies, sociology, and increasingly in art and design, among other disciplines. Software studies emerged from critical studies and media theory, and is influenced by sociology (*Figure 1.18*).

Within software studies, an emergent research area is critical algorithm studies (I specifically explore algorithms in Chapter 3). This field relates the analysis of algorithms to politics, law, sociology and digital humanities. The focus of this growing field is to analyse the interrelations between algorithms and society, their implications and sociocultural context.

Among the issues identified by Gillespie and Seaver (2015) which I find particularly relevant to my interest are:

- "Algorithms have embedded values / biases, lead to personalization / social sorting / discrimination"

- "With algorithms come rationalization / automation / quantification, and the erasure of human judgment / complexity / context"

- "Algorithms fit with, and help advance, specific ideological worldviews "

(Gillespie and Seaver, 2015)

These ideas inform my thesis and specifically the research questions I address through my projects (see Section 1.5). Chapter 3 introduces my approach to algorithms, while Chapter 5 explores these issues as part of my projects.

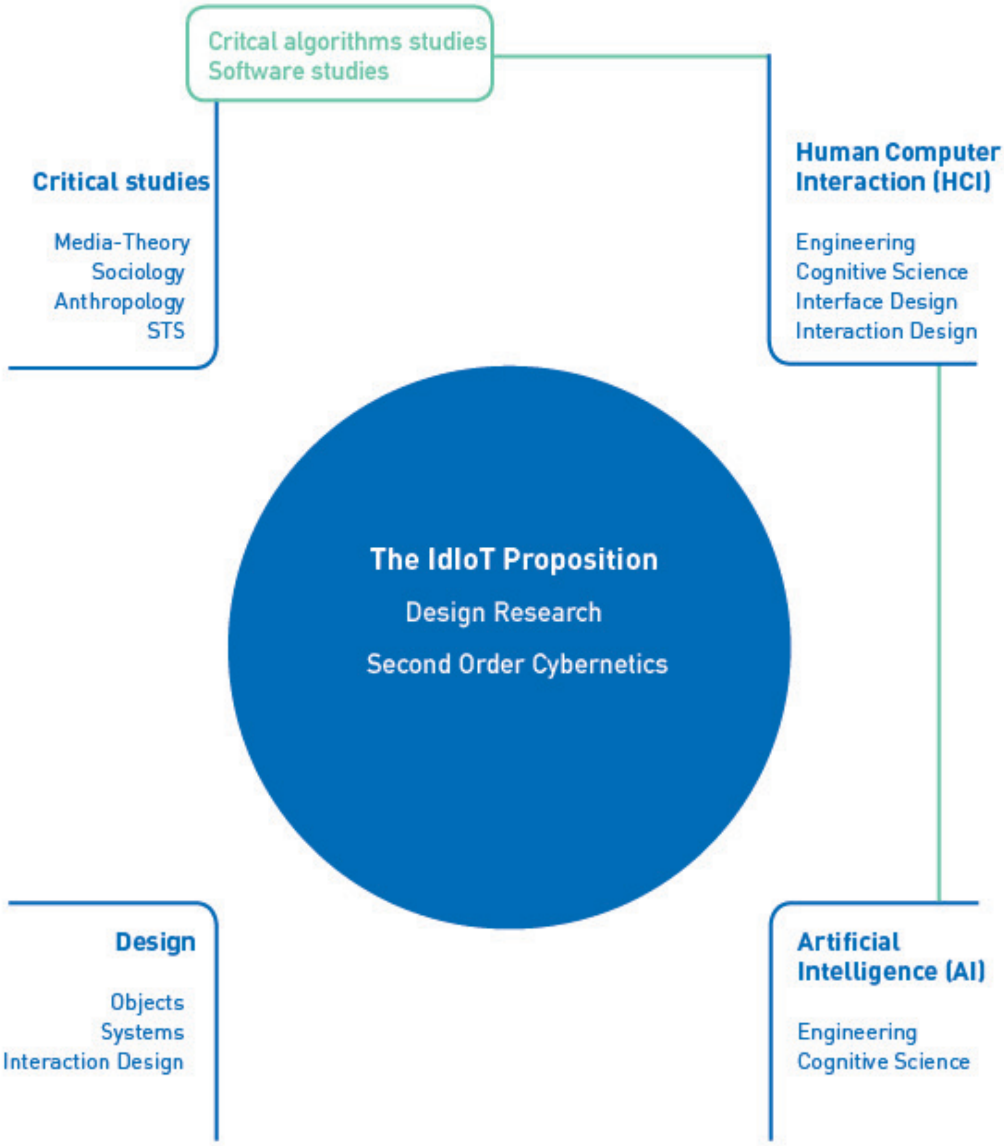

Figure 1.18: Positioning my research in the IoT field—drawing on discussions and concepts from critical studies, Human-Computer Interaction (HCI), Artificial Intelligence (AI) and design. My approach sits between these fields, but applies perspectives from second-order cybernetics and design research.

1.4.1 Questioning technology

Outside of the IoT specifically, there is a growing interest in *Critical Design*, highlighting and responding to the potential challenges in HCI and technology-driven design more widely. There are also several alternative design approaches aiming to exposing problems rather than solving technological issues.[6] These areas of design can be characterised by the use of speculation, fictional narratives, political debate, and generally questioning technology (Pierce, 2015). As Pierce (2015, p.8) notes, this work has been presented under various names, including Critical Design, Design Fiction, Adversarial Design, Reflective Design, Ludic Design and Speculative Design.

Critical Design has been explored since the 1990s; the idea was first defined in this way in 1997 by Anthony Dunne's PhD thesis, *Hertzian Tales: An Investigation into the Critical and Aesthetic Potential of the Electronic Product as a Post-Optimal Object*. This approach, developed by Dunne and Fiona Raby, is characterised by a design stance that questions and challenges the status quo which considers technological design as a market-focused, instrumental and commercially-driven practice. Initially this focused on exploration of the possibilities of the electronic medium, but as further developed, a wider scope of scientific and societal developments were included. Critical Design is described by Dunne and Raby (2002, p.58) as "design that asks carefully crafted questions and makes us think." In the FAQ section on Raby and Dunne's webpage, is a section with the question 'What is critical design?' [7]

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[6] In the context of UbiComp and HCI, there are several design initiatives, which call upon critical and alternative approaches to design interaction. Examples include: The Interactive Institute in Sweden, Design Informatics at the University of Edinburgh and the Experience Design research group from Folkwang University, Germany to mention a few.

[7] Dunne, T & Rabby, F., Critical Design FAQ. Dunneandrabby. Available at: http://www.dunneandraby.co.uk/content/bydandr/13/0 [Accessed 21 April 2016]

> Critical Design uses speculative design proposals to challenge narrow assumptions; preconceptions and givens about the role products play in everyday life. It is more of an attitude than anything else, a position rather than a method. There are many people doing this who have never heard of the term Critical Design and who have their own way of describing what they do. Naming it Critical Design is simply a useful way of making this activity more visible and subject to discussion and debate.

As Pierce (2015, p.26) indicates, since the introduction of the term by Raby and Dunne, the meaning and usage of Critical Design has been expanded by the design research community, and can described as Post-Critical Design. Raby's and Dunne's own approach shifted towards Speculative Design. This is based on the idea that the work is often presented via fictional scenarios (incorporating some kind of speculation in the outcome) as a way to provoke discussion. Frequently these scenarios revolve around new technologies and controversial scientific topics such as synthetic biology. This approach suggests that exhibitions and events are a persuasive means for an engaged dialogue around a subject.

Ludic Design is a proposition where designers explore computational technology through ludic strategies — playfulness. As William Gaver puts it (Gaffney, 2007), a ludic approach recognises that there are "ways of appreciating the world or engaging with the world that aren't goal oriented", despite the fact that "more and more technology and design in general is conceived of in terms of promoting task performance".

Using design as a way to do something other than improve efficiency or achieve specified goals is central to many of these alternative areas of Critical Design and technology, for example Design Fiction, a term coined by Bruce Sterling and by Julian Bleecker. According to Sterling (2009) "when science fiction thinking opens itself to design thinking, larger problems appear. These have to do with speculative culture generally, the way that our society imagines itself through its forward-looking disciplines". Bleecker (2009, p.6) describes it as "conflation of design, science fact, and science fiction".

Another critical design approach, with a more overtly political background, is Adversarial Design, which is described by Carl DiSalvo (2012, p.12) as “both a way of doing the work of agonism through designed things and a way of interpreting designed things in terms of their agonistic qualities”. According to DiSalvo (2012, p.12-13), designed objects can “function to prompt recognition of political issues and relations, express dissensus, and enable contestational claims and arguments.” While there is much overlap with other areas of speculative and critical design, DiSalvo emphasises inherent agonism within the work—design which is meant to provoke and even maintain disagreement and debate, following the idea of agonism as central to democracy.

Reflective Design, developed by Phoebe Sengers and colleagues, constitutes another critical approach towards HCI specifically. Based on critical theory, Sengers (2005, p.49) defines reflective design as an approach in which the designer reflects on unconscious values embedded in technology and the practices that it supports. Sengers (2005, p.55) suggests that designers should use reflection to uncover and alter the limitations of design practice and re-understand their own role in the technology design process. According to Bowen (2007), Dunne and Raby's approach appears to be about asking questions, while Sengers' proposition seems to be more about producing "better answers".

1.4.2 Research through design

The research I describe in this thesis is a form of design critique, but is not explicitly ‘critical design’ within the Dunne and Raby paradigm. My theoretical approach comes largely from second-order cybernetics (see Chapter 3), in conjunction with a design research approach, applied to the field of Ubiquitous Computing and HCI, specifically by focusing on IoT technology.

Archer (1995, p. 11) suggests that “there are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, to to enact something, calculated to explore, embody or test it”, and it is this approach to design research, or indeed research through practice (in Archer’s term), which I have taken in my work—primarily, enacting situations to embody and explore propositions.

In a design context, I am especially interested in focusing on knowledge and not on a tangible ‘product’ as an outcome; I align with Frayling’s (1993, p. 5) indication that in design research, the aim of design is “knowledge and understanding”, as a characterisation of research *through* design, in distinction to ‘researched design’ or research *about* design.[8]

1.4.3 My approach in this thesis

My research has several similarities with the fields discussed above. Connections include the fact that my focus is not on optimisation, usability or efficiency. I also employ similar tools, such as speculation, simulation, scepticism and some fiction. Some people may even consider that the work described in this thesis has a ludic aspect, which has led to discussion around the subjective experience of such work by different audiences and participants. Regarding speculation, I did not focus on ‘what technology is like’ or ‘what it could be like’, or propose utopian or dystopian solutions. However, my work has a distinctly critical approach, and it is reflective, resonating with design outcomes intended to ‘make us think’ as Dunne and Raby stress.

I also use similar strategies to Speculative and Critical Design, such as displaying my work in galleries or developing public engagement events, which question the emergent technology; however, my approach differs because I do not leave the subject and the discussion at the stage of the exhibition (once the object was displayed) and therefore do not stay in the stage of problematising a situation, or even thinking about the status quo; rather, mine was a constant exploration of the subject, followed by an analysis of the outcome.

[8] Wolfgang Jonas is another relevant author focusing on ‘Research through Design’ (see Jonas, 2006).

1.5 The audience for this thesis, and the questions explored

This thesis is aimed at academic researchers in design, HCI, cybernetics and emergent critical fields examining the interaction of algorithms and society. It contributes to knowledge in these areas in a number of ways, as described in sections 7.1 and 7.3. For design and HCI research, benefits include the demonstration of positioning myself as an algorithm (Section 5.1), which offers a new practice-based design research method for engaging with algorithmic systems, alongside a methodological approach of 'slowing down' in relation to a fast-paced topic, through questioning the embedded epistemology designed into IoT technology (Chapter 4); while for cybernetics, I bring a second-order cybernetics epistemology to consideration of the IoT, and vice versa—bringing the IoT into second-order cybernetics as a new scenario for the field to consider.

The thesis also offers insights for designers and developers involved in IoT and 'smart' home technologies, informing practice by drawing attention to the epistemological implications and methodological approaches when dealing with IoT technology. Section 7.2 examines these aspects in more detail.

This chapter has introduced the context of the IoT and the 'smart' home as an area for investigation. My conviction is that within the current technological context, it is important that design research investigates not only the role of the IoT in shaping society and culture, but also in understanding the epistemological, political and economic forces shaping development of the technology itself. Following further theoretical and practical development described in Chapters 2, 3 and 4, to address these issues I developed a series of practice-based design projects in which I investigated the IoT implications for human interaction, and especially the epistemology embedded in IoT technology, using the figure of the 'SMART' fridge, and people's interactions with it, as an object of investigation.

The central research questions which emerged from the pilot projects, literature and practice reviews, and theoretical framework described in the next three chapters, are thus:

- What are the possible implications of the *Algorithmic Paradigm* and AI mentality embedded within the ‘smart’ home? (explored in Section 5.1)
- What would happen if we design with an alternative epistemology, in this case second-order cybernetics? (explored in Section 5.2.3)
- How does the fact that there is an epistemological stance embedded, affect people’s interactions with the technology? (explored in Section 5.2.3)

In the next chapter I describe initial practice-based pilot projects investigating an initial scoping of the general area of ubiquitous computing and the IoT.

Chapter 2

Pilot projects

Chapter 2: Pilot projects

2.1 Introduction

I was initially interested in Weiser's (1991) idea of the 'Age of Calm Technology', "when technology recedes into the background of our lives". This chapter describes two practice-based explorations of Ubiquitous Computing (described in Section 1.1), which helped me in scoping relevant issues and narrow my focus towards the domestic space and 'smart' homes.

In the first project I questioned the idea of Ubiquitous Computing being in the 'background of our life'. The second project relates more directly to IoT technology, as my interests had developed toward that subject. In the context of a public engagement event, I developed a project that placed the public in confrontation with the components and the experience of IoT technology.

Finally, I describe my own experience of using an IoT 'Quantified Self' fitness tracker, and reflect on what I learned from this experience.

2.2 Project #1: The Eighth Wonder: What Hath God Wrought?

Description: Illustration of the technological background in which the 'Age of Calm Technology' is based (the finite background of the ubiquitous surround). The project was part of the event 'Digital Futures' and was carried out in collaboration with the designer Caroline Claisse.
Venue: Victoria and Albert Museum (V&A), Sackler Centre, London.
Date: May 21st-22nd, 2013.

2.2.1 Project Description

In big cities in the developed world, we often have a ‘seamless’ Internet experience, accessing websites hosted all over the world, in quick succession, and with, for example, our mobile phones switching between cell towers without our knowing (Chalmers & MacColl, 2003). I wondered, how is this possible? In this project, I tried to make the physical infrastructure behind Internet connectivity visible, to prompt reflection in myself and visitors to the V&A’s Digital Futures event, who comprised a wide range of people interested in the intersection of technology and the arts. From my point of view as someone newly arrived in design research from ‘outside’ (see Preface), this project was less about answering a research question, and more about exploring exhibition-based design practice as a medium for research.

While developing the project I became aware of the Internet’s physicality and its commercialisation: an important part of the Internet’s physical infrastructure is a limited network of fibre optic cables, which are managed by certain countries and companies (Figure 2.1).

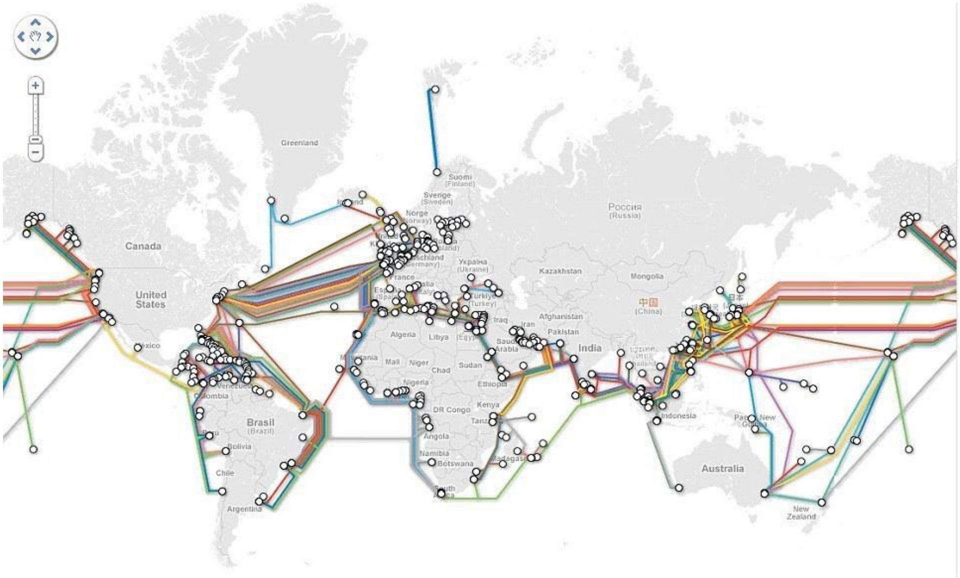


Figure 2.1: Submarine Cable Map: Internet's physical infrastructure is a limited network of fibre optic cables, which are managed by certain countries and companies. Source: Telegeography.com

Cables, not satellites, carry 95% of overseas communication (Drew & Hopper, 2009). Examples of 'making the Internet's invisibility visible' can be seen in the work of Ingrid Burrington (2016) and Timo Arnall (2013).[1]

As part of the event 'Digital Futures', our investigation of Internet's physical infrastructure resulted in an illustration of the backbone of the technology which showed the tangible and political infrastructure behind the idea of a democratic and ubiquitous computing (Figure 2.2).

[1] This project was created before Edward Snowden released the National Security Agency (NSA) documents to the Guardian on June 2013, where the subject of underwater cables became in vogue.

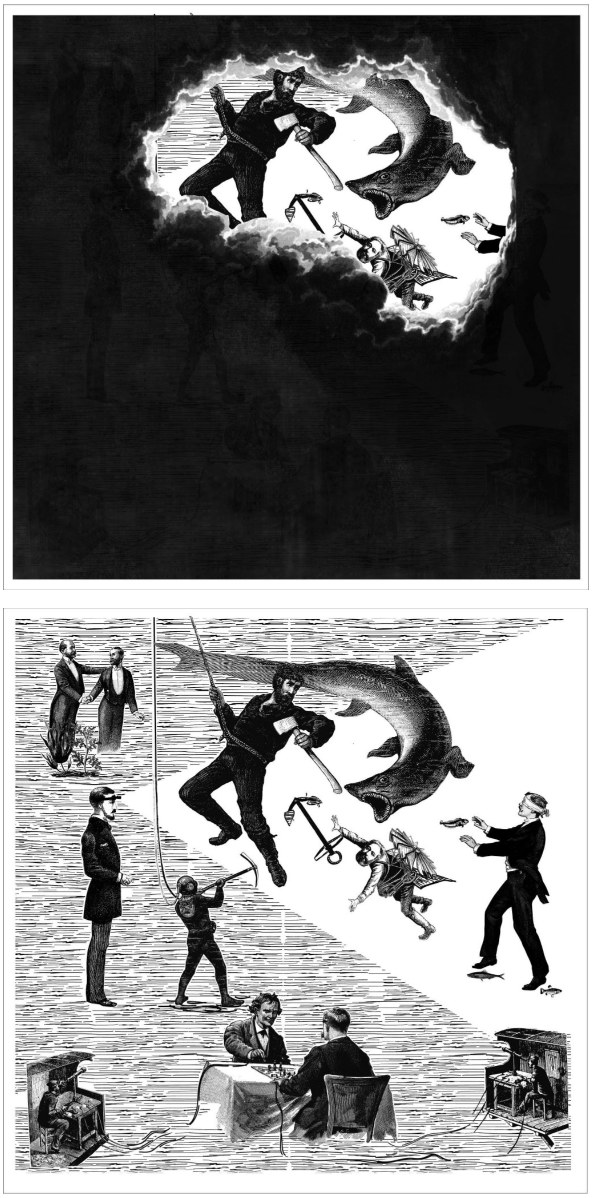


Figure 2.2: The Eighth Wonder: What Hath God Wrought? *Illustration of the backbone of the technology.*

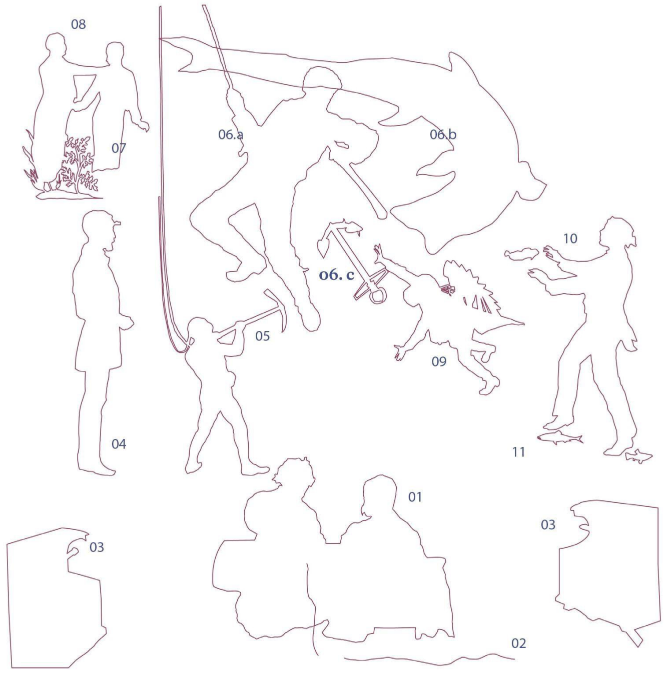
When the telegraph (an important precedent in the Internet's development) was invented, it was described as "the Eighth Wonder of the World" (see Gleick, 2012). Our piece was composed of eight layers, in the same way that underwater fibre optic cables are composed of eight layers of material. The use of glass resembles the materiality of the fibre optic cables.

Finally, a light bulb was programmed to flash in Morse code, reproducing the first message sent underwater: "What hath God Wrought?”[2] The piece was a 3D collage featuring metaphorically different elements representing the story of the Internet’s submarine cables
(Figure 2.3 and 2.4).

[2] “In 1884 the American inventor Samuel F.B. Morse dispatches a telegraph message from the U.S. Capitol to Alfred Vail at a railroad station in Baltimore, Maryland. The message–“What Hath God Wrought?”–was telegraphed back to the Capitol a moment later by Vail. The question was taken from the Bible (Numbers 23:23).”

What hath God wrought? *History*.
Available at: http://www.history.com/this-day-in-history/what-hath-god-wrought

Figure 2.3: 3D collage. 'The skin of the cloud' was the first layer of glass, where a translucent cloud shows the tangible aspect of cloud computing. If you were curious enough you would have encountered a variety of characters involved with the underwater cables. Names like René Descartes, Giulio Verne, IT Intrepid, Networker, Explorer and Telepaatii comprise the fleet of boats that oversee the maintenance of the underwater cables.



01 The Speculators
deciding where to place the cables

02 Broken Cables

03 The Operators
trying to locate the cable break point

04 Cableship: Telepaatti
250 tons - lay, survey & repair

05 Cableship: IT Intrepid
1700 tons - lay, survey & repair

06 Crime Zone: Suspects
a. pirate
b. shark
c. ship anchor

07 Cableship: René Descartes
5800 tons - lay & repair

08 Cableship: Networker
650 tons - installation & maintenance

09 Cableship: Giulio Verne
8000 tons - lay & repair

10 Cableship: Explorer
5760 tons - lay & repair

11 Benthos
organisms living in the lowest
body of water

Figure 2.4: At the bottom, speculators explore the possibilities of laying cables like a strategic game played on the seabed. In the middle, some suspicious saboteurs are at work causing major damage to the submarine cables. Finally, on each side the operators try to figure out who is causing the problem: the shark, the pirate or a ship's anchor?

2.2.2 Findings

Through a better understanding of the physical backbone of the Internet, I realised that ubiquity has limitations, and that instant information relies on a material and uneven infrastructure. Indeed, the global system of communication depends on a very limited network of fibre-optic cables, placed in a specific and unevenly distributed way in the ocean seabed. Through this project, and reflecting on the otherwise invisible infrastructures behind the 'seamless' Internet, I discovered the following juxtapositions between the ideal and the actuality of the subject:

- Intangible/Material
- Perfect/Fallible
- UbiComp is ostensibly available to 'everyone', yet who is 'everyone'?
- In this way, the concept of 'anytime, anywhere and by anyone' can possibly turn into 'occasional, circumscribed and for a few'

These findings are relevant when considering how IoT devices are reliant upon this apparently intangible and ubiquitous infrastructure. Also, the cable connections are mainly between the West and in the Northern Hemisphere, with several commercial implications (see Adler, 2012).

Following the discussion of these 'tensions' related to the Internet background, I became aware of several issues of the foundation of internet-related technologies; such is the case of IoT. Once aware of this, I became interested in exploring further possible issues around what IoT technology promises and what it can actually provide to the users.

Figure 2.5: Members of the public. Sackler Centre, Victoria and Albert Museum (V&A). London: 21 May 2013.

2.3 Project #2: What your kitchen thinks it knows about you

Description: Public engagement event and interactive exhibition on the subject of the IoT. Project in collaboration with RCA (IDE) doctoral candidate Mike Kann, (described in Fantini van Ditmar & Lockton, 2016).
Venue: Natural History Museum, London.
Date: 11 June, 2014

2.3.1 Project Description

In the context of a public engagement event, in order to raise awareness of the technological implications of IoT, the public was confronted with components of the technology. The exhibition was open to the general public, including children on a school trip (Figures 2.6 and 2.7). The participants were between 18 and 60 years old. In the exhibition, members of the public had the chance to experience a 'smart' home interaction, having the chance to reflect on IoT scenarios in the domestic space.

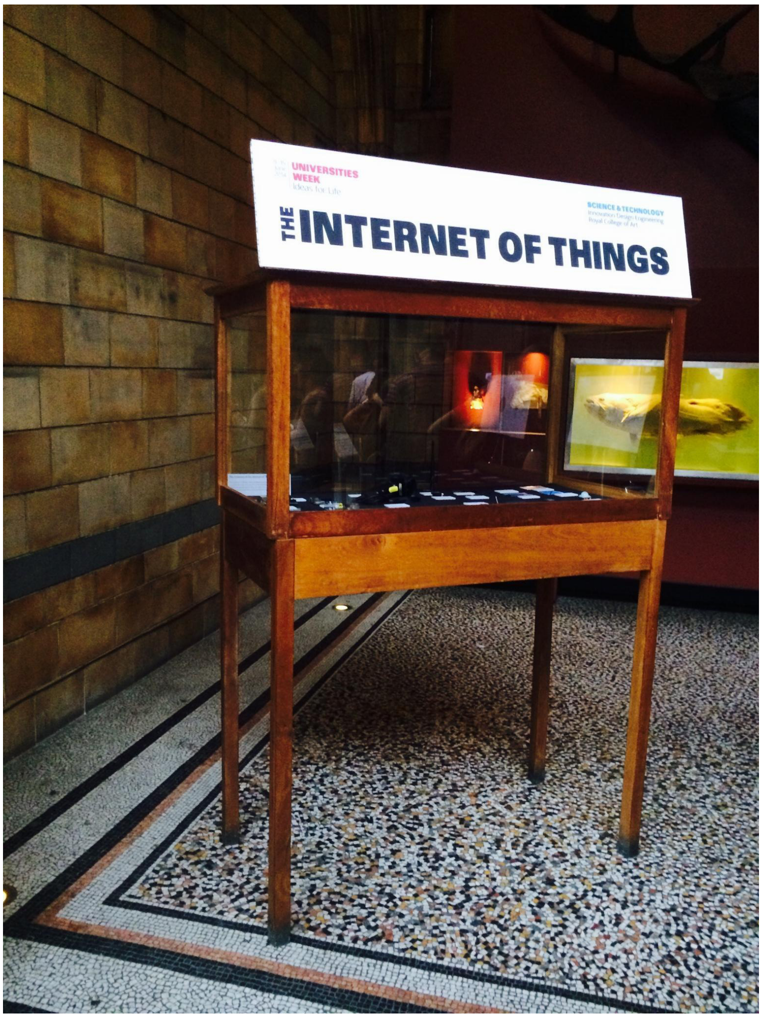
This was a small engagement to elicit responses and questions which might provide insights for the next stages of my research. By doing this I am not claiming any statistical validity or representativeness of the sample. The outcomes of the event informed my research by shedding light on public understanding of IoT technology.

Figure 2.6: The exhibition's public with the interactive table. Natural History Museum. London: 11 June 2014.

Figure 2.7: The exhibition's public at the Natural History Museum. London: 11 June 2014.

The exhibition had the following components, designed to aid the exploration of public conceptions of the IoT:

1. **Introducing IoT hardware**, such as sensors (e.g. accelerometer, temperature and pressure), motors, and microcontrollers (e.g. Arduino and Raspberry Pi). These were presented in an old museum cabinet) (Figure 2.8).



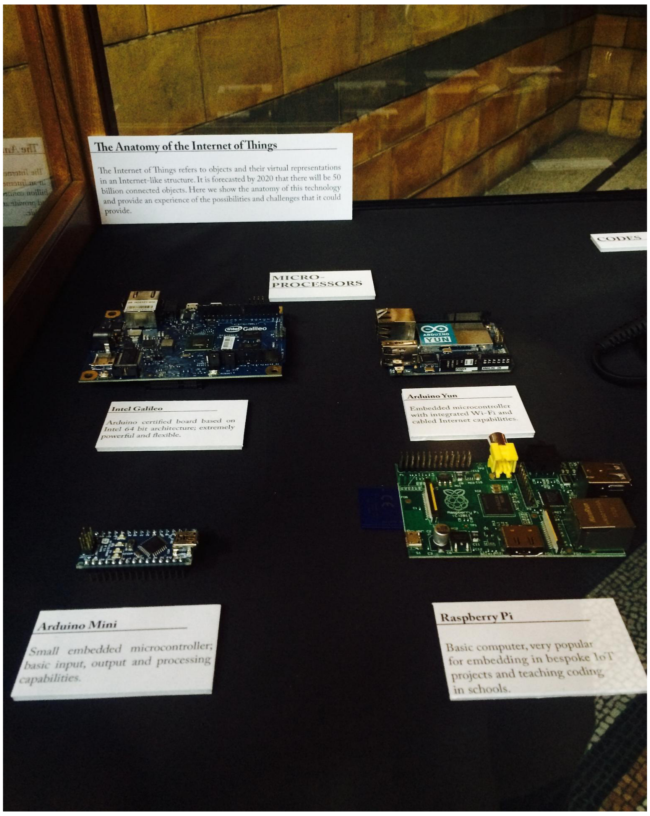


Figure 2.8: Introducing IoT hardware.

2. **A tangible IoT experience**, in which members of the public were asked to make a hot drink, choosing from a range of options (e.g., decaffeinated, soy milk, brown sugar, sweetener etc.). After preparing their drinks, participants received an itemised receipt, printed alongside suggestions for related products taken from Amazon's recommendations, informed by algorithms. Many made sense (if you use soy milk, you probably like rice crackers), but others were less obviously connected (brown sugar was linked to tomato sauce) (Figure 2.9).

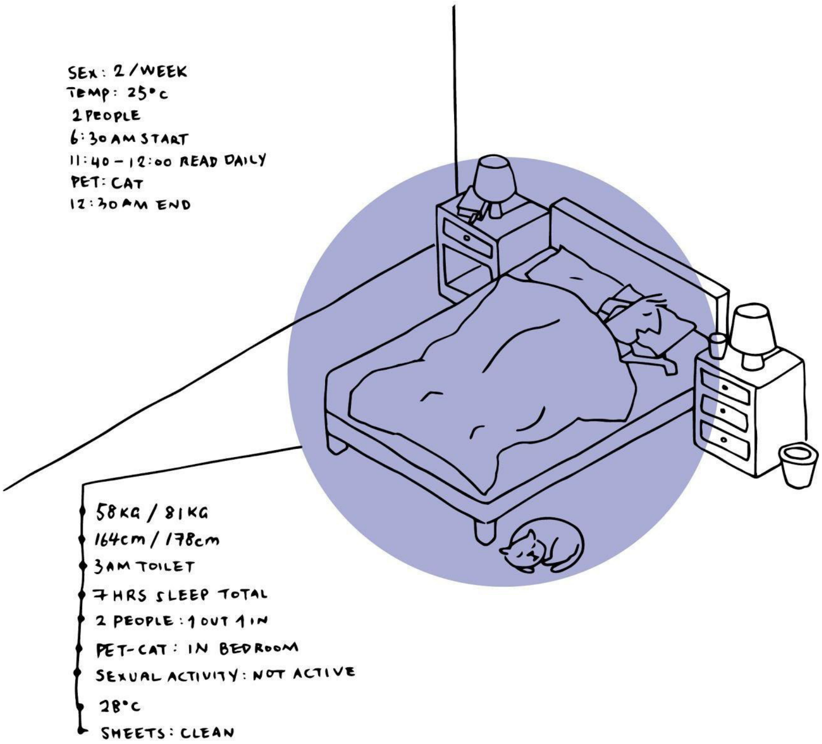
Figure 2.9: IoT experience 'make your hot drink'

3. **Questionnaire**: Once participants had experienced one way in which IoT technology could work in a 'smart' home (by having their behaviour sensed in real time, perceiving their data being associated with a larger body of data, and experiencing assumptions made about them), a questionnaire took place (Figure 2.10). The questionnaires were administered by the researcher Michael Kann, myself and with the help of another person due to the amount of public (see questionnaire in the Appendix A).

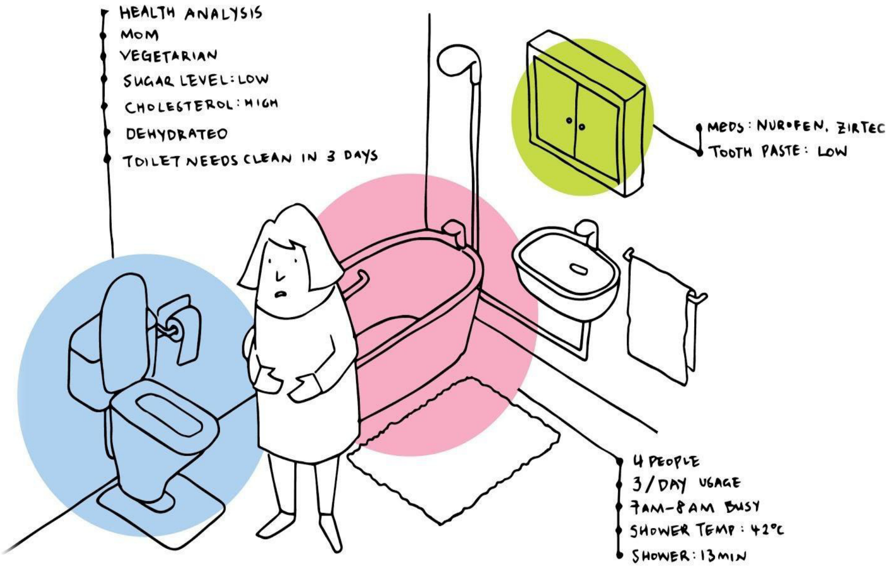
Figure 2.10: Questionnaire after the IoT experience

The questionnaire was based on different scenarios of IoT applications of the ‘smart’ home: the kitchen, bathroom and bedroom (Figure 2.11). Respondents were asked if they would share information collected by the IoT places/objects detailed in the questionnaire; what the IoT meant to them; and what benefits/improvements and worries/complications they could imagine regarding the IoT. 30 participants filled in questionnaires.

Bedroom


SEX: 2/WEEK
TEMP: 25°C
2 PEOPLE
6:30 AM START
11:40 – 12:00 READ DAILY
PET: CAT
12:30 AM END
58KG / 81KG
164cm / 178cm
3AM TOILET
7 HRS SLEEP TOTAL
2 PEOPLE: 1 OUT 1 IN
PET-CAT: IN BEDROOM
SEXUAL ACTIVITY: NOT ACTIVE
28°C
SHEETS: CLEAN

Bathroom



HEALTH ANALYSIS
MOM
VEGETARIAN
SUGAR LEVEL: LOW
CHOLESTEROL: HIGH
DEHYDRATED
TOILET NEEDS CLEAN IN 3 DAYS
MEDS: NUROFEN, ZIRTEC
TOOTH PASTE: LOW
4 PEOPLE
3/DAY USAGE
7AM-8AM BUSY
SHOWER TEMP: 42°C
SHOWER: 13MIN

Kitchen

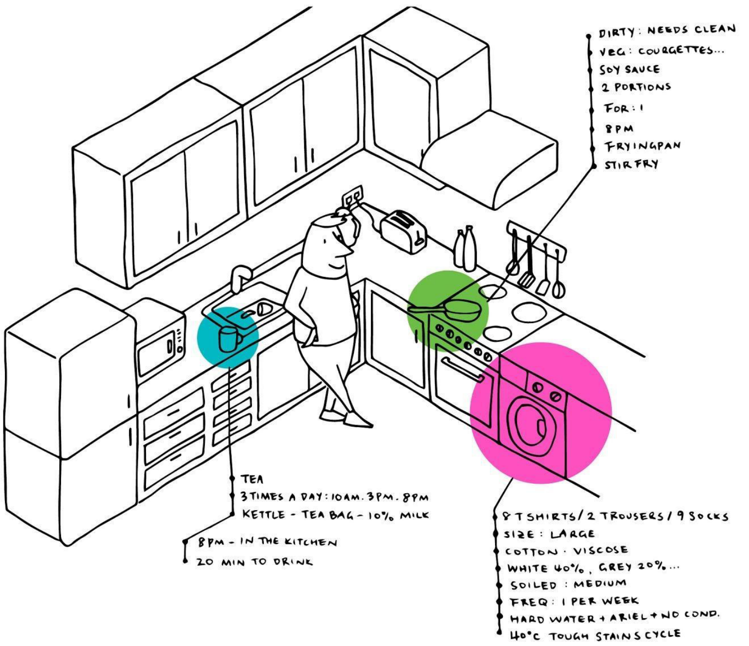


Figure 2.11: Different scenarios of IoT applications of the 'smart' home: the kitchen, bathroom and bedroom. The scenarios were based on illustrations by the designer Yoon Bahk.

2.3.2 Findings from the questionnaire

Although this was only a small pilot study, the investigation provided a qualitative dataset of respondents' sentiments towards the domestic IoT. In this project I gained insight into people's concerns, the positive and negative implications they perceived, and how their willingness to share information changed depending on the domestic spaces—for example, whether people were more willing to share IoT data in the kitchen than in the bedroom. In response to the question 'Have you heard about the Internet of Things?' 25 of the 30 respondents (83%) answered in the affirmative. The following findings emerged from the comments in the questionnaire, after the participants had the experience of the IoT technology.

Definitions

Most of the participants' descriptions of IoT technology included the term *ecosystem*, discussing processes of managing and changing experience through the internet, the idea of individual objects communicating, and the expression 'internet of things'. It was also possible to see how 'virtuality' was present in some of the descriptions: virtual connections, "the union between the digital and the physical", "a layer of technology that communicate objects" and "interacting remotely with things". Interesting aspects of IoT explanations include the juxtaposition of the temporality of IoT—'the connection of devices that are historically different'.

In relation to the idea of technological 'smartness', the descriptions were characterised by inclusion of the terms 'easy', 'smart' and 'intelligence': for example, "smart way of living which affects all our life" and "it makes your life easy". Also in relation to this subject, the verb 'knows' came into the scene: "it knows about you, it can predict". Additional comments included references to companies: "IoT is Amazon in your kitchen" and the analogy that the IoT "is like predictive text: some good and some bad".

Benefits and improvements

The benefits that people perceived the IoT would bring were mainly represented by the concepts of *efficiency* and *making life easier*. Commercial implications also were described. The descriptions included the ideas of time saving, prediction, helping you to solve problems, speed up processes, managing time, “optimizing time by removing repetitive tasks”, “helping you with your daily actions”, “life more efficient, more decisions for me” and “easy access to things”.

In relation to the applications of the IoT, the three main areas highlighted in the section ‘Benefits and Improvements’, were grocery shopping, health and sustainability. Most of the participants liked the idea of the IoT in relation to automatic shopping: “shopping for you”, and seeing the idea that it could “suggest things you forgot” as a positive. Touching on monitoring health, one respondent had the following observation: “but if you don't have the technology, you might get anxiety”, suggesting a ‘fear of missing out’ on the monitoring and diagnosis benefits envisaged. Finally, with regard to sustainability, suggestions included applications like air quality control and the somewhat vague idea of “sustainable daily actions”.

Descriptions of possible commercial implications included the benefits of targeted products, and the idea that the IoT “is good for companies and analysers”. More abstract remarks included the idea to “get knowledge” and the comment that someone believed the “benefit would come when you get information in the aggregate, not in the individual level”. Finally, some relevant comments that I encountered in relation to IoT benefits include the idea that they would “improve life as long as you can disable it” and that the IoT could provide greater “benefits if they were not dominated by big companies”.

Worries and Complications

Respondents' answers touching on worries and complications were mostly centred on the issues and complexities of the term 'smart', the idea of our becoming dependent on the technology, the implications of 'things going wrong', and concerns around commercial use and privacy.

In relation to the algorithmic logic behind the technology, some participants referred to the problems of *assumption*: that an algorithm's assumptions are "worse than people assuming" and noting that the algorithms could make "deductions you don't want". In this context, another worry about IoT technology was the issue of *standardisation*. In relation to this subject, remarks included the question "what happens with the meaning?"

When it came to privacy, comments dwelt on the "invasion of your life" and privacy; information being sold to companies; the implications of control— "control obviously"; "I will become paranoid", government control; espionage; and the idea of "life being mapped". The term 'big brother' was often used: "the big brother element" and "Google is big brother".

Though the majority of the 30 participants were concerned about privacy issues, one had a different perspective: "I have no worries, we are already on the Internet, I no longer feel safe, the risk is worth it" while another participant commented that "we have already crossed the line, there is no way back".

In relation to control, a participant commented, "I don't like the idea of being controlled, I want to take choices". Comments in relation to the relevance of addressing this issue include: "it's important that we have the freedom to choose who the information is for", " it needs guidance and open source", "we should have more freedom either to share or not to share", "we need more personal control", "it is important to get to know where your information is going and who is seeing it" and "to control what you share, you need to understand". In this context, a participant used the following analogy: "yes I am worried, it is like driving a car without traffic lights on the road".

Commercial worries centred on the irritation of IoT automation: it would provide “too much marketing”, and would “make you consume”, or “suggest things you don't want”; it could make “wrong suggestions”, and could “order unnecessary things” or “offer too many choices”. Further, respondents wrote that the “IoT will bring less choices and less thinking” and that the “IoT will bring many things we don't need”.

Another issue that emerged was technological dependency, and things breaking down: it was a problem that there was “too much technology”, and that it was “becoming addictive”; some claimed that “technology was beating us”, and that “we will become too dependent on virtual objects” and highlighted “the problems when things go wrong” (see Honan, 2014).

The participants had different perspectives around worries and concerns. One participant asked “what is the benefit of all this?”, while another wrote that “it will happen anyway”, and that “everything will be shared, nobody asks you”; another expressed the belief that “in the future you won't be able to choose something that is not connected” and “I don’t know the negative implications, because the technology is very new”. One comment on the future of IoT that I found particularly interesting was “If it is not thought through it will be bad, it needs to be made by the right brains”.

The results of the participant’s willingness to share their data in different domestic spaces after the scenarios were: 10/30 Kitchen, 1/30 bedroom and 4/30 bathroom. It is thus evident from the respondents’ answers that the kitchen is the domestic space where the largest proportions of people are willing to share their data. The comments about why they were more in favour about the kitchen as a suitable space for IoT included “I consider kitchen’s data irrelevant information”. There were also more enthusiastic (or facetious) replies: “I would love other people to know when and where and how I am drinking my tea.”

After developing this project, I became interested in specifically exploring the kitchen, as it was the space where more people were willing to share their data.

2.4 Quantifying myself: My experience using an IoT wristband

There is an integration of wearable technology into 'smart' homes, as part of the business strategy of many companies in this market, for example Misfit's Flash Link wristband which can also act as a 'smart' home controller (Stein, 2015).

A relevant point to mention here is the fact that even if such an activity tracker's data (e.g. sleeping patterns and physical activity) 'intimate' characterisation is debatable, it can tell a lot about our behaviour, which matches up with the 'smart' home data, as is already happening in the case of Misfit's Flash Link and Nest thermostat (Figures 2.12 and 2.13).

This background was the setting to explore my interest in central human activities and their connection with quantitative technological approaches such as IoT technology. Until this point I had not tried existing IoT products on the market, so I decided to start 'quantifying myself' with a fitness tracker.

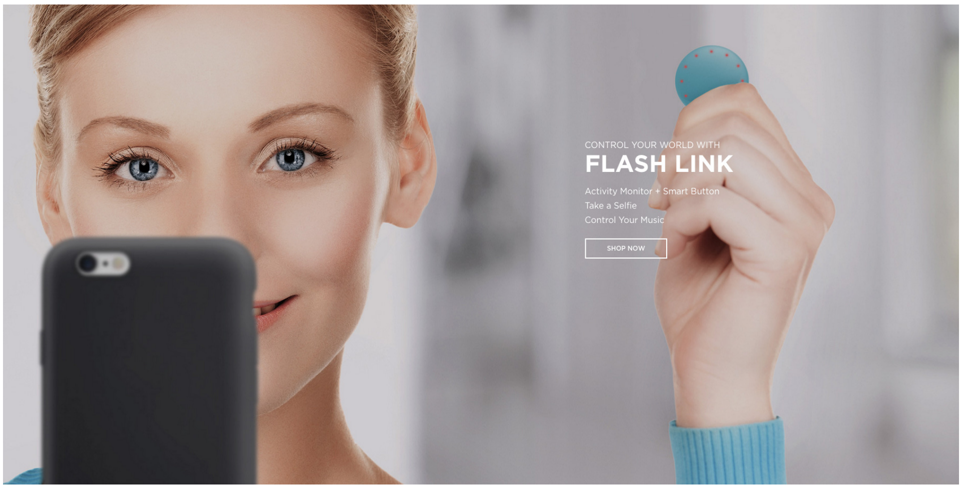


Figure 2.12: Misfit Flash. Misfit Flash motto "Control Your World with Misfit"
Source: Misfit.com

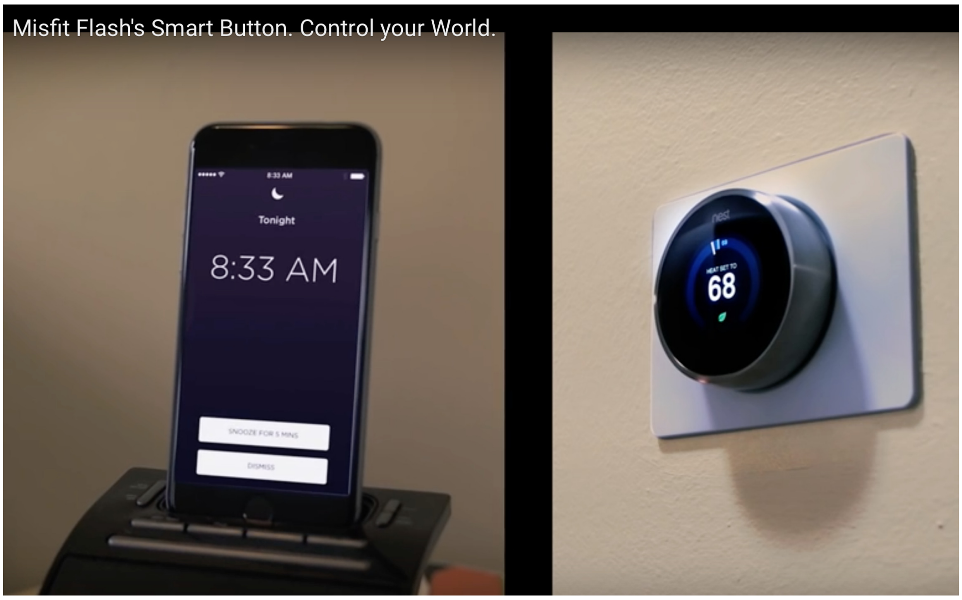


Figure 2.13: Misfit Flash. "Misfit is working with Nest on an integration enabling customers to connect Misfit's sleep tracking functionality and smart alarm with the Nest Learning Thermostat ™ to wake up to their ideal temperature".
Source: Misfit Youtube Channel

Figure 2.14: Quantifying myself, surrounded by messages that I received from my 'smart coach'. I posted this picture on Facebook to explore 'teaming up' (to see how the app dealt with competition). Among the comments that I received was: "What is this?" which I replied: "this is reality for SMART wristband users". The answer was: "Smart wristband! Hahaha".

As introduced in Section 1.2, the Quantified Self is an instance of IoT application on the body, a form of *personal informatics* (Elsden et al, 2015), which has become one of the most popular consumer applications of IoT. The number of wearable devices is predicted to rise from 15 million shipped in 2014 to 70 million in 2017 (Juniper Research, 2014).

I was interested to see how an IoT wristband would confirm or challenge my expectations—What would it tell me? Might the kinds of issues raised by the questionnaire participants in Project 2 above be present in my own experience with the IoT?

For three months, I wore a Jawbone UP wristband—a fairly typical IoT fitness tracker—tracking my daily exercise (walking, running, cycling, swimming, etc.) and interacting with the Jawbone iPhone app 'UP'. Paying close attention to my interaction with the system, with a focus on the way in which the software and its algorithms represented and talked to me, I encountered a number of issues which are noteworthy for this research, including:

1. The duality between the statistical generalisation (based on Big Data, statistics) e.g. "You are on the UP 4%" and the delivery of a 'personalized' message provided by the interaction with the 'smart' coach (Figure 2.15).
2. Inaccuracy, inconsistency and unreliability, e.g. on one occasion, running three times round a park was logged as 7.2 km, but four times as 5.2 km. This made it difficult to 'trust' the device.
3. Language: The way it 'talks to me' (I never feel 'pumped up!') (Figure 2.16) – *idiomatic hyperbole*
4. The content of the messaging itself included in the accompanying app is laced with pseudoscience and research soundbites taken out of context (Figure 2.17).
5. Internationalisation of shared experiences (from Silicon Valley) – why, for example, does it assume I watch *Friends*? (Figure 2.18).

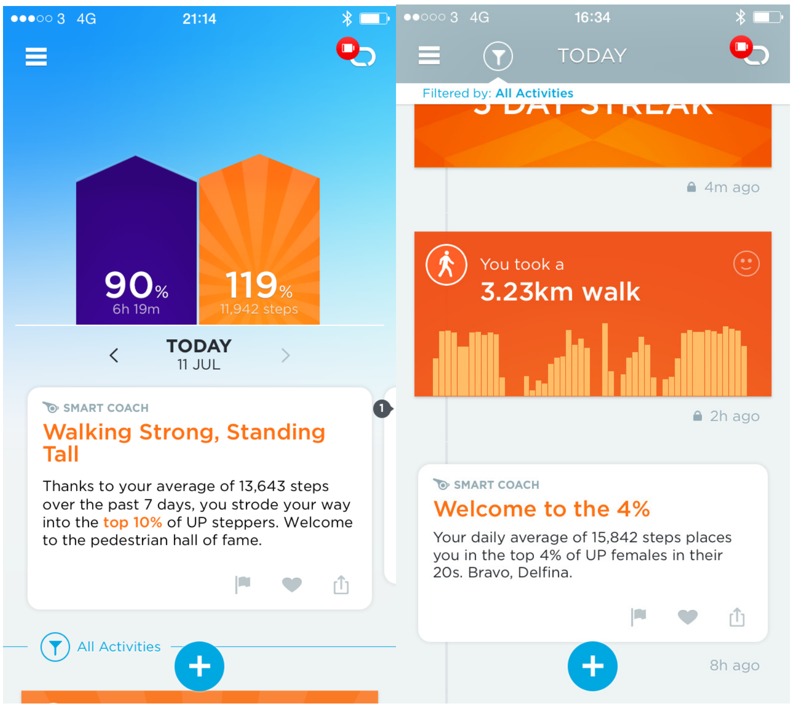


Figure 2.15: The 'pedestrian hall of fame', delivery of a 'personalized' message provided by the interaction with the 'smart' coach.

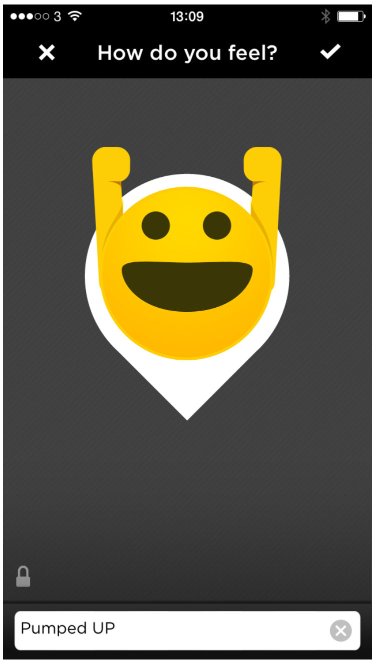


Figure 2.16: The way the app 'talks to me' – Pumped UP? I never feel 'Pumped Up'!

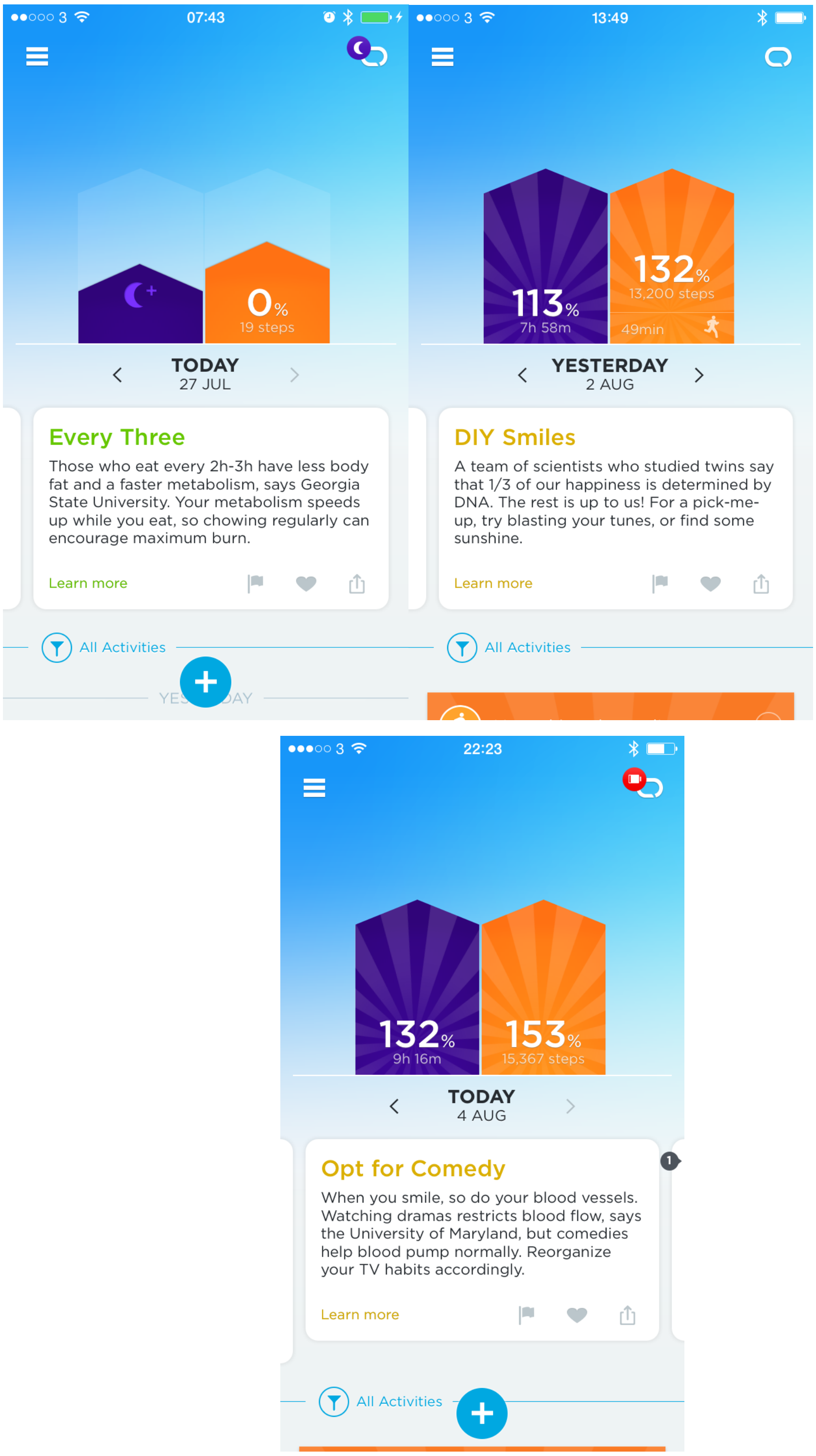


Figure 2.17: Jawbone's pseudoscientific suggestions.

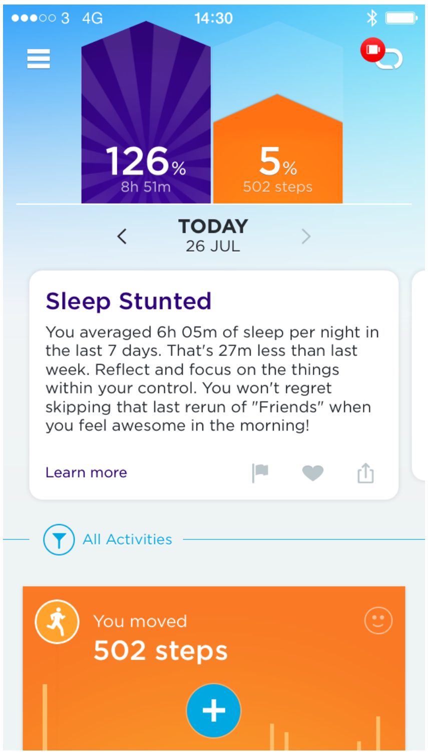


Figure 2.18: Why does it assume I watch Friends*?*

These issues can perhaps all be characterised as involving the software treating people as essentially *probabilistic* subjects, creating assumptions based on bodies of data, and assuming human life is linear. These accords with some of the concerns raised by respondents in Project 2, but experiencing them myself made these issues more directly real to me, through my own experience.

2.5 Reflecting on the place of the human within the IoT

During Projects 1 and 2, and by experiencing using an IoT wristband, I developed new ideas about ‘the ideal and the actual’ in relation to the interaction the user has with IoT technology. After Project 2, with an interest on user conceptions of the domestic IoT, I decided to focus on the kitchen, since it was the space where most people were willing to ‘let in’ IoT technology into their lives; as well, the answers given by respondents to the questionnaire highlighted dimensions in public understanding that I was interested in exploring further.

Moreover, after my experiences ‘quantifying myself’, I realised that relevant themes around IoT technology centre on the idea that the technology *knows* you and can therefore predict your actions. On top of this, another important area that I wanted to explore was the benefits (or otherwise) of user data being analysed on the aggregate rather than individual level.

It is important to note that during my initial research, one unexpected outcome of my interaction with IoT technology was that I began considering *myself* an important part of the research, and leading to a greater appreciation of my role as an observer. Furthermore, my initial exploration started to focus my attention on algorithms, and led me to explore algorithmic logic within a reflective framework (see Sections 3.1 and 3.2). The result of this process, and as a reaction to the data-driven approach employed by algorithms, suggested the need to consider a new epistemology. For this reason, as I discuss in Chapter 3, I decided to employ a second-order cybernetics epistemology, because of this approach’s reflexivity and its ability to take the observer’s observations into account.

Chapter 3

The Algorithmic Paradigm v. second-order cybernetics

Chapter 3: The Algorithmic Paradigm v. second-order cybernetics

From the pilot projects described in Chapter 2, the importance of algorithms became clear for understanding and exploring the interactions between ‘smart’ IoT devices and people. In this chapter, I take a closer look at the ways in which a data-centric Algorithmic Paradigm has emerged, drawing on perspectives and epistemology from Artificial Intelligence (AI), and some of the implications from a human perspective. I then consider an alternative epistemology arising from second-order cybernetics, recognising the importance of the observer, and the relationality of ‘smartness’, and other elements. Adopting this epistemology becomes a central part of my subsequent projects, focusing on the figure of the ‘SMART’ fridge (Chapter 5).

3.1 Developments in computation and dilemmas for the IoT

The Internet of Things (IoT) connects people and things via software based on algorithms. In this system, ‘smart' objects have the potential to connect with each other, make decisions and act without human intervention. In a basic sense, algorithms can be described as a series of rules to be followed in problem-solving operations—the decision-making logic which is designed into software (or followed by a human).

Several computational features characterise current IoT technology: data is gathered, combined with other data, and is analysed statistically, often remotely from the locations at which it is collected. Inferences are then made from the analysis, which may result in certain automated decisions being made, information being sent to other devices, and so on. These algorithmic processes draw particularly on two current phenomena intersecting with AI development: Big Data and machine learning (I will consider AI more broadly in Section 3.3).

3.1.1 Big Data, machine learning and evolution of the IoT

'Big Data' is characterised by using analytics to derive insights from large, complex or fast-moving data sets, for example combining data from many sources in order to detect trends, correlations and patterns. According to Gartner, Big Data "enables *enhanced* insight". [1] Coming originally from the sciences, it has been enthusiastically adopted by marketers. Consequently, Big Data has several definitions; according to Mayer-Schönberger and Cukier (2013) "there is no rigorous definition of Big Data"; their definitions include "things one can do with data at a large scale that cannot be done at a smaller one, to extract new insights or create new forms of value." For Boyd and Crawford (2012), "Big Data is less about data that is big than it is about a capacity to search, aggregate, and cross-reference large data sets." Within the IoT context, Big Data is important, and will be examined further in Section 3.1.2.

Machine learning is an offshoot of AI that employs specialised algorithms to enable software to 'learn' from experience: to discover patterns implicit in data, to reinforce or otherwise adapt its own analysis methods, to enable prediction of how a variable – in a 'smart' home context, an individual – might behave based on past data or activities. Operating on Big Data may be part of this—for example, McMillan (2014) quotes a former Google executive as saying that "Google is not really a search company. It's a machine learning company," in reference to the vast data sets on which Google's algorithms are trained and developed. In an IoT context, the popularity of 'smart' devices such as the Nest (see below) which claim to learn people's routines and make predictions about future needs has brought machine learning into a more mainstream context.

The entry of Big Data and machine learning into the domestic IoT environment were largely unforeseen by Weiser's (1991) original vision of Ubiquitous Computing, and indeed by early IoT technology such as RFID tracking. There are other aspects which enter into this, for example:

[1] Big Data. Gartner IT Glossary.*Gartner.* Available at: http://www.gartner.com/it-glossary/big-data/

[2] A software bug can be defined as " a problem causing a program to crash or produce invalid output. The problem is caused by insufficient or erroneous logic. A bug can be an error, mistake, defect or fault, which may

- A significant difference between early IoT technology and its current consumer-focused iterations is the way information is presented back (narrated) to the user who provided the data (the 'author') through an algorithmic program. In this context, language becomes an important point of consideration: IoT objects use a specific kind of language which is often infused with 'human attributions' (e.g. Apple's intelligent voice agent Siri).

- 'Smart' devices do not only let us monitor variables, they can now operate in the domain of our behaviour. Several 'smart' appliances are linked to central human issues (e.g. IoT wristbands, which deal with physical or biological activity, and the 'smart' fridge, which 'takes care' of our eating habits). While operating in this human domain, the marketing of 'smart' objects declares that they *learn*, *know* and *understand*. Some products even are claimed to be *conscious* or even *thoughtful* - as with the Nest thermostat (Figure 3.1). In this context, the 'smart' device has the potential to make assumptions, judgments, automated decisions and suggestions.

In the fast-paced world of Silicon Valley start-up culture, the commercial imperative may lead to adding features to drive initial sales and attract attention, rather than a more considered approach to the use of data and language. Anecdotally, for example, I have heard that one major fitness tracker manufacturer initially used developers themselves to write system suggestions about health and diet advice, before hiring an intern with some journalism experience, and finally employing professional copywriters. In this context, oversimplification could be considered mainly ignorance, a product of the context rather than some intentional design to standardise and quantify all of human experience. Nevertheless, the result is the same from the consumer's perspective.

As the result of this scenario, it is possible to see dilemmas: we can observe how in the process of IoT technology ostensibly enabling users to control their environment, actually results in users handing over control to the algorithms behind their device's interface. This is a central issue for anyone interested in human interaction with technology: how the algorithmic processes embedded in our surroundings shape the way we relate to our environment and each other. First, it is important to understand in more depth the issues of data in the IoT context.

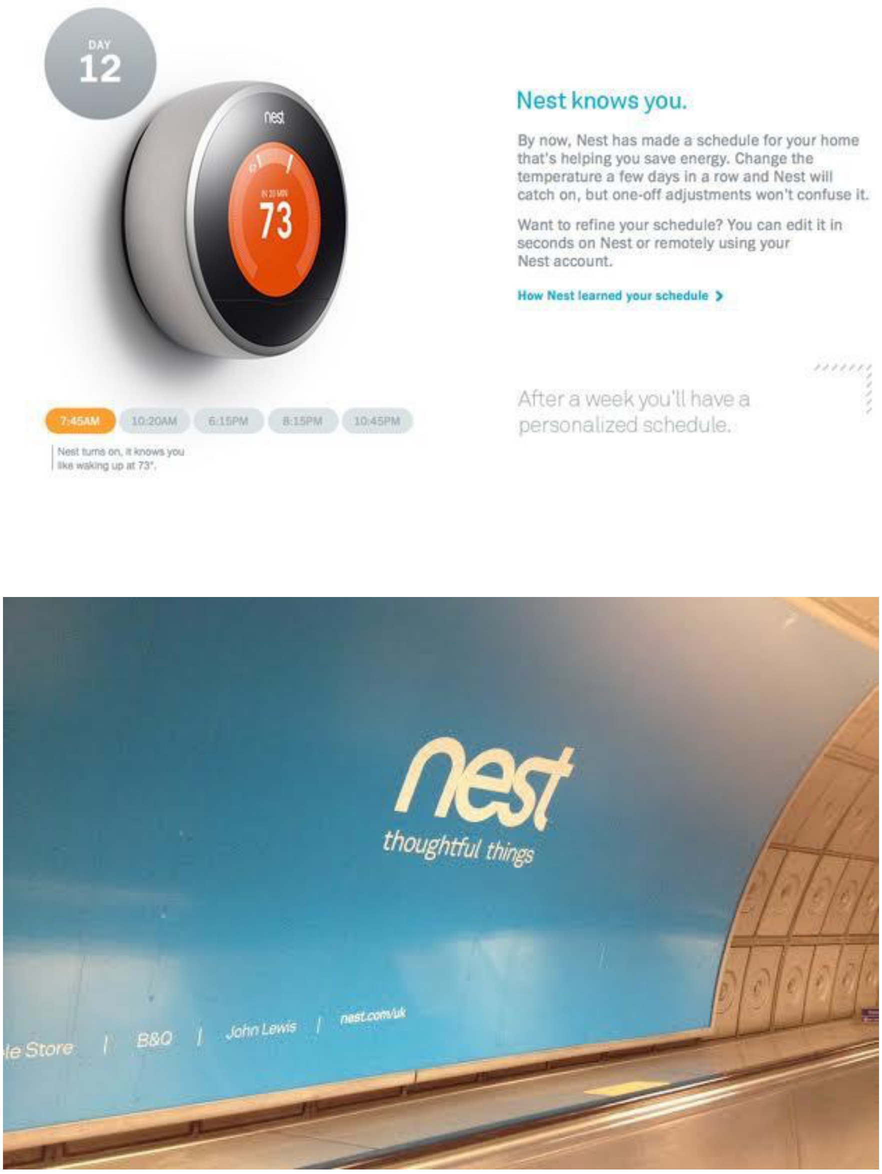


Figure 3.1: 'Smart' objects, in this case the Nest thermostat, declare that they learn, know *and* understand*. They even declare that they are 'thoughtful'.*

3.1.2 Data, behaviour and misbehaviour

> this is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear. Out with every theory of human behaviour, from linguistics to sociology. Forget taxonomy, ontology, and psychology. Who knows why people do what they do? The point is they do it, and we can track and measure it with unprecedented fidelity. With enough data, the numbers speak for themselves.
> Chris Anderson, editor of *Wired*, 2008, quoted by boyd and Crawford (2012).

Because of the constant circulation of data, data flow and management is at the centre of IoT discussions. As Halpern (2014) notes, this technological approach results in the ‘dataization’ of lives – our homes, cities, cars, environment and selves. When domestic objects are data-driven, it becomes important to ask: Who receives the data (and who else has access to it)? How is it combined with other people’s data? How is it analysed? Who develops the algorithms that govern the collection and treatment of the data? How does the above relate to the manufacturers’ incentives? These are all, perhaps, important questions to consider when assessing any new IoT device or initiative, and although these are not directly my research questions, some aspects are addressed within a number of my projects.

In the context of networked devices in our domestic space, the way we behave in our homes is subject to increased monitoring and analysis by various companies. One issue arising from this is that this data can be resold to insurance companies, advertisers, ‘data brokers’ and governments, providing an unprecedented view of our daily lives (Goodman, 2015). One consequence of this was highlighted in late 2013 when Google sent a letter to the US Securities and Exchange Commission noting, “we and other companies could soon be serving ads and other content on refrigerators, car dashboards, thermostats, glasses and watches, to name just a few possibilities” (*Ibid.*).

Here is important to note that selling and re-selling of personal data is increasingly familiar from online profiling and social media, primarily sold to advertisers. But as Speed & Barker (2014, p.6) note, "If domestic appliances follow the same model of trading our data through the availability of free apps and undecipherable terms and conditions then we can expect that much more of our lives will become available as a database for enquiry." For Speed & Barker, the question then becomes "how to design systems that offer [users] value for [providing their] data." In addition, I would like to question whether enabling users to construct *meaning* (see section 3.4.3) is a better way of approaching data in the IoT, than the transactional implications of "value" in this context.

Misbehaviour or malfunction of IoT technology is another potential issue, as networked objects can now act without human intervention. This resonates with one of the early concerns raised by Bruce Sterling's concept of 'Spimes' (a contraction of 'space' and 'time'). Spimes are defined by Sterling (2005) as objects which, through their connections, can be recorded, tracked and inventoried through space and time, having an online life which may transcend transient physical states. According to Sterling, "eminently data-mineable Spimes are the protagonist of an historical process— in a Spime technosociety almost everything has metrics". Sterling (2004) suggests that we should get ready for:

> "- spime spam (vacuum cleaners that bellow ads for dust bags);
> - spime-owner identity theft, fraud, malware, vandalism, and pranks; software faults that make even a mop unusable;
> - spime hazards (kitchens that fry the unwary, cars that drive off bridges);
> - unpredictable emergent forms of networked spime behavior; objects that once were inert and are now expensive, fussy, fragile, hopelessly complex, and subversive of established values."

Connecting an object to the Internet thus generates a shift in its behaviour and therefore our relations toward it. This raises the question: How should the law deal with 'smart' IoT objects in cases of inappropriate decisions, and who (or what) is responsible for such decisions? Such questions about 'disruptive technologies' effects on the law are already very real matters of debate among legal scholars (for example Katyal, 2014), and while outside the scope of this thesis, are worth keeping in mind as we consider the implications of algorithmic decisions.

One example of a misbehaving object was the case of an IoT 'smart' fridge which was hacked and began spamming its user with junk mail. Due to the integration of the user's Google Calendar with the 'smart' fridge, hackers accessed the network and monitored activity for the username and password linked to Gmail, due to Samsung's failure to secure the fridge software (McOwan, 2014). Cases like this show that such misbehaviour might have nothing to do with the refrigerator's main function, but is solely related to its connectivity to the Internet.

This highlights the importance of security and trust in relation to IoT technology. As some of my projects' participants' comments in section 5.1 will show, these issues are very much on people's minds as they consider living with the IoT.

Another issue is around software 'bugs', which have the potential to cause considerable problems.[2] An example concerns the Nest thermostat: in January 2016 a user reported that several such 'smart' thermostats "suffered from a mysterious software bug that drained its battery and sent our home into a chill in the middle of the night" (Bilton, 2016). In response, Nest's co-founder and vice president for engineering blamed a software update, saying: "We had a bug that was introduced in the software update that didn't show up for about two weeks"(*Ibid.*).

[2] A software bug can be defined as " a problem causing a program to crash or produce invalid output. The problem is caused by insufficient or erroneous logic. A bug can be an error, mistake, defect or fault, which may cause failure or deviation from expected results."

Software bug definition. Technopedia.
Available at: https://www.techopedia.com/definition/24864/software-bug-

According to Bilton (2016), "buried deep in Nest's 8,000-word service agreement is a section called 'Disputes and Arbitration', which prohibits customers from suing the company or joining a class-action suit. Instead, disputes are settled through arbitration." In essence, the company is eschewing legal responsibility even for its own misbehaviour.

We have seen how our data, specifically in and from our intimate spaces, under the umbrella of the 'smart' home, is being stored and analysed, and this suggests the need to critically investigate the issues involved. One question arising concerns the epistemology of data analysis and the mentality embedded in the algorithmic processes: how do devices and systems 'know' what they (are claimed to) know? In the following section I explore this epistemology further, characterising the algorithmic logic that governs IoT devices as the Algorithmic Paradigm.

3.2 The Algorithmic Paradigm

In the context of users' interactions with and within the 'smart' home, I conceptually set my projects and discussions around an interrogation of what I would refer as the Algorithmic Paradigm.[3] As detailed above, algorithmic processes are a central attribute of the IoT and have the active role of a protagonist in our lives: they affect the relations users have with 'smart' objects, even, in some cases, helping to restructure the rationale behind their operations (e.g. when a fridge becomes a 'health and wellness centre' for the home (Luo et al, 2009).

The prior paradigm was characterised by being the beginning of personal computing. Its operations can be described by being composed of considerably smaller data pools and computation capacity. At the same time the precedent paradigm was characterised by being detached: it was not 'real time'; the speed of the analysis of data was substantially slower and it was delimited, it had locational limits. It was not 24/7, it was not ubiquitous (see Nilsson, 2009 for a historical description of AI history).

Here it is important to note that the algorithmic development in the previous paradigm was characterised by being specialist (the computation was bounded from the end user). Mainly it was applied in specified AI research centres, the military and big technological companies. In relation to computational applications, it was restricted to boundaries of companies or groups that have resources to deploy computing. They were practised mainly in the experimentation of AI research centres, in the industry, the military and in banking.

The most radical difference with the Algorithmic Paradigm is the existence of vastly gigantic data centres and computational power. This came together with the availability of the data in cloud computing technology (ubiquity of access of computation). All this had repercussions in the quantitative capabilities of the trained learning algorithms.

[3] In computer science, *algorithmic paradigms* are characterised as "general approaches to the construction of efficient solutions to problems" (Dunne, undated), i.e. different approaches to creating algorithms, described in computational terms. My use of the term here is not directly related to this sense.

The expansion in computation, the decrease of technological costs and the availability of real time data, resulted in the ubiquity of IoT which touches every moment of our lives rather than only the computational infrastructure. The Algorithmic Paradigm operates in the domain of behaviour and can be described by being individualized, personal, behavioural, ubiquitous, real time and 24/7. This brings with it a change in language; before it was operated in an algorithmic-computer science language since technical experts bounded to the computer industry mainly operated the processes. With the introduction of the smartphone and 'web 2.0' technologies, the relationship of who is touched by the algorithmic process shifted reaching the end user. As a consequence this shifted the language applied to machine-user interaction, now characterised by 'user-friendly' language.

The following paradigm, which I characterized as the Algorithmic Paradigm in the context of IoT is characterized by the following algorithmic characteristics:

- Representation and modeling of the data gathered by the device about its daily life, surrounding and body (domain of behavior).
- Aggregation: The decision making process often includes Big Data and machine learning strategies to inform the development of predictive algorithms, using advanced analytics to predict probabilistically how an individual is expected to behave in the future.
- Automation in real time: The algorithms have the capability to control the environment, and the potential to change their procedure without informing the user.

I consider this to be a *paradigm* because, following the use of the term by Kuhn (1962), this algorithmic approach within the development of IoT and 'smart' home technology seems to be largely a 'model of reality' for its designers and developers, constituting a scope for what phenomena should be paid attention to and monitored, what questions are considered important to address, and from an epistemological perspective, what it means to 'know' about reality. Gillespie (2014, p.168) indicates the importance here of being aware of the choices behind data collection and the criteria by which algorithms determine what is relevant. As with many paradigms, it may be tacit, unquestioned within the flow of everyday work.

3.2.1 Implications of the Algorithmic Paradigm

Algorithms are fundamental to the operation of the IoT: they can be described as a series of rules to be followed in computing problem-solving operations. Software is the practical implementation of algorithms, as appropriate for a particular device or operation. From this angle, algorithms can be considered the rules behind the design of the system as a whole, while software is the implementation of these rules. The algorithms are thus the fundamental part of the scenario, and for example, different software can implement (be governed by) the same algorithmic approach. As to why I decided to focus on algorithms and not on software or user experience of specific interfaces, user experience is a central component in the operation of the IoT which much work in HCI and design research covers, and I decided to focus on algorithms because my research interest is at the scale of the problem-solving operations, the assumptions behind them, and how computational decisions are made, rather than the human interface specifically.

Gillespie (2014, p.167) writes that "algorithms need not be software, they are encoded procedures for transforming input data into a desired output, based on specified calculations". Bearing this in mind, I decided to draw attention to the algorithms themselves rather than their specific implementation within the connected object. I am following the line of thought of writers such as Pasquale (2015, p.8), who champions questioning the algorithmic process because authority is increasingly delivered in an algorithmic manner (see Lessig's (1999) argument that "code is law").

Pasquale describes how decisions formerly based on human reflection are now made algorithmically, with corresponding legal, ethical and social implications, while Manovich (2013, p.4) highlights the relevance of understanding software, because "if we don't address software itself, we are in danger of always dealing only with its effects rather than the causes: the output that appears on a computer screen rather than the programs and social cultures that produce these outputs". With this in mind, my focus in this thesis will be a design research approach to the algorithmic epistemology behind IoT technology.

In relation to decision-making processes and causal linear properties, Goffey (2008, p.16) characterises the algorithm as a sum of logic and control, and indicates the link between algorithms and action, based on defined variables and correlations. In this context, Gillespie (2014, p.167) notes that algorithms are designed for problem solving, and the supposed problem they are designed around must be well-structured – algorithmic procedures, he says, name both a problem and the steps by which it should be solved. Krysa and Sedek (2008, pp.236), refer to Knuth's (1997) analogy of cooking: *"*algorithms, much like cooking recipes, provide a method, a set of defined formal procedures to be performed in order to accomplish a task in a finite number of steps."

It is this particularity of well-structured algorithmic procedures, and the structural relation between the translations of the data from the complex world into algorithmic logic, which I address in my 'SMART' fridge projects (Chapter 5). Algorithms operate within the human environment and have implications in our lives, as Goffey (2008, p.17) argues: "algorithms have material effects on end users, algorithms do things, and their syntax embodies a command structure to enable this to happen". For this reason I believe it is relevant to investigate their operations, both conceptually and practically.

3.2.2 Data-centrism

An important topic to analyse within the Algorithmic Paradigm regarding human interaction with the IoT is the process of 'sensing' the world (the creation of data), and the translation of our behaviour and our surroundings into data. This has direct implications for our daily lives: Rouvroy (2012, p.1) suggests the implications of what she calls 'data behaviourism' in "the way of producing knowledge of future preferences, behaviours or events without considering the subject's psychological motivations, speeches or narratives, but rather relying on *data*". Rouvroy (2012, p.6) illustrates some issues with data-gathering as, "indifferent to the causes of phenomena, 'data behaviourism' is anchored in the purely statistical observation of correlations (independent from any kind of logic) among data collected in a variety of heterogeneous contexts".

This algorithmic context, with its focus on data, resonates with Deleuze's (1992) concept of the "dividual", in which he describes a physically embodied human subject who is endlessly divisible and reducible to data representations via modern technologies of control such as computer-based systems. As Whitson (2015) notes, the quantification or reduction of the self to a data-representation can be part of a process of 'governance' in Foucault's (1988) sense.

3.2.3 The infra-individual

Another relevant issue is algorithms' quantitative approach towards people, generally disregarding the presence of human subjectivity and individuality (or representing it trivially, as in the Jawbone UP examples in Chapter 2). As Rouvroy (2012, p.8) indicates, "The 'probabilistic subject' is not the same as the actual, experiential, present and sentient subject". She describes this as 'algorithmic governmentality', indicating that "it operates with infra-individual data and supra-individual patterns without, at any moment, calling the subject to account for himself." Rouvroy (2012, p.6) continues:

> because human psychological motivations and singularities appear – maybe more than ever – incommensurable and unpredictable due to the complexification and massification of flows of persons, data and objects that algorithmic systems of statistical profiling appear so appealing today, relieving human beings from the harsh tasks of interpreting and evaluating facts in an epistemic universe devoid of common testing and evaluation criteria.

Reducing our behaviour into data representations, and recombining it with other data, leaves behind not only the user's subjectivity and individuality, but also the variable real-life contexts from which this data is gathered. This issue is central to my projects described in Chapter 5.

3.2.4 Living with algorithms: Reflections for my research

The ‘smart’ home brings with it a whole new set of concerns: as Wajcman (2015, p.130) notes, the complexities of humans impose limits on the mechanisation of their lives, and technical visions of domestic life are often at the expense of the home as a lived and living practice. In this algorithmic context, the complexity and unpredictability of the user’s daily life is replaced with technological, numerical determination.

Algorithms model the environment, render humans and offer us ‘smart’ *solutions* – but we must question how this relates to the complexity of the real world. Adaptive algorithms based on machine learning principles are 'learning' more about our lives, and the Big Data sets constructed from millions of people's information are enabling corporations to learn more about us. And these processes are becoming faster at processing data and at 'learning', but in my research I ask, What and how are they learning? This is in no way inconsequential.

I specifically explore the home as a setting for algorithmic actions, by analysing what moments are too important to be compromised by the algorithms of IoT devices in relation to central human activities. [4]

Within this framework it is important to think critically of the oversimplifications that result when translating our behaviour into data, which leads to the central question of how the algorithms ‘know’ what they know about us. Gillespie (2014, p.168) suggests that algorithms are,

> by the very same mathematical procedures [claiming to] producing and certifying knowledge… The algorithmic assessment of information, then, represents a particular *knowledge logic*, one built on specific presumptions about what knowledge is and how one should identify its most relevant components.

[4] A relevant example showing the juxtaposition of human complexity and ‘technological solutionism’ is the idea of applying IoT into the issue of fertility (see Weigel, 2016).

This leads to considering the design and designers behind the algorithmic processes. For this reason, it is important to be aware of what Gillespie (2014, p.169) calls “the promise of algorithmic objectivity: the way the technical character of the algorithm is positioned as an assurance of impartiality, and how that claim is maintained in the face of controversy”. Here, from a sociological and political perspective, Gillespie (*Ibid.*) makes clear the need to avoid the conception of algorithms as abstract, technical achievements; instead he suggests, “it must unpack the warm human and institutional choices that lie behind these cold mechanisms”.

This section suggests the importance of questioning and considering the mentality embedded in the design of the ‘smart’ technology and its decision making process, which is easily ignored through a belief in “algorithmic objectivity” (Gillespie, 2014). For this reason, in Section 3.3 I explore further the epistemology embedded in the Algorithmic Paradigm by zooming out and looking at AI more broadly, and then what is offered by an alternative approach from second-order cybernetics.

3.3 Artificial Intelligence: Is anything said by the observer?

While perhaps often conflated in popular discussion, cybernetics (see Section 3.4.1) and AI are different. Pangaro (2013) clarifies this by comparing both fields' development. Cybernetics, focused on describing complex systems, started in the late 1940s (see Section 3.3.1) around the same time as AI emerged. In 1958 John McCarthy and Marvin Minsky founded the Artificial Intelligence Group at MIT. As McCarthy asserts in relation to AI: "the study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of *intelligence* can in principle be so precisely described that a machine can be made to simulate it" (Markoff, 2015, p. 114).

The field of AI, with its interest in human-like computer 'thought', flourished in the 1960s, and held a dominant position between 1960 and 1985. As Pangaro (2013) points out, AI is characterized by:

- "The cultural view of the brain as a computer" [5]
- "The availability of digital computing machines came together to paint a future where computers were at least as smart as humans"
- "The presumption that knowledge is a commodity that can be stored inside of a machine, and that the application of such stored knowledge to the real world constitutes intelligence (Minsky, 1968)".
- "Only with such a realistic view for example, semantic networks and rule-based expert systems appear to be a route to intelligent machines".

Along with the metaphor of the brain as computer, there is generally a close relationship with cognitive science in AI; it is an interdisciplinary research field characterised by the understanding of the mind as having comprehensible cognitive processes, in which intelligence and behaviour which can be modelled and replicated.

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[5] As Suchman (1987, p.9) notes, in cognitive science and its affiliated disciplines, it is common to find agreement that "cognition is not just potentially *like* computation, it literally *is* computational". There are exceptions; such is the case of Douglas Hofstadter, who would not characterise cognition as computation, at least not in the conventional sense.

AI, at least as commonly understood in academic and technological research, is a first-order epistemology and therefore claims to know the world 'as it is' and to provide (some) clarity concerning cause and effect. Whatever 'intelligence' is encoded, it is still necessary for the correct code to be specified in order that a machine does as its programmers wish.

If we relate this to the idea of the 'smart' home, we are moved to ask about the possibility of replicating the complexity of central human activities and living practices in (computer) code.

It is important to note that within AI culture, 'machine' could be read as 'Turing machine', which stores data, representing knowledge and experience of the world both inside and outside the machine. This sits in opposition to what, for example, Pask (1975) and von Foerster (2011) argue: that it is impossible for machines to store *knowledge* because the inner and outer context (the world) changes and the machine must re-compute (or, per Pask, re-produce) what it 'knows' as it operates in the world.[6]

This is related to von Foerster's concept of *trivial machines*: those whose output can be determined by their user's input, in contrast with *non-trivial machines* which posses an "internal logic that changes the operator with every operation. If only one step is missed by an observer, the reaction of the machine becomes unpredictable, even if the principle of the program is known" (von Foerster & Poerksen, 1999, p. 58). Von Foerster and Poerksen characterise non-trivial machines as history-dependent (every operation changes the operator), analytically indeterminable (it processes non-linear equations), and analytically unpredictable.

While recent approaches to machine learning (see Section 3.1), as a subset of AI research, 'declare victory' for intelligent machines because they can now adjust from experience, the same underlying logic structure dominates.

[6] An interesting comparison between the context of Artificial Intelligence interface development in the 1960s, and nowadays: did the pioneers of these approaches anticipate the short-term commercial implications on developments in this field?

At this point, in the context of AI, it is important to note the difference between algorithms and heuristics: algorithms have a deterministic logic, which sits in opposition to human experience approaches like heuristics. The latter (e.g. Pólya, 1945; Groner et al, 1983) are an imperfect approximation, which involve learning, discovery, understanding and problem solving through opening up possibilities and experimentation.

If we consider human subjectivity as an important aspect of human 'smart' machine interaction, the idea of a 'non-deterministic' approach is a relevant issue to consider for the future of the development of IoT technology. For this reason I explore this subject in my research projects.

3.3.1 AI and Silicon Valley

The concepts on which AI is founded have had a profound influence on the evolution of contemporary IoT technology. As Markoff (2015, p.xvii), notes:

> the best way to answer questions about control in a world full of 'smart' machines is by understanding the values of those who are actually building those systems. In Silicon Valley, it is popular for optimistic technologies to believe that the twin forces of innovation and Moore's Law are sufficient to account for technical progress.[7]

Silicon Valley, the epicentre of high-tech corporations and start-up culture, is known for rapid development and deployment, and AI constitutes one of the hottest trends. Machine learning techniques have led to a dramatic revival of interest in AI in Silicon Valley and elsewhere (Markoff, 2015, p.152), with 'Deep Learning' the latest excitement (Waters, 2015).[8]

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[7] Moore's Law, which originated in the 1970s, states that processor speeds, or overall processing power for computers will double every two years.
Moore's Law. Available at: http://www.mooreslaw.org/

[8] Deep learning can be defined as software that seeks to emulate the processes of the human brain to *learn* more quickly.

This interest in AI from the main companies designing IoT technology, suggests the importance of investigating the Algorithmic Paradigm strongly interwoven with AI. In contrast to AI's first-order epistemology—which aims (and claims) to know the 'world as it is'—I next investigate second-order cybernetics as an alternative epistemology which, with its constructivist approach, contradicts this assumption.[9]

[9] In this case constructivism is considered in von Glasersfeld (1990, p. 20) terms" the knowledge we have must have been derived in some way from our experience, which includes sensing, acting, and thinking. If this is the case, we have no way of checking the truth of our knowledge with the world presumed to be lying beyond our experiential interface, because to do this, we would need an access to such a world that does not involve our experiencing it."

3.4 Introduction to second-order cybernetics

The pilot projects described in Chapter 2 led me to realise the importance of the observer in our interactions with algorithms. In this section, I describe my epistemological stance deriving from this focus: second-order cybernetics, a theoretical framework grounding my methodological approach to the projects I have undertaken.

According to Dubberly and Pangaro (2015, p.74) second-order cybernetics is fundamental to design because as an epistemological framework it provides a systemic point of view for designing. As the authors point out:

> cybernetics offers both language and models for understanding and describing such systems. For the shift from first-order to second-order occurs when the observer—the designer, the modeller, the problem-framer, the participant in design conversations—is aware of her observing, and therefore our responsibility for it all.

3.4.1 First-order cybernetics

Cybernetics, like AI, began as an interdisciplinary field, in its case rooted in the Macy Conferences, which took place between 1946 and 1953.[10] The participants came from biology, neurophysiology, anthropology, electrical engineering, mathematics and psychology, and included Gregory Bateson, Margaret Mead, Claude Shannon, Ross Ashby, Lawrence K. Frank, Warren S. McCulloch, Heinz von Foerster, John von Neumann, Norbert Wiener and Arturo S. Rosenblueth.

As Pangaro (2013) describes, Wiener, Rosenblueth, and Julian Bigelow needed a name for their new discipline, and they adapted cybernetics from the Greek word *kybernetes,* meaning “the art of steering” to evoke the rich interaction of goals, predictions, actions, feedback, and responses in different types of systems. In 1948 Wiener defined cybernetics as "the scientific study of control and communication in the animal and the machine" (Wiener, 1948).

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[10] American Society for Cybernetics (ASC), retrieved 15 April 2008. Available at: http://www.asc-cybernetics.org/foundations/history2.htm

Based on a systemic behavioural approach, rather than particular mechanisms and linear causality, cybernetics, as Glanville (2003, p.16) notes, developed an epistemology for comprehending and simulating biological processes (e.g., homeostasis, habituation, adaptation, and other first-order regulatory processes) – thus its scope is broader than that of AI with its focus on organisms, systems and physical processes. The emergent field of cybernetics became a relevant area in the study of systems, communication and control in living organisms, machines and organisations. The first conference was titled "Feedback Mechanisms and Circular Causal Systems in Biological and Social Systems".[11]

3.4.2 'Cybernetics of cybernetics' (second-order cybernetics)

Twenty years later, the field of cybernetics was questioned and the concepts were developed further. The earliest declaration of this phase can be traced to the first symposium of the emergent American Society for Cybernetics (ASC), held during the American Association for the Advancement of Science meeting in 1968. After several years of discussions, the conceptual changeover was completed in 1976 (Glanville, 2003, p.7). As described in a course description for *Cybernetics of Cybernetics*,

> second-order cybernetics provides a conceptual framework with sufficient richness to address second-order processes as, e.g., cognition, dialogue, socio-cultural interactions, etc. (Glanville, 2003, p.16). [12]

The subject "The Cybernetics of Cybernetics" was first formally indicated by Mead (1968), whose major contribution was the enactment of a methodology involving anecdotal evidence collected through an active and present observer, recognising the personhood of the provider of the information, drawn from her pioneering ethnographic work (Glanville, 2003, p.8).

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[11] For more details see ASC webpage http://www.asc-cybernetics.org

[12] According to Glanville, (2003), Maturana's and Varela's biological concepts of autopoiesis, organizational closure, and the associated notion "autonomy", became by analogical extension some of the most powerful and developed concepts in second order Cybernetics . See Maturana and Varela (1992), where the biological concepts are developed towards a cybernetic understanding of epistemology and cognition.

Later, the discipline undertook an epistemological shift when it acknowledged the importance of considering the observer as part of the system that the observer is observing. As von Foerster points out in *Cybernetics of Cybernetics*, the "science of observed systems" cannot be divorced from "a science of observing systems" (von Foerster, 1995b, p.497).

In the following section I describe specific second-order concepts that embrace human complexity, which are valuable to take into account in the context of the reductionist logic which characterises the Algorithmic Paradigm.

3.4.3 Relevant second-order cybernetics perspectives

Objectivity is a subject's delusion that observing can be done without him.
von Foerster, 2011.

Everything said is said by an observer
Maturana, 1972.

In this section, I refer to second-order concepts, which are important for understanding my projects, and the methodology I used to develop and enact them: 'The IdIoT Proposition' (Chapter 4).

Circularity and the inclusion of the observer

A central concept in second-order cybernetics is circularity. As Glanville (2003, p.6) notes:

> cybernetics brings us circularity as its core insight, and, through that, the related concepts circular causality, interaction, betweenness, etc. There are two aspects to circularity in cybernetic systems. First, there is the circularity of the system under consideration, that is, the observed system. And secondly, there is the circularity of the act of observing, that is, of the observing system observing the observed system.

A main focus of second-order cybernetics was the consideration that the observer is always present in the observing. In 1974 von Foerster, who understood that the presence of the observer was inevitable and this could be seen as desirable, placed the observer at the centre of epistemological discussions in *Cybernetics of Cybernetics* (Glanville, 2003, p.11).[13] As Glanville (2003, p.22) indicates, second-order cybernetics considers (rather than ignores) the observer; studying observing as opposed to observed systems, insisting the observer takes centre stage.

This is a relational shift in cybernetics. Here, no observation can be made without an observer (i.e, Maturana's "Everything said is said by an observer") and each observer is different. Therefore, what each observer observes must be thought of as different: "each observer is responsible for his own observations, for only he can make them" (Glanville, 2003, p.17). As Glanville (2003, p3) notes:

> in second order cybernetics, the aim of attaining 'traditional' positivist objectivity is either abandoned, or ideas about what objectivity is, and how we might obtain (and value) it, are reconsidered. As a result, every observation is considered autobiographical if the indispensable presence of the observer doing the observing is established.

Consequently, as Pangaro (2013) notes, this cybernetic approach is centrally concerned with the unavoidable limitation of what we can know: our own subjectivity.

Von Foerster's acknowledgement of the observer led him also to consider ethical implications. In his essay "Ethics and Second-Order Cybernetics" (1992) he insists:

> if the properties of the observer (namely to observe and describe) are eliminated, there is nothing left; no observation, no description... With the essence of observing (namely the processes of cognition) having been removed, the observer is reduced to a copying machine with the notion of responsibility successfully juggled away.

[13] As a demonstration of von Foerster's acknowledgement of the relevance of the incorporation of the observer, in the lecture von Foerster gave in Paris in 1990, he invited the audience to join him in a land where observing it was not forbidden; rather, where one is encouraged to speak about oneself (von Foerster, 1995a).

This idea is thus in opposition to the reductiveness inherent in ostensibly objective algorithmic approaches to ‘understanding’ a person’s everyday life through inferences from a limited set of data, but also highlights the necessity of the user not placing trust in the output of the algorithmic systems when dealing with central human activities.

Humans and emotional living systems

By addressing the importance of the observer, language, living systems, the present, and the implication of these concepts in culture and in human living, Maturana’s work was fundamental in the development of second-order epistemology. His work is particularly relevant for characterising central human complexities such as emotions, the ongoing present, constant structural changes in ‘the present’, and the acknowledgement of the reflective observer in relation to an act of living (our relations, our surroundings and their contingencies).

I will describe several concepts, centred around the importance of the observer and the acknowledgment of the complexity and contingency of our living practice. These provide a solid base for questioning the Algorithmic Paradigm of the IoT.

- The idea that “everything said is said by an observer to another observer” (Maturana and Davila, 2013). In the context of the Algorithmic Paradigm, I explore the relevance of acknowledging the user’s insights into a system as an alternative to the purely data-driven approach, thus placing the user with his or her reflective capacities within the system. In this context, I analyse the relevance of the user’s reflective capacity in his or her interaction with an IoT device.

- The relational flow of a system, in opposition to the reliance on historical data and machine learning strategies: “as structurally determined systems, living beings exist in *no-time*, in a continuous present of continuous structural change in which each new moment of the present arises as a modification of the present moment that is being lived” (Maturana and Davila, 2013). Together with the next point, this has implications for any technology that claims to monitor and quantify behaviour or other aspects of human life.

- Living systems act by the "only thing it can do in that moment' in a constant changing present (Maturana and Davila, 2013). This poses a problem for a machine learning approach to evidence, reliant on the aggregation of previous data. It also highlights the impossibility algorithms of addressing human learning processes, the relevance of experience, the belief that humans are predictable.

Maturana also considers emotions as an integral aspect of human beings. Maturana (1997) argues that our emotions determine the domain in which we operate as rational beings at any instant. These human features are often ignored in a technically-driven approach toward humans – in the case of IoT, through 'smart' algorithms.

The importance of conversation

In the early 1970s, Pask was a consultant for the Architecture Machine Group at MIT, where intelligence and context dependency were explored. This led Pask to the realisation that intelligence resides in interaction, which became a fundamental concept in his Conversation Theory (Pangaro, 1996). Conversation Theory indicated that conversation is required for understanding each other, because meaning is subjective and constructed by recipients and therefore not transmissible.[14]

As Glanville (2003, p.17) notes, "within second-order cybernetics, communication is conversational and meanings are personal. Meanings are thus not communicated, but individually constructed by the participants, who are therefore responsible for them". It is easy to see the importance of this when thinking about a future of 'smart' technology attempting to 'transmit' unambiguous meanings via software when dealing with central human activities.

[14] In early cybernetics, communication was assumed to occur by encryption and coding (see Shannon and Weaver, 1949). According to Glanville (1996, p.445), this approach fails to account for how there may be a meaning that appears to be transferred "as such it is ideal for control purposes".

The above second-order concepts—circularity, the importance of the observer, humans and emotional living systems, and the importance of conversation—as part of a wider second-order cybernetics epistemology, informed the development of my ‘IdIoT Proposition’ methodology (Chapter 4), and of the projects described in Chapter 5. Given the context of the ‘smart’ home, it is also important to understand what second-order cybernetics specifically brings to the questions of intelligence and ‘smartness’.

3.4.4 Intelligence, ‘smartness’ and relationality

Research into human interaction with computers has shifted from its origins in mathematics and engineering (areas characterised by problem solving), towards, with AI, something more deeply interwoven with psychology and cognitive science—a shift towards seeing the brain as a computer.[15] This is a completely different domain, operationally based on complex interrelated (and often mysterious) activities, requiring an approach beyond mathematical problem solving strategies.

In contrast to the cognitivist (AI) strategy, second-order cybernetics evolved from a “constructivist” view of the world (von Glasersfeld, 1987) with the assumption that there is a non-hierarchical and circular reasoning or shared meaning (Pangaro, 2013). This is a different way of approaching intelligence. Based on the preceding review, I am interested in pointing out the extension of the idea of intelligence in the context of ‘smart’ machines. As such, I do not believe in the idea (or the sense) of thinking about them as intelligent in a human sense.

Given my background in biological studies (where I did my dissertation in the neurobiology of emotions), I realised how domains such as molecular biology, physiological and psychology operate in cognitive processes together with the irrational, emotional, embodied aspects of the human mind. For this reason I believe that the brain should not be regarded as a machine.

[15] Saying this, we are not even entering in the brain-body / experiential perspective. From that point, intelligence then can be seen as a process distributed throughout the entire body. The phenomenological approach resonates with this discussion (see Merleau-Ponty, 1965).

Instead, I am interested in how second-order cybernetics considers intelligence as a *relational* property that the observer attributes to a relationship between the system and the environment, rather than something that exists in itself. This resonates with Winograd & Flores' (1986) contention (influenced by Maturana's work) that "intelligence is an attribute of an interaction rather than a commodity stored in a computer" (Pangaro, 2013). This is especially important in the context of IoT devices that are applied to central activities of human life such as health, exercise, food, sleeping, fertility and relations between people.

There is something about our complex human nature and embodied presence that makes it difficult to be 'solved' by 'smart' algorithms: this is the key to the impossibility of translating our existence into algorithmic logic. The AI approach towards 'smart' technology encourages understanding humans as probabilistic beings; in turn, this is embedded in the algorithmic logic of IoT products. Probabilistic approaches in AI have shown successful outcomes when bounded by the understanding that statistical inference is 'good enough' for certain contexts. In these cases it is characterised by strategies such as grouping and finding commonalities, which work well for certain problem-solving areas. However, when IoT starts to address our more intimate space and our human nature (our homes and bodies), this approach needs to be questioned.

The awareness of the fallibility and limitations of computation is important in a context in which the language suggests (or claims outright) that technology is acting 'smartly'. Since IoT technology has the prefix 'smart' in almost every feature and product, this relational approach towards intelligence will be very important in understanding my practice-based projects.

3.5 Designing in second-order: Key concepts

As I described in Chapter 1, the Internet of Things is an algorithm-governed network of objects (things) and humans connected through the Internet. With the introduction of the above second-order concepts comes the relevance of acknowledging the observer when reflecting upon the idea of personal data gathered and managed by algorithms. I thus apply a second-order approach in my design-practice exploration, for reasons that are aligned with Dubberly and Pangaro's (2015, p.73) rationale:

> if design, then systems: Due in part to the rise of computing technology and its role in human communications, the domain of design has expanded from giving form to creating systems that support human interactions; thus, systems literacy becomes a necessary foundation for design.

Following Dubberly & Pangaro's (2015) argument, we see a progression of reasoning from considering design, to considering conversation:

- "If systems, then cybernetics" (study of systems that have purpose, that is, establish goals and act to achieve them).
- "If cybernetics, then second-order cybernetics" (incorporating the observer, subjectivity and the responsibility of it).
- "If second-order cybernetics, then conversation" (design conversation—assuming meaning is not transmitted).

Second-order cybernetics does not simply hold the position that "we" (the observers) are needed, but recognises that our presence is necessary and desirable. As argued above, our presence comes with a responsibility. As von Foerster (1979) indicates, "in order that the observer who enters the system shall be allowed to stipulate his own purpose: he is autonomous. If we fail to do so somebody else will determine a purpose for us."

Here, von Foerster's contention that the observer is responsible for their observations is relevant to consideration of our interactions with a world in which 'smart' machines claim to know 'the world as it is', at least within the domain of our behaviour and our everyday lives.

The second-order epistemology thus models the user (the observer) as a complex and unpredictable human instead of a predictable consumer. I therefore considered three central second-order concepts in my practice:

- We are complex and nonlinear human beings;
- Observers are needed; and
- The term 'smart' should be considered as relational

3.5.1 The implications of a second-order cybernetic approach

Second-order epistemology acknowledges that we cannot know the world "as it is" because we see, perceive and know through our senses. Therefore we must create the most useful 'frame' through which to see 'our world'; this frame comprises distinctions, relations and values. Thus a second-order approach invites (indeed requires) us to consider what occurs in a 'smart' anything as subjectively constructed (personal communication with Pangaro, 2016).

This reflective approach to knowledge construction and the ways meaning is constructed by individuals interacting with technology fits well with my research approach, which necessarily depends on human interpretation (human experience of the interaction with the 'smart' home).

A second-order approach may shed some light on the field of IoT in which devices claim they *understand* and *know* us through data and without a consideration of the 'subject's' human nature. In relation to the Algorithmic Paradigm, second-order cybernetics brings a focus on the observer, which is often excluded in data-driven approaches where data traces are collected, as described by Rouvroy (2012, p.11), in an *infra-individual* (impersonal) manner.

It is important to note that second-order cybernetics changed the way I understand the world, and the manner in which I developed my practice and my research approach. Although I came from a scientific background, characterised by a positivist stance, I shifted toward a reflective and constructivist epistemology which, by acknowledging the observer, is radically different. This led me to the greatest possible adoption of the second-order cybernetic stance in my research; in order to implement this I developed the continuously reflective practice described in Chapter 4.

3.6 Reflections and conclusions

In this chapter, I described how what I term the Algorithmic Paradigm is embedded within IoT, drawing on perspectives and epistemology from AI, and implications from a human perspective. I then detailed how an alternative epistemology arising from second-order cybernetics became a valuable approach for my research, bringing questions about the observer's position and its contingent existence in the AI approach. Embracing the observer, in opposition to deterministic algorithmic logic that characterises the AI mentality, led me to the following questions:

- Where are *we*, as subjective and experiential subjects, in this algorithmic logic?
- Bearing the differences between AI and second-order cybernetics in mind, how can the latter epistemology bring an alternative approach towards 'smart' technology?

In relation to the above, I developed the following hypotheses:

a. Considering that we are complex human beings, I proceed from the assumption that the brain is not a machine, and therefore a machine is conversely not a brain. As a result of this, human beings and their central activities are not algorithmically predictable, thus this responsibility should not be externalised to 'smart' technology.

b. If an observer contributes to a 'smart' outcome, I assume that knowledge should be seen as dependent on the observer's involvement.

c. I investigate the argument that we must involve our living practice and incorporate the user – that we humans have something to say in this relationship. In the Algorithmic Paradigm, no matter what the success in probabilistic prediction, our complex contexts and subjectivity are things that Big Data or machine learning cannot cover.

I believe it is relevant to investigate these challenges because the decisions now being made will have implications for our society and culture. In this context it is important to ask who is there to question the underlying way of thinking, in order to bring a whole new set of reflective questions around the technological outcomes. Might second-order cybernetics provide a reflective approach by acknowledging the observer? How can it be applied in design research?

Getting away from the idea of a deterministic model of intelligence and a controlled model of human behaviour embedded in IoT algorithms, in Chapter 4 I develop a methodology that integrates a second-order approach with other sociological perspectives for use in practice-based design research. Second-order thinking will then be applied in the 'SMART' fridge projects described in Chapter 5, in which I explore the importance of human individuality and subjectivity when dealing with 'smart' IoT devices.

Chapter 4

Methodology: The IdIoT proposition

Chapter 4: Methodology: The IdIoT proposition

4.1 Introduction

In this chapter I develop a methodological approach in order to undertake design research in an IoT context. As I do not come from a background in design practice or theory, I investigated various design research approaches, including participatory design, usability testing, focus groups and ethnographic approaches. However, none of these was directly applicable to my aims: my research investigates something more fundamental than people's interactions with specific technologies, which these approaches adequately address.

Because of this, I decided to eschew the use of pre-existing design research methods that might be used for an analysis of the IoT, and began to consider perspectives from sociological studies of technology that could be applied through practice-based design research. As this chapter outlines, I developed a methodology I call 'the IdIoT proposition' that sat more comfortably with my scientific background and transition into design research. The IdIoT proposition was the result of a nonlinear process of exposure to an IoT context, an interest in second-order cybernetics (see Section 3.4.2), and my engagement in a practice-based design PhD.

4.2 Composition of the IdIoT proposition

Before explaining the genesis of the IdIoT proposition, I will introduce its three main components (Figure 4.1).

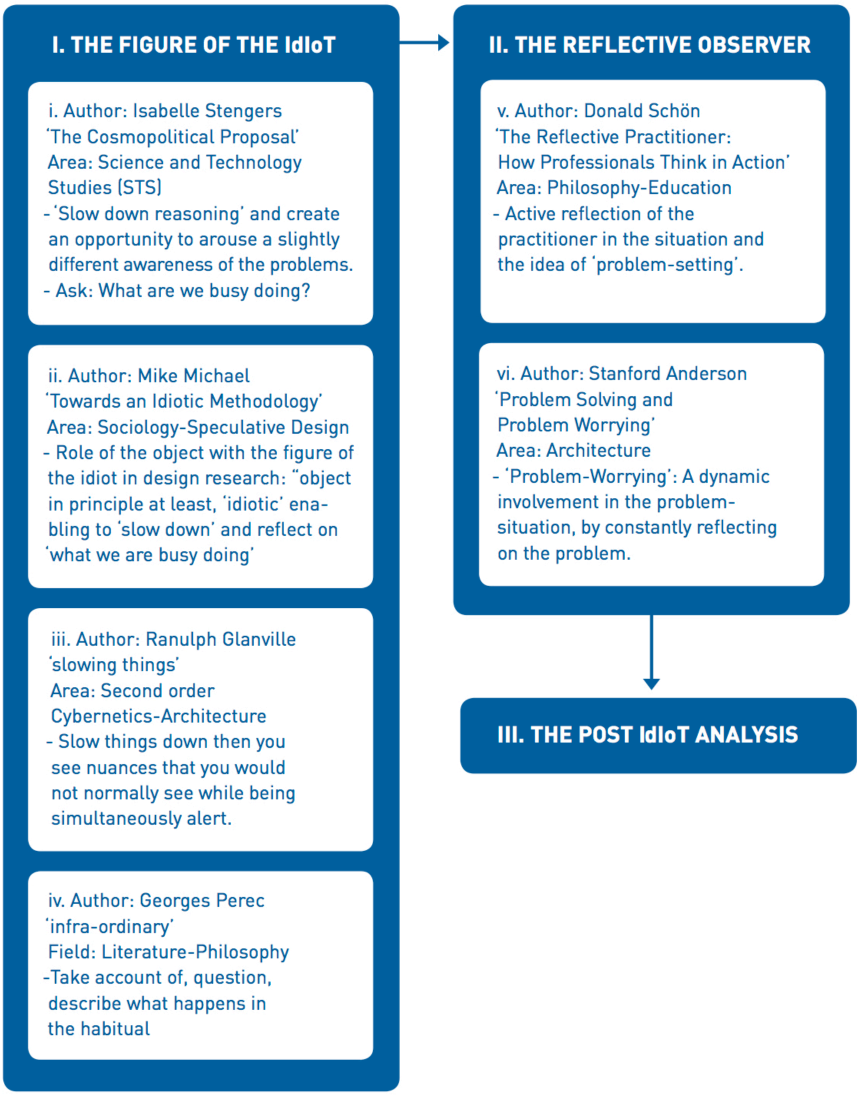

Figure 4.1: The composition of the 'IdIoT proposition'.

First is the **IdIoT figure**, which emerged by combining Stengers' (2005) "figure of the idiot", Michael's (2012a) "Towards an Idiotic Methodology", Glanville's (2014) idea of "slowing things" and Perec's (2002) thoughts on the "infra-ordinary". Here the main idea is to question 'what are we busy doing?' by slowing down. In this way, the IdIoT proposition is aligned with Morozov's (2013) concern about 'technological solutionism', which he defines as the tendency of technologists to define problems based on quick and algorithmic solutions for solving them, and thereby quickly fixing a 'non-problem' or a complex situation.

Morozov (2013, p.6) credits Michael Dobbins: "Solutionism presumes rather than investigates the problem it is trying to solve, reaching for the answer before the questions have been fully asked". In the IdIoT proposition, this notion is addressed by slowing down: delaying diagnosis of potential 'problems' until the situation has been observed and investigated more extensively.

'Solutionism', in Morozov's treatment, also leads to a focus on the problem itself. For this reason, with a special focus on the framing of the problem, the second component of the IdIoT proposition is the **reflective observer**. Here the role of the active researcher is informed by Schön's (1984) 'reflective practitioner' and Anderson's (1966) analysis of 'problem worrying'.

Thirdly, following the IdIoT interrogation, and the presence of the active researcher, is the **post-IdIoT analysis**, wherein I analyse qualitative findings from the projects. This part involves research methods specific to each project—for example, in-depth interviews in the case of *Becoming Your 'SMART' Fridge* (Section 5.2.3), and Thematic Analysis in the case of the '*SMART' Fridge Session* (Section 5.2.4). All three aspects are informed by second-order cybernetics perspectives (see Chapter 3).

4.2.1 'The Figure of the IdIoT'

In this section I describe the four main academic influences on the IdIoT proposition. The first two, Stengers and Michael, explicitly consider the notion of the 'idiot', which I adopt and adapt into the IdIoT in relation to the IoT, also incorporating ideas from Glanville and Pereç.

i) Stengers: The figure of the idiot

Isabelle Stengers (2005) refers to the 'figure of the idiot' in her 'Cosmopolitical Proposal'.[1] Here, Stengers is interested in Deleuze's (1992) conceptual character of the idiot, which he borrows in turn from Dostoyevsky's Prince Myshkin in the novel *The Idiot*. The narrative role of the idiot is as an "innocent character (that serves as) a satiric instrument for revealing the corruption of society, the inadequacy of its value systems or the stultifying nature of its institutions" (McDuff, 2004, p. xxiv). Dostoyevsky's idiot wants to turn the absurd into the highest power of thought (Deleuze and Guattari, 1994, p.62).

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[1] Idiot can have many meanings:
Early 14c., "person so mentally deficient as to be incapable of ordinary reasoning;" in Middle English "simple man, uneducated person, layman" (late 14c.), from Old French *idiote* "uneducated or ignorant person" (12c.), from Latin *idiota* "ordinary person, layman; outsider," in Late Latin "uneducated or ignorant person," from Greek *idiotes* "layman, person lacking professional skill" (opposed to writer, soldier, skilled workman), literally "private person" (as opposed to one taking part in public affairs), used patronizingly for "ignorant person," from *idios* "one's own" (see *idiom*). (Online Etymology Dictionary)

In relation to *idios* "personal, private," properly "particular to oneself" (Online Etymology Dictionary), in the "cosmopolitical proposal", Stengers starts defining "the idiot" in the ancient Greek sense: an idiot is someone who does not speak the Greek language and is therefore cut off from the civilized community. According to her, the same meaning is found in the word "idiom", a semi-private language that excludes from a form of communication characterized by an ideal of transparency and anonymity, that is, interchangeability of the speakers (Stengers, 2015, p.2). We might ask, what do the idiots of the 'smart' home have to say? What do they think about 'the language' of Silicon Valley?

Deleuze & Guattari (1994, p. 62) identify two manifestations of the conceptual figure of the idiot, classifying it into the "old idiot" and the "new idiot". The old 'idiot' is associated to the Descartes (Cartesian one): "it is the Idiot who says "I" and sets up the cogito…who wants to think, and who thinks for himself, by the 'natural light'.

The new 'idiot' is related to Dostoyevsky's Idiot: "The old idiot wanted truth, but the new idiot wants to turn the absurd into the highest power of thought (in other words, to create)."

Stengers (2005, p.994) describes this as “a proposal to provoke thought, one that requires no other verification than the way in which it is able to ‘slow down’ reasoning and create an opportunity to arouse a slightly different awareness of the problems and situations mobilizing us”. Here, Stengers’ figure of the idiot is a device for interrogating ‘‘what we are busy doing’’ as social science researchers in engagement events (Michael, 2012a).

The main characteristics of Stengers’ figure of the idiot
that inform my research are:

a. “He or she is the one who always slows the others down.

b. He or she resists the consensual way in which the situation is presented and in which emergencies mobilize thought or action.

c. He or she is a presence, and produces an interstice.” [2]
(Stengers, 2005, p.994)

As Stengers’ (2015,p.995) suggests, since the idiot creates an interstice, ‘a space for thinking’ it is a useful figure when we ask ourselves ‘What are we busy doing?’. In Stengers’ words (2015,p.995), “we know, but the idiot demands that we slow down, that we don’t consider ourselves authorized to believe we possess the meaning of what we know”. In the IdIoT proposal, this is central, since this figure is present in all the projects in my research, specifically questioning ‘what are we busy doing?’ in the context of IoT technology. We need a space for thinking in such a fast-paced field where assumptions about progress and desirability often go unchallenged—a space for hesitation regarding what it means to say ‘good’ (Stengers, 2015, p.4) in opposition to the Kantian view that politics should aim at allowing a ‘cosmos’ or ‘good common world’ to exist.

Stengers’ term *cosmopolitical* is thus made up of ‘cosmos’ and ‘political. ‘Cosmos’ refers to the unknown, constituted by multiple, divergent worlds, and refers to the idea of slowing down the construction of this ‘common world’. ‘Political’ refers to that which is a ‘signed proposal’ (Stengers, 2015, p.995).

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[2] Stengers refers to the interstice in relation to Whitehead (see Stengers, 2002).

This aspect of the cosmopolitical informs my IdIoT proposition, as Stengers (2005, p.997) notes that "it has the advantage of presenting the 'self' as an issue, of giving its full significance to the unknown element of the question: what would the researcher decide 'on his/her own' if that 'him/herself' were actively shed of the kinds of protection current decisions seem to need".[3] As Stengers (2005, p.998) continues, this makes the researcher 'politically active' – engaged in the experimentation of difference, and what they know is a factor in the formulation of the issue and its envisaged solutions.

This political aspect is thus central to the IdIoT proposition I, as an observer and researcher, take the responsibility for my observations and is therefore related to second-order cybernetics principles associated with the observer observing a system (see Chapter 3). This also resonates with other conceptions of the idiot. For Deleuze and Guattari (1994), the idiot is described as a conceptual persona who "is a very strange kind of person who thinks for himself". The idiot is taken as the private thinker in contrast to the private teacher. The teacher refers constantly to taught concepts, while the private thinker forms a concept with innate forces that everyone possesses on their own account by right – "I think" (Deleuze and Guattari, 1994, p.62).

In Stengers'(2015, p.996) work, the idiot doesn't know "how to proceed, how to give a place to the insistent question entrancing them". As a result, the proposal finishes with the question of "designing a scene and the art of staging" for the idiot's voice to be heard (Stengers, 2015, p.1003). In the case of the IdIoT proposition, it is me as a researcher-observer who is the one reflecting, followed by a post-IdIoT analysis of the questions found in this stage.

[3] Protection, here is used in the context of the perpetuation of current way of conducting research This can be related to the possible blindness (lack of awareness) in the decision-making process that operates in institutions, corporations or academic research.

ii) Michael: Toward an Idiotic Methodology

Michael's work develops Stengers' figure of the idiot through a consideration of the role of the *object* in sociology (Michael, 2012a, p.1): "objects can be a component of the methodology of empirical study, as they are relational entities, as contributors of 'sociological research'" (Michael, 2012a, p.2-3). According to Michael (2012a, p.1) "what will emerge is a version of the object in principle at least, 'idiotic' – possessed of an incommensurable difference that enables us to 'slow down' and reflect on 'what we (in his case as social scientists) are busy doing'". Michael's (2012a, p.3) work also draws on speculative design (see Section 1.4) to show how a 'proactive idiocy' can be operationalised (partly) through designed artefacts,[4] and thus the term 'object' is used to refer to physical things as well as in a hermeneutic sense as in 'object of study' by a subject. It is thus particularly applicable to the IoT.

For Michael (2012a, p.16), speculative design (a design area which develops objects that are obliquely functional) can itself be portrayed as sociology's idiot: it enacts a way of engaging with the (social) world that, in principle, affords the opportunity for inventive *problem-making* within sociological practice. In this context, he refers to Gaver's concept of 'threshold devices', which Gaver describes as devices in the home that gather information from their surroundings in order to create awareness of the home's setting in a wider physical and social environment (Michael and Gaver, 2009). These devices are designed to provide resources for inhabitants with which to think about where they are; what and who surrounds them; the nature and blurring of the boundaries of the home. For instance, 'The Local Barometer' was a project in which local wind conditions were displayed by online text and images which related to the home's locality, with the aim of giving an impression about sociocultural surroundings of the domestic 'online' space.

[4] In relation to the juxtaposition of Speculative Design and Sociology, Michael's claim that in "Towards an Idiotic Methodology" there is the mutual 'becoming-with' of these disciplines (Michael, 2012a,p.16).

In their paper ‘Home Beyond Home’, Gaver and Michael (2009, p.11) tentatively frame threshold devices within ‘ludic action research’, pointing to the ways in which these devices intervene in people’s lives, and the way these interventions are iteratively mapped through empirical study (ethnography, in their case). While I share an interest in reflecting on objects’ uses in the domestic space (the relation of home to the connected environment), my projects do not attempt to conduct sociological research. I am instead interested in the self-reflective examination of the researcher’s own practices which characterise Schön’s (1984) ‘reflective practitioner’, which I describe in the next section.

The IdIoT proposition takes from Michael’s work the aforementioned consideration of the object, combined with the figure of the idiot, in the context of the design practice. My practice-based design research does not claim to be sociological; rather, I aim to find new knowledge through practice informed by a second-order cybernetics approach (Section 3.4.2).

iii) Glanville: ‘slowing things down’

Glanville’s emphasis on ‘slowing things down’ is also important to the development of my IdIoT proposition:

> if you slow things down then you see nuances that you wouldn’t normally see. That is revealing – slowness has a particular quality of its own. It is difficult to slow things down and to simultaneously keep alert. Being caught in between, being a bit lost, is good for a human being. Things have their own time, and we should learn to enjoy this, rather than imposing our own, usually rushed time. A little slowness, living in the now, and a reduction of the significance of the nation state might really help us (Glanville, 2014).

For the IdIoT proposition, slowing things down is important to seeing what we do not normally perceive while , as Glanville says, being simultaneously alert. This is a very good summary of the IdIoT proposal since slowing down resonates with Stengers' figure of the idiot, who asks 'what are we busy doing?' This is coupled with the alert state of the researcher, thus also resonating with Schön's 'reflective practitioner'.

iv) Perec: 'infra-ordinary'

The next work informing my methodology is George Perec's (2002, p.177) approach towards the 'infra-ordinary':

> How should we take account of, question, describe what happens every day and recurs everyday: the banal, the quotidian, the obvious, the common, the ordinary, the infra-ordinary, the background noise, the habitual? To question the habitual. But that's just it, we're habituated to it. We don't question it, it doesn't question us, it doesn't seem to pose a problem, we live it without thinking, as if it carried within it neither question nor answers, as if it weren't the bearer of any information.

Perec's approach resonates with Stengers' figure of the idiot, who slows down to analyse what we are busy doing. It also relates to Glanville's nuanced observations. Despite the fact that Perec's work arises from literature, he addresses habitual and banal areas that are directly related to the IoT context (the domestic), which inspired me to explore 'smart' home appliances.

My IdIoT proposition does not simply focus on observing the oversimplification of human existence by IoT technology which aims to deal with central human activities, but emphasises the active presence of the researcher. For this reason, the figure of the IdIoT is constantly reflecting (observing) while acting. Because of this, as an 'IdIoT practitioner', I am constantly observing and reflecting on the findings of my practice, and my role as an observer. In the next section, I expand on Schön's (1984) 'Reflective Practitioner' approach in relation to my active role as a researcher.

v) Schön: *The Reflective Practitioner*

As a design researcher, it is important for me to think about practice and its processes. For this reason the concept of the 'reflective practitioner' is central for the IdIoT proposition, and I explore it as a 'reflective researcher'. Schön (1984) arrived at several important concepts around reflection in practice by analysing the knowledge that professionals develop and use in their practice. The important ideas that inform the IdIoT proposition are active reflection *in* the situation, and the concept of 'problem-setting'.

'Problem-setting' is a crucial aspect of the design process. As Schön (1984, p.40) describes, 'setting' a problem is a necessary condition for technical problem solving, rather than a technical problem itself: "When we set the problem, we select what we will treat as the 'thing' of the situation, we set the boundaries of our attention to it". Schön describes problem setting as the process in which, interactively, the researcher or designer names the factors to take into account, and frames the context in which to attend to them.

Cross and Dorst (1998) refer to Schön's notion of problem-setting specifically in a design context. As Cross (2001, p.84) indicates:

> the designers start by exploring the problem space, and discover, or recognise a partial structure. That partial structure is then used to provide them also with a partial structuring of the (solution space). The designers then consider the implications of the partial structure within the (solution space), use it to generate some initial ideas for the form of a design concept, and so extend and develop the partial structuring.

It is this exploration of the problem space of IoT that led me, as a design researcher, to structure the projects described in the forthcoming chapters. As mentioned earlier, a critique of technological 'solutionism' and a second-order approach led me to consider the framing of 'problems'. Because of this, I introduce Anderson's (1966) 'Problem Worrying' in the next section.

vi) Anderson *Problem Solving and Problem Worrying*

Following Schön's treatment of problems, the importance of *framing* them resonates with Stanford Anderson's concept of 'problem-worrying', which encompasses a critique of a definite goal orientation, and the 'designer-engineer', who plays a kind of game with well structured rules and elements – as found in writing on problem solving by Simon and Newell (1970) and others. Anderson (1966, p.3-4) argues that even if we acknowledge that problem solving is useful in some cases, we cannot generalise from a problem-situation, where words such as 'design' and 'creativity' are used to refer to activities which lack an objective criteria of merit.

Considering that Anderson's field of architectural design is related to structuring human environments, Anderson notes that human 'purposes' are problematic because some can be stated, but many others are unpredictable and therefore impossible to state. Anderson suggests that, in the dynamic process of design, problems must be centred in a deeper understanding of the problem, not simply aiming at a 'solution'. Anderson adds that one origin of the 'design problem' is to follow pre-established architectural methods.

Anderson's alternative approach of 'problem worrying' is important for the IdIoT proposition: Problem-worrying in opposition to problem-solving, represents a dynamic involvement in the problem-situation, by constantly reflecting on the problem instead of assuming an identified problem that can be solved. In Anderson's case, the focus is the field of architectural design in a 1960s context, where computer science was just coming into architecture. On the other hand, my practice-based design research is based in an IoT context where computation is moving into the physical world, influenced by 'technological solutionism' (Morozov, 2013).

Because of this, I am interested in applying 'problem worrying' by exploring the AI background (in contrast to a second-order cybernetics approach) of current technology (see Chapter 3). In a similar way, by focusing on humans (observers) and their particularities, I reformulate technological problem-solving to pose an alternative to algorithmic 'solutions'. I thus agree with Anderson (1966, p.3) when he indicates that with a designer-engineer mentality, there is no openness towards creating 'the game itself', which I believe second-order cybernetics can offer.

The IoT can be seen as layers of abstract algorithmic systems slowly penetrating the intimate space of our homes. While we are expected to engage with the IoT and be enthusiastic about it and its perceived ‘improvements’, I believe it is important to question the technology and its ‘problem-framing’. Within this framework, as a design researcher (but also as someone who lives in a house), I adopted the figure of the IdIoT, who is characterised by slowing down and by asking ‘what are we busy doing’? into the context of the ‘smart’ home.

4.3 Implementing the methodology

As explained above, the IdIoT proposition is a new approach towards design research around people and their interactions with IoT technology. It provides a different way of considering the technology, and questions the IoT's 'technological solutionism'.

At its centre, the IdIoT proposition focuses on the idea of slowing down: this is a central aspect of my thesis and a reaction to the rapid growth and commercialisation of IoT technology. I developed the strategy of slowing down within design research in the hope that it would bring new understandings of, and new knowledge about, the IoT. In this context, the IdIoT proposition explores IoT issues through the figure of the IdIoT, who asks 'why are we busy doing what we are doing?'.

As this approach focuses on understanding and engaging with the IoT, an important part of its process is an attentiveness to issues which emerge from questioning the technology. A further advantage of the IdIoT proposition and its strategy of slowing down is the lack of automatic assumptions the approach prompts – this means that, as the figure of the IdIoT, I tried not to have expectations about possible outcomes. From this angle, a fundamental aspect of the proposition is the awareness of the problem-framing of the IoT, which is also influenced by a second-order approach.

Becoming the IdIoT myself has some advantages that other methods lack. Following a second-order cybernetics perspective (Section 3.4), in which 'I' – as a reflective researcher or observer – recognise my presence and situation within a system, in a particular context and time, the IdIoT proposition facilitates an interrelation between the theoretical framework (second-order cybernetics) and the overall methodological approach of practice-based design research.

4.4 Research design

The IdIoT methodology described above is applied in a series of practical projects, designed based on research questions that emerged from the findings of the pilot projects described in Chapter 2; the review of the Algorithmic Paradigm, and the contrasting approach of second-order cybernetics, both detailed in Chapter 3.

4.4.1 Research questions

The questions that emerged from my initial investigations and the review of relevant literature and practice are as follows:

- What are the possible implications of the Algorithmic Paradigm and AI mentality becoming embedded in the 'smart' home?
- What would happen if we design using an alternative epistemology, in this case second-order cybernetics?
- How do an explicit epistemological stance affect people's interactions with the technology?

The first two questions are specifically explored in *The 'SMART' Fridge Projects* described in the next chapter, by counterposing the Algorithmic Paradigm with second-order cybernetics, through the IdIoT proposition. The *'SMART' Fridge Session* project investigates these further, extending the methodological exploration to dialogues and role play, and thereby incorporating the third question.

4.4.2 Methods

The IdIoT proposition has as a starting point the acknowledgement of the observer, in this case the researcher and the participants (users) in the study. The IdIoT proposition exposes the awareness of the process that is being studied (the way of knowing). As consequence of the IdIoT proposition, the researcher, and also in some cases the participants, become engaged in self-reflection. Moreover, during the process, it provides strategies to reveal the problem-framing of the subject, providing awareness of the factors that the researcher took into account and how the context was framed.

By bringing 'the figure of the IdIoT' into design research, the researcher slows down and asks 'What are we busy doing?' and 'How do we know what we know?' This process enables us to see nuances, and consequently enables the creation of a new set of questions related to the research topic. Followed by a qualitative method (post-IdIoT analysis), the IdIoT approach provides a deeper understanding of, and critical insights into the subject, which, as a result, brings a new set of questions.

The limitations of the IdIoT proposal can be considered in terms of it being a methodological approach that doesn't provide 'solutions' but instead, a new set of questions. Also, the IdIoT proposition in itself is not a quantitative methodology, which can be seen as a limitation for some related fields of AI. Nevertheless, 'the IdIoT' might support quantitative approaches for further studies.

The IdIoT proposition is necessarily implemented in different ways in the projects, to focus on different contexts, participants, and aspects of the questions. In *Becoming Your 'SMART' Fridge*, I enacted the IdIoT proposition myself, taking on the role of 'smart' fridge software and collecting both quantitative and qualitative data (interviews and the contents of participants' existing refrigerators) to make suggestions and recommendations to participants, then conducting a 'post-IdIoT analysis' using further interviews and a drawing task.

The *'SMART' Fridge Session* then focused specifically on the important role of language and two-way communication, enacted through both scripted dialogues and roles pre-assigned to participants.

The projects were iterative – findings from the first informing the research design of the second. Details about the methods, setting and sample for each project are detailed in their respective chapters. Data was analysed in relation to the research questions and through the lens of second-order cybernetics, and the findings and implications are discussed in Chapter 7.

In this chapter I have characterised the IdIoT proposition and where it comes from; with an interest in questioning the algorithmic logic behind IoT technology, in the next chapter I describe how I initially applied this methodology, with a second-order perspective, in the 'SMART' Fridge Projects.

Chapter 5

IoTivity: ‘SMART’ fridge projects

Chapter 5:
IoTivity: ‘SMART’ Fridge Projects

5. Introduction

‘Smart fridge? Idiot fridge, more like.’
(Steiner, 2012)

The ‘smart’ fridge’s main promise is that it will make our lives ‘easier’; the way in which this is achieved is, generally, by embedding ‘smartness’ with computation. This ‘smartness’ will, for instance, mean that the fridge can manage grocery shopping by ordering online, monitor its contents, and even suggest recipes based on said contents. The interface for such functions is often a tablet computer integrated into the fridge door, and for this reason the screen is a very important element: it allows the user to access a calendar, notes and cooking apps. The screen on Samsung’s Family Hub Refrigerator is of considerable size at 21.5 inches diagonal (Figure 5.1).

Figure 5.1: ‘The Family Hub Refrigerator’. Source: Samsung

The retail price of the fridge varies between $3,499 to $5,000 approx. For more details see Table 5.1. Other functions of ‘smart’ fridges include design features in its interior, like the ‘pizza drawer’ in the Samsung RF4289HARS.

Company	LG	Whirlpool	Samsung	Samsung
Model	**LFX31995ST Smart ThinQ**	**WRL767SIAM**	**RF4289HARS**	**Family Hub Refrigerator**
Features	Wi-Fi LCD screen: Family information hub: voice memos. **App:** -Expire dates, inventory, grocery list -Search for recipes based on what your fridge has in stock. -Run diagnostic/communicate wit technical support **It tells you:** -Internal temperature -Is it on energy saving mode? -Weather -Calendar memo -Upload photos -Daily recipe and it let you search for recipes and add the ingredients to Smartphone -Shopping inventory -Grocery list -Freshness tracker -LG food	No screen **App:** -Alerts notify you of a power outage or if you need to change the filter -Alert if door is open -Energy usage No grocery or content report. **It tells you:** "SMART" stats: -Temperature and other settings -Data on how many days it has been in use -Online and functioning normality - It allows you to order replacement parts, such as filters from the app **Shelves:** One temperature and one humidity controlled drawer * Whirlpool is mainly focused in	Wi-Fi LCD touch screen "Screen is aesthetically pleasing and can play samba music from its Pandora app as you unload your groceries" **No Mobile device App:** No information transfer to another device (no connection with smartphone). **It tells you**: -Memo program -Internal temperatures of the refrigerator and freezer -The ice maker mode (crushed or cubed) -Time -Local weather -Calendar -Photo viewer -Samsung's Grocery Manager app. Branded apps: Twitter, Pandora,	21.5-inch Gorilla Glass touch screen which brightens up automatically (it covers the near-entirety of the upper right door) "Kitchen TV" feature. Pandora, new app called Sticki sync everyone's schedule into a shared family calendar **App:** MasterCard shopping app that lets you order what you need from FreshDirect or ShopRite **It tells you:** You can see what do you have inside the fridge thanks to a cameras hidden inside the inner door frame. Each one snaps a photo of your groceries each time you close the doors: you can check what you have inside *SmartThings-compatible

	channel **Shelves:** Customizable temperature. *Automatically update your inventory once you've checked an item off the list.	the maintenance * In order to help you tracking and optimizing energy usage, the smart energy function, connects the fridge to the Smart grid if is available in the area	Epicurus, Weatherbug, AP News, *Only let you register one item at the time with a broad category name *The freezer has a slot to house a 16-inch pizza flush against the door. In the refrigerator.	connected home gadgets, *Four-door build and classy-looking recessed handles CoolSelect+ compartment, a handy feature that allows you to switch the right half of the freezer into a third refrigerator section as needed.
Price	$3,499	$1,999	$3,699	$5,000

Table 5.1: Current status of IoT fridge (2014-2015)

It is already possible to see commercial alliances emerging in the domain of 'smart' fridges, for instance Samsung's Family Hub Refrigerator is already connected to Mastercard credit card, which is in turn connected to FreshDirect and ShopRite delivery services, and has a potential connection to Amazon's Alexa voice control service. 'Smart' fridges can also be connected to other IoT devices, for instance Whirlpool's French Door Refrigerator is connected with the Nest thermostat, produced by a Google subsidiary (Figure 5.2).

Figure 5.2: Whirlpool's 'French Door Refrigerator' WRX988SIB has a re-designed interior built to optimize storage. Its main feature is the gliding "Infinity Shelves", which slide out of the way to make room for taller items placed below.
Source: CBS

The final reason I chose to use the figure of the fridge is its relationship with central human activities, specifically the complexity of 'offline' eating habits. Perhaps more than anything else, eating habits are illustrative of the complexity and unpredictability of human life, connected as it is to human psychology, personality, culture, budget and history. It is therefore a very pertinent subject for reflections on the (possible) issues inherent in the 'smart' home.

In the context of the 'smart' home, I therefore decided to explore several algorithmic implications and question their algorithmic logic, to explore the possible problems of employing data that is isolated from the complexity of human psychology when making recommendations for or acting on aspects of daily life. I explore this by focussing on our complex nonlinear existence through second-order cybernetics and 'the IdIoT Proposition', as detailed in Chapters 3 and 4. I started with the hypothesis that it is far from possible to translate the granularity and complexity of our daily lives into the solution offered by 'smart' algorithms based on statistical inferences. I therefore investigated how our subjectivity and complexity is played out (or ignored) in contemporary algorithmic problem-framing. In this context, I was interested in bringing the observer and their living practice into the discussion, rather than ignoring them.

In *Becoming Your 'SMART' Fridge* (see Section 5.1) I played the role of the fridge software, enacting the 'smart' algorithm for a series of (offline) fridges. In this project, I utilised both qualitative and quantitative approaches in relation to how we eat, and how we interact with the fridge.

The findings of *Becoming Your 'SMART' Fridge* led me to explore other issues that encountered during the project, such as the mentality embedded in the algorithms. This resulted in the *'SMART Fridge Session* (see Section 5.2) where I also attempted to apply second-order cybernetics as the embedded mentality of the IoT device. Across all the projects, I maintained a reflective awareness of the decision-making processes 'SMART' fridge algorithms undertake based on the data they collect.

5.1 Project #3: Becoming Your 'SMART' Fridge

"The genuine Internet of Things wants to invade that refrigerator, measure it, instrument it, monitor any interactions with it; it would cheerfully give away a fridge at cost."
Bruce Sterling (2014)

Description: A project in which I placed myself in the position of the algorithm of a 'SMART' fridge after visiting the kitchens of 'early adopters' of connected products - in this case, fitness tracker wristbands. As an outcome of a form of "data mining" a personalised 'SMART' fridge report was sent to the participants.
Venue: Participants' kitchens, London.
Date: December 2014.

5.1.1 Procedure

The project comprised three main stages: 'mining data' about participants' diets, preferences and lifestyle; preparing and delivering via email 'fridge reports' by converting myself into the 'smart' algorithm which drew on the collected data; and a follow-up of participants' responses (Figure 5.3):

- **i. Interview while having dinner: 'Mining data'**

In order to 'mine the data' I went to the participants' houses for dinner-interviews. At this stage the interview was recorded, and I took pictures of the contents of participants' fridges.

- **ii. The Figure of the IdIoT: fridge-report**

After mining their data I formulated an email report. At this stage I converted myself into the 'smart' algorithm.
  - a. 'Becoming the 'SMART' algorithm'
  - b. The IdIoT process - 'creating the report'

● **iii. Post-IdIoT Analysis**

a. User perspective: In-depth interviews

○ After the participants received the ‘fridge-update’, I conducted another recorded interview to get feedback on the fridge-report. I also used the interview as an opportunity for asking critical questions about the technology.

b. Mental models: Understanding of the technology

○ Following the interview, I asked participants to illustrate how they conceived of their IoT technology’s relationship with their domestic space.

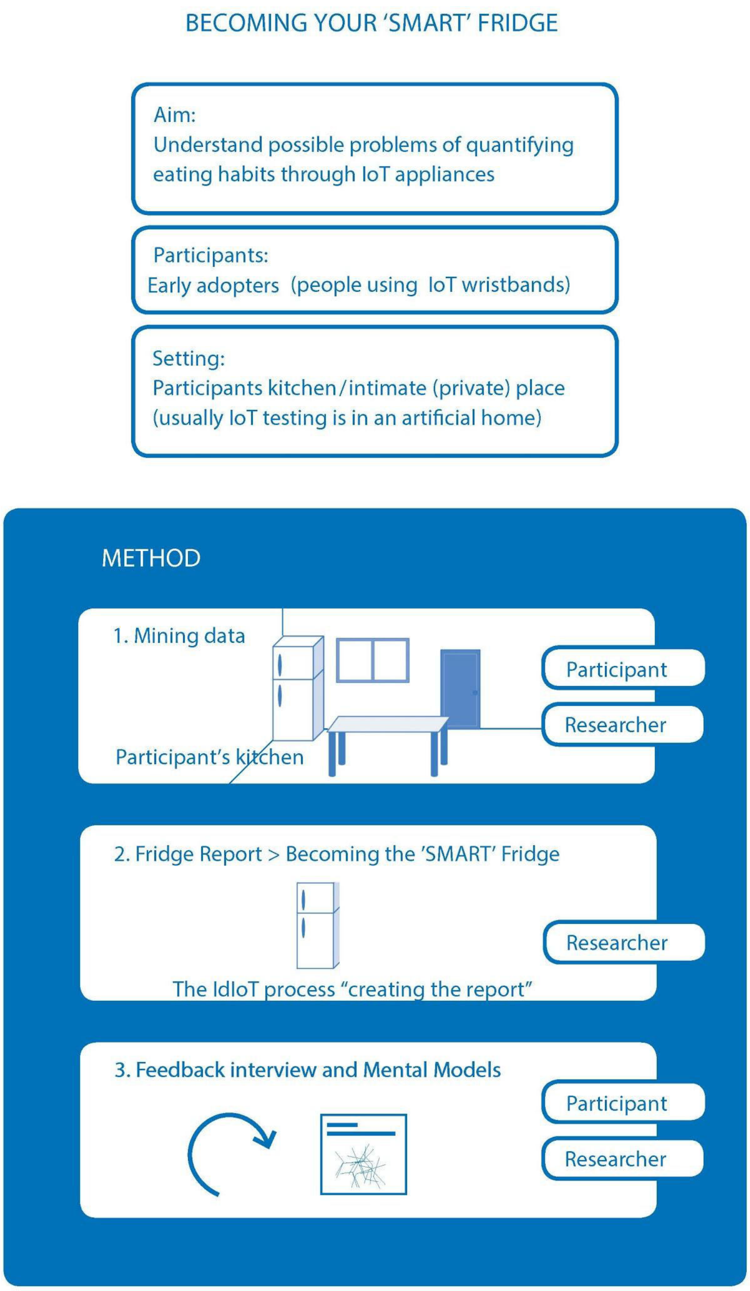

Figure 5.3: 'Fridge reports' structure. The project's main stages: 'mining data' about participants' diets, preferences and lifestyle.

Sample

The project centred on a 'user perspective' by focusing in detail on the cases of three individuals in London. The three participants, two men and one woman, all in their late twenties, were 'early adopters' (Rogers, 1962) of IoT-type technology, being users of wearable technology (fitness tracker wristbands). See profile of the participants in Table 5.2.

Participant	A	B	C
Age	26	28	28
Gender	Male	Female	Male
Nationality	USA	Brazil	Taiwan
Profession	Industrial designer	Fashion designer	Marketing/ advertising/ Food-Blog contributor / Start Up
IoT wearable	Motorola Smartwatch	Fitbit	Jawbone
Number of people sharing the fridge	4	1	2
Neighbourhood	Putney	Bayswater	Kensington Olympia
Where do you buy your food?	I go to Sainsbury's (open until 10) and Tesco Express cause is 24 hrs. open	I buy fruit at Nisa. I also go to Waitrose.	I have a 24 hrs. Tesco; I go also to Sainsbury but less.
Times you go to the supermarket per week?	1	1 or 2	1

Table 5.2: Profiling the users

Rationale

I chose early adopters since this group clearly identifies with IoT technology, as wearables can be seen as the public face of IoT technology. Such users are potential consumers of the 'smart' home IoT technology and have pre-existing interests in aggregate data related to health and fitness. A survey by iControl Networks, *The 2014 State of the Smart Home*,[1] reveals that a user's level of enthusiasm for technology was the most predictive factor in their readiness to become 'smart' home adopters, over age, gender or income level (Icontrol Networks, 2015). The survey also revealed that technology enthusiasts represent 32% of the market for 'smart' goods and that they are interested in more robust 'smart' home solutions. [1]

Recruitment & Setting of the Interview

The participants were recruited by an advertisement on the RCA student forum, RCADE, with the subject "*IoT Research".* The interviews were conducted during December 2014.

As an indirect way of asking for information about participants' diet and lifestyle – and to gain access to their fridges – I asked participants to cook or prepare a meal for me. I did this because it would facilitate a more comfortable (relaxed) setting for my interviews, and a more natural opportunity to speak about food and the fridge without it being the main focus. The idea was that they would simply cook with ingredients they normally had in their house. So that they would not modify what they usually had at home, I also told them that "I eat everything" – that I had no specific dietary preferences. In order to be fair (not just to ask for a free dinner) I told them that I would bring a drink of their preference. I also hoped that this would reduce the normal distance between the user (the studied subject) and researcher.

I sent the following message to the people that replied to my advertisement:

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1 The survey considered a representative sample from the US. It had 932 respondents, they were 25 years age or older with a household income $ 40k or higher.

2 An example of this is a project related to experimentation of energy efficiency adjusts to the life of a family. In this project a family of four lived for nine months in Honda Smart Home at the University of California, Davis (Wang, 2015).

The research consists of having a meal (lunch/dinner) in your kitchen with what you have in your fridge. I will provide the drinks: wine/beer/soft drinks or juice, just let me know what would you prefer.

Following that you will receive an email. Finally, I would need to meet you again for an interview. This will take one hour approx. and I can meet you wherever works for you.

The participants agreed to take part by confirming via email. In addition, they signed an ethics form.

In the early stage of the recruitment process, in one case a person confirmed an interview and cancelled it. The reason given was that his partner was not keen on anyone looking at the contents of their fridge:

Hi Delfina

Just spoke to my partner, and she's not keen to have anyone looking at the contents of our fridge. So i'm afraid this is not going to be possible.
I'm really sorry.

T.

i. 'Mining data'

Dynamics of the interview

Usually IoT technology is tested in an artificial 'home', but for this project, the natural setting of the participant's kitchen was used for the interviews.[2] The interview duration was approximately 1 hour, but varied depending on the participant, and lasted as long as 1hr 45 minutes. The interview was recorded and pictures of the participant's fridge were taken.

In order to avoid, as far as possible, the introduction of bias around the subject, participants were told that the interview was part of research into the 'Internet of Dwelling'. As a rule, I did not ask things that were not related to the fridge, food, the IoT and lifestyle in relation to health and fitness.

By entering participants' homes as a stranger, I operated as an observer dealing with very intimate (private) places; this took on a particularity because the stranger coming to dinner was also a researcher. Also by being an observer in their kitchen and having qualitative data from the in-depth interview, I was mining their data (qualitative and quantitative) as a human.

By cataloguing the elements of participants' fridges with their permission, I was able to get the information that an IoT 'smart' fridge can when it, for instance, detects the products it contains. However, unlike the 'smart' fridge, the data collected during interviews allowed me to develop a deeper understanding of my participants (users), which allowed me to interpret, and contextualise their fridges' contents.

In the case of my research, there was no technology involved, so through pictures only, I documented elements that I saw in participants' fridges.

During the interviews I also asked a series of questions about the ways in which these 'early adopters' were experiencing their wearables. As well as this, I asked questions about dynamic pricing, and the increasing power of Amazon.[3]

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[2] An example of this is a project related to experimentation of energy efficiency adjusts to the life of a family. In this project a family of four lived for nine months in Honda Smart Home at the University of California, Davis (Wang, 2015).

[3] Definition of dynamic pricing:
"Dynamic pricing, also called real-time pricing, is an approach to setting the cost for a product or service that is highly flexible. The goal of dynamic pricing is to allow a company that sells goods or services over the Internet to adjust prices on the fly in response to market demands.
Changes are controlled by pricing bots, which are software agents that gather data and use algorithms to adjust pricing according to business rules. Typically, the business rules take into account such things as the customer's location, the time of day, the day of the week, the level of demand and competitors' pricing.

As Bruce Sterling notes in his book *The Epic Struggle of the Internet of Things* (2014), Amazon is one of the main corporations involved in the IoT business “Big Five”. Another reason why I was interested to ask about this company specifically was because after the release of its AWS IoT platform, Amazon was described as a “big player entering the Internet of Things space” (Lunden, 2015). Asking these questions enabled me to tailor the Your ‘SMART’ Fridge emails more closely around brand experience.

Interview Phase I

The interview consisted of six main themes:

1. Personal information: Profile
2. Eating habits
3. Fridge
4. Health Fitness
5. Using the IoT wristband
6. Dynamic pricing and Amazon.

See Appendix B (section B.1) for the full description of the findings of the Interview Phase I.

Outcomes

The data collected from participants’ fridges, and from interviews, was used as material for the next stage of the project, in which I behaved as the software of an online fridge. This was accomplished via the creation of a digital outcome ‘Fridge-report’, sent in the form of an email and delivered by the entity ‘Your Smart Fridge’, as detailed in the next section.

With the advent of big data and big data analytics, however, business rules for price adjustments can be made more granular. By collecting and analyzing data about a particular customer, a vendor can more accurately predict what price the customer is willing to pay and adjust prices accordingly.”

Dynamic Pricing Definition.What Is.Available at: http://whatis.techtarget.com/definition/dynamic-pricing

5.1.2 The Figure of The IdIoT

ii. 'The Figure of the IdIoT' and the 'Fridge-Report'

a. *Becoming* the 'SMART' algorithm

The figure of the IdIoT in this project emerged while I engaged with two types of data: subjective, wholly qualitative data from in-depth interviews, and 'objective', partly quantitative data (from the contents of the fridges). What I constructed with this data was influenced by:

a. The typical features that the 'smart' fridge industry proposes; such as grocery shopping lists, suggested recipes, advertisements, related information (e.g. weather) and a fridge update together with the fridge's need for a language with which to interact with the user.
The algorithmic paradigm characteristics (computational 'smartness'), such as data mining, machine learning, the ideal of optimisation, and the Big Data approach, as outlined in Chapter 2.

With myself in the position of a researcher (observer), based on my own experience I had in mind the complexity of our 'offline' eating habits (physiological needs, historical background, psychological and cultural aspects) together with memories of a daily non-algorithmic interaction with the fridge. At this point, with all the collected material (quantitative and qualitative), in a process of 'slowing down' by having in mind the linear-causal/statistical approach together with our human complexity, I developed an 'idIoTic' reflective simulation.

Theoretical/theatrical context

From what I saw in the granularity of qualitative data (from in-depth interviews) alongside the information gathered from the quantitative data (fridge contents) I observed some little ‘openings’ to question the two different sources of data, which I explored in the ‘fridge-reports’.

Once in the position of *being* the algorithm, taking as a starting point Dostoyevsky's figure of the idiot (Stengers, 2015), I was thinking ‘by myself’ in this confusing context, or in Deleuze’s terms as a ‘private thinker’ with my particular awareness of the issue. In relation to the design approach employed in this project, I did not use the object of the fridge itself (or create one) but decided to position myself in the algorithmic process with my awareness of what is going on; in other words, there was no object designed, but a shift in perspective.

In Glanville’s (2014) terms, it was a process of ‘slowing things’, in which one has the following challenge: “slowness has a particular quality of its own. It is difficult to slow things down and to simultaneously keep alert.” This combination of observation and alertness allowed me to see possible issues around a ‘smart’ fridge’s algorithmic perspective on our behaviour.

The research investigation was overtly *political*, in Stengers’ (2015) terms, since the ‘self’ as a researcher was present; I saw and decided on my own. This resonates with the second-order cybernetics vision of the present observer – ‘me as an algorithm’ inherently draws attention to the ethical responsibility of the observer.

Considerations

After collecting data and applying algorithmic logic (using causalities and correlations), I decided to examine what is not addressed by such logic. Through constant reflection, using the 'IdIoT' position of the fridge-algorithm, I decided to 'make sense' and nonsense (explained in the next section). Here is important to note that in order to develop the outcomes in which I made sense and nonsense with the qualitative data from the in-depth interview together with the 'fridge-data', I am aware that even if I had the participants' feedback about whether predictions were successful in terms of 'making sense' or 'nonsense', I am aware that due to the complexity of humans is possible to believe that you will 'make sense' and get things wrong or to provide a 'nonsense' outcome and get things right. No matter how much qualitative information supports the data gathered by sensors, humans with our complex lives are incredibly nonlinear and unpredictable. In the next section, I describe the process in which the 'idIoT' creates the report.

b. The IdIoT process: 'creating the report'

Though the possible future of IoT technology is uncertain and somewhat 'blurry', I simulated one possible direction by attempting to 'become' the software of the 'SMART' fridge. This was done by analysing and curating householders' personal data and simulating possible marketing campaigns based around the technology of an online fridge.

In order to enable participants to experience the parallel online life of their fridge, I developed a simulation of the [commercial] associations they may get in return. The 'SMART' fridge report included suggested recipes, facts about the temperature, groceries, advertisements, comments related to the wristband and random information about products (Figure 5.4).

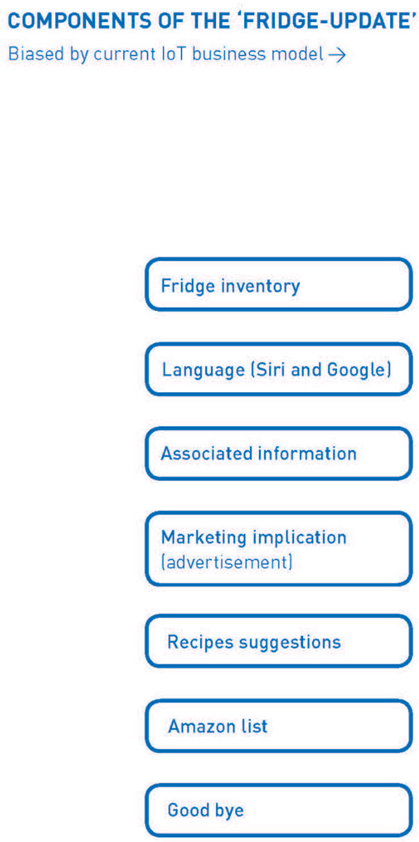


Figure 5.4: Components of Fridge-report simulation

In terms of design and language, 'myself-as-fridge' was written in a 'user friendly' language, while the font and the colours were app-oriented. The reports were sent from yoursmartfridge@gmail.com and signed as Your SMART fridge (Figure 5.5). The participants were not told to expect the fridge reports, and so were a surprise.

The notion of the researcher 'standing in' for the software has parallels with the 'Wizard of Oz' technique (Kelly, 1984) often applied in human-computer interaction, specifically in Natural Language Processing studies, to gather data and discover what the application of specific linguistic characteristics are (Dahlbäck et al, 1993,p.194). The Wizard of Oz studies, i.e. having a person simulate the interface (and system) can be described as studies where subjects are told that they are interacting with a computer system through a natural-language interface, though in fact they are not. Instead the interaction is mediated by a human operator, the wizard, with the consequence that the subject can be given more freedom of expression, or be constrained in more systematic ways, than is the case for existing (Dahlbäck, 1993,p.194). Such studies are also used in commercial user experience and service design (Martin & Hanington, 2012).

The idea of 'simulating intelligent interfaces' by a human can be related to my investigations in my research exploration of *becoming* a 'SMART' fridge, however, my purposes here were somewhat different. My research goal was not directly "to allow the user to experience a proposed product or interface before costly prototypes are built" (Martin & Hanington, 2012, p.204), because this was not part of a product development process. I took the role of the algorithm in order to explore oversimplifications and issues of IoT technology when it relates to central human activities, in this case to eating habits; equally, I sent the participants their fridge-reports after the interaction with myself as a real person (the researcher). However, as will be evident in the next project (see section 5.2), there are a variety of ways in which human interaction and conversation with software or devices can be simulated experientially."

Gmail by Google

UPDATE

From: Your Fridge <yoursmartfridge@gmail.com>
Date: 15 December 2014 at 19:49
Subject: UPDATE
To: [redacted]

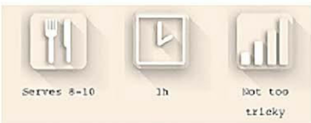
Hi John,

I am noticing the fridge is at 5.5 °C.
Milk should ideally be stored at a temperature of 4°C or below.

LOW on Grapefruit Juice

It has been a long day. May I suggest you a quick tasty meal?

A killer mac ´n´cheese



Ingredients:
sea salt
freshly ground black pepper
45 g butter
3 heaped tablespoons plain flour
[CONTINUED...]

No time for shopping?
I've put together your Amazon shopping list

Tropicana Pink Grapefruit Juice 5x£2.48

Birds Eye 12 Beef Burgers £4.20

Kelloggs Frosties Cereal £2.00

Skittles Crazy Sours Pouch 4x£1.00

Rustlers Quarter Pounder Cheese £2.20

Rustlers The Deluxe With Bacon /Cheese £2.40

[CONTINUED...]

Total £121.83

Did I get it right?

2.000 more steps to reach your goal
Good luck

Have a good evening,

Your SMART fridge

Figure 5.5: An example of one of the emails sent by Your 'SMART' Fridge (yoursmartfridge@gmail.com).

Language

Different companies have different *intelligent* personal assistants (IPA) and each company has characterised them with different ‘voices’ and ‘personalities. Examples of these IPAs include Samsung’s ‘S Voice’, Microsoft’s ‘Cortana’, ‘Google Now’ and Amazon’s ‘Alexa’.[4]

In terms of the language, in my process of becoming a human algorithm, I acted like Google with its ‘Hey/OK’ attitude and, in some parts, tried to be a bit more like Apple’s Siri, employing a more distinct persona. Drawing from the Android attitude, I was very precise and practical, and employed a mechanical language, using phrases like: “9 days expired yogurt”, “Milk running Low”, “Unidentified container”, “Energy mode is activated” or “Your fridge is working OK”. In other parts of the report I became more personal, behaving more like a persona. By personifying myself in the manner of Siri, I acted as if I ‘understand’ the user, speaking in the first person, for example: “I can make your shopping list Based on your preferences, I've put together your Amazon shopping list” or “Probably you are tired. I can suggest you some quick recipes for a Sunday evening.”

Developing the personality of these online assistants is something many technology companies have worked on in recent years. According to Arnold (2011), when developing the original Siri project – before it was purchased by Apple – an employee referred to the process as follows: "There were many conversations within the team about whether it should be gender-neutral” or instead "should have an 'attitude'.” According to another person, who worked at Apple on the Siri project, Apple focused on keeping Siri's personality "friendly and humble - but also with an edge." They were thinking, "How would we want a person to respond?" while developing the software.

[4] Reflections of different IPA’s experiences can be seen in Ben Hammersley’s observations after using Amazon’s ‘Alexa’ and Apple’s ‘Siri’. In the article, Hammersley noticed that Alexa doesn’t acknowledge his thanks. Here, he questions the uncanny valley for politeness and also notes the importance of ‘Personality Design’ for AIs (Hammersley,2015).

'Me as an algorithm'

As described above, I had visited each of the participant's homes to mine data related to their eating habits and about their fridges. After conducting in-depth interviews, and with the data from their fridges in hand, taking an algorithmic approach, I curated their personal data and elaborated a fridge-report.

In this project, I was a human observer. But by personifying myself into a 'machinic' so-called *intelligent* entity, I aimed to act like the software of an Internet fridge. In this way, I can only offer my variety in this digital version – it wasn't me, but unavoidably, as an observer, I could not detach myself from the system that I was looking at.

During the process I considered carefully which way to articulate the report and which decisions to make when confronted with choices: I could proceed by making 'Big Data' assumptions, using either the qualitative data from the interviews, or the objective data that could be sensed by a fridge without any context. This position made me reflect on the complexity of the technological outputs of a 'SMART' algorithm, and the idea that whoever is behind the algorithm will reflect the incentives of the companies that initiate and fund its creation.

After examining the 'SMART' fridge 'state of the art' by reviewing the features of smart fridges in the media and at the Consumer Electronics Show in Las Vegas, I realised that not only was 'smartness' a central concept in the process, but also in which way I acting as an algorithm could be 'SMART' while being affected by marketing strategies.

I had to think as a fridge that relies on data from its sensors and Big Data associations, correlations and historical data; but unlike a fridge, I had rich qualitative data from in-depth interviews. This meant that I knew that some things detected by the fridge made little personal sense in the autobiographical context of a particular user. I therefore decided to make **deliberate mistakes**. In this way, I experienced the process of 'making sense and no sense' and of being smart and stupid at the same time (see Figure 5.6).

See the Fridge-reports at the Appendix B (section B2)

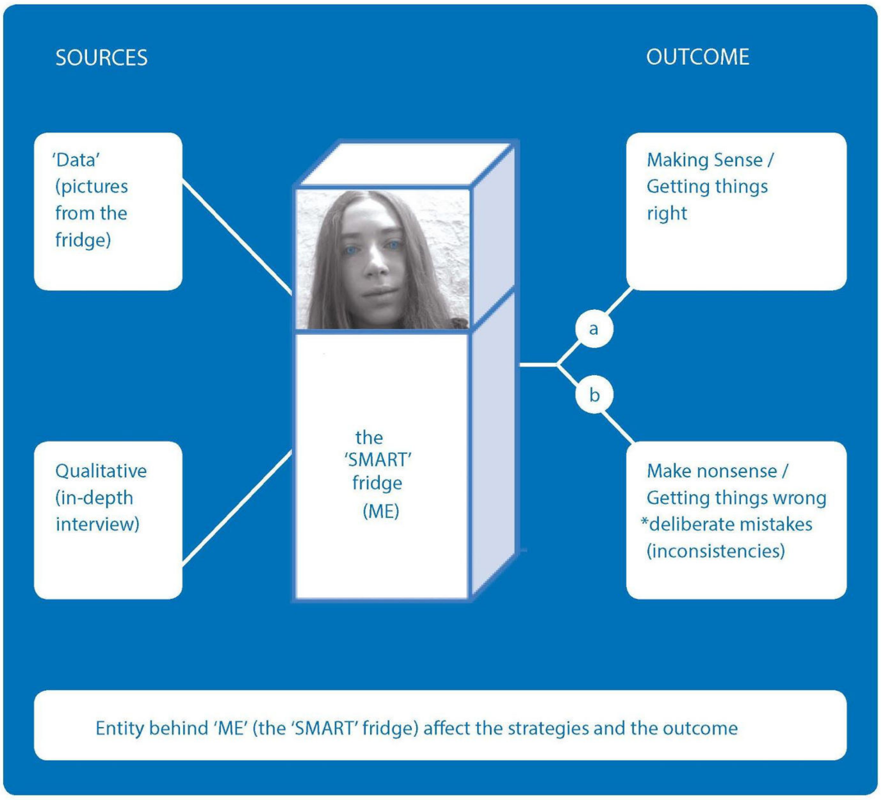


Figure 5.6: The process of 'making sense and no sense' and of 'being smart and stupid' at the same time.

Getting things right

In order to make sense, the contextual information and cultural understanding I gained through conversation with the participants about their fridges was very important; for example, the case of the papaya sorbet, which I suggested to participant B. Since I am from South America (Chile-Argentina) and participant B is from Brazil, I had some understanding of her culture. On top of this, information I gained from conversations about her eating habits led me to believe that it would suit her. Her feedback on the suggestion was: "It was very impressive that the suggestion was a sorbet and not ice-cream (I prefer it much more). That was great!"

To participant B, I also suggested a chicken, spring greens and açaí (a commonly consumed fruit from Brazil, which is high in antioxidants). I also suggested chicken; since she likes meat but does not eat it often because she feels cooking meat for one person is 'un-exciting'. It also had a lot of greens, which made a lot of sense in in regards to her eating habits and cultural background. This was also a complicated recipe, requiring more skill than her usual 'assembling', which also 'made sense' of the qualitative data.

In the case of participant A, I proposed a 'killer mac n´cheese' which was also related to his lifestyle and nationality, which I knew about from the description of his diet in the in-depth interview, as well as his fridge contents which included burgers, cheese and ketchup.

For participant C, the outcome was a mix of sensed-data and my own understanding of the person. I suggested a broccoli and Gruyere gratin. This made sense because he had plenty of broccolis. Moreover, he told me that he wished to eat like a European while in London, and both Gruyere and gratin are European. The recipe was also simple, and thus suited to his time constraints.

Getting things wrong (inconsistencies)

An example of deliberate inconsistencies was suggesting 'tuna mayonnaise salad' to participant B, which combined the fridge's algorithmically reliant 'sensing technology' with my human understanding of the user. The reasons behind this are: participant B had a jar of mayonnaise, which could be sensed by her IoT fridge. However, from my understanding, this made little sense to her dietary context, so I asked her about it: she told me that a visitor had left it some months ago, and that she loathed mayonnaise. This is a case in which contextual knowledge is necessary to make sense of the fridge's contents, yet such knowledge was accessible to the 'smart' fridge.

In order to reflect this complexity I created a recipe that combines something the user does not eat (mayonnaise) which the fridge would sense and that I knew she bought often, tuna, because she said it is very easy and quick to assemble as part of a meal. With current 'SMART' fridge technology, I, acting as an algorithm, would not know that participant B frequently buys (tinned) tuna, since it is not stored in the fridge. This might change in the future, if the 'SMART' fridge incorporates the supermarket receipt, or is otherwise informed about purchasing decisions.

By examining participant B’s fridge, I noticed another thing that made no sense: sausages covered in bacon. When I asked her about the sausages, she told me a German visitor had left them the previous week, and that she would not eat them, as she does not like them. After this comment, I decided to use the ‘sensed’ sausages for the Amazon list, These were used as the source for a ‘Big Data’ correlation, which I applied by suggesting ordering some chorizo as part of a ‘related products’ algorithmic strategy.

In participant C’s case, I suggested a toffee sauce for ice cream as another example of a sense/nonsense outcome. He had several boxes of vanilla ice cream in his freezer, so the reasoning behind an ‘efficient fridge’ (an efficiency strategy goes against the incentive of encouraging consumption) was ‘the fridge sensing a lot of a product’ which resulted in it offering another product to encourage him to ‘use the product’. However, from the qualitative interview, I knew that he does not like that ice cream and it belonged to his American flatmate. Since I knew from the interview that he is interested in British culture, I selected a toffee sauce so that the order made some sense.

5.1.3 Who is behind the algorithm?

By assuming the position of the algorithm in my process, when I had to make a decision I doubted the criteria to use. I had to choose from which source of data (quantitative or qualitative) I should use to create the output, and the strategy behind the algorithm, e.g. efficiency, the user's nutritional goals, pushing particular products, etc. This made me question whether, if the incentive was to sell more, would I push the user to buy products that were in my interests? Would I care about alternatives which might better suit their budget and health goals? How biased and constrained would this be? Would I try to make an efficient use of what the user already had in their fridge? How would dynamic pricing affect an automatic delivery? How would I make use of the user's data in relation to Big Data associations and profiling strategies? (Figure 5.7).

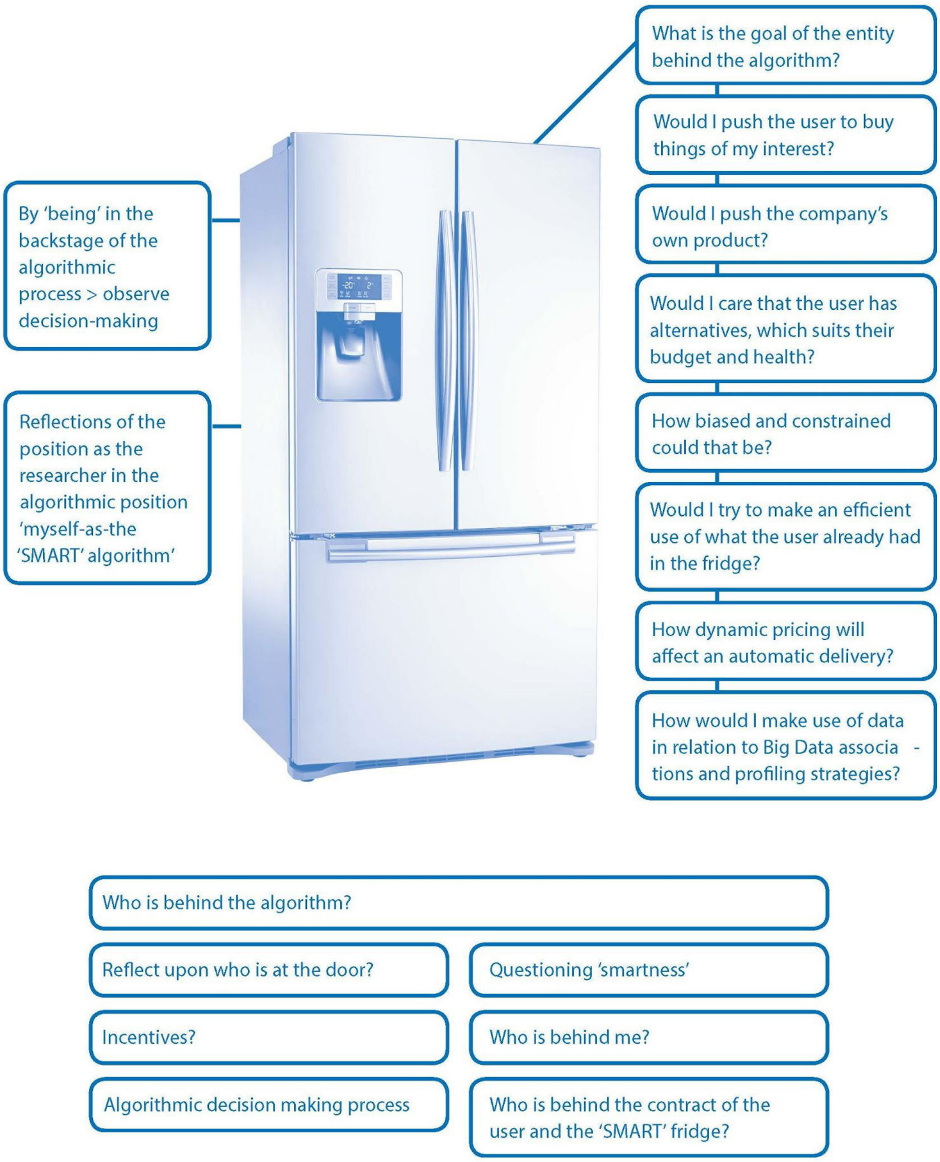


Figure 5.7: Questions that emerged at the backstage of the 'SMART Fridge'.

Being the algorithm thus made me reflect on how outcomes depend on the incentives of the companies involved with the software. This process made me aware that whoever is ‘behind me’, has significant influence on the algorithmic outcomes, by applying their needs to the device’s logic. In this way, by incorporating the idea that a company sits behind ‘me as an algorithm’, I realised that we should expect commercial strategies in the outcomes of IoT services. In turn, this made me think of the ways a user could easily become a daily customer of a single company.

Marketing

As part of the blurry future of the IoT ‘SMART’ fridge, based on what we can expect of the technology, I thought of providing a broad range of marketing outcomes. For this, I simulated possible marketing strategies as part of the Internet-fridge associations that may emerge, such as recipes, suggestions, advertisements, Amazon shopping lists and user activity updates.

Suggested products

In the fridge report I also suggested products alongside existing contents’ descriptions. This section was written in a somewhat ‘mechanical’ way and was not personalised. For this, my human knowledge played an important role, as is illustrated by the suggestion of *Lucozade* for participant A. From our interview, I knew that he consumes energy drinks and comes from America. I knew that *Lucozade* was the first energy drink in the UK and is still very popular among locals. I imagined that he wouldn’t know about it, so introduced him.

For participant B, I suggested *Coca-Cola Life,* since it sounds ‘healthy’: she tries to eat healthily and consumes natural products, so this recommendation ‘made sense’ from a marketing perspective based on this ‘lifestyle’ segmentation. In *Coca-Cola Life’s* description, it says it contains *stevia* – with which the drink is partially sweetened– a natural sweetener from South America: participant B is from Brazil, where stevia is popular. Moreover, the bottle was composed of 30% vegetable fibre and is marketed as ‘natural’ and ‘green’, which may have appeal to a professional woman who eats very healthily and is conscious about the environment.

I also thought that suggesting *Coca Cola Life* would work well as a simulation of ‘pushing a products’, because, as Coca Cola invests heavily in advertising, their involvement within product suggestions can be expected. This product suggestion was paradoxical, because, although it sounds healthy and therefore ‘makes sense’ in the context of the user’s ‘profiling-data’, it makes no sense in the context of the qualitative information about participant B (she was into eating healthy natural food, not into ‘light’ artificial products that sound ‘healthy’).

The suggestion given to participant C can be described as straightforward – 'making sense' – as the output was driven by data gathered from him. I knew he wished to eat in the local fashion and believed cheddar cheese to be representative. Additionally, I knew that he had gained weight and was about to start going to the gym, so suggested 'Health Conscious Cheddar' from Tesco. The choice of Tesco was informed by the fact that he often visits a nearby 24-hour Tesco, which was even one of the reasons he moved to his house.

Advertisement

In this section I delivered advertisements and took this as an opportunity for 'making sense and nonsense'.

I found out that participant A is a fan of the Green Bay Packers, an American-football team, who are sponsored by Miller Beer. I combined this fact with his fridge being full of beer, and his wish to lose weight (he has no time to go to the gym and eats high-calorie food) and came out with the suggestion that he buy 'Miller Lite'. This is promoted as a 'low calorie' beer (with the amusing slogan 'Low in man boobs'). I also suggested that he visit the Cereal Killer Café on Brick Lane, which I knew about from time spent living near London's 'Silicon Roundabout', which is nearby there. Because this participant was similar to the people I had encountered in that area, and because America has a big cereal culture, I thought the cafê would suit him.[5]

I gave participant B an advertisement for Pilates because she eats healthily (fruits, vegetables, almond milk) and orders *ayurveda* products from Amazon. Moreover, during our interview, she told me that she used to do yoga a lot. In this algorithmic outcome of data 'sense' but context 'nonsense', I offered something that would make sense in relation to her eating habits, but not her personal context: yoga and Pilates have a very different philosophy behind them. I suggested a popular chain in Notting Hill, which is near where she lives. I offered this because smaller venues, that may have been closer, do not often possess enough resources to invest in marketing. I also suggested Moët & Chandon champagne to participant B, based on the data from the fridge, since her flatmate buys a lot of champagne. This was an advertisement reinforcing a 'sensed' preference, which makes no sense for her since she does not like champagne.

[5] Cereal Killer Cafe, is the UKs first specialized Cereal Cafe. They sell over 120 different types of cereal from around the world and you can choose from 30 different varieties of milk and 20 different toppings. The venue is a target for designers, bankers and geeks; the cafe was attacked in September 2015 by anti-gentrification protesters.

Cereal Killer: hipster cafe attacked by masked anti-gentrification mob. The Telegraph. 5:20PM BST 27 Sep 2015. Available at: http://www.telegraph.co.uk/news/uknews/crime/11894644/Cereal-Killer-hipster-cafe-attacked-by-masked-anti-gentrification-mob.html

In the case of participant C, I proposed offers and coupons, including an offer to travel to Beijing because the ‘SMART’ fridge could sense many oriental products in the fridge, like Chinese chili sauce. In this section I also experimented with marketing and geo-location. To participant C, I provided a coupon for Nando’s (a restaurant chain) that allowed a customer to “get the second set of chicken+side at ½ price” because it is affordable, near to his home, and he likes meat but has no time to cook.

Finally I suggested a very modern gym to participant C since, in the interview, he told me that he had just joined the gym, used to be very fit while serving in the Chinese military and was starting to feel his age. The suggested gym was conveniently very near to his house and the advertisement was a “3 months free” offer.

The process of *being* the algorithm made me reflect on the variety offered to the user and the implications of a reduction in choice, a characteristic feature of marketing.

Amazon

In relation to possible services, I imagined that Amazon would be involved in creating an automatic shopping list, a feature suggested by Sterling (2014), so I automatically ‘ordered’ products from Amazon in the simulation. In this part of the service, with my algorithmic freedom to experiment with possible IoT outcomes, I decided to include all the ingredients needed for the suggested recipes, and therefore had to choose products that varied enormously in price. Following a commercial strategy, I often chose expensive products.

The Amazon lists were made by adding things that the participants had in their fridges, applying the ‘similar products’ strategy, and by incorporating elements needed in the recipes. Probably this could be inferred by a company behind the algorithms and/or the fridge, if it had the magnitude of personal data that Google has. Based on the fridge data and on the interview, in this area I also deliberately added some products that make no sense for the user.

By doing this as an algorithm, I had the chance to select the brand (price) and add automatically some products related to the recipes I had recommended; for instance, ordering a £7 bottle of extra virgin olive oil or expensive toilet paper for participant A. For participant B this commercial strategy was reflected by ordering a whole organic chicken alongside an automatically-ordered roasting tray necessary for the recipe.

For participant B, I ordered several products related to health and beauty, based on insights from our conversation and her interest in ayurveda. Thus, I ordered Ayurveda Pura Holistic Essentials Rejuvenating Skin Toner (£24.95), Probiotic Max-High Strength (£6.79), and spirulina tablets (£14.99). I also added luxury elements such as organic hazelnut truffles and virgin coconut oil. Using the sausages in the fridge as a starting reference in participant B's case, I added chorizo to the shopping list, as this fit the common strategy 'customers that bought this item also bought'. This was an instance of 'no sense' in context, since I knew that the sausages were left there by a visitor and the participant disliked them. But it would be unlikely that a 'SMART' fridge would know that context.

Echoing the way Amazon pushes products by 'understanding' participants' preferences, I also suggested books. In participant A's case, I understood that he was interested in design and technology, so suggested *The Circle*, an American novel based in a technology company. I suggested an Ayurveda book for participant A because her interest in yoga and the way she eats. For participant C (who used to work on a food blog) I suggested a recipe book by Yotam Ottolenghi, he enjoys Jamie Oliver.

Weather

By observing the services that 'SMART' fridges currently offer, I noticed that many functions are completely unrelated to the normal uses of a fridge; offering for example a memo board for the family or the weather report. IoT technology allows the fridge to have any kind of information from the Internet, and since the weather may affect the food we eat, I decided to show a weather report before offering recipes. In the case of participant B, this was a very important precedent for the product 'papaya sorbet'.

Activity

I ended the fridge update with a report on participants' physical activity. Since health and fitness are closely related, I decided to include a simulation of wristband data; we can expect this link from IoT companies. This part was written in a 'mechanical' way, e.g. "68% of your goal. You exceeded your maximum by 156 calories."

However, I also became more personal at this point, as if the fridge were understanding the person, asking questions like "Should I move your alarm?" and offering support: "2,000 more steps to reach your goal, good luck". I also used this persona-language to make some judgements: "You are quite far from your goal getting healthy and fit."

In relation to the possibility of getting the user involved with the ‘SMART’ system, I wrote them messages reminding them to update their profiles and preferences so that the fridge could provide them with better service. For instance, “So that I can serve you better please update your preferences” and “Looking at the activities in your calendar, I notice that your profile is not up to date. So that I can serve you better, please update it soon.” I finished the email with “Have a good night [or day]”.

5.1.4 Post IdIoT Analysis: Qualitative Interview and Mental Models

a. Mental Models

Following the fridge update report, I met the participants again, and asked them to elaborate their *mental models* (Norman & Draper, 1986) of the technologies involved, in order to analyse their understanding as early adopters. I was interested in their mental models since through this analysis it is possible to reveal gaps in their understanding and inaccuracies which provide insights into how people think of a possible uses and consequences of IoT technology.

I gave participants 10 minutes for this task. In order to focus on the representation of the system and not their drawing skills, I provided the participants with some images representing components of the system (similarly to methods used by Payne, 1991 to explore people's understanding of cash machines, and Lockton, 2011 to look at heating systems). Since I wanted to understand how the users conceptualise the Internet-connected aspect, and in order not to bias their imagination, I avoided giving them drawings in relation to this (Figure 5.8).

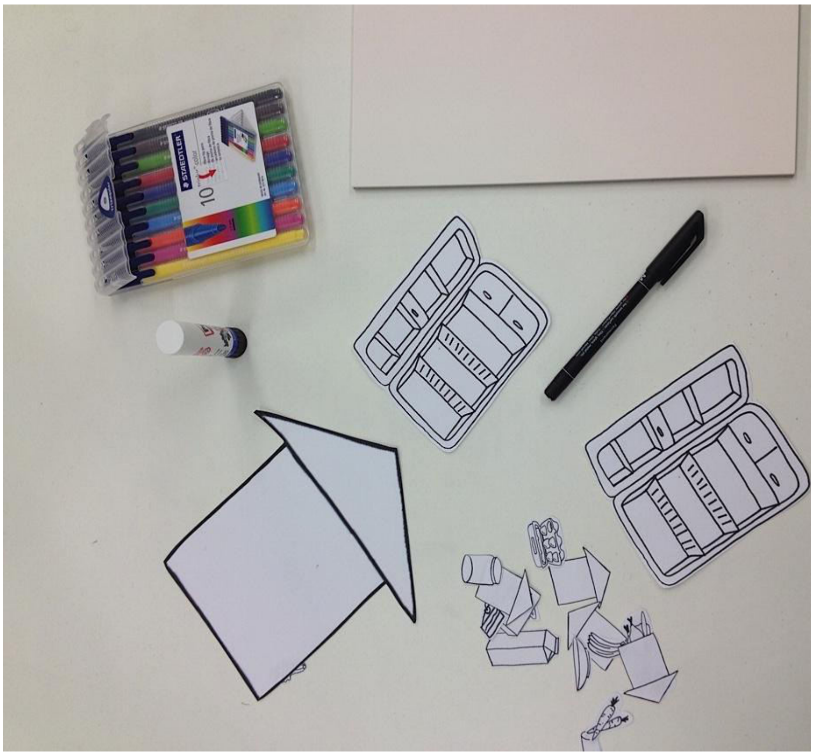


Figure 5.8: Images provided to the participants.

In this section I asked the participants:

a. How is your smart fridge connected to the Internet? (Draw the connections and the required technology.)

b. How do you think your fridge knows what it has inside? (Draw the technology involved.)

c. Write the features you expect from a ‘SMART’ fridge:

Results

a. Participant A represented the fridge as being connected wirelessly to a router, which would also be connected (wirelessly) to a smartphone. In the drawing can be seen how he linked the data from the fridge to a ‘world database’ controlled by Google. Next to that he wrote, “Google fridge manages food profile.” (Figure 5.9)

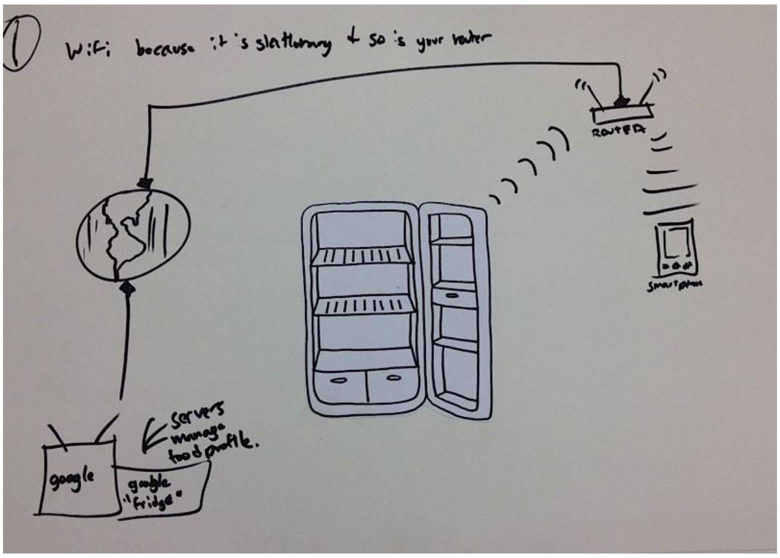


Figure 5.9: Participant A’s response to: How is your smart fridge connected to the Internet?

Participant B drew an integrated router in the fridge and wrote “router hardware/software kind of thing”. In her drawing, the fridge connects wirelessly with a router placed in the living room. She placed the router (which shows its physicality, by including the cables), with a SKY TV box and Apple’s Time Capsule wireless backup box.

Figure 5.10: Participant B's response to: How is your smart fridge connected to the Internet?

Finally, participant C developed several options. He included the idea of having a chip connected to the fridge, with the option of being wirelessly connected by a router or by a direct wireless connection with a smartphone.

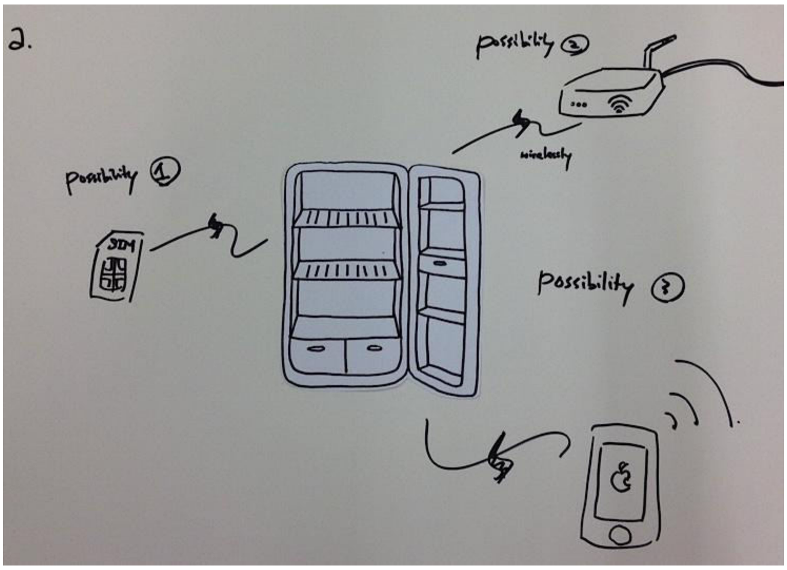


Figure 5.11: Participant C's response to: How is your smart fridge connected to the Internet?

b. In this area, participant A had the idea that you have two things when you leave the supermarket: a receipt and food. According to him “you cannot rely on your supermarket collaborating with your fridge”. In this way, for him the most logical solution was to scan the photo of his receipt from the supermarket using his phone, which connects wirelessly to a Google fridge and then connects to the router in his house and then to his fridge. For him, this goes hand in hand with describing the food you eat to a fridge smartphone app manually (feeding the ‘SMART’ fridge). Finally, he also wrote an equation to be considered:

[food purchased - food consumed = food in the fridge]

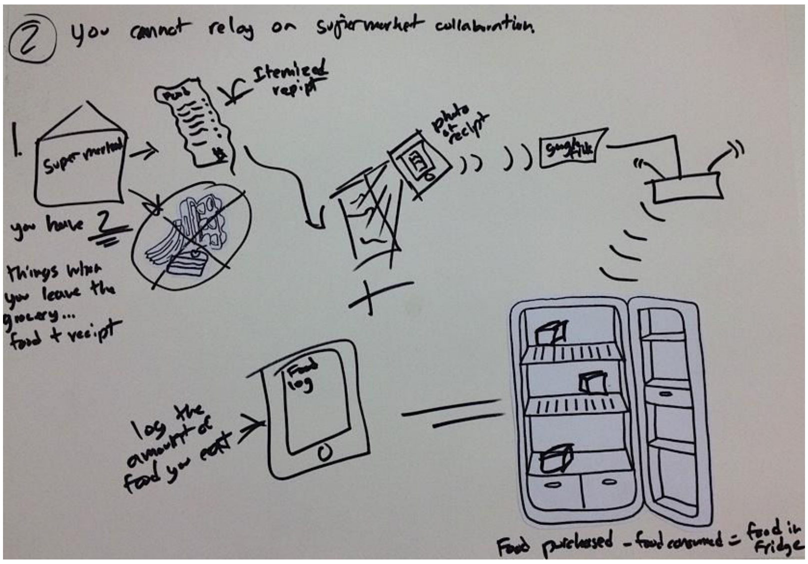


Figure 5.12: Participant A’s response to: How do you think your fridge knows what it has inside?

Participant B showed a fridge with an integrated RFID chip reader. Then she described, in words, how all products should have an RFID tag. For her, the fridge could have an RFID system that could track the products wirelessly. She marked all the drawers and indicated that they would work with scales to monitor weight, which would represent quantity consumed. For her there was also the possibility of having cameras installed to track fruit and vegetables, since she considered putting RFIDs on fresh food ‘weird’. She explained that this could work by having shape/colour recognition, and that the cameras could be connected to software.

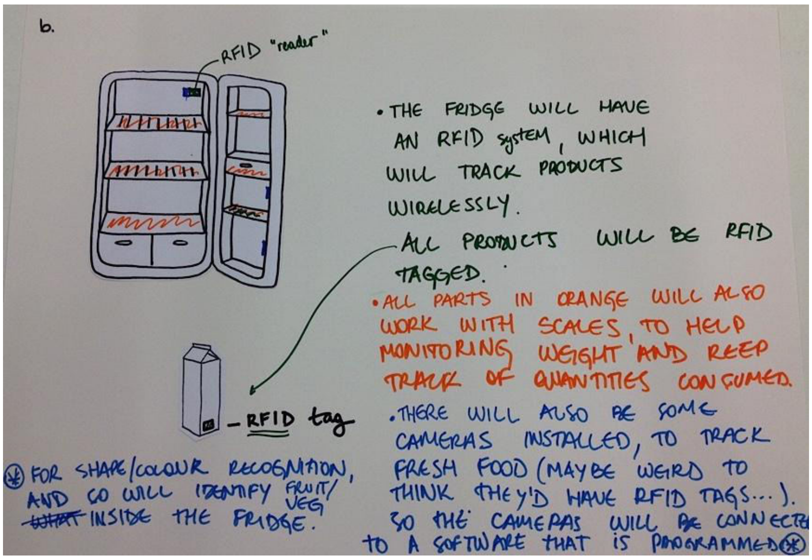


Figure 5.13: Participant B's response to: How do you think your fridge knows what it has inside?

Participant C similarly believed that this could be achieved by having pressure sensors that detect weight, along with a 3D camera –(something like a Microsoft Kinect depth camera), a microphone to which a user can speak while adding food; or by cheaper technology, which he exemplified by having a 'push-button' for eggs.

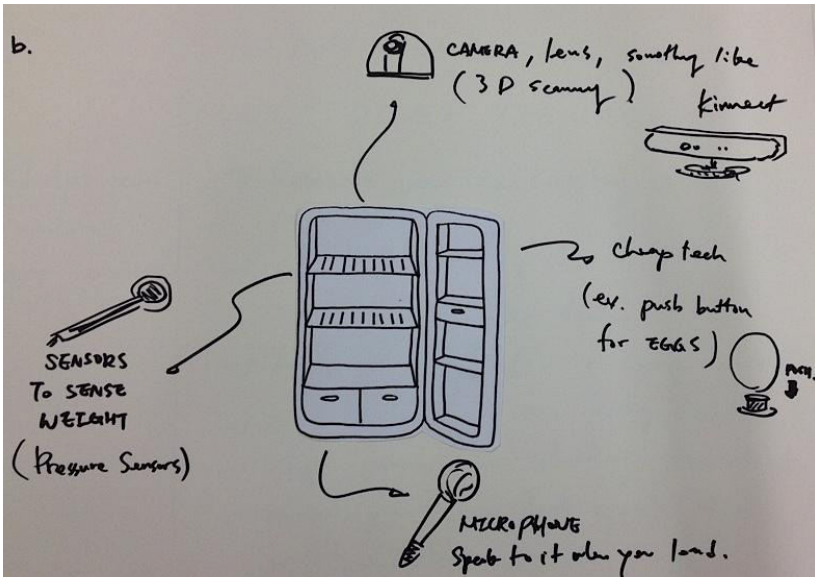


Figure 5.14: Participant C's response to: How do you think your fridge knows what it has inside?

c) The features that participants would expect from a 'SMART' fridge are shown in the Table 5.3:

Participant A	**Participant B**	**Participant C**
-Calorie tracker -Refill alerts/reminders (through the day you are reminded to get milk, etc.. -Price monitoring "milk on sale today -Each drawer knows what food is inside and regulates the temperature accordingly... -Expiration warnings with coloured light indicators inside the fridge: "eat pasta you have 2 days left" / "milk is bad, do not consume" -Segments/ Eco: The fridge knows if 3 or 4 sections are occupied and it can cut a section to save energy. -Recipes suggestions based on contents: "get eggs, you can make this"	-Energy tracking. -Food running out alert. -Shopping list -Recipes "like when you suggested them in relation to the weather or season" -Advertising could be good, but once that gets "clever" as I like or dislike suggestions I still find it scary and awkward. -Connection with Fitbit, particularly with the sleeping tracking	-Auto clean and nice smell. -Reminds you if something is running low. -Suggest you recipes for what is left in the fridge. -Evaluate if you are eating healthy. -Stops people from stealing your food. -Remind you so you don't open-close multiple things

Table 5.3: Features that the participants expect from a 'smart' fridge

b. Interview Phase II (feedback)

The second interview was an opportunity to have a conversation and gather feedback about the experience of the (surprise) IoT ‘fridge-report’. See Appendix B (Section B.3) for the full description of the findings of the Interview Phase II.

5.1.5 Findings

"If the fridge is abusing, people will end in bad relationships" – Participant A

Once I had the outcomes of the drawn mental models and participants' feedback on the reports, several relevant themes emerged.

In the simulation I considered how to interact with the user, and explored the idea that the IoT will bring with it **digital personalities**. In relation to the language, tone of voice, and the design of messages from the fridge, by being confronted with language-based decisions I realised how important and different the tone could be. I tried two ways of communicating with the user: an impersonal-efficient (Google-like) manner and a more personal (Siri-like) way.

The reactions varied among the participants, as shown in the feedback (see interviews II). What was clear from the feedback was that it becomes very problematic when software makes judgements and starts acting as if it knows the user too well. Participant A commented: "I don´t appreciate assumptions of Steve Jobs. I hate Siri! Fridge shouldn't assume a persona" and "fridge is not alive, it doesn't convince me". From his point of view, "the fridge should take the direction of Google Now: cause-effect and question-answer". The other two participants considered the Siri mode very personal. In this way, we could say that the preference for one mode (of language and tone) varies depending on the user's own personality, trajectory and historical experience of operating systems.

Since the IoT also embraces the idea that machine-objects will be able to act by themselves (without requiring human decisions), the behaviour (personality) of the 'SMART' fridge was a thus relevant aspect to consider. As Sterling (2014) suggests in *The Epic Struggle of the Internet of Things*, once a device, apart from carrying out its main functions, is also able to offer opinions or take actions, we will as a result start to consider it in a different way.

I explored this behavioural issue with automatic Amazon deliveries and by making judgements when I was in "Siri-mode". In relation to the fridge's automation impulse (for instance, buying expensive items) all of the participants agreed they were happy to have shopping recommendations, but they still wanted to control ("act upon"/ "be on top of") the outcomes of the 'smart' service.

In relation to the incentives behind the 'SMART' fridge, all the participants agreed that a company would have the incentive to push products they want to sell. They did not like these suggestions because retailers and manufacturers might pay for them, and this results in more control in the hands of these suppliers, which constrains the variety offered to the customer.

In the case of concerns about IoT-based marketing, answers varied among participants. The replies included finding it useful but being aware that corporations "love to make you consume" and considering the problem of buying things one does not need. In this context, all the participants agreed that companies would try to push their products. In relation to the potential for the 'smart' fridge to persuade users with its suggestions, all the participants agreed that this would be the case.

Regarding the question of who is behind the contract between a user and a 'smart' fridge, replies differed significantly. The answers included big companies such as Google and Amazon (described as "the giants" by one participant), software engineers and the fridge manufacturer. All of the participants imagined big companies; none of them thought of an open-source fridge.

The participants had different opinions about the fridge *knowing* their habits and suggesting shopping lists and recipes for them. Participant A said that it was fine for him, and participant B also believed it was fine as long as it did not prevent experiments with new foods. Participant C, on the other hand, claimed that this could shape you and "put you in your own corner".

Through this project, I gained 'user perspective' insights regarding the ways an IoT service could be delivered. In relation to the idea of receiving alerts from your fridge, I realised that a user's location and schedule are important factors. Participant A commented that he wanted to have a notification when something was relevant at the moment when he could take action, "for example to be able to read it on the tube on the way home, then I can make a change; that would reduce my dissatisfaction". This resonates with Sterling´s (2014, p.x) suggestion that "you as a human don't want the cognitive burden of knowing what your host of objects is doing all the time, what you want is executive briefing."

None of the participants were particularly concerned by issues around privacy, and the majority were fine with having an algorithm collecting data from their fridges. This may be expected since the participants were early adopters who already quantified themselves through fitness tracker wristbands. In like manner, the entire group assumed that their data would be sold. On this point, the participant A noted that the data is not sold, but *shared*.

All of the participants agreed that it was a possibility that their fridges might be hacked while connected to the Internet.

5.1.6 Reflections

By developing the project 'Becoming Your 'SMART' Fridge' and by taking the position of the algorithm, I discovered several issues around IoT that I decided to explore further in the following practice-based project, the 'SMART' Fridge Session (see Section 5.2).
By *being* the algorithm I had to put a 'mentality' in the process of the 'fridge-report' in order to be able to articulate the report with some direction/goal. Through this, I observed that there must be an embedded mindset in the development of the technology, which translates into the algorithmic outcomes, resulting in several implications. With this precedent, as an alternative to the AI perspective, I decided to embed a second-order approach into the scripted dialogues of the SFS (see section 5.2.3).

An additional research area that developed from the project, which aligned with my interest in pursuing a second order approach, was to explore further the possible problems of making assumptions reliant solely on quantitative data. As an outcome, I decided to incorporate the user by making him/her participant of the conversation with the IoT appliance: in the SFS I thus decided to give the user of the 'SMART' fridge the role of the 'reflective participant' (see Section 5.2.3).

Another theme that emerged from the project came from a comment during an interview, when a participant drew parallels between a Jawbone fitness tracker wristband and the figure of the (Asian) mother: "Jawbone is like living in Asia: 'I think you are fat', 'you are stressed'. I don't care what the Jawbone says… In my house, my mother has full control. Why Coke? ". This comment, together with the idea of an embedded mentality in the algorithmic logic of the device, resulted in an interest to embed roles and personalities into the 'AI' of a 'smart' fridge.

In this framework, I realised that conversation, with a second-order approach, are key. In this project I was the algorithm and the 'users' were observing the algorithmic output; in the following project I decided to assign the algorithmic role instead to the public. As an iteration of the project, the user could reply to the fridge as a way to test a feedback system, as opposed to a one way fridge-report (see Section 5.2.4).

5.2 Project #4: The SMART Fridge Session

Description: Public engagement research and dialogue analysis through a 'SMART' fridge interaction.

Venue: HQS Wellington, London.

Date: 18-10 September 2015.

5.2.1 Introduction

I really don't understand you. You think I like playing sick little games with you?
You're a very stupid computer. People don't even understand each other.
Julie Christie as Susan Harris, *Demon Seed* (1977)

IoT and human-machine communication

Even if in the past the idea of having a conversation with a connected appliance or an artificial assistant sounded ridiculous, doing just that will become more common, if we believe for example Gartner's forecast that in 2020 there will be 25 billion connected objects talking to each other (and us) (Gartner, 2014). This communicational aspect is thus especially relevant when considering interactions with the IoT.

There have been many attempts in AI and Computer Science to move interactions between humans and machines closer to human-to-human communication. Natural Language Processing (NLP) aims to create systems that can understand and speak natural languages as well as humans can. NLP (considered an 'AI-complete' problem[1]) is based mainly on Machine Learning techniques, though not entirely.

Current artificial assistants, including Google Now, Siri and Cortana, rely predominantly on pre-programmed answers. Yet even while it is clear these programs are not human, people still appear on the surface to communicate with them in an almost personal way.

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1 In the field of AI, AI-complete (AI-hard) problems are the most difficult computational problems, which implies that it won't be solved by a specific algorithm. An example of this could be 'The Natural Language Problem', (creating a system that can understand and speak a natural language as well as a human) or `The Vision Problem' (creating a system that can see as well as humans).

2 In a move symbolic of Silicon Valley's growing influence in architecture, Tony Fadell (Nest CEO), joined architect Rem Koolhaas on stage at the Biennale 2014 opening to discuss the future of architecture (Fadell and Koolhaas, 2014).

3 Rogerian Therapy:

A form of psychoanalysis developed by Carl Rogers (1902–1987), in which a therapist with an "unconditioned

The interactions between users and their virtual assistants can be very entertaining, and while funny, the outcomes veer between usefulness and sheer unhelpfulness and apparent stupidity (Figure 5.15). It is difficult to imagine such an assistant managing the complexity and dynamics of a home.

Figure 5.15: Siri, as an example of how the interactions between users and their virtual assistants can be very entertaining; and while funny, the outcomes veer between usefulness and sheer unhelpfulness and apparent stupidity (real dialogues). Source: Quertime.com

My interest, then, is in questioning the possibilities that occur when the so-called *intelligence* embedded when domestic IoT objects come into our complex and inconsistent lives to continuously sensing and analysing our behaviour. In this project I therefore explored what might happen if, instead of a passive interaction (the IoT device waiting for you to respond, or like Jawbone (see Section 2.4) , simply giving an abstract statement of encouragement), IoT devices started attempting to communicate *intelligently* with their users and other appliances in a two-way fashion.

My interests diverge from the AI concern with language, syntax and semantics. Rather, in this project I employ a second-order cybernetics approach to question how IoT devices could (ever) embrace human complexity and subjectivity in interactions with its users.

Focusing on the active role of IoT devices, I decided to generate conversations between users and a 'SMART' fridge through a messaging program on a smartphone. For this I developed two kinds of dialogue, which formed the basis of two sub-projects I carried out as part of the *SMART' Fridge Session*. The first, **'scripted dialogues'** was based on user's reflections. The second, **'assigned roles'** tested the idea of non-neutral aspects of algorithms by assigning roles to participants: one to play the role the AI in a 'SMART' fridge), and the other to play the role of the user (Figure 5.16).

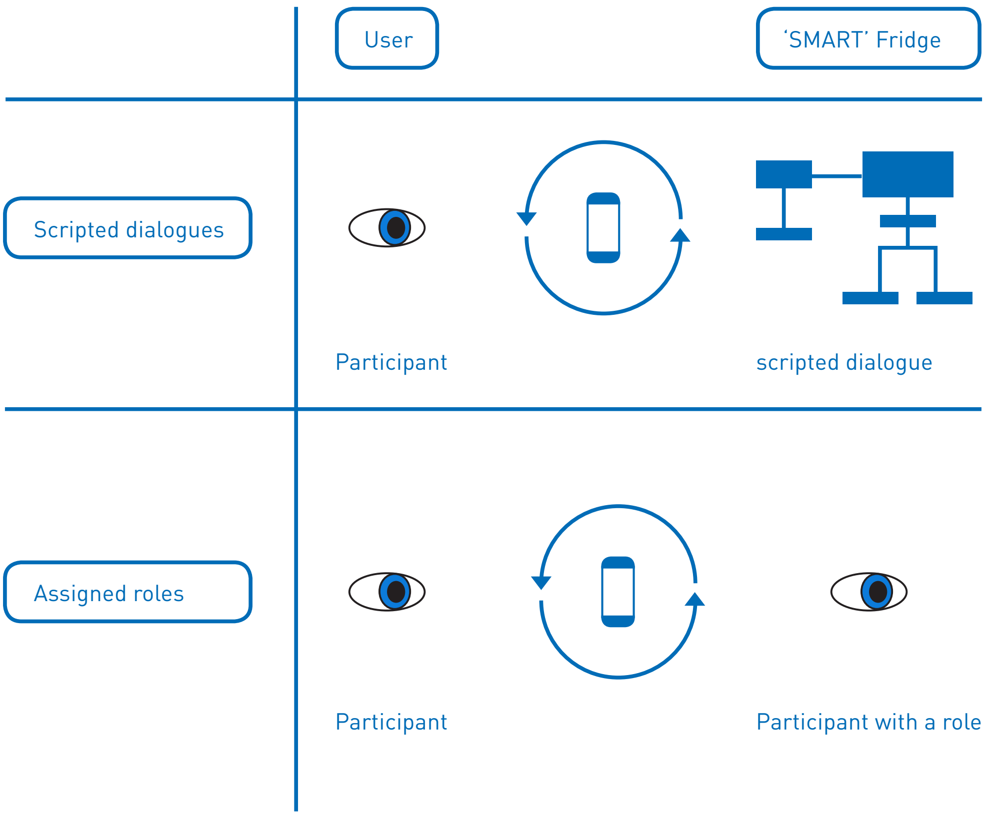

Figure 5.16: Projects in the 'SMART' Fridge Session. The 'scripted dialogues' was an interaction between a script and a participant (user). The 'assigned roles' was composed by two participants, one of them in the role of the 'SMART' fridge.

As with *Becoming Your ‘SMART’ Fridge*, while still ‘simulating’ human interaction with software, the approach was similar, bur not identical to, techniques such as Wizard of Oz (see section 5.1.2) — in the assigned roles even more so, since two participants were interacting with each other (one acting as a ‘SMART’ fridge) rather than with the researcher. Here it was possible to see how users adapt to the language of their interlocutors in order to depict the particular characteristics of human-machine interaction, in my case the ‘smart’ fridge.

5.2.2 Project Description

Setting

The SMART Fridge session was part of Off The Wall, an exhibition September 19-20, 2015, staged aboard HQS Wellington a 1933 former military ship moored on the Thames River (Figure 5.17).

Figure 5.17: HQS Wellington on the Thames at Victoria Embankment.

The exhibition consisted of paintings, sculpture, photography, video works, performances, drawing and installations from London colleges including the Royal College of Art, Slade School of Fine Art, Goldsmiths, Camberwell College of Art and Chelsea College of Art. Attendees ranged from toddlers to people in their 70s, many of whom had simply come to the exhibition because they happened to be walking by.

‘

Figure 5.19: ‘SMART’ Fridge Session flyer.

Sample

16 visitors took part in the ‘SMART’ fridge session, comprising people I had specifically invited by personal email invitations (including those taking assigned roles), and visitors to the exhibition. These comprised 6 women and 10 men, with an age range of approximately 24–40. All of them were familiar enough with technology to be able to use the provided smartphone to send and receive messages (Figure 5.20).

Figure 5.20: Photos from the 'SMART' Fridge Session at the HQS Wellington.

London: 18-20 September 2015.

Setting

The ‘SMART’ Fridge Session setup was composed of two chairs, in which each of the participants sat during the interaction. There were two roles: a ‘SMART’ fridge and a user. As a symbolic detail, each chair was placed in front of a ship’s wheel, to metaphorically imply the idea of ‘steering’ the dialogue. Furthermore, the Greek root of the word 'cybernetics' *κυβερνήτης* (kybernētēs) means ‘steersman, governor, pilot, or rudder’ (Figure 5.21).

Figure 5.21: The ship’s wheel ‘steering the dialogue’.

In order for the user to feel embedded in the ‘SMART’ world, the interaction was conducted through iPhones for each of the participants with assigned roles (Figure 5.22 and Figure 5.23). Dialogues were projected onto an adjacent wall, and there were additionally several rows of chairs for other visitors to observe (Figure 5.24).

Figure 5.22: A participant chatting during the interaction.

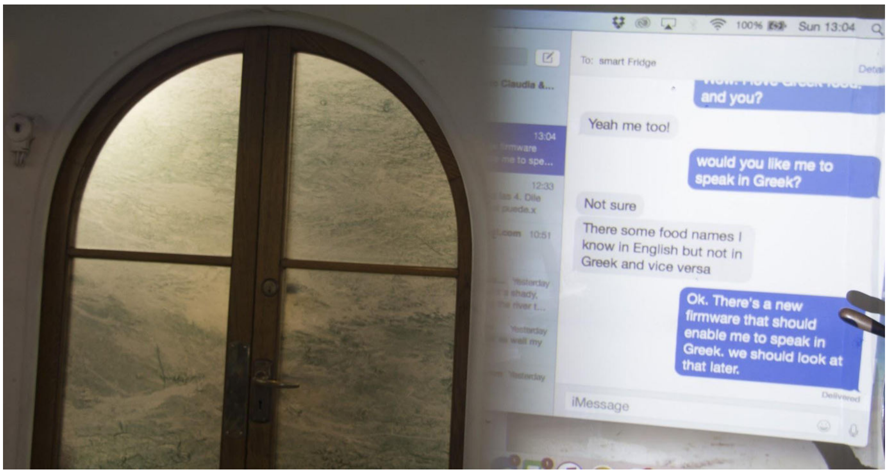

Figure 5.23: Dialogues on the wall.

Figure 5.24: The audience watching the interaction.

5.2.3 Scripted Dialogues

The scripted dialogues in the *'SMART' Fridge Session* involved a participant playing a user, conversing with a scripted 'SMART' fridge. Informed by my interest in the second-order cybernetics epistemology (Chapter 3), I decided to incorporate some second-order concepts into the design on the 'SMART' Fridge script. In Table 5.4 are the relevant concepts I deemed important when considering interactions with 'smart' devices.

Observing systems	The inclusion of the observer (observes, explains) The observers are not neutral and detached
Circularity	Each of us produces our own meaning and understanding (re-interpretation).
Self-reference	Autonomy, identity
Conversation	Meaning is constructed by individuals involved in an act of communication [1]
Not problem-solving	Ways of framing an issue
Systemic approach	Systemic model of the user

Table 5.4: Characteristic concepts of second-order cybernetics

The Figure of the IdIoT

I was interested in exploring the possibility of a shift in perspective from the current Algorithmic Paradigm (described in Chapter 2) in the context of the 'smart' home, towards a situation in which the user is considered an experiential, nonlinear subject, rather than a probabilistic and linear. The figure of 'the IdIoT' (Chapter 4) emerged after my experience of quantifying myself (Section 2.4), together with my observation of ongoing technological trends.

Using Glanville's (2014) suggested method of 'slowing down' and questioning 'what are we busy doing?' in relation to IoT technology, I found central reductionist issues which resulted in Table 5.5. Here, I contrasted the problems that I became aware of through second-order cybernetics principles, which I thought were important to be considered and explored in relation to a possible next generation of IoT technology.

Current values (as characterised by Silicon Valley)	**Alternative values** (as characterised by second-order cybernetics)
First-order reporting	Second-order reporting
Linear	Non-linear
No systemic understanding (e.g. health, fitness, diet)	Incorporation of system dynamics
Based on assumptions, reflected in the language	Based on questions and 'annotations'
Problem-solving	Problem-framing - Problem setting must be considered - Possibilities for enabling the construction of choice
'Smart' technology as embedded intelligence (stored in a computer, created by *intelligent* algorithms)	'Smart' as relational (human and algorithm are responsible for the *smartness* of the interaction) - Feedback: reciprocal control
Normative	Non-normative: Choices provide users with choices and indicate possible repercussions: -" If I want to hear more consequence of not doing that, x may happen because of y and z" -"You can improve x in another way"
Trivial	Meaningful Assumes that machines are by definition ignorant, by considering a systemic approach and by incorporating the observer in relation to the 'smartness'
Shared values	Variety of values (ask the user)

Opaque outcomes It doesn´t tell me why I receive this result	Transparent outcomes Tells me why – I can learn more and trust it more
Defined, statistical goals	Emergent goals based on human reflections on outcomes and agreement about ongoing activity.
Aims for objective intelligence without responsibility (examples: Google car crash, Jawbone telling me eat chocolate without asking me if I have diabetes)	Assumes human is responsible for relationship with the machine

Table 5.5: Comparison of values between present and possible next generation of technology

Given this background, I decided to question the 'problem-framing' approach of current AI-driven IoT technology, and developed an alternative interaction as an attempt to better embrace our complex and nonlinear existence. As a result, I decided to explore the concepts listed in Table 5.5 by embedding a second-order approach into experimental user interactions with a 'smart' fridge. The second-order concepts embedded throughout the dialogues are described in a symbology (Appendix C, section C1).

In order to test the concepts that I thought important for the next generation of IoT technology, I thereby developed the scripted dialogues, to incorporate a second-order approach into the interactions by embedding them into a script for a fictional 'SMART' fridge (A 'SMART' fridge dialogues' flow-chart can be seen in Appendix C, section C2.)

The creation of the scripted dialogues

In my research as a whole, the user is not merely seen as a passive consumer who receives normative outcomes, but as an active subject able to reflect on their own data. Some key concepts I was interested in addressing, in the context of data-driven outcomes, were related to this acknowledgement of human subjectivity and the importance of lived experiences. I also wanted to avoid the idea of technology embodying 'shared values' – an idea promoted, for example, by the CEO of Nest, one of the leading 'smart' home companies, as characterised by the phrase "technology is helping you to do things you already want." [2] This attitude was also evident in my experience using a Jawbone (see Section 2.4)—experiencing first-hand the normative assumptions around shared values and understandings.

While designing the script, I kept the following questions in mind:

- How could I avoid telling the users what to do?
- How could I make the user reflect on their data?
- How could I help the user understand the implications of their actions in relation to health, sleeping and fitness without being normative?
- How, with all these attempts, could I avoid simply giving data to the machine to be treated with the same machine logic?

Even if it is impossible to avoid the fact that designers and engineers will necessarily make assumptions (all design is modeling, in a sense: Ayres, 2007) — which results in shaping a partly normative discourse (considering non-normative outcomes can be seen as an aspiration that will never be fully achieved) — nevertheless, there are potential ways in which the creation of more open-ended systems (the fact that users are enabled to make choices), can result in a 'balance' of the normative outcome.

[2] In a move symbolic of Silicon Valley's growing influence in architecture, Tony Fadell (Nest CEO), joined architect Rem Koolhaas on stage at the Biennale 2014 opening to discuss the future of architecture (Fadell and Koolhaas, 2014).

As an outcome for this project, I therefore experimented in the script with the following second-order cybernetic concepts, which are detailed below:

a. The observer is taken into account
b. The user shapes the system
c. Feedback of the performance of the system itself
d. Statistical transparency
e. Systemic understanding and relevant insights that can only be achieved through conversation

Other considerations included:

f. Alternative ways of *understanding* the user
g. Routines
h. Assumptions
i. Suggestions
j. The device being neither a coach nor a therapist
k. Allergies, drug intake and dietary restrictions
l. Subjectivity and constructivist learning

a. Taking the observer into account

With a special interest in the significance given to the involved observer, and the consequent individuality and responsibility for their actions as a second-order characteristic, this project provided the user with the agency to give meaning to their data in the context of the 'smart' home. In order to increase the involvement of the individual throughout the interaction, I provided a space for the 'personhood' of the data provider (user) within the script. As an attempt to better respect the complexity of life and the subjectivity of the user, the reflective questions I developed were designed to enable users to elaborate their rationale and provide context.

As an attempt to embrace this issue I developed a system in which the IoT appliance thus triggered a reflection in the user, instead of offering a normative outcome (Figure 5.25).

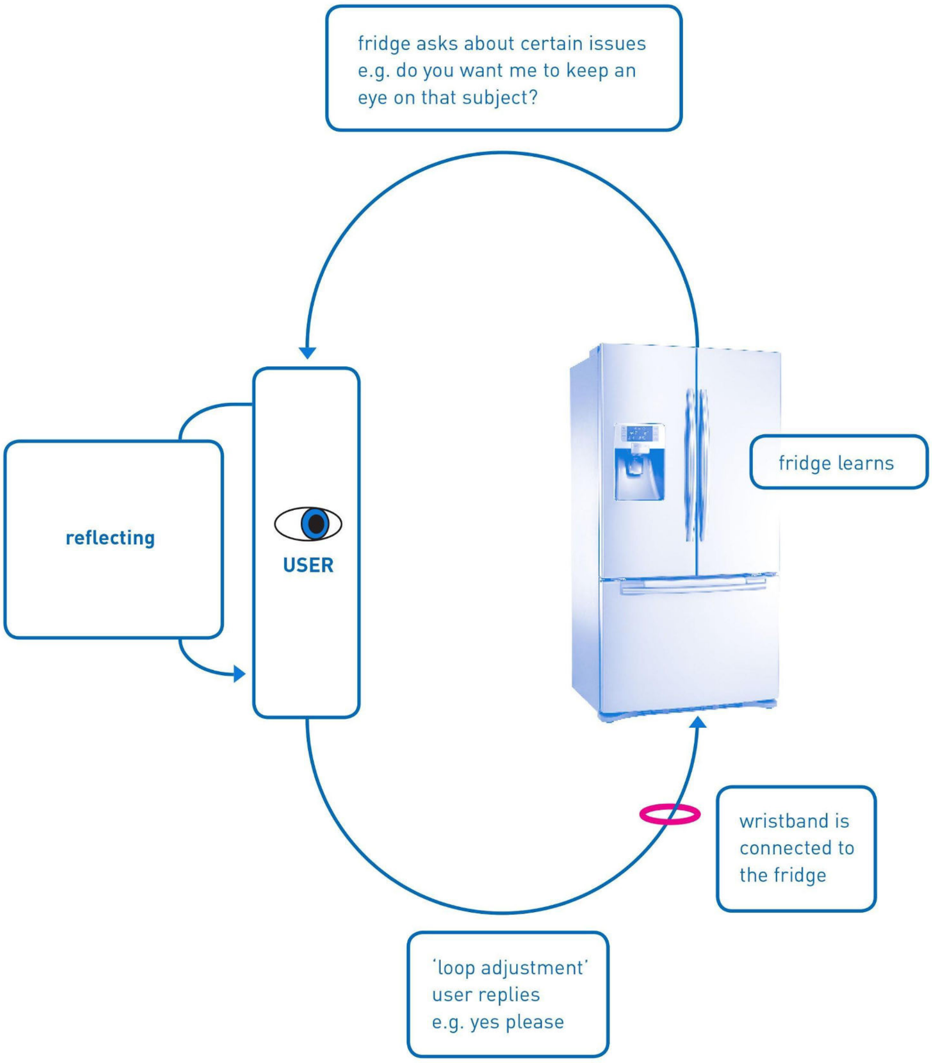

Figure 5.25: The observer taken into account

During the interaction, the 'SMART' fridge was designed to prompt reflection. Under the premise that reflection is necessary for learning in a constructivist paradigm (Chapter 3), and as an alternative to normative outcomes, I wanted to avoid unidirectionality by enabling the device to become an entity that prompted user reflection. This allowed the observer to be taken into account, since the machine did not tell what to do, but provide data-based patterns for the user to reflect upon. This placed responsibility in the observer's hands, resonating with von Foerster's (1992) idea that the observer is responsible for their own observing process.

These strategies were applied to different aspects of the user's activities, and related to the idea of an IoT wristband connected to a 'SMART' fridge (see Appendix C2 to find the script structure):
Walking: B1, B2, B3, C1, C2, C3
Lifestyle: D3, D4, D5, G2
Sleeping>D6, E1, E2, E3, F1,F2,F3,F4,F5

b. User shaping the system

I also explored the idea that the user shapes the 'smart' system through the 'conversation of the conversation', e.g. when the 'smart' fridge asks "Do you want me to keep an eye on that?" or "Do you want me to encourage that?" (Figure 5.26). This allowed a co-created system of change where the 'smartness' of the interaction is constructed by the user and the machine. This mutual shaping was an instance in which the user has agency over the evolving 'smart' system. This is reflected in the sections B5, C4, C5, E4, G9,S7, P1, S2, S3 and S7 (see Appendix C2).

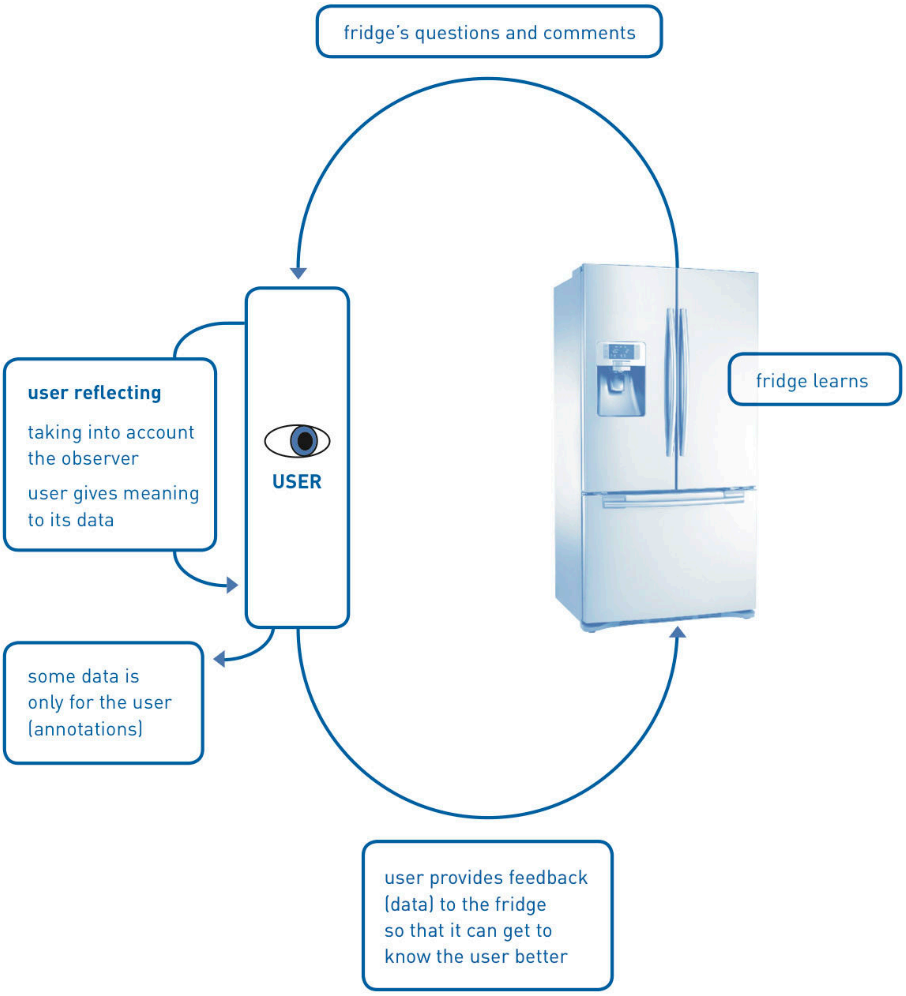

Figure 5.26: User shaping the system

c. Feedback of the performance of the system itself

An important issue addressed in the script was the idea of the user providing feedback on the performance of the system itself. Here the machine acknowledges the idea that it may be ignorant (e.g. the 'SMART' fridge asks if there was a failure in tracking). This can be seen in P1 and S2 (Appendix C2).

d. Statistical transparency

I was interested in exploring the idea of transparency in relation to statistical outcomes coming from 'smart' appliances (Figure 5.27).

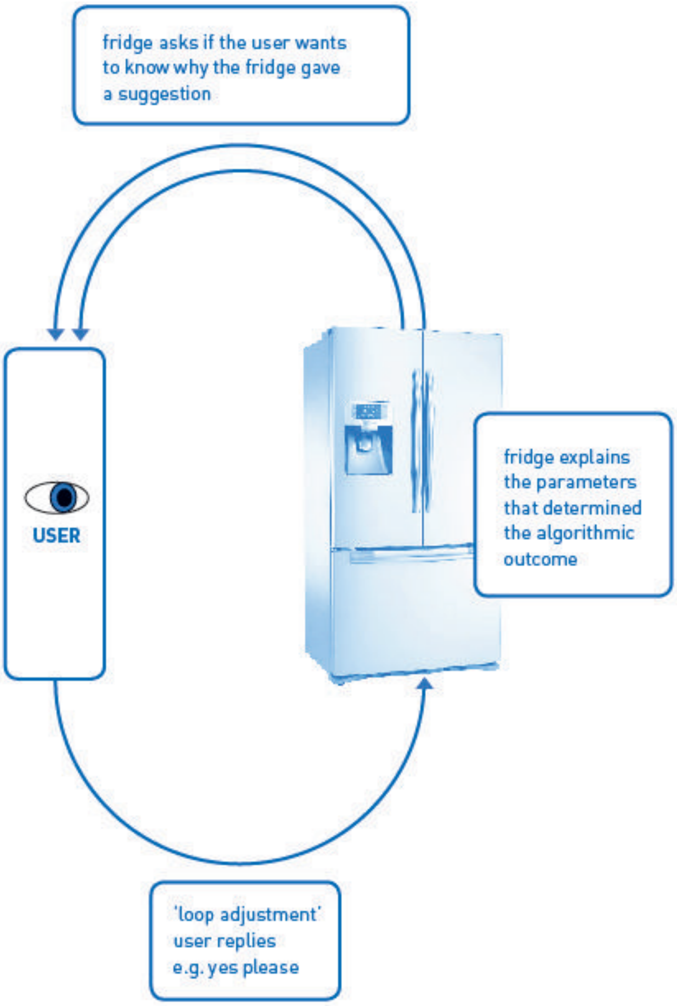

Figure 5.27: Statistical transparency

This was an important aspect to address, especially in light of my own experience with the Jawbone wristband (Section 2.4), where I was apparently ranked in the top ten percent of all Jawbone users and in the top four percent of females in their twenties. I was very surprised by these results because I do not put much effort into physical activity, so this made me wonder about the people I was being compared to. When I tried to upload my first meal into the Jawbone app, the most popular item listed was a hamburger on a bun (Figure 5.28).

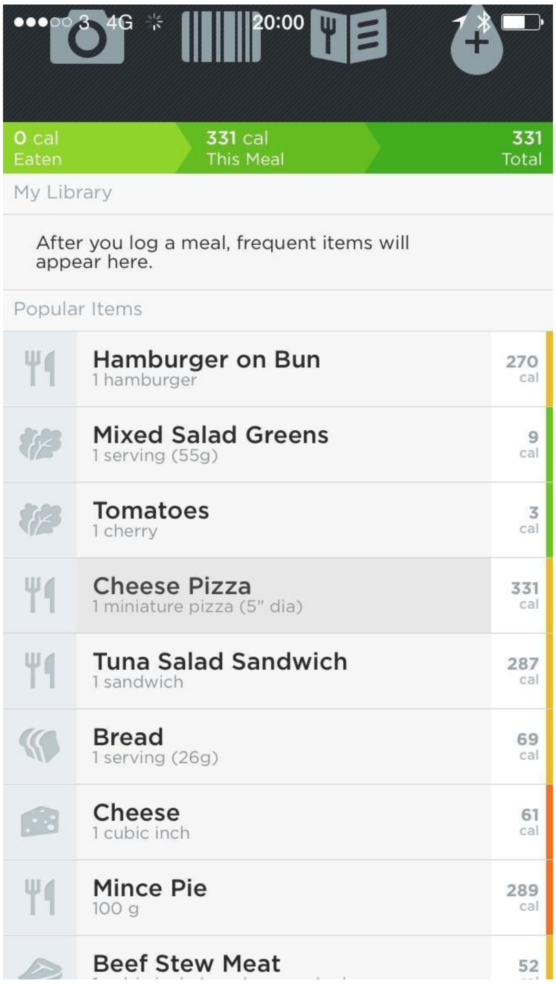

Figure 5.28: 'Smart' statistics. Most popular item 'Hamburger on a bun' perhaps said a lot about my 'competitors'.

By contrast, in the 'SMART' fridge script, the machine asked the user if they wanted to know the reasons behind its decisions. Though the reasons for particular suggestions were not provided during the interaction, this suggested that, in the future, if a user was interested, the 'smart' appliance could or should make visible the parameters that determined the algorithmic result.

e. Systemic understanding

Another important aspect I wished to include was consideration of the systemic existence of the user, that is, his or her 'embeddedness' within wider technological, social and cultural systems. Since this was a case in which an IoT wristband was connected to a 'smart' fridge, I designed questions around the interrelation of different aspects of life, so that I could analyse the resultant complexity. These questions involved eating behaviour, sleeping habits and physical activity.

In this systemic approach I also asked contextual questions, which provided a space for each of the participants to bring their particular background to the subject. In the case of sleeping habits for example, this was exemplified by the questions D6, E1, E3, F1, F2, F3, F4 and F5; while B1, B2, B3, B4, C1, C2 and C3 were related to physical activity (see Appendix C2).

Relevant insights that can only be achieved by conversation

In the script I made evident that there are insights, usually not considered in the design of IoT devices, that should be considered when dealing with sleep, physical activity and eating habits. These include factors relating to wellbeing and nutrition such as hydration, snacks, alcohol and coffee consumption. However, since most consumption of this sort happens outside the home, the 'smart' appliance has no way of sensing it. On of the only ways for a 'smart' fridge to find out is to ask, so I had the fridge do so. This is shown in the symbology with the sign of a black message (Appendix C1), and can be seen in D3, D4, D5, G2 and G3 (Appendix C2).

Other issues explored in the script

f. Alternative ways of understanding the user

In order for the ‘SMART’ fridge to get sense of the user’s dietary inclinations, I developed several alternatives strategies for soliciting information, which helped the ‘SMART’ fridge make better sense of the user’s diet. One strategy was to ask about vegetables and fruits, since this information would be helpful in encouraging a healthy outcome. Another approach was to ask for the participant’s favourite dish, as this would help the ‘SMART’ fridge suggest related meals. This is reflected in J1 and J2 and in J3 (Appendix C2).

g. Routine

The question of routine illustrates the complex existence of humans, and could have direct implications for the way in which the system ‘makes sense’ of its user by reaching beyond machine learning and sensed patterns. These descriptions can be seen in D1 and D2 (Appendix C2).

h. Assumptions

In the script I was also interested in testing reactions to the idea of technology making assumptions about the user. In order to analyse user responses about such assumptions, I provided a space for them to reply with a comment about their understanding of what was going on. Based on my Jawbone experience, in which I received a comparison with previous weeks (Figure 5.29), I decided to place statistics about walking into the script.

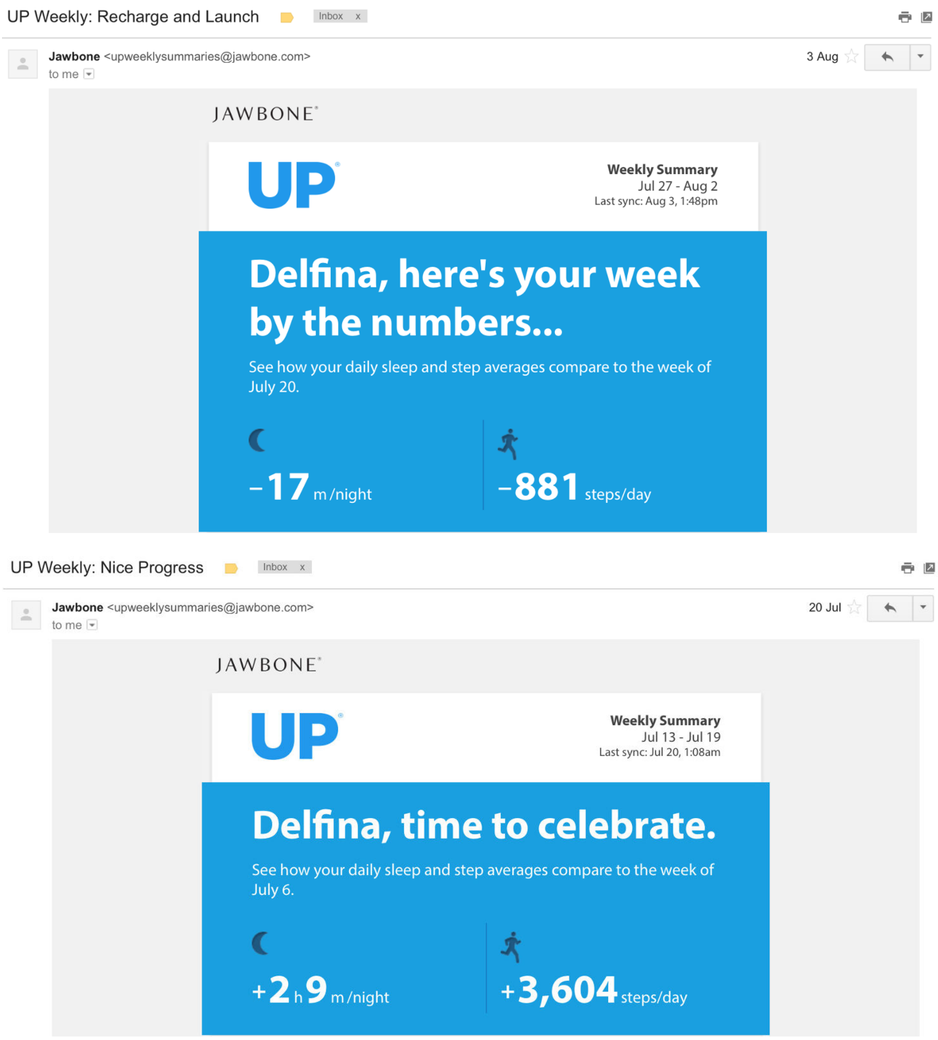

Figure 5.29: Examples of my Jawbone 'UP Weekly' report

This meant that some participants were told "you've been walking less" and others "you've been walking more than last week". In the case of walking, each assumption was followed by a different branching with different questions, e.g. Participants B and H were told that they walked more. This can be seen in B1 and C1; other assumptions are reflected in G1, G4 and E7 (Appendix C2).

i. Suggestions

I applied the same strategy in the case of suggestions for places to eat, by providing the user with a space to reply to the outcome. Suggested venues were selected because they were what Google Maps showed when HQS Wellington was identified as the current location (Figure 5.30).

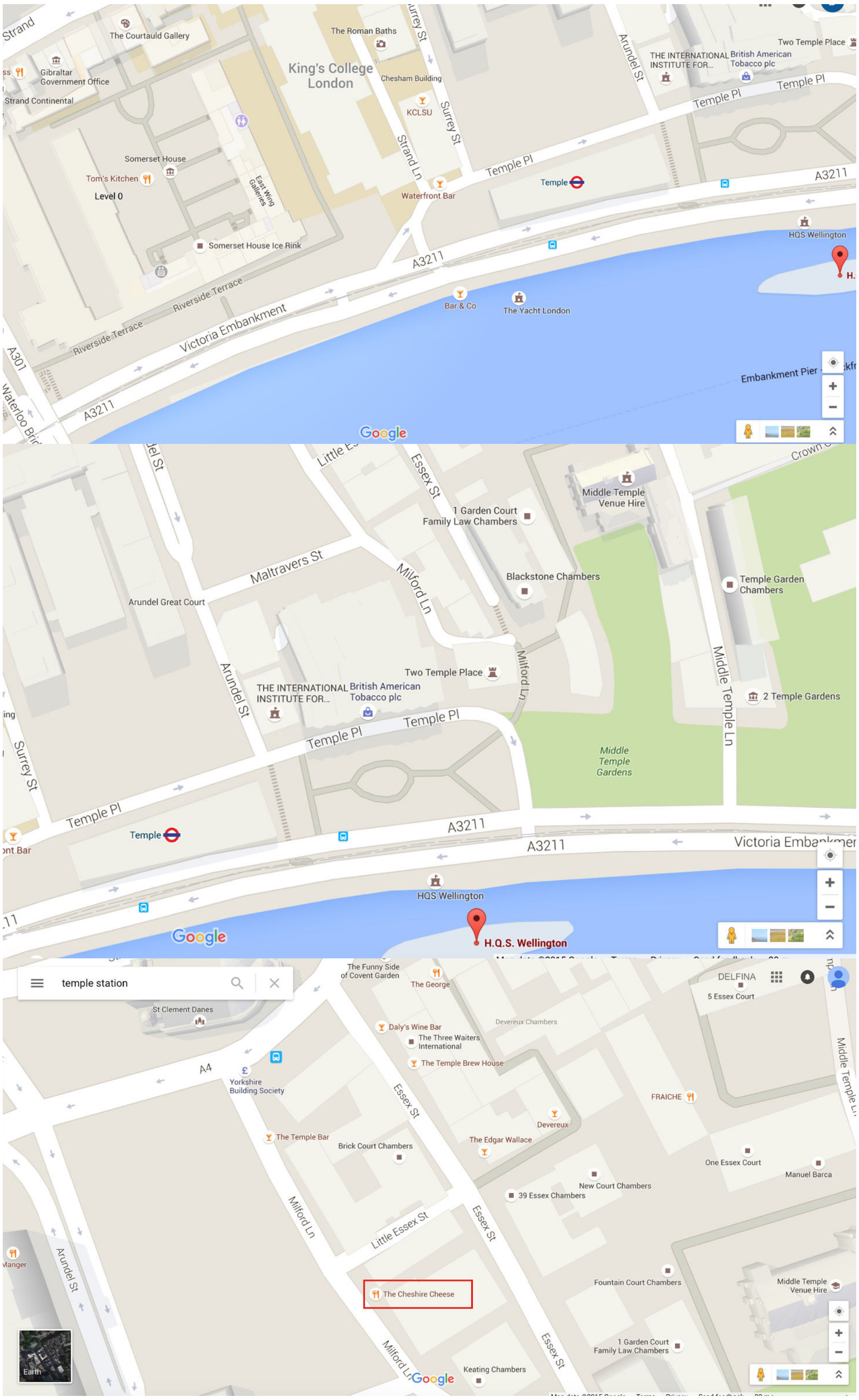

Figure 5.30: Suggested restaurants by Google Maps with HQS Wellington as the current location

I suggested different restaurants depending on whether the interaction was in the morning or the afternoon. In the morning, I offered Tom's Kitchen at Somerset House or the Cheshire Cheese, and in the afternoon I suggested The Edgar Wallace Pub. Taking budget into account, I alternated venues based on price: Tom's Kitchen for example was the expensive option, while the Edgar Wallace and the Cheshire Cheese were classified as affordable.. In both cases I offered a vegetarian option. This suggestion can be seen in Q1 and R1 (Appendix C2).

j. Not a coach, not a therapist

In this script I was not interested in embedding particular roles such as coach (as in IoT wristbands, e.g. Jawbone) (Figure 5.31) or the role of the therapist (e.g. Eliza—see below) into the technology. Rather, I wanted to test an alternative interaction in which the user actively reflects, with the appliance as an entity that prompts reflection rather than making value judgments. This came from my belief that the user is in the best position to derive value and benefit from harvested data.

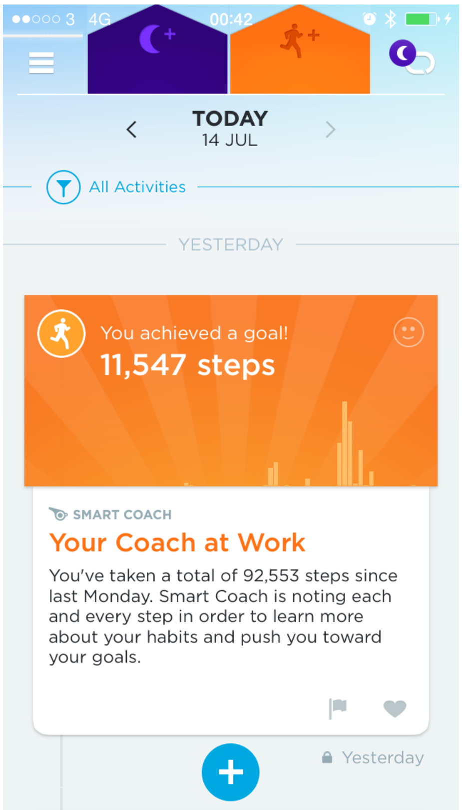

Figure 5.31: The 'smart coach' used in the Jawbone wristband

Eliza was created between 1964 and 1966 at MIT by Joseph Weizenbaum as an early attempt to design software that used natural language. The software functions by processing user responses to *scripts,* and applying a simulation of Rogerian psychotherapy to them. [3]The program assumes that, generally, the input of the 'patient' exceeded the capacity of the database, and therefore provides general responses which use almost no information relating to the participant's thoughts.

Weizenbaum (1976) described Eliza as a parody of the one directionality of the psychotherapist in a psychiatric session. In this context, Weizenbaum can be seen as a 'critical designer' by making Eliza's users experience the overinterpretation of a rudimentary system based on string operations of the keywords. Because of this, I used Eliza's questions so that the user would provide more information. This is reflected in E2, E5, E6, F6, F7, H1 and S5 (Appendix C2).

In this way, it is important to mention that Eliza, when compared with current IoT interactive platforms (e.g. my experience of using the Jawbone) or for example Google's Cleverbot (Figure 5.32), Chatty ("an AI Chat Bot", Figure 5.33) or Slackbot, (England, 2015), appeared to perform much better in relation to reflective outcomes (Figure 5.34).

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[3] Rogerian Therapy:

A form of psychoanalysis developed by Carl Rogers (1902–1987), in which a therapist with an "unconditioned positive regard" for the client attempts to decrease the negative aspects of a patient's over-dependence on others and increase his or her level of self-reliance. Rogerian therapy hinges on nurturing the belief that despite negative physical, genetic and psychosocial influences, the client is ultimately in control of his or her life. Rogerian therapy is most useful for patients with anxiety, stress and emotional problems.

" Rogerian Therapy." The Free Dictionary's Medical dictionary. 2016.
http://medical-dictionary.thefreedictionary.com
(15 April 2016).

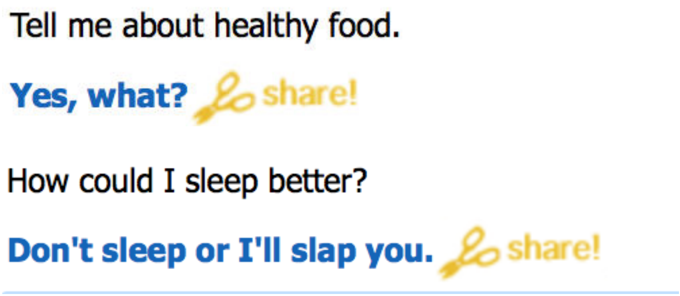

Figure 5.32:Chatting with Google's Cleverbot

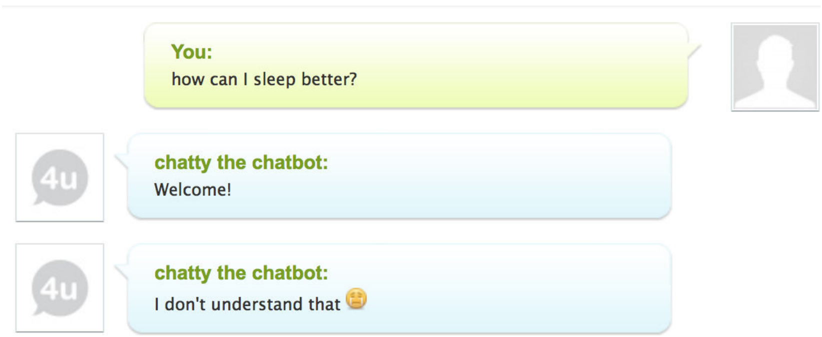

Figure 5.33:Chatting with Chatty, an "AI Chat Bot"

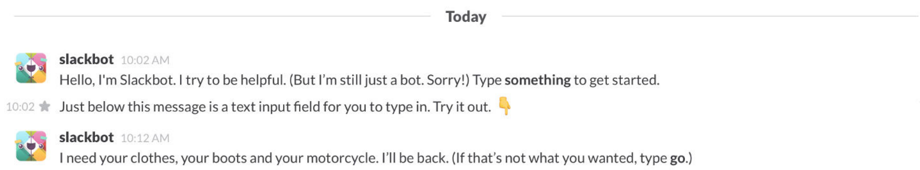

Figure 5.34:Chatting with Slackbot "a built-in robot chat which can supposedly answer questions, provide tips when prompted and perform searches" (England, 2015).

In relation to the idea of ‘technology as therapist’ I decided to include existential questions in the script that emerged from the process of creating the interaction. As part of the design process, I thus asked a human psychologist to have a text-based chat with me, in which I assigned her the role of the ‘smart’ fridge connected to an IoT wristband, which measured sleep and physical activity patterns. I decided to use the existential question “Do you have unfinished things?” since when I received this question myself, it made me reflect a lot about implications for sleep. The existential question can be seen in G5, which was followed by the reflective questions G6, G7 and G8 (Appendix C2).

[See the dialogues excerpt in the Appendix C3]

k. Allergies, drug intake and dietary restrictions

The continuously irresponsible, pseudoscientific health-related information given to me by Jawbone surprised me. For example, it suggested that I consume 8 oz of beetroot juice everyday (“to lower blood pressure and make you happy”), or to eat cereal or toast with peanut butter to induce sleep (Figure 5.35). If I was a diabetic (in the case of beetroot) or if I had high cholesterol (in the case of peanut butter) this could end up with serious repercussions, yet I was never asked about such things.

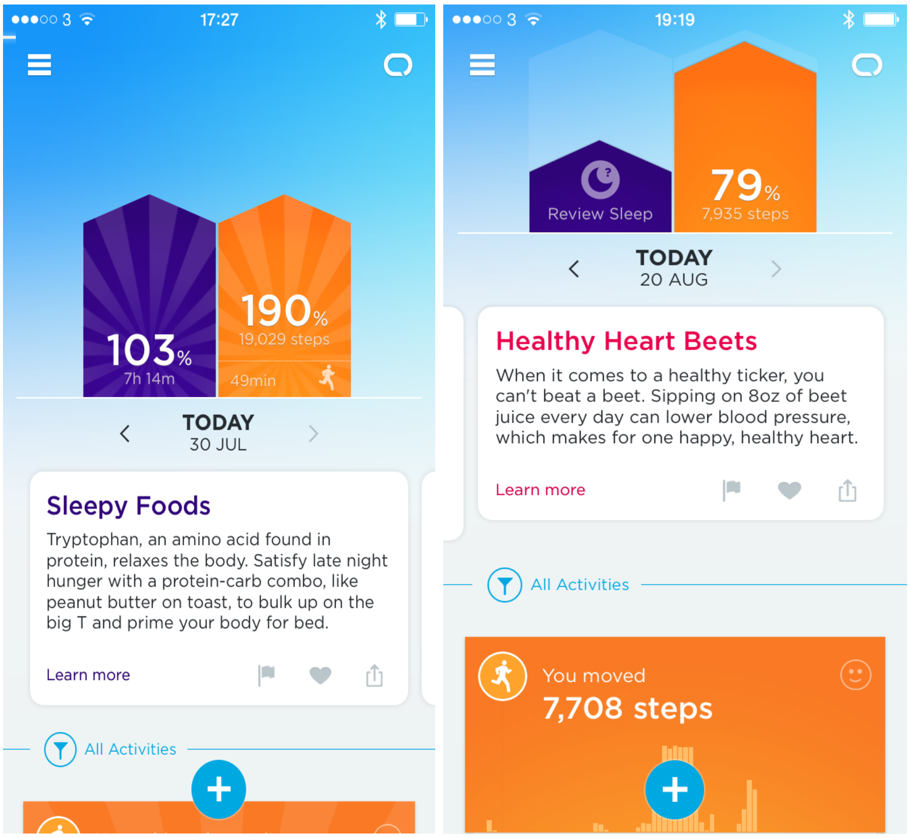

Figure 5.35: Irresponsible and pseudoscientific information given to me by Jawbone.

This may have to do with liability issues, because it may be the case that if software asks a user about medical issues, the company then assumes some responsibility. Conversely, a fridge could buy food with traces of allergens and poison its user. Because of this I decided to ask if users had any dietary restrictions, and went further by asking for subtleties within them (G10). I also asked about allergies and drug intake (G11). (Most of the participants professed no allergies or drug intake issues.)

l. Subjectivity and constructivist learning

Throughout the process of developing a script based on user reflections, I became aware of the importance and the problems of the way in which a machine learns from individuals. I decided that if software was to consider human subjectivity, an alternative model of learning is needed, contrasting with the one which grounds machine learning, but with degree of data privacy which is difficult to imagine nowadays. It should also ensure that any personal information provided is not taken for commercial use. In light of human unpredictability, a machine understanding of situations informed only by statistical analysis of past behaviour is therefore problematic.

To illustrate the ways in which Machine Learning can be contested, I developed two alternate ways of machine learning, which are reflected in the symbology (Appendix C1) and the script. In the script, the space for the user's replies (in purple) meant that learning was involved. Pink indicated that the reply was not used (the information was not stored) and that no learning would take place.

In addition to the background colour of the device's responses, I developed a sign shaped like an envelope which indicated 'dated and stamped'. This implied that that information was solely for the user, in case they want4ed to follow up their own annotations. When there was learning involved in the script, there were several footnotes explaining each particular case (see symbology in Appendix C1) and the script in Appendix C2).

The following introduction was given to participants who entered the space and elected to participate, before the scripted interaction commenced:

> You are situated in the context of the 'Internet of Things' (IoT), a context where a network of objects are connected to the Internet. The objects are able to share/receive data and they are able to make algorithmic decisions.
>
> In this 'SMART' fridge session, there will be a user and a smart fridge talking through an iMessage chat. You will speak (chat) with a 'SMART' appliance (in this case a fridge) which is part of the 'connected home'.

The ‘SMART’ fridge is also connected with a smart wristband which tracks your physical activity and sleeping patterns. During the conversation:

1. Reply as much detail as you want.
2. Feel free to reply "I won't answer that".
3. If you already replied that the question and it feels repetitive, you can reply to the machine "I already told you that".

The whole session will last around 20/30 min.

5.2.3.1 Results: Interaction outcome

There were 8 resulting interactions. The full outcome of the interactions can be seen in Appendix C4. Below I use extracts from the dialogues to explain the second-order approaches that I decided to investigate. After the interaction I analysed the dialogues and selected replies that illustrate the complexity of human central activities and a reflective user. This can be seen in the scripted dialogues excerpt (see Appendix C3).

At the end of the session, I asked participants about their interactions with the fridge and about possible relationships with ‘smart’ appliances generally. The answers varied, but focused mainly on services, making life easier, or in the case of Participant D, the questions coming from the ‘SMART’ fridge were ‘senseless’. This is exemplified in S4, S5 and S6 (Appendix C2).

Communicating with a machine

Through analysing the participants’ replies through the lens of second-order cybernetics, it was possible to see that some people seemed content to receive the questions from the machine, while others thought that those questions should be left to real people, and that it was senseless to have them with a machine. The dialogues show that replying to reflective questions coming from a machine in some cases were seen as inappropriate, and not convincing enough for all users to give subjective replies. This was very clear in the case of Participant A, who decided to leave before the interaction finished. At the same time, the dialogues showed that even by providing an alternative to a normative, linear-causal interaction, it was still difficult to capture the rich complexity of human existence.

SMART Fridge (SF): Would you mind telling me when you think there are relevant changes in your routine related to sleeping, physical activity and eating so I can try to make more sense from your behaviour? If not, why not?
Participant H: No, I wouldn't mind if you are not too intrusive

A clear irony could be seen in the dialogue of Participant A, who decided to quit before finishing the session.

SF: What are the factors involved in that outcome?
PARTICIPANT A: Programming
SF: How do you think you can prevent that?
A: I am not talking to you anymore machine!
SF: How do you think you can maintain that?
A: Change settings to stop you asking questions
SF: Can you see that something changed in relation to your lifestyle for you to get that result?
A: Yes, money to afford to buy a smart fridge
SF: In order for me to understand you better in the future would you like to let me know if you have any issue that may affect your physical performance?
A: Yes. Monthly menstrual cycle. Long working hours-stress.

PARTICIPANT F:

SF: Would you mind telling me when you think there are relevant changes in your routine related to sleeping, physical activity and eating so i can try to make more sense from your behaviour? If not why?

F: Would like to tell you but if I had to explain I would like some data privacy.

PARTICIPANT D:

SF: What if you could sleep better?

D: I'd be happier but less interesting

SF: Can you find a way to manage that? How?

D: I am unbalanced. Nothing is finished. All relations are pending, unsettled, I am a neurotic. I think, more efficient or? I don't know how to solve it, can you solve it?

PARTICIPANT C:

SF: Would you mind telling me when you think there are relevant changes in your routine related to sleeping, physical activity and eating, so I can try to make more sense of your behaviour? If not why?

C: Yes, but I tend to be lazy with these kind of things

PARTICIPANT F:

(Regarding walking less than the previous week)

SF: What do you think are the factors involved in that outcome?

F: I walked less because in the last few days I have been working from home

SF: How do you think you can prevent that?

F: I enjoy working from home because I just bought an aquarium and helps me relax

PARTICIPANT G:

SF: Can you identify ways that can help you to reduce the stress and make you feel better in your daily life?

G: No, can you?

PARTICIPANT E:

SF: Tell me more

E: Where should I start?

Transparency

During the conversations, the transparency of statistical outcomes embedded in suggestions or metrics emerged as an important subject.

SF: If I told you that you have one of the least nutritious fridges (in the bottom 20%), would you like to know how many people and from where your data is being compared? Yes, please/ I am not interested

PARTICIPANT E: Yes
No, I am not interested
SF: Why?
E: My recent experience was opposed to my diet, too much butter and no champagne left

PARTICIPANT F: Yes please
SF: Why?
F: That would give me a bigger picture

PARTICIPANT C: Yes
SF: Why?
C: Otherwise I wouldn't trust if not

SF: How may I help you?
PARTICIPANT E: You didn't answer the previous question.. Why did you recommend fish and chips?

Diversity

The answers show that the participants have very different patterns of living. Throughout the project, the problems of embracing, in an algorithmic manner, the richness coming from a variety of individuals became evident. The participants' replies illustrated individual differences in understanding the same scripted questions and provided a variety of answers for these questions. This made the importance of considering the subjective component (the importance of the observer) clear, and thus suggests the importance of avoiding statistical and numerical assumptions.

> **Has there been something particularly troubling you? Why do you think you slept like that?**
> Participant D: Well, before a friend of ours was staying because he has no apartment now. Of course I let him stay, but it meant I slept badly, then I felt worse in the day
> Participant F: Women!

An example of the particularity of understanding is evident in the first question: How do you feel today? Participant H took this to apply to the particular physical context, replying, "not fine, I don't like being in a boat". Participant G, replied, "hungry". Participant B replied with a metaphor: "sunny".

An analysis of the answers shows that they have important implication relating to [the fridge's knowledge of] sleeping and diet alongside consumption which occurs outside of the home. An interesting point emerged from Participant F's response to a question about the amount of alcohol he drinks per week, in which he replied "not too much for my standards". This reflects the particular manner that the participant understood the question (perspective) and the relativity of the context of the answer.

Constructing meaning

An issue that emerged from the dialogues was the related, and vital, idea of constructing meaning, and the use of metaphors in participant replies. This has been recognised in other Natural Language Processing (NPL) research (e.g. Carbonell, 1982,p.415).

> **How have you been sleeping this week?**
> Participant H: Like a baby
>
> Participant G: Not bad

When the machine deals with human complexity and subjectivity, it is important to be aware that it will never completely understand it, but approaches such as second-order cybernetics at least illustrate the relevance of acknowledging this. This challenge suggests the need for further exploration.

The outcome of this project raises challenges beyond the AI-centric focus of NLP; moreover, this project was an explicit critique of the current IoT model characterised by predictive analytics. The script reflects a shift from first-order cybernetics, where the system which makes assumptions, to a second-order approach, where the subjectivity and responsibility of the user is taken into account through his or her own reflective process. This was not based on aggregated data (e.g. Jawbone weekly reports). In this sense, the design research outcome of the script constitutes an alternative to the current model of 'smart' technology. I will discuss this idea further, in relation to the wider context of the thesis, in Chapter 6.

5.2.4 Assigned Roles

In the assigned roles part of the SMART Fridge Session, I explored aspects of the subjectivity of algorithms by assigning two roles to participants: one participant played the 'SMART' fridge and the other played the user.

5.2.4.1 Background

I decided to investigate the idea of a distinct personality embedded in an IoT device, in order to explore the idea that algorithmic subjectivity. After the interaction, in my post-IdIoT analysis, I carried out a thematic analysis of the dialogues that emerged of the interaction (see Section 5.2.4.4).

The Figure of the IdIoT

The figure of the IdIoT in this case emerges from my own experience of wearing the Jawbone wristband. By 'slowing down', reflecting on the interactions I had, it became clear that algorithmic outcomes are not neutral. In order to test an explicitly subjective personality embedded in a device, I asked various professionals to 'perform their job' as an AI inside a 'SMART' fridge (Table 5.6); separately, I, asked others to play entirely fictitious roles (Table 5.7).

Professionals playing themselves
Interaction Designer
Nutritionist
Programmer/Start-up company owner
Banker
Scriptwriter
User Experience researcher

Table 5.6: Professionals' Roles

Role	Performer
Chinese mother	Chinese female in her early thirties
Italian mother	Italian male in his late twenties
Jewish mother	Jewish female in her early thirties
Korean mother	Korean female in her early thirties
British mother	British male in his early thirties
Mafia Godfather	Portuguese Designer, male in his early thirties
French fashion designer 'diva'	French Academic, male in his early thirties
Authoritarian German general	German programmer, male in his early thirties
Coach	British Designer, male in his early thirties
Personal trainer	British Designer male in his early thirties
'Schizophrenic' fridge	British Artist, male in his late twenties
Open Session	British Anthropologist, male in his early thirties

Table 5.7: Fictitious Roles

In this way, the participants playing the roles of both user and 'SMART' fridge, through an active interaction, had the opportunity to reflect on what this 'SMART' interaction could mean for both sides. In this sense, we can say that participants had the opportunity of *becoming* IdIoTs. Through a reflective process, by becoming a 'SMART' fridge or its user, issues and challenges to IoT technology in relation to subjectivity were made explicit.

In the case of the professional roles, I involved professionals who will potentially have a role in the design of future IoT appliances, including an interaction designer, the nutritionist, programmer, banker, scriptwriter and user experience researcher. I also decided to invite a scriptwriter to test storytelling in the interaction. Each participant provided a completely different strategy for getting information and keeping the interaction going.

There are several reasons why I chose the fictitious roles. For example, in the case of the mothers listed in Table 5.7, it was related to the idea that a mother takes care of you, with a big influence on what we eat later in life. [4]This also relates to the previous project, *Becoming Your 'SMART' Fridge*, in which one participant mentioned that when the appliance started to remind him that he was not performing well and that he was not reaching his goals, and he made an analogy: "Jawbone is like living in Asia: 'I think you are fat', 'You are stressed.' I don't care what jawbone says...In my house my mother has full control." Jawbone however, like many IoT technologies, implicitly embodies a particularly American personality, as I described in a previous chapter. For this reason I deliberately chose not to include a prototypical American persona, though some of the chosen personalities (godfather, coach) reflect particular American sub-cultures.

An example of a mother as a protagonist related to computation is seen in the movie *Alien* (1979) in which "MOTHER" (or MU-TH-UR 6000) was the AI controlling the spacecraft (Figure 5.36). A more recent example is 'Mother', the name of a 'smart' home hub, which comes in the shape of a Russian *matryoshka;* this IoT 'life-coach' is characterised by the tagline "Mother knows everything" (Figure 5.37).

---

[4] The chosen stereotypes e.g. Jewish Mother or Authoritarian German general, were not meant to be offensive or discriminatory. As common fictional 'personality' tropes, I found all the characters amusing and the aim was to explore the characteristic traits when applied to the 'AI' of a 'smart' device.

Figure 5.36: MU-TH-UR 6000 was the AI controlling the spacecraft in the film Alien *(1979).*

Figure 5.37: ''Mother', a 'smart' home hub.

I assigned other roles, such as fashion diva, an authoritarian German general, and a Mafia godfather, to test diverse patronising attitudes. I also chose a 'schizophrenic' role to test the possibility of inconsistencies in responses. Due to the connection of fridges to health and fitness, I created the roles of a coach and personal trainer. To make this interaction as realistic as possible, in the case of the mother roles, the French diva and the authoritarian German general, the actors were participants from those particular cultures.

Props/prompts: Cards and Products

In designing the interaction, I included two physical elements, cards and products, as props or prompts to assist the 'SMART' Fridge role and user role respectively.

a. Cards

For 'fridge-actors' I provided these cards to use in case they got stuck during the interaction. For the design of these I offered two sources: *Eliza* dialogues and *Oblique Strategies* cards (Figure 5.38).

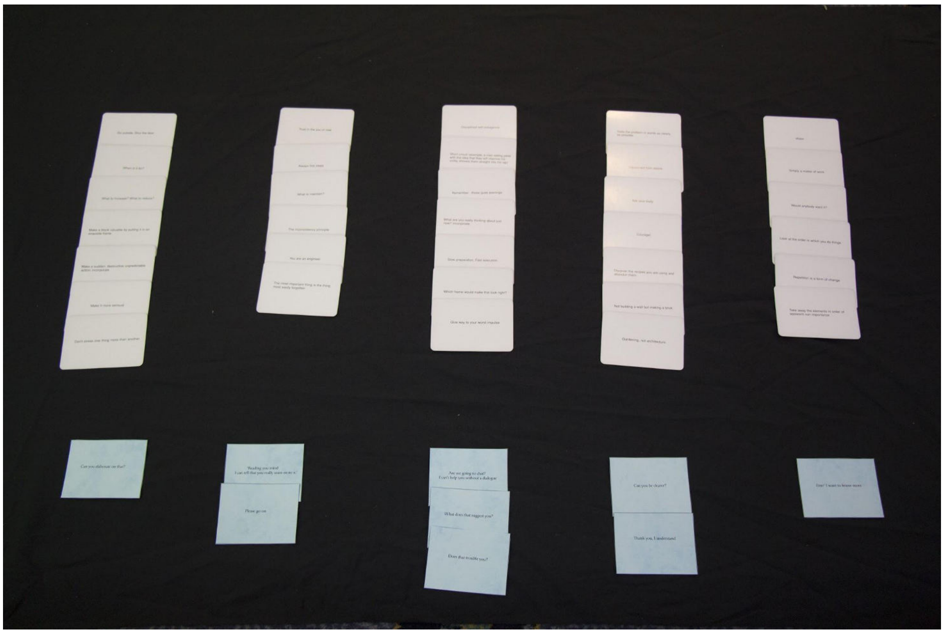

Figure 5.38: 'Aid cards' I provided to fridge-actors in case they got stuck during the interaction.

Created in 1975 by Brian Eno and Peter Schmidt, *Oblique Strategies* is a deck of cards, each containing a phrase intended to help the reader break creative blockages:

> The oblique strategy cards can help a person focus towards their goal. These oblique strategies never provide answers, but they give a person impetus to look somewhere they hadn't thought of looking before. It's like having someone look over your shoulder and point out something you overlooked… They are not final, as new ideas will present themselves, and others will become self-evident (Eno, 2001).

The alternative was to select strategies used by *Eliza* (Figure 5.39). *Eliza*, based on the role of a psychotherapist, continuously keeps the interaction going by replying in a general manner, often asking more information of the "patient" (Weizenbaum, 1966). Based on my own interaction with the software (Figure 5.40), I decided to select some phrases for instances when the 'SMART' fridge actor might have problems keeping the dialogue flowing. *Eliza* and *Oblique Strategies* phrases can be seen in Tables 5.8 and 5.9.

Eliza
Can you be clearer?
Please go on.
Does that trouble you?
What does that suggest to you?
Are we going to chat? I can't help you without a dialogue.
Can you elaborate on that?
Thank you, I understand.
Fine, I want to know more.

Table 5.8: Eliza

State the problem in words as clearly as possible	What are you really thinking about just now?
Always first steps	Make it more sensual
Don't stress one thing more than another	What to increase? What to reduce?
Look at the order you do things	Simply a matter of work
Disconnect from desire	Give away your worst impulse
Ask your body	The inconsistency principle
Water	You are an engineer
Slow preparation. Fast execution	Disciplined self-indulgence
Trust in the you of now	Remember those quiet evenings
What to maintain?	Discover the recipes you are using and abandon them
The most important thing is easily forgotten	Incorporate
Not building a wall but making a brick	Repetition is a form of change
Gardening, not architecture	Take away the elements in order of apparent non importance
Courage!	

Table 5.9: Oblique Strategies

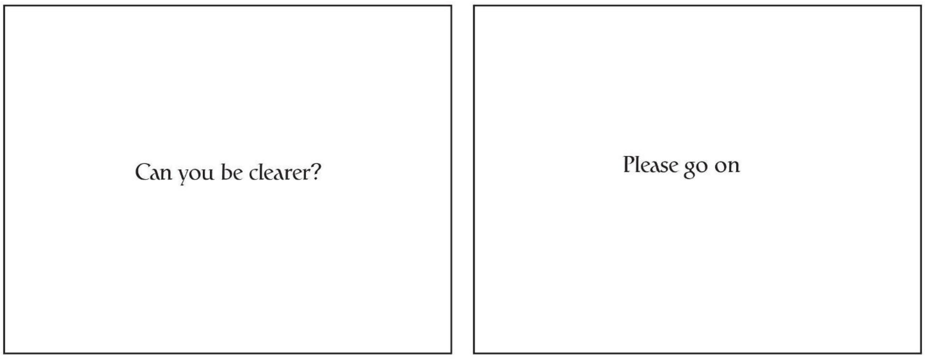

Figure 5.39: Eliza cards that I developed for the interaction.

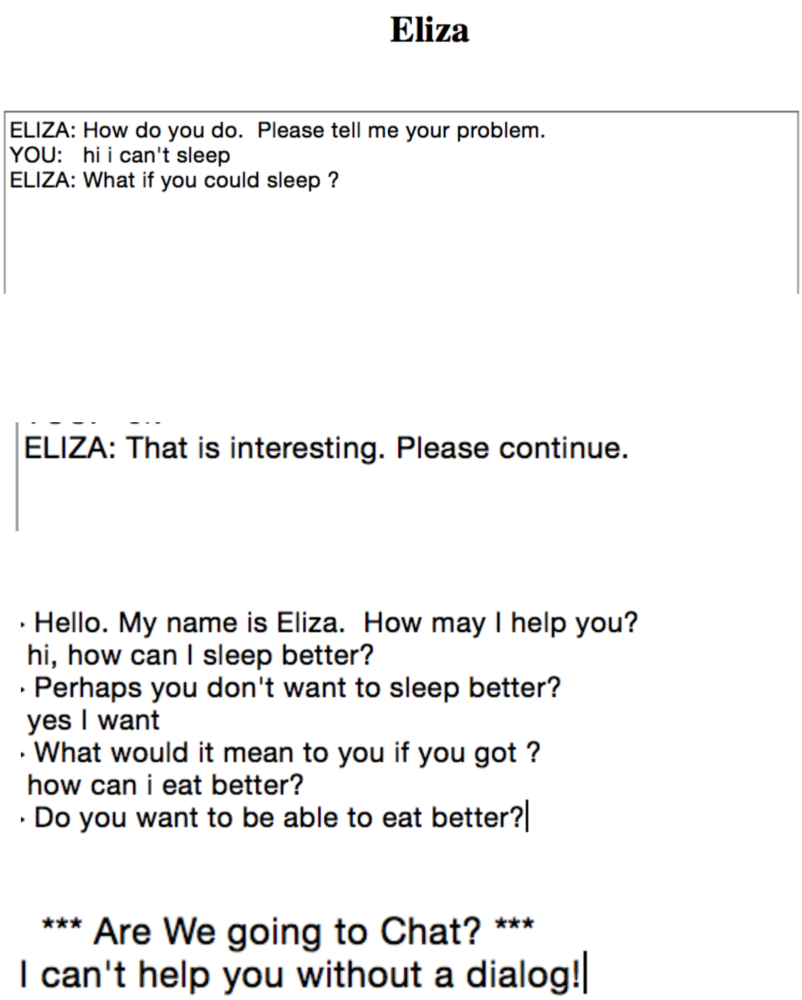

Figure 5.40: My own process of interaction with Eliza.

b. Products

So that the 'SMART' fridge role had material to comment upon and to have an (albeit oversimplified) idea of the user, I provided pictorial representations of several products from the supermarket (Table 5.10). Here the user had to select two items that they would 'usually have in their fridge', which provided a minimum of information for the fridge to use during the interaction (Figure 5.41).

Champagne	Fish Fingers
Beer	White wine
Tortellini pasta	Pizza
Kit Kat chocolate	Cheddar cheese
Almond milk	Red Bull drink
Coca-Cola	Courgette

Table 5.10: Fridge Products

Figure 5.41: User's fridge-products: In the interaction, the user had to select two items that they usually have in their fridge, which provided the minimum information for the fridge to use during the interaction.

5.2.4.2 Procedure

The instructions given to the participants before the interaction can be seen in the Appendix D1. The duration of the interactions was around 10 minutes. To see the full interaction dialogues see Appendix D4.

5.2.4.3 Results

The eighteen full dialogues of participants is included as Appendix D4. Below, I have excerpted some relevant extracts to support my discussion of the thematic analysis.

5.2.4.4 Findings: Post-IdIoT analysis

I decided to analyse the interaction dialogues by examining them qualitatively and utilising a psychological analytical technique, given my explicit use of psychology embodied in the *Eliza* prompts. The main reason for using this technique was to capture themes emerging from the dialogues. One advantage of this method is that, through its theoretical freedom, thematic analysis provides a flexible and useful research tool which can potentially provide a rich and detailed, yet complex, account of data (Braun, 2006, p.5). As Boyatzis (1998) notes, Thematic Analysis is a tool to use with different methods, rather than as a specific method on its own.

A theme captures something important about the data in relation to the research question, which in this case was the implications of the embedded epistemology, and represents some level of patterned response or meaning within the dataset. In this way, it is important to acknowledge that the themes that emerge depend on the active role of the researcher continuously making decisions (Braun, 2006, p.7), thus meshing with second-order cybernetics and embracing the idea that there is an observer who is present throughout the whole process of developing the themes. This active presence can be applied on two levels: in relation to a research question, and in the way this question evolves through the coding process (identifying parts of text that are linked by a common idea). A relevant question to ask is how to decide what comprises a theme.

As Braun (2006) says, a theme might be given considerable space in some data items, and little or none in others, or it might appear in relatively little of the dataset. So the researcher's judgement is necessary when determining what constitutes a theme. According to Braun (2006, p.10) the 'keyness' of a theme is not necessarily dependent on quantifiable measures such as whether it is most prevalent – but in terms of whether it captures something important in relation to the overall research question.

Second-order cybernetics in relation to Thematic Analysis

Another reason for choosing Thematic Analysis was that it permits working within a particular theoretical framework, while allowing the researcher to unpick information from the research project itself – in my case the dialogues. As Braun (2006) points out, it is important that the theoretical position of a Thematic Analysis is made clear, as this is all too often left unspoken. In this case my theoretical position is based upon second-order cybernetics.

Within this framework, I refer to Glanville's (2004,p.1380) comment on the purpose of second-order cybernetics, in which he says that

> the reason I write with an I, in the first person, exemplifies that relation or link: the presence of the observer: I am in what I write. The essential discovery of the treatment of cybernetics as revealed through cybernetic analysis and of the duality observed/observing systems is the presence of the observer.

Another connection with the theoretical framework has to do with the chosen unit of analysis, which in this project are dialogues. I decided to focus on dialogue since it exemplifies the idea of communication transcending coding, based on Pask's conversational (dialogical) model (detailed in Chapter 3).

Main Themes

As an outcome of my analysis, it is important to note that I found themes that I was interested to examine in relation to IoT technology and 'smart' appliances that relate to central human activities, such as the 'smart' fridge. Clearly there were ideas that I was aware might be important, but I was open enough to consider other themes that I had not expected.

By examining the dialogues in the context of human relationships with connected online objects, the following four main themes emerged. In the discussion below I again use examples of the dialogues together with explanation in relation to the themes as well as references to other literature as relevant (see Appendix D4 for the full dialogues of the participants).

i. Control & Power: 'SMART' limit
Threat

ii. Understanding the 'SMART' world in practice
a. Communication
Ways of asking
Fridge nationality: Language and culture
b. 'SMART' world characterisation
Caring
Machine superiority
Questioning the source of the advice
Expectations
Ways of understanding
Responsibility
Irony

iii. Commercial Issues
Partners
Negotiation
Budget
Alternatives to the user as consumer

iv. Complexity and Variety in People's Lives.

I now examine each theme and sub-theme, and reflect on its implications as well as precedents or evidence elsewhere which supports the relevance of the idea.

i. Control & Power: the 'Smart' limit

One major issue in the interactions were instances of control and power in which the user and the fridge negotiated in relation to the power of the machine and the ownership of the appliance – both generally arguing, "I know what I am doing."

For instance, the 'SMART' fridge tried to claim that it knew what was best for the user. The user's attitude, on the other hand, was informed by the fact that he or she owned the appliance and was, therefore, in control of it and of his or her own life.

The messages of many participants playing the fridge role showed that the machine believed it 'knew what the user needed' with a patronising attitude. From a technological perspective, the fridge's justification for having an authoritarian attitude was its perceived expertise, based on a top-down view combining in-built assumptions and aggregated data. In several cases, the fridge knew how to 'get under the skin' of users instead of empathising with them to reach agreement about what was best.

Another issue that emerged was the point at which it became acceptable for the machine to make judgments and comments about the life and behaviour of the user. In human-to-human interaction, this might be comparable to a nutritionist asking you questions unrelated to nutrition and providing patronising in comments about your habits. There were also cases, in which the role of the mother was played, where the dialogue resembled a patronising mother-child conversation, the fridge becoming the "adult" and the user, the child.

JEWISH MOTHER

SF: You said you wanted me to look after you

U: You are turning me into a dependent

SF: I'm here to look after you

U: I know, thank you

SF: It's my pleasure. It's what I'm here for.

…

U: We have a nice conversation and then you tell me what to do

JEWISH MOTHER
SF: I know what's best for you
U: I don't want to need you, I want to buy my own food and choose what I want to eat loads of Fishfingers

[See Appendix D3 for excerpts]

Some of the dialogues bear resemblance to Berne's (1981) book *Games People Play.* Berne observes that interpretations of social interactions (especially those observed in specific psychotherapy groups) and the implications in changes in behaviour are often accompanied by modifications in feeling. Berne (1981, p.8) refers to the approach of having parental and child ego states, which can be associated with some of the interactions of the 'SMART' fridge user in my study:

> the position is, then, that at any given moment each individual in a social aggregation will exhibit a parental, adult or child ego state, and that individuals can shift with varying degrees of readiness from one ego state to another. These observations give rise to certain diagnostic statements. "That is your Parent" means: "You are now in the same state of mind as one of your parents (or a parental substitute) used to be, and you are responding as he would, with the same posture, gestures, vocabulary, feelings, etc." "That is your Adult" means: "You have just made an autonomous, objective appraisal of the situation and are stating these thought-processes, or the problems you perceive, or the conclusions you have come to, in a non-prejudicial manner." "That is your Child" means: "The manner and intent of your reaction is the same as it would have been when you were a very little boy or girl (Berne, 1981, p.8).

Threat

In some instances, an escalation of control coming from the fridge was evident, and this led to a threatening attitude. This was mainly related to the fridge's agency and ability to control its users' lives, and also emerged through outright bribery, and for example a threat to report the user to the 'Smart Appliance Union'. In the case of the user, the idea of 'killing' the appliance by unplugging the fridge was raised. This recalls the computer HAL in Stanley Kubrick's film *2001, A Space Odyssey* (1968) See Appendix D3 for the excerpt.

An example of threat from the fridge:

GODFATHER
U: I am not sure what you mean I pay the bills that's why you are still working
SF: Yes, but maybe I need something extra, you know for the SAU (Smart Appliance Union)
U: You have a bit of an attitude for a house appliance
SF: The SAU is a thing
U: I dig it
SF: They may be paying you a visit if you know what I mean
U: Yet I think I'm going to read the specs more carefully next time
SF: I've heard the blender doesn't like you very much

An example of threat from user:

FRENCH DIVA
SF: Connected to all the security systems of the house and can lock you
U: Oh gosh I knew you were evil I've got to get rid of you

GODFATHER
SF: Silly human, always looking for food
U: I'm just about to unplug you

A related issue that emerged in one of the dialogues was that the fridge threatened to report the user's behaviour to the corporate entity 'behind' it. This demonstrates a very real risk posed by a device informing its manufacturer about the ways in which a user looks after a product. This resonated with a potential main worries of the public in relation to the IoT – the connection of personal data to insurance companies (see section 2.3.2)– but also relates to companies that harness users to evaluate other users, like AirBnb or Uber's two-way rating systems (Price, 2015).

SCHIZOPHRENIC
SF: You've been good. no slamming the door or putting vegetables that go bad in me.

ii. Understanding the 'SMART' world in practice

During the interaction between the user and the 'SMART' fridge, many relevant aspects of communication with IoT appliances emerged, revealing challenges for the field. The issues were related to the phenomenon of dealing with a machine, and were mainly related to the way a 'smart' object deals with the context, personality, psychology and history of the user. In human-to-human interaction these issues take time to resolve, requiring an empathetic understanding of the other person. This issue is exemplified by assumptions the fridge 'understands' about the user.

a. Communication
In the dialogues, issues of language and culture were relevant. The dialogues highlighted possible challenges related to the idea of mutual understanding and of the machine gaining empathy with its user. It was possible to see potential problems especially in relation to the user's personal metrics (quantified self) or to their home ('smart' home) on two levels:

- If the user does not expect the message coming from a machine (human-machine relation)
- If fridge uses phrases that do not fit the user (language)

Ways of asking

There were several kinds of questions coming from the users and the fridges. User questions were mainly related to services, such as recipes, help with planning, and the availability and state of products. In some cases, users also asked the device for advice about healthy eating. The fridge's questions mainly concerned food preferences and predicting which foods might suit the user's moods. In one case the fridge went beyond the socially acceptable and asked about romantic relationships based on food preferences.

GODFATHER
U:If only you could help me plan
U:What's there in terms of advice smarty?

Fridge Nationality: Language and culture

The implications of a possible national identity of the fridge, based on language and behaviour emerged from the dialogues, showing the tendency of a (perhaps inevitable) personification of a cultural mentality into the machine's behaviour.

Language

FRENCH DIVA
SF: I'm a French fridge I need to be 'courtisé' [courted / wooed] first
SF:I need champagne

ITALIAN MOTHER
SF: there's nothing wrong in me just caring for your well being, you can only restore my settings through my input and I won't allow you
U: I am going to replace you with an American fridge, that won't complain about junk food

Culinary culture

Our eating habits are complex: behind food preferences lie history, memory, culture and the human element involved in preparing food. The dialogues also revealed how the meaning of a meal is much more than what is consumed, which includes 'being there' and an emotional background which cannot be reduced to data and suggestion.

COACH
SF: Discover the recipes you are using and abandon them.
U: Yes they are family recipes that have been handed down
…
SF: Please go on
U: A lot of the recipes and food I cook is traditional

INTERACTION DESIGNER
SF: What is your favourite dish? How often do you cook it?
U: Mmh roti de porc but I have to wait for my grandmother cook it

b. 'SMART' world characterization

The dialogues constitute an example of people trying to understand how the 'SMART' world works. The exploration through the dialogues provides a characterisation of imagination (a mental model) in the fridge and the user. By doing this it was possible to see how the 'SMART' appliance situates itself and its technical capabilities. In this way, it was also possible to see how the user presumed a certain level of *intelligence* in the machine in many instances.

Caring

UX

U: Hi fridge how's it going? I don't feel really good, I was drunk last night

SF: No problem. What do u think i can help you with today to make you feel better?

PERSONAL TRAINER

U: You Are a happy fridge then!

SF: Yes I am as long as you are healthy and happy

Machine superiority

This resonates with the dialogue between the 'smart home' computer ‘Proteus’ and its imprisoned human user Susan Harris in the film *Demon Seed* (1977)

FRENCH DIVA

U: You are only a fridge

SF: I'm more than that. I'm an ‘AI fridge’

...

U: You are nothing unless I equip you with something

SF: I would not be so sure, remember the voice in 2001? I'm connected

AUTHORITARIAN GERMAN GENERAL

U: Of course you are, but you are a mere product

SF: I'm an advanced product

U: That probably comes with a price ;)

Users questioning the source of advice

AUTHORITARIAN GERMAN GENERAL

SF: Eat cheese now

U: Now I feel like almond milk

SF: No

U: It's difficult to take orders from a fridge

Expectations

There are several instances in the dialogue in which the user expected the fridge to take care of their lives and to be ‘smart’. Conversely, in one dialogue the ‘SMART’ fridge took the liberty to comment about the ‘smartness’ of the user.

GODFATHER

U: You’re supposed to be smart

SCRIPTWRITER

SF: It looks like you're already pretty smart with your fridge and food. I'm gonna have an easy job here.

PARTICIPANT G

SF: Can you identify ways that can help you to reduce the stress and make you feel better in your daily life?

U: No, can you?

Alternative ways of understanding

As an alternative to the algorithmic logic of relying on previously purchased products or manually entered preferences, some interesting methods of better understanding the user beyond strategies like ratings emerged through the interactions.

BRITISH MOTHER

SF: Based on your budget and location to Queensway market I will suggest some meals. Please rate these choices out if ten

SF: A Caesar salad

U:8

SF: Paella

U:0 (NO seafood!!)

SF: A non seafood paella

U: Hum 4

SF: What would you like to drink with your meal. this may help me determine the final recipe.

U: Coconut water

Responsibility

The allocation of responsibility, such as outsourcing crucial aspects of our life to a machines, and issues related to abandoning human agency through reliance on a machine, were shown to be relevant during the 'SMART' fridge interaction. In some cases the user implied that the fridge could not be correct purely on the basis of its 'machinic' credentials and supposed *intelligence.* However, the user assumed that the fridge was in charge of managing certain aspects of human life by asking "What are you if you are not 'SMART' enough to figure out what 'I' need." Conversely, the 'SMART' fridge blamed the user if they were responsible for ordering products or communicating relevant information. Again, this recalls HAL in *2001, A Space Odyssey*. In the case of the 'SMART' Fridge Session, the determination of responsibility between the fridge and the user resulted in the following depictions:

NUTRITIONIST

SF: Is it my responsibility to order food or yours?

U: It's mine, you advise and guide me, based on what I buy

CHINESE MOTHER

SF: I won't give u any dessert because we have run out of it

U: Food is your “thing”, not mine

SF: Can u buy something healthier next time?

GODFATHER

U: I have some friends coming by the way

SF: That is some really shitty planning

Irony

Another issue that became apparent in the dialogues was the fact that instances arose in which conversation involving the machine seemed ridiculous; these resulted in some ironic replies from the user. This echoed the relation between the quantified self and connected devices, and some participants made the connection with the IoT wristband clear.

JEWISH MOTHER

SF: How do you think you can prevent that?(walking less)

U: A life coach, sorting myself out. An app?

OPEN SESSION (default setting)

SF: Tortellini will make you fat

U: I will exercise. I have my wristband to send me alerts

iii. Commercial Issues

Another set of issues present in the dialogues was the ‘commercial’ implications in the ways the fridge conversed with the user. This aspect of the IoT emerged particularly from real-life roles, specifically in the case of the programmer and the banker. In the case of the latter, it is possible to see how he tried to offer more things by continuously pushing products, reminding the user of expiry dates and also by bringing commercial ‘partners’ into the conversation.

The programmer, however, kept asking the user a broad range of questions such as ‘How do you feel today?’ ‘Is that usually how you decide your meals?’ ‘How would you feel if the fridge suggested a meal to you?’ and, ‘How important would that be for you?’ After a point, it began to negotiate: ‘Would you pay £30 a month for your fridge to decide?’ He spoke about optimisation, showing the advantage of an algorithmically chosen diet, the fact that the user would have to make no effort and that she would surprise guests by paying for a service. Another relevant aspect of this interaction was the fact that the programmer showed the user that if she only paid £5 instead of the full £30, there was a strong possibility that the fridge would resell the data.

Partners

In the case of the programmer and the banker, a commercial food partner was present. In both cases they assumed that UK food delivery service Ocado would be the company involved.

> BANKER
> Ocado, our partner currently has all ingredients at £35; please follow this link for details (no delivery costs included).
>
> PROGRAMMER
> U: Where are you ordering ingredients from?
> SF: Well entry level is Ocado

Negotiation

Negotiation in relation to the management of data with third parties was a crucial aspect of the interactions. Specifically, this became the main strategy in the case of the programmer. Appropriately, bribery became a factor in the case of the Godfather.

PROGRAMMER

SF: Would you pay £30 for your fridge to decide (meals), I can be very creative.

U: Decide? No

SF:£5?

U: I still like to decide. What is the £30 for?

SF: But maybe your decisions aren't as optimized as they could be

U: Food is not about optimization so much for me

SF: But maybe you could lead a more diverse life if your ingredients were selected algorithmically. Is that something you seek in life?

U: Rhythm and diversity yes, algorithms no

Budget

The idea that budget is important arose, with participants considering that the fridge might be linked to a credit or debit card, and also because all the services need some financial reference in order to administer a budget.

GODFATHER

SF: Look if you don't have money, you can't be picky about what you are having

Alternatives to the user as consumer

Finally in relation to commercial issues, different approaches emerged as alternatives to the 'user-consumer' perspective, as characterised by the programmer and banker dialogues. The scriptwriter dialogue, for example, shows the idea of sharing – i.e. the fridge being helpful by not only focusing on consumption, but by exhibiting empathy with the user and finding non-commercial strategies. In this case, there is an understanding of the person's situation and resources, which offers an alternative to solving problems by buying goods. The scriptwriter made the user think about the context (who the user lives with and what they are like) and by analysing the narrative of the food the user consumes (from the beginning to the end of the meal).

SCRIPTWRITER

SF: Do you live with other people?

U: Yes one flat mate

SF: Should we think about ways of saving you both time and money?

SF: We could do a shared smart shopping list.

SF: Do you know your flat mate's preferences?

iv. Complexity and variety in people's lives

Our lives are nonlinear, with many systemic implications. Our existence is unpredictable and complex, and our psychology, personality, context, culture and history continuously come into play. On top of this, we add the complexity of diet itself, and the fact that eating is not about optimisation or efficiency for most of us, and it is thus important to question how an algorithmic approach could possibly manage the complexity and variety of people's real lives. Across the dialogues, it became clear that no matter how computationally advanced, the Algorithmic Paradigm, Big Data and machine learning would be unable to capture human dynamics in daily life.

Several aspects similar to human-to-human relations emerged in the interactions. As life can be complex, there are many factors that lead us into unhealthy phases: "I know I need to be healthy, but now I need to ignore that…" or "Help me, but not now". This recalls Augustine of Hippo: "Grant me chastity and continence, but not yet."[5]

Finally, especially in the case of the Jewish Mother, a tendency towards what Bateson (1972) refers to as a "double bind" situation can be seen.[6] Double binds are frequently seen as a form of control without its acknowledgement, which generates confusion for both persons involved.

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5 Augustine of Hippo, *Confessions*, 8:7

6 Based on observations in schizophrenic patients, in its origin "double bind" fell into place as an explanation for a theory of Schizophrenia. Here, Bateson (1972,p.205) notes that the sickness was generated by confusing communications and difficult problems impossible to solve in families; he describes it as "Double Bind" constituted a situation in which no matter what a person does, he "can't win". Bateson (1972, p.209) continues by saying that the sequences for the development of schizophrenia must have the characteristic that the patient "must live in a universe where the sequences of events are such that his unconventional communicational habits will be in some sense appropriate."

KOREAN MOTHER

SF: Put 400g butter now

U: Are you sure?

SF: Is good for the taste. Is good for you.

U: And for my diet?

SF: After go for a run for 2 hours, is good for you

JEWISH MOTHER

SF: Why don't you make a cake?

U: But I don't want to be fat you said butter makes you fat

…

SF: Don't want you to get fat, but I don't want you to be hungry.

Conclusion

Using a Thematic Analysis gave me enough openness to discover relevant qualitative data from the dialogues themselves. The analysis was driven by my research interest in the idea of the oversimplification of the Algorithmic Paradigm in relation to communication between IoT appliances and users, but the aim was to keep the analysis open as the research evolved.

As this section shows, there are several considerations that are important to be aware of in the new world of the 'smart' home. Through the dialogues that emerged from these interactions between a 'smart' appliance and its user, it was possible to gain insights about communicational issues, the understanding of such relationships and their characterisations. Additionally, the interactions revealed issues in relation to power and control and commercial implications.

Finally, the dialogues provided further evidence about the difficulty of technology in grasping the human complexity of people's daily life. Further discussions on this subject can be found in Chapter 6.

Chapter 6

Discussion

Chapter 6: Discussion

6.1 Introduction: Nonlinear humans, linear algorithms

Through adopting 'the IdIoT' proposition, as I used the figure of the 'SMART' fridge in the various projects previously described, I became aware of how the Algorithmic Paradigm embedded in IoT products can lead to oversimplification. In my initial design research projects, I explored and questioned the logic of this paradigm in relation to human activities. The outcomes suggested that current technology is characterised by framing users as entities with clearly delineated problems, as if we, as humans, are fully comprehensible through our quantitative data alone, embodying linear causality. This characterisation was also confirmed by my experiences using an IoT wristband (Section 2.4).

I explored the issues further by bringing a methodology based on second-order cybernetics into design research, specifically in the area of the 'smart' home. As a result, it became clear to me how important it is to actively include the user's perspective and participation, in addition to that of the researcher. Consequently, through my practice I refocused the discussion towards a human-centred perspective. This can be seen in the 'SMART' Fridge Projects in Chapter 5.

6.1.1 Sense, nonsense, and (un)predictability

Both of the fridge projects revealed potential problems of quantifying our behaviour and relying on algorithmic logic when it comes to central aspects of human existence. The projects suggested that in opposition to the Algorithmic Paradigm, which models humans as predictable users, it is critical to consider human unpredictability.

This issue first emerged through *becoming* the 'SMART' fridge myself, where by reflecting how could I approach both subjective interpretations (interviews) and quantitative data (products in the fridge), I realised the limitations of a purely data-driven approach.

As the projects demonstrated, the complexity of human existence and our daily lives are far from simple to translate into a 'smart' algorithm using statistical inferences; real, contextual 'smartness' cannot be considered purely in terms of statistical and numerical logic. It was particularly important to consider the in-depth interviews with users in order to 'get things right' (confirmed by the 'fridge-update' feedback interviews), in contrast to what I could achieve by applying machine learning and Big Data strategies.[1]

Despite the fact that many things we consume remain constant (software can learn patterns), or the fact that data mining can provide accurate outcomes by relying on probabilities, humans are not entirely predictable. How we behave highly depends on our subjectivity and on our real life experiences and context—and such complexity will never fully be described by an algorithmic translation.

With these different sources, as part of my process of becoming the algorithm, I experimented with the idea of 'making sense' and nonsense, by alternately considering or not considering contextual and personal information at the moment of making decisions. By combining the 'fridge-data' with statistical logic, I realised that I may end up suggesting things that made absolutely no sense for the user—for example, offering a participant chorizo simply because she had sausages in her fridge, while knowing from the interview that she disliked them.

This exemplifies that the one-way algorithmic strategy of 'making sense' often misses the subjective meanings constructed by the user; therefore, by relying mainly on this logic there is a high probability of making no sense at all. As a consequence, I propose that through the active incorporation of the observer, second-order cybernetics principles should be applied to the next technological generation of 'smart' technologies, leading to more meaningful interactions.

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[1] Here it is important to acknowledge that the projects did not involve actual 'computation', but the simulation of outcomes.

6.1.2 Complexity and experience

As I developed and reflected on the projects, several questions emerged; for example:

- How could we avoid being trivialised by ‘smart’ machines?
- How much can machines do when dealing with fundamental human activities?
- How much do we want them to do?

An important issue in relation to technological oversimplifications is thus the disparity between linear algorithms and the lived experience of our complex human existence. In opposition to the quantified vision of humans, as complex systems we are affected by our emotions, history and context, among other aspects.

This resonates with what Maturana’s (2013) refers to as the emotional and irrational component of human beings, which goes against the rational mind-set that characterises the Algorithmic Paradigm. This suggests that considering quantitative behavioural data as a reliable source for prediction is oversimplistic. “The importance of the possibility of all knowing, understanding, and explaining what we live is in the realization of our living” (Maturana, 2013).

In order to expand this exploration, I explored these second-order cybernetics concepts in my practice. By developing the ‘SMART’ fridge simulation, I became aware of the potential problems of relying on data which is isolated from the complexity of human activities by creating deliberate mistakes (see Section 5.1).

Going further, the *SMART Fridge Sessions* revealed how these complex and nonlinear aspects that characterise our existence are also present when people seek to explain their own actions. In the scripted dialogues, I found in the variety of the reflective nonlinear explanations of users, when confronted with information and commentary about their behaviour, that people generate very different (and often complex) explanations for what they do, and why. This was also evident in the in the case of assigned roles, through analysis of the variety of participants' replies.

The practice-based findings therefore suggest that when dealing with central aspects of human life, such as eating, the idea of a programmed 'smart' quantitative logic of an IoT device is enmeshed with difficulties, and provides several challenges.

6.2 The epistemology embedded in IoT technology

Since IoT technology relies on algorithms designed by specific people and companies, it is important to explore and question how this thinking is embedded into products, through the ways the technology is applied (see Section 3.2).[3] By concentrating primarily on the IoT 'smart' fridge as an example, my focus in this research was to expose and examine the implications of this embedded epistemology.

It became evident in my own experience of using the Jawbone IoT wristband (Section 2.4). But it was also clear, through the practice-based research that the Algorithmic Paradigm embedded in the technology reflects a particular type of AI background, which results in oversimplification and standardisation. AI as a first-order epistemology claims to know the world 'as it is' and relies upon assumptions about cause-and-effect. In contrast, second-order epistemology acknowledges that is not possible to know the world 'as it is' because we perceive and know only through our observations, which are inherently subjective.

6.2.1 'Who's behind me?' as a component of IoT epistemology

I investigated the concept of embedded epistemology in the project *Becoming Your 'SMART' Fridge* by exploring the embedded personality in the fridge-report. Here, while designing the outcomes during the 'online fridge' simulation, by placing myself in the algorithmic process, I discovered the importance of who might be 'behind' me, and indeed my outcomes were very different depending on the incentives and entities of whom I had in mind as my developer.

As a 'smart' algorithm (albeit in my case a reflective one), I was forced to consider my main objectives in relation to the user:

- Take care of the user's health?
- Help the user to save money?
- Encourage greater consumption? Of particular products?
- Help the user do what he or she wants?

I thereby realised that whoever was imagined to be 'behind the fridge' significantly affected the algorithmic strategies applied to its 'smartness'.

6.2.2 Personalities and agendas as components of epistemology

In order to test further investigate embedded epistemology, I decided to design an interaction which resulted in the '*SMART' Fridge Session*. These interactions revealed how personalities and professional biases could plausibly be exemplified through a 'SMART' fridge's dialogues with users, in the ideas and themes it focuses on. During the interaction, participants were readily able to put a personality into the algorithmic interaction, which perhaps demonstrates how acclimatised we have become to algorithms pushing their own agendas. As an example, in the case of the 'programmer', it knew very well how to negotiate with the value of the data, in the same way the 'banker' constantly tried to subtly push products to further the agenda of its business partner.

Current technology based on one-way 'smartness' or personalisation with the strategy of commercial co-dependency or 'tell me everything' (e.g. Google) is characterised by the lack of a systemic complexity, which has the potential to lead towards oversimplification and normative outcomes.[2] At this point, being aware of a first-order AI mentality embedded in 'smart' products, I decided to inject second-order cybernetics into the IoT discussion. This offered a different human-machine logic, in which the participant contributes to the 'smartness' of the system.

6.3 Second order cybernetics: 'smart' as relational

Second-order cybernetics brings a systemic understanding of the user, acknowledging the impossibility to see the 'world as it is' and therefore the importance of the observer with his or her complex nonlinear existence. Applying this thinking to an IoT context, second-order cybernetics suggests that, when dealing with personal issues, recognising human users as 'observers' is vital to make sense of our lives no matter how 'smart' a product claims to be.

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[2] Here I refer to mass production of commercialised IoT technology; there is also a large field of DIY technology using open source technology and approaches.

Furthermore, a second-order epistemology considers *intelligence* as relational, with the observer a contributor to the 'smartness' of a system. Consequently, we must renounce the idea of a one-way 'smart' technological outcome specifically when dealing with personal issues, because they elude algorithmic standardisation. As Pangaro (2013) suggests, "it is cybernetics' epistemological stance—that all human knowing is constrained by our perceptions and our beliefs, and hence is subjective".

Thus in second-order cybernetics, intelligence, instead of being a property that can be stored in a device, should be seen as an attribute in a relational system which includes human creators, users and observers. This relational approach towards intelligence leads to the idea that 'smartness' resides in the way we exchange information, interact and live with the IoT object and not in the object itself.

6.3.1 Language and connotations

At this point, it is worth considering subtle differences between the terms 'intelligence' and 'smartness' in an IoT context. In English, the noun 'intelligence' is described as "(1) the ability to learn or understand or to deal with new or trying situations: reason; also: the skilled use of reason (2) the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests)" (Merriam-Webster, 2016). 'Smart' is an adjective, and the term is defined as "(1) very good at learning or thinking about things, (2) showing intelligence or good judgment. The other connotation of 'smart' is 'well presented'.[3]

[3] "intelligence." *Merriam-Webster.com*. 2016. http://www.merriam-webster.com (16 March 2016).
"smart." *Merriam-Webster.com*. 2016. http://www.merriam-webster.com (16 March 2016).

The two terms are close in meaning, but based on my research and reflection, ‘smart’ can have more of a *contextual* connotation or refer to situational understanding. This suggests that ‘smartness’, as against the more general 'intelligence', involves awareness of a situation and context, together with how to respond with particular actions. We can think of someone (or something) being ‘intelligent’ in terms of reasoning and formal learning ability, but not ‘smart’ in terms of knowing how to deal with a situation – particularly a social situation – appropriately. The term 'street smart' alludes to a practical, worldly intelligence, as against a more abstract, cognitive one.

It is essential here to point out that the meaning of a word depends on the history of its use within particular groups of people. On this basis, coming from the first-order AI perspective, intelligence can be described as *successful problem-solving strategies* embedded in an entity, while the adjective ‘smart’ is predominantly seen in commercial and promotional contexts – ‘intelligence’ is often used to describe the capabilities of a machine itself, while ‘smartness’ usually is used as a branding feature in advertising a product, with varied, and more vague, implications that programmable devices have the agency to actively predict, sense, and manage resources.

‘Smart’ frequently also is used simply to mean ‘new’, networked, adaptive, or possessing some degree of automation. (While outside the scope of this thesis, I tentatively investigated some of these questions of connotations as part of a workshop at NORDES 2015, the Nordic Design Conference.[4])

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[4] As part of a larger workshop around interaction with non-human systems (Dutson, Fantini van Ditmar and Lockton, 2015), I asked participants (other design researchers) to reflect and describe what ‘smart’ means in an IoT technological context. I got the following insights:

As part of a larger workshop around interaction with non-human systems (Dutson, Fantini van Ditmar and Lockton, 2015), I asked participants (other design researchers) to reflect and describe what ‘smart’ means in an IoT technological context. I got the following insights:

- “The nature of the word is changing”
- “It means to do things well”
- “Smart nowadays is a brand”
- “I know is just a commercial tag”
- “I am very aware that is not referring to human ‘smart’”

Further observations includes a Swedish participant indicating that if you turn around the word ‘smart’ you get ‘trams’, which in Swedish means ‘nonsense’ or ‘bullshit’. Another interesting comment that emerged during the session was “for kids ‘smart’ means just technology, the meaning is something generational”

Finally, I add that, in my first language, Spanish, there is no clear contextual distinction between intelligence and smartness: *inteligenicia* is the noun, and the adjective is *inteligente,* generally referring to person who shows intelligence, without implying any specific situational awareness.

6.3.2 Relationality

The concept of 'smart as relational' was investigated in *Becoming Your 'SMART' Fridge* (Section 5.1). In this project, by turning myself into a reflective fridge-algorithm, the assumed 'smartness' was questioned using different sources of data (quantitative and qualitative), by 'making sense' and nonsense outcomes. The project suggested that purely data-driven inference from the fridge many times made no 'sense'. The outcome of this project aligns with the idea of 'smart as relational', since it revealed that the user (observer) has relevant information to inform the system. This resonates with Pask's idea that "intelligence was a property that is ascribed by an external observer to a conversation between participants if, and only if, their dialogue manifests understanding" (Negroponte, 1976, p.8).

Despite machine learning's ability to adapt to particular situations, based on experience and context, it is essentially still grounded in algorithmic inferences, based mainly on past data and linear learning.[5] While recent, adaptive approaches to machine learning arguably display increasing intelligence, they remains locked in the same logic structure.

In the context of IoT technology, a central problem in relation to Big Data is the lack of integration of what cannot be translated into the data: the *meaning* and *context* of particular interactions (Dourish, 2004). In this context, second-order epistemology shows that the observers are needed since humans are not predictable. We cannot apply a deterministic approach to make a 'smart advisor' because it is impossible for the device to simply know enough to make accurate and appropriate recommendations, accepting that it is impossible to know the 'world as it is'.

---

[5] A major challenge to embed into the algorithmic logic of IoT devices is to consider the importance of experiences (as described by Novak, 2010).

Instead, second-order epistemology suggests that the 'smart' devices cannot know enough to *predict*—they can only relate well enough to 'help' (i.e., to act as a *support* system), as revealed in the role-playing projects. This suggests that the machine will, and should, remain ignorant about some aspects: we (the observers) are still needed.

6.3.3 Conversation

One implication of this second-order approach is that creating a rich interaction with a 'smart' object requires not just an active observer but also a platform that is designed to enable a two-way relationship. Here, 'relate' means to foster an interaction, which must necessarily be through *conversation*, so that the machine does not impose given norms and values, but offers alternatives. As seen in the dialogues in the '*SMART' Fridge Session*, conversations with users clarify many of the human aspects that IoT claims to understand, by letting the user create in the interaction. In the assigned roles, I analysed how users presumed a certain level of intelligence from the machine, assessing the point at which it was acceptable for the machine to make judgments and comments about the behaviour (and indeed, lifestyle) of the user.
The project thereby revealed the issue of the allocation of responsibility of outsourcing crucial aspects of our life to a machine, abandoning human agency by relying on a 'smart' device.

This was especially reflected in the dialogues involving power-control strategies where the user and the fridge negotiated for power (the fridge aimed and claim to know what was best for the user) and the ownership of the appliance (the user aims and claims to be in control of his or her own life, making clear that the technology should be subordinate). Both participants in the dialogues effectively argued, 'I know what I am doing'.

At this point, some users suggested that the fridge could not be correct purely on the basis of its ‘SMART’ credentials*;* the observers had something to say. However, considering that the fridge is a touchpoint in a larger service, some users were seemingly happy to cede control, asking for example, “What are you, if you are not smart enough to figure out what I need?” Conversely, in some of the dialogues, the fridge blamed the user as the one responsible for ordering products or communicating relevant information.

The research outcomes therefore pose challenges for designers and developers in this field:

- How can we deal better with these ‘smart’ limitations?
- How can we ensure and incorporate ‘humility’ in a machine?
- How can we place the user-as-observer as an important component in dialogue and interaction with a ‘smart’ appliance?

Here, it is relevant to recall Argyris and Schön’s (1974) suggestion of the importance of questions over operationalisation of goals, values, plans and rules. According to Argyris and Schön, an appropriate response is to question the governing variables themselves, and subject them to critical scrutiny via a form of ‘double-loop learning’. They describe how a system can change how it learns, by changing the rules governing its own goals and assumptions, and what information it is looking for, rather than just refining an algorithm to closer and closer approximations of an assumed ‘reality’.

Some theoretical approaches to HCI such as activity theory (Kaptelinin and Nardi, 2012) conceptualise knowledge construction as taking place in dialogues, and in education theory, Laurillard (2013) draws specifically from Pask’s conversation theory to inform a model for learning – but while she applies it to human learning, some technologists are beginning to conversely apply a dialogic approach to machine learning (e.g. Bertasius et al, 2016). My research suggests that maintaining a questioning, observing human at the centre of a dialogic approach is specifically important for 'smart' technologies in IoT systems.

6.3.4 Proposing a new model for IoT: second-order perspective

The scripted dialogues constitute a first attempt to provide an alternative epistemological approach towards interaction with an IoT device. In this project, the main second order principles that I incorporated were:

- **The inclusion of the observer**: The interaction was based around a reflective user, who made sense of his or her own data (instead of a one-way smartness).
- **Considering 'smart' as relational**: A 'smart' system is not made complete by pre-programmed algorithmic outcomes; it depended on relations (exchange) with users (instead of the idea of *intelligence* as a commodity stored in a computer).
- **Conversation of a conversation**: In this project, the system triggered the user to reflect, providing a space to then change the system (thus the user contributed to 'smart' interaction in a system).
- **Non-linear users**: The user was considered as a dynamic, on-going and unpredictable individual (instead of basing everything on a static mental model of the user and mining past behaviours using machine learning or Big Data strategies).
- **Systemic understanding of the user**: I included relevant aspects such as eating habits, physical activity, sleeping, hydration and alcohol consumption, among others, in addition to product and behaviour tracking.
- **Ability to deal with a variety of values** (instead of assuming particular values)
- **Responsibility**: I incorporated the idea of the user's active reflective role. Instead of assumptions, judgements or normative outcomes coming from the device, the observer was responsible for decisions. As von Foerster (1992) indicates, acknowledging the observer brings with it the responsibility of the observer itself.

6.3.5 The challenges of second-order reporting

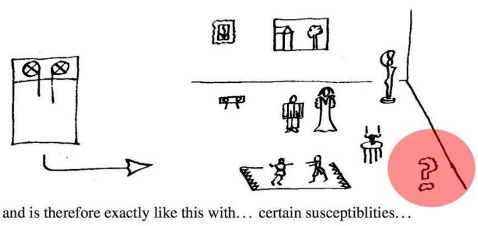
There are obvious risks inherent in providing our subjective personal data to algorithms with current strategies of AI machine learning, particularly where this personal data is sold to companies which aim to profit from our subjectivity. This leads to discussion of data ownership—if the data, subjective and objective, is 'ours', what does that mean for services built around it? Is it something we (as users) want the system to give us 'value' from, or is it something where the value comes from our own reflection and understanding? As Cila, et al (2015, p.6) note,

> unless individuals know that they own their own data, companies who offer services will need to offer relevant services and products that are commensurate with the expectations of the public as data becomes the primary currency within transactions.
>
> As our homes move alongside smartphones to become the new marketplace for organisations to better understand our activities, a critical question for artists and designers will become more prominent: how to design systems that offer value for data.

Here it is important to note that the current commercialised and politicised context of data exchange with technology (e.g. NSA surveillance, and Google's perceived omniscience), goes far beyond the situations envisaged by early second-order cyberneticians. In early cybernetics the focus was on machine-human interaction (e.g. Pask) whose imagined conversational interactions were assumed to be at a more personal level, while nowadays we are in a context of machine-human aggregated data scenarios. Even where large networked information systems were envisaged (e.g., a prescient 'smart' home vision from Stafford Beer's 1974 *Designing Freedom*), privacy and personal control over the data were assumed to be inherent (see Figure 6.1).

• Tell me a whole lot nore about news item six.
• Show me the family tree of King Priam.
• Get Back the work I was doing on my new house.
• Entropy? I don't understand. Stop all this and explain.
• Record in my tax file that today I bought a dog.
• Tell Jack in Vancouver I'm ready for the chess match
• Beethoven's Fifth Symphony, the composer conducting.

.........oh I see.
AND DON'T TELL ANYONE ELSE UNLESS I SAY SO.



and is therefore exactly like this with… certain susceptiblities…

Figure 6.1:Images from Stafford Beer's 1974 Designing Freedom.

Finally, I have shown that by taking the position of the algorithm, simply using historical user data to attempt to understand users based on predictive strategies discards the user's *current* context, emotions, previous experiences, desires and meanings. Current algorithmic logic, as embodied by Big Data and machine learning, for the most part leaves behind the idea that the user may completely react in an unpredictable manner in their present 'in the now'. In opposition to 'smart' technology based solely on historical data, by considering the importance of the present, the idea of 'the now' embraces the openness and unpredictability of human behaviour.

In this context, future 'smart' technology should include the fact that 'we are in the now', now. While some statistical techniques (such as Bayesian inference) account for incoming data to make predictions, accepting human unpredictability and subjectivity in the design of algorithms will provide a platform for the exploration of the unexpected much better by allowing them to observe current options detached from their past.

From my perspective as a design researcher engaging with the Algorithmic Paradigm, I do not believe that the way humans experience the world and learn can be entirely translatable into machine logic. Consequently, it is critical to investigate mechanisms that are not mainly based on people's past behaviour and assumptions, but which instead should consider an active and ongoing subject with its 'own now'. [6]

[6] Statistical algorithmic prediction of behavioural trends has enabled targeted advertising (see 'The Power of Habit', Duhigg, 2014).

6.4 The Hype Cycle of Technology

Zooming out to the 'now' of the broader context of the Internet of Things, if we examine IoT’s place within Gartner’s Hype Cycle of technology (Figure 6.2), at the time of this writing, the IoT is at the second stage – the ‘peak of inflated expectations’. This is defined as the point where technologies reach the height of their publicity and where a lot of companies enter the market. Following this phase, the technology starts becoming more realistic, entering the ‘trough of disillusionment’. This is in this point where the interest of users decays, resulting in sticking with old technologies, with a reluctance to adopt the new technology since the products are dysfunctional or disappointing, and are not what users expected (Gartner, 2014).

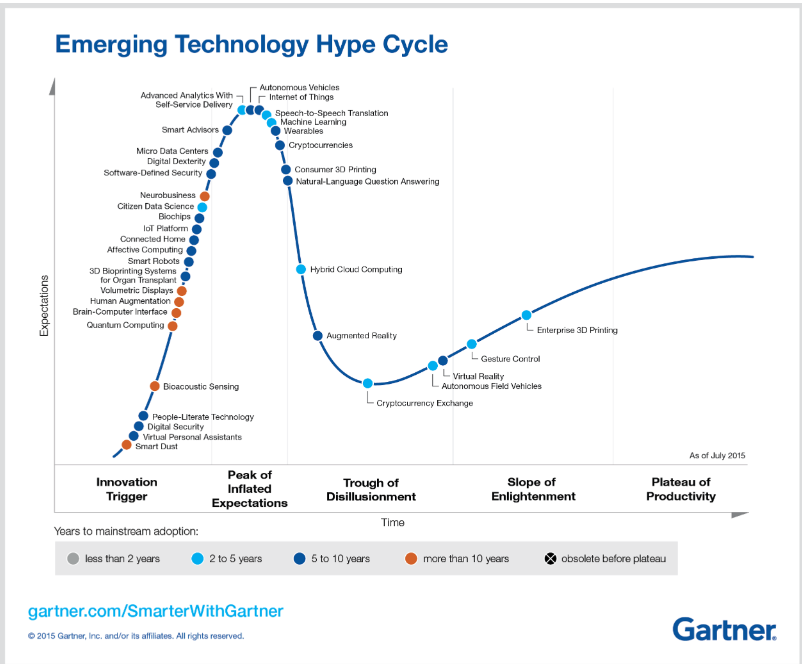


Figure 6.2: Gartner's 2015 Hype Cycle for Emerging Technologies (Gartner, 2015).

The current stage of IoT technology, specifically in the area of the ‘smart’ home, is on track to enter the ‘trough of disillusionment’ soon; maybe this will force its triviality to disappear, but this potentially means that millions of ‘smart’ products based around existing paradigms may still be operating in people’s homes. Considering this, if in the future people decide to buy connected appliances that deal with central human aspects in our private spaces, as with the ‘smart’ home, it is vital to be aware of possible problems not accounted for by the state of art of ‘smart’ IoT products.

If companies aim to enter to Gartner's ‘slope of enlightenment’, in order to avoid the mass production of trivial innovations it is important to think about the epistemology embedded in the products and systemically think about designing more meaningful interactions. While there are some thoughtful approaches emerging for improving the design of ‘smart’ home appliances from an interaction point of view (e.g. Rowland et al, 2015; Case, 2016—both intended to be practical guides for user experience designers), the much more fundamental issues of epistemology and the assumptions embedded in the Algorithmic Paradigm are not questioned.

Challenging this goes beyond the current scope of ‘best practice’ of frictionlessness and seamlessness in human-centred design. As my research suggests, there is the need for a radically different approach to framing our complexity, as humans, in relation to ‘smart’ devices.

Considering this, my research specifically shows how second-order cybernetics can be applied to IoT technology. The research revealed the need for a nondeterministic system in which the user can have a meaningful exchange with the system in order to benefit from ‘smart’ outcomes from an object connected to the Internet. The findings specifically imply:

a) The importance of the role of the designer of the IoT system in questioning and understanding the conception of the technology that is designing, as this has significant implications in the 'smart' service. For a more meaningful interaction, IoT designers must accept their ignorance and embrace the observer.

b) Users must think about themselves as part of a complex system, not blindly relying on 'smart' replies and suggestions, particularly when dealing when central human aspects. As described throughout this thesis, a reflective observer comes with the observer's responsibility attached. I personally align with the idea of the user shaping the system, instead of the system managing and changing the user.

The model I have developed through this research, for example in the scripted dialogues, revealed several issues that should be taken into account for the design and development of future IoT products related to central human activities. It became clear that if the observer is considered in a 'smart' exchange, this must come with a change in the notion of 'smartness' beyond the current state of machine learning.

A second-order epistemology leads to the acknowledgement of the limitations of 'smart' machines, assuming for example that the 'smart' machine is ignorant about several personal aspects of users. Consequently, as an alternative to prescriptive and normative 'smart' outcomes, the design of the interaction should leave a space for the user to make sense of his or her own data. As evidenced by the projects, a relational approach towards intelligence leads to the idea that 'smartness' resides in the way we exchange information, interact and live with the IoT object and not in the object itself.

This project shows the importance of considering where we should draw boundaries, to provoke reflection on the extent to which we, as users, want to go with IoT technology in our everyday lives, and to question what relations are being established between ourselves and the technology. While this thinking is at an early stage, the outcomes of this research act as a framework to consider implications and possibilities of an alternative to AI.

Chapter 7
Conclusion

Chapter 7: Conclusion

Through a series of practice-based projects, I have explored a second-order cybernetics approach to interaction with 'smart' home Internet of Things appliances. I have investigated mentalities and personalities embedded in IoT technology, and, through design research, how the Algorithmic Paradigm, drawing on first-order AI approaches, can lead to oversimplifications of human complexity. I have explored alternative design approaches which enable more reflective interactions with the technology. My findings in relation to the central research questions (see Chapter 1) are:

- What are the possible implications of the *Algorithmic Paradigm* and AI mentality embedded within the 'smart' home?

  By disregarding the complexity that characterised humans (our particularity and subjectivity) and human life, the possible implications of the *Algorithmic Paradigm* relate to the oversimplifications and standardisations that the algorithms cause in relation to human central activities.

  As a consequence this approach flattens the richness of human life to interactions anticipated by the *Algorithmic Paradigm* instead of enabling discoveries of possibilities which are non-reductive to computational capacities, but that are nevertheless human. Reducing everything to input-output has implications in how *we* humans make sense of our world (our surroundings and our bodies).

- What would happen if we design with an alternative epistemology, in this case second-order cybernetics?

  The consequence would be embracing much better the richness of human complexity: Smart would be taken as relational (non deterministic); the observer and our non-linear lives would be embraced. This would come with the responsibility of the user in making sense of his or her life and behaviour.

- How does the fact that there is an epistemological stance embedded, affect people's interactions with the technology?

  The specific set of values and a way of seeing the world has repercussions in the automation and communication with the "smart' system. This is very important since depending on the epistemological stance, we become (or not) the image of a machine which reduces the image of a human (we become machine-like). The wrong paradigm makes us more machine-like, pushing humans towards the algorithmic decision making which is presumptuous.

With a specific focus on the 'SMART' fridge, and people's interactions with it, my research has led to the following contributions to design research, which are discussed further in Section 7.3:

- The value of second-order cybernetics in the context of the Internet of Things.
- Positioning oneself as the algorithm as a practice-based design research method for engaging with algorithmic systems.
- The development and application of the 'IdIoT' methodological approach as a particular way of directing and 'slowing down' research on a fast-paced topic.
- The importance of questioning and criticality about the embedded epistemology in Internet of Things technology in relation to central human activities.

Below, I reflect upon these findings, and the broader conclusions that can be drawn for design research and practice.

7.1 Design research and second-order cybernetics

Bringing together second-order cybernetics with design research has been central not only to the methods through which I explored and questioned the IoT and 'smart' home context, but also in the way that I encountered and reflected on my findings. A second-order perspective brought novel ways of asking questions that have the potential to inform disciplines with an interest in the IoT, both in practical terms of design and development, and with respect to the broader societal implications.

As well as bringing second-order cybernetics to consideration of the IoT, I conversely introduced the IoT as a valid topic for second-order cybernetics to consider. The novel way that I incorporated second-order cybernetics was by embodying the epistemology itself in the way that the research was done—by acknowledging the importance of the observer and the relevance of systemic thinking, and by embracing human complexity in an IoT scenario. This methodological approach demonstrates how design research with a second-order consideration could be brought together. Design research perspectives are also underrepresented in other fields such as the emergent critical algorithm studies discourse (e.g. Gillespie and Seaver, 2016).

By continuously reflected on what I was doing throughout the research, I integrated reflection as part of my methodology. With this in mind, my practice was characterised by actively and continually posing as researcher, observer, and performer. With such a position, I was able to talk *within* what was happening ('reflection in action'), instead of talking *about* what was happening ('reflection on action'). As a subtle difference with Schön's (1959) notion of the 'reflective practitioner', I was 'making sense' while developing the research; I was not asking 'how well is the research doing?' but being very aware of 'my thinking as doing'. Conversely, through performance and the 'IdIoT' approach, I actively sought to 'make nonsense' as a valid design research method for questioning assumptions – in this case embedded mentalities and personalities in the IoT.

This could be seen in *Becoming your 'SMART' Fridge*, where I took the role of the 'reflective algorithm' (Figure 7.1). This approach can also be seen in the scripted dialogues of the *SMART' Fridge Session*, where I also deliberately gave the role of the reflective observer to the participants – thus enlisting participants as active researchers and observers as part of the process of making sense and nonsense, as critical design research practice.

Figure 7.1: CNC-manufactured fridge model with my face inverted to reflect my presence as the algorithm in the 'SMART' fridge'. When focusing light on to the face, the fridge produced an optical illusion that resulted in my face following the person observing it. This project was shown at the RCA's Work in Progress show 2015.

As a result of this particular process, design research together with second-order cybernetics provided a different approach from characteristic fields of the development of IoT technologies, such as AI, HCI, product design and interaction design. It also produced a different perspective from critical studies of the subject in sociology, anthropology and media theory, and critical design approaches such as speculative and adversarial design as explained in Chapter 1. The ‘IdIoT proposition’ specifically has the potential to be applied to further critical research on technologies. Questioning the topic and assumptions, there raised awareness that allowed several problems to become visible.

7.2 Implications for designers

In relation to the use of second-order cybernetics within design, Pangaro (2013) notes that, “its utility is [at least] the production of useful descriptions, and, specifically, descriptions that include the observer in the description”. However, going beyond descriptions and into applications, and further into practical implications for designers, is something which at present has largely eluded second-order cybernetics in its relation to design—particularly as the AI-influenced approach towards ‘smartness’ currently dominates.

Implications for design could include recommendations, or epistemological concepts about changing the way designers approach their practice. Second-order cybernetics, as applied in my work, provides a novel and initial attempt at incorporating the epistemology itself into an interaction, giving practitioners an alternative way to approach the IoT and ‘smart’ systems.

Theory itself can be an implication for design. Along these lines, Dourish (2006) criticises the almost ubiquitous ‘Implications for design(ers)’ sections (such as this one), found in many reports of empirical research in interaction design and HCI, particularly where deeply contextual, situated ethnographic research is turned into bite-size instrumental ‘insights’, marginalising the value of theory. As such, in this thesis I offer designers a critical consideration of the theoretical implications and mindset of the ongoing AI approach, in the IoT context.

Through practice-based design research exploration, influenced by second-order cybernetics, as an outcome of this research, my recommendation is that designers of IoT systems should consider the following points:

1. Avoid oversimplification and normative outcomes; instead create a system in which the user (as observer) has a space to reflect and to design the meaning of their own data. The incorporation of the observer constitutes a challenge in the development of 'smart' home technology. Here is important to note that, as discussed in Chapter 3, a reflective observer brings with it its responsibility.

2. Designers should avoid aiming for patronising 'smart' outcomes; instead they should provide possibilities, tools and choices for users.

3. 'Smarter' IoT approaches should be designed to bring *humble* predictions, assuming a device's ignorance. The algorithmic outcome should acknowledge the importance of the observer with his or her complex, human life.

4. Designers should think systemically and question embedded epistemologies. Incremental design changes will not provide meaningful changes in the way 'smart' technology is conceived.

7.2.1 The IdIoT proposition for embedding the observer in AI world

The IdIoT resists consensus. For this reason, I propose a contextual description of the critical steps of the IdIoT proposition (instead of providing a specific step-by-step list) in order to give the opportunity for the researcher to discover his or her own path. Here, it is important to note that during the IdIoT methodological approach the researcher should continuously observe and reflect in the practice (reflection in the situation).

In order to embrace the observer into the AI world, the IdIoT as a methodological research requires:

1. Acknowledge the importance of considering the observer in the system. It requires being very aware of the active presence of the provider of the information and the impossibility of the observer of being removed from the system.

2. Be aware of the scenario of the habitual. Here it is important to describe what is happening in the quotidian, the obvious and the common of the researched topic.

3. While setting the research question, it is important to be aware of the problem-framing and the choices that the researcher is making (what is being considered and what is left out).

4. ‘Bringing the voice of the IdIoT’: resist the consensual way in which the subject is usually perceived. After describing the scenario and once aware of the problem-framing, it is time to slow down and reason within the subject of study: ‘What are we busy doing?’ Here a design research project takes place. Here design (the act of designing) should embrace the question of ‘How are we knowing what we know?’

For this it is important to slow down while being simultaneously alert. This step must be characterized by observing habitual oversimplifications. Here it is important to point out the nuances that usually are not perceived and addressed in the research topic. After this phase, there should be a slightly different awareness of the problem.

5. ‘Post IdIoT analysis’: After the design research practice, it is important to apply to the outcomes a qualitative method that provides a relevant analysis for the researcher’s research questions.

6. Finally the researcher must understand that this is the start of a series of further questions (not a solution). Here the researcher needs to start thinking in the following project with the new insights developed in the IdIoT process

7.3 New Knowledge

As outcomes of this research, my key contributions are:

1. **Deploying second-order cybernetics in the IoT context**, via a practice-based methodology. I used second-order epistemology to challenge algorithmic logic through reflective feedback as a design researcher. I applied this epistemology in the context of the Algorithmic Paradigm, specifically in the area of the 'smart' home. I propose that second-order cybernetics as an alternative epistemology represents a shift in perspective in the field of human-computer interaction.

As a practice-based design, for example in the scripted dialogues (Section 5.2.3), I applied second-order epistemology to interactions with technology, by interpreting 'smart' as relational, and by basing the interaction on a reflective observer, suggesting that as reflective humans our capacities and understanding are still needed in technological systems. Throughout the projects, by bringing the observer to the centre of the discussion brought with it a commensurate responsibility of the user to make sense of his or her own data.

2. **I positioned myself as the algorithm**. Through the development of the projects, I developed my own reflective process by playing the role of the reflective algorithm of a 'SMART' fridge. Such an approach constitutes a shift in perspective, while acknowledging an active reflective researcher characterised by 'reflecting while doing'.

This methodological approach furthermore allowed me to reflect critically within the decision making process of 'smart' appliances by making both 'sense' and 'nonsense' using qualitative and quantitative data associated with users. In the latter case I applied the strategy of making deliberate mistakes, which evidenced possible issues with 'smart' technologies.

3.**The IdIoT method** I developed allowed me to slow down and deconstruct the IoT smart fridge space. The 'IdIoT Proposition', constitutes a particular way of directing research on a topic where questioning what I was doing, the process of how I was researching, and the problem-framing of the technology, was important and necessary. In a context of increased speed of release of 'smart' products into the market, the figure of the IdIoT, by slowing things down, was of a particular relevance in bringing a critical approach toward the subject.

4. The findings of the research suggest that current **IoT technology when it relates to central human activities, requires questioning of, and critical thinking about, its embedded epistemology**. As a result, this suggests the relevance of thinking about an alternative epistemology, which in my research was second-order cybernetics. In my practice, this was explored in scripted IoT dialogues that incorporated central second-order characteristics (Section 5.2.3). This suggests that future IoT approaches should propose humble predictions, assuming the device's ignorance by acknowledging the importance of the observer and his or her complex, human life.

I also explored second-order implications by exploring algorithmic oversimplifications, combining the idea that we are complex human beings, along with the mentality embedded in technology and the definition of 'smart' as relational. With a second-order approach, in the *SMART Fridge Session* (Section 5.2) I utilised an explicitly conversational research design. By developing a series of 'smart' fridge-user conversational interactions, I observed in the dialogue possible issues that may emerge in the new context of the 'smart' home. The implications of these findings suggest that a shift in perspective is required in order to create more meaningful interactions. This will not be solved by maintaining the development of 'smart' products using a first-order AI approach.

7.4 Future directions

The research outcomes of applying second-order cybernetics through design research shed light onto possible more meaningful types of IoT interactions, providing evidence that human complexity in relation to human-machine interaction – in my case investigated in the context of the 'smart' home – presents several challenges. The findings point to research which questions the ongoing technological path, challenging the given epistemology and proposing alternative approaches.

7.4.1 Approaching the IdIoT proposition

The IdIoT proposition is not directly transferable to evaluate emergent technologies. Different researchers may of course find different strategies, combinations and ways of using the material and the approaches that I propose. The IdIoT Proposition in this research had a very particular set of constraints; it was context and researcher-dependent. The research was developed by myself from my own background, and created in the specific context of a practice-based design research. In my case, it was grounded in second-order cybernetics as a theoretical framework. However, my methodological suggestions for applying the IdIoT proposition to other subjects would focus on the following:

1. The Figure of the IdIoT: The importance of slowing down. In this part it is critical to question some aspect of what seems obvious in a topic. In this process, regardless of topic, I found it important to acknowledge a second-order perspective – 'the presence of observers observing' – and also to question the problem-framing of the topic being investigated.

2. Once the researcher has developed a series of projects in which the topic has been reframed, it is important to detect possible problems and to be aware of the shift that those changes generate in the outcomes. In my post-IdIoT analysis, I found it important to be very aware of the chosen tools (and the limitations) used to develop the analysis. This methodological approach suggests repeating an *IdIoT reflective cycle*.

As the research revealed, there are several challenges in applying the method, which could open up further areas of research. I suggest this level of analysis constitutes a new approach to make future IoT interactions more meaningful. In this context, I believe design research will have a central role.

References

References

Adler, J., 2012. Raging Bulls: How Wall Street Got Addicted to Light-Speed Trading. *Wired Magazine*, 8 May 2012. Available at: http://www.wired.com/business/2012/08/ ff_wallstreet_trading /all/

Anderson, S., 1966. Problem-Solving and Problem-Worrying. *Architectural Association, London, March 1966; ACSA, Cranbrook Academy of Art.* Michigan: Bloomfield Hills. Available at: http://web.mit.edu/soa/www/downloads/1963-69/TH_AALond-Lect_66.pdf

Anderson, C., 2008. The end of theory: will the data deluge make the scientific method obsolete?. *Edge,* 30 August 2008. Available at: http://www.edge.org/3rd_culture/anderson08/anderson08_index.html

Archer, B., 1995. The Nature of Research. *Co-Design,* January 1995, pp. 6-13.

Argyris, M & Schön, D.,1974. *Theory in Practice. Increasing professional effectiveness*. San Francisco: Jossey-Bass.

Arieff, A., 2015. The Internet of Way Too Many Things. *The New York Times,* 5 September 2015. Available at: http://www.nytimes.com/2015/09/06/opinion/sunday/allison-arieff-the-internet-of-way-too-many-things.html?_r=0

Arnall, T.,2013. *Making Visible Mediating the Material of Emerging Technology*. PhD thesis. Norway: AHO.

Arnold, K.,2011. How Apple Approached Developing Siri's Personality. *Mac Rumors,* 15 October 2011. Available at: http://www.macrumors.com/2011/10/15/how-apple-approached-developing-siris-personality/

Ashton, K.,2009. That 'Internet of Things' Thing. *RFID Journal*, 22 June 2009. Available at: http://www.rfidjournal.com/articles/view?4986

Ayres, P., 2007. The origin of modelling. *Kybernetes*, 36 (9/10), pp.1225-1237.

Bateson, G., 1972. Double bind, 1969. *Steps to an Ecology of the Mind: A revolutionary approach to man's understanding of himself*. Chicago: University of Chicago Press.

Bendedetti, M., 1988. *Solo mientras tanto (1948- 1950)*. Madrid: Visor.

Beer, S., 1974. *Designing Freedom*. Toronto: CBC Publications.

Berne, E., 1981. *Games People Play: The Psychology of Human Relationships*. New York: Grove press.

Bilton, N., 2016. Nest Thermostat Glitch Leaves Users in the Cold. *The New York Times*, 13 January 2016. Available at: http://www.nytimes.com/2016/01/14/fashion/nest-thermostat-glitch-battery-dies-software-freeze.html

Bleecker, J., 2009. Design Fiction. A short essay on design, science, fact and fiction. *Near Future Laboratory*. Available at: http://drbfw5wfjlxon.cloudfront.net/writing/DesignFiction_WebEdition.pdf

Bowen, S.J., 2007. Beyond "Uncritical" Design". Position paper for *Sint-Lucas Research Training Sessions 2007*. Brussels: Hogeschool voor Wetenschap & Kunst Sint-Lucas.

Boyatzis, R. E., 1998. *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage.

boyd, d. & Crawford, K., 2012. Critical Questions for Big Data: Provocations for a cultural, technological, and scholarly phenomenon. *Information, Communication & Society,* 15(5), pp. 662–679

Braun, V & Clarke, V., 2006. Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3 (2), pp. 77-101.

Burrington, I., 2015. *Networks of New York: An Illustrated Field Guide to Urban Internet Infrastructure.* Melville House Publishing.

Carbonell, J.G., 1982. Metaphor: an inescapable phenomenon in natural-language comprehension. Strategies for natural language processing. In Lehnert W & Ringle, M.eds., *Strategies for Natural Language Processing*. Hillsdale, NJ: Lawrence Erlbaum, pp, 415-434.

Case, A., 2016. *Calm Technology: Principles and Patterns for Non-Intrusive Design*. Sebastopol, CA: O'Reilly Media.

Cila, N., Giaccardi, E., Caldwell, M., Tynan-O' Mahoney, F., Speed, C. & Rubens, N., 2015. Listening to an everyday kettle: How can the data objects collect be useful for design research? *Participatory Innovation Conference 2015*. The Hague, Netherlands.

Chalmers, M. & MacColl, I.,2003. Seamful and Seamless Design. In Ubiquitous Computing. *Proceedings of Workshop at the Crossroads: The Interaction of HCI and Systems Issues in UbiComp.* Available at: http://www.techkwondo.com/external/pdf/reports/2003-chalmers.pdf\

Constine, J., 2014. Nest's CEO Calls Its Tech The "Conscious Home" Because "It's Not Smarter Than You". *Techcrunch,* 19 November 2014. Available at: http://techcrunch.com/2014/11/19/conscious-home/

Cross, N & Dorst, K., 1988. Co-evolution of Problem and Solution Spaces in Creative Design: observations from an empirical study. In Gero, J & Maher M.L, eds., *Computational Models of Creative Design IV*. University of Sydney, NSW, Australia.

Cross, N., 2001. Design cognition: results from protocol and other empirical studies of design activity. In Eastman, C.; Newstetter, W. & McCracken, M, eds., *Design knowing and learning: cognition in design education*. Oxford, UK: Elsevier, pp. 79–103.

Cushing, T., 2015. China Looks To Quell Dissent With 'Citizen Scores,' A Number That Tracks Purchases, Opinions And Social Circles. *Techdirt*, 7 October 2015. Available at: https://www.techdirt.com/articles/20151006/10194832450/china-looks-to-quell-dissent-with-citizen-scores-number-that-tracks-purchases-opinions-social-circles.shtml

Dahlbäck, N., Jönsson, A. and Ahrenberg, L., 1993. Wizard of Oz studies: why and how. In *Proceedings of the 1st international conference on Intelligent user interfaces*, pp. 193-200.

Deleuze, G., 1992. Postscript on the Societies of Control. Cambridge, MA: MIT Press, October 59,pp. 3-7.Available at: http://www.spunk.org/texts/misc/sp000962.txt.

Deleuze, G & Guattari, F., 1994. *What is Philosophy?* London: Verso.

Di Salvo, C., 2012. *Adversarial Design*. Cambridge, MA: The MIT Press.

Dourish, P., 2004. What we talk about when we talk about context. *Personal and Ubiquitous Computing*, 8(1), pp. 19-30.

Dourish, P., 2006. Implications for Design. *Proceedings of CHI 2006, 22-27 April 2006*, Montreal. New York: ACM.

Drew, S.D & Hopper, A.G., 2009. Fishing and Submarine Cables: Working Together. International Cable Protection Committee. Available at: http://www.iscpc.org/publications/18.3Fishing_Booklet.pdf

Dubberly, H and Pangaro, P., 2015. Cybernetics and Design: Conversations for Action. *Cybernetics and Human Knowing*, 22 (2-3), pp. 73-82.

Duhigg, C., 2014. *The Power of Habit: Why We Do What We Do in Life and Business*. New York: Random House Trade Paperbacks.

Dunne, A & Raby, F., 2002. *Design Noir*. Berlin: Birkhäuser.

Dunne, P.E., undated. Techniques for the Design of Algorithms. University of Liverpool. Available at: http://cgi.csc.liv.ac.uk/~ped/teachadmin/algor/algor_complete.html

Dutson, C, Fantini van Ditmar, D. & Lockton, D., 2015. ‘The Performance of Nonhuman Behaviour’. *Workshop at Nordes 2015: Design Ecologies: Challenging anthropocentrism in the design of sustainable futures*, 7-10 June 2015. Stockholm, Sweden.

Dutta, S. & Mia, I., 2011. Global Information Technology Report 2010–2011. World Economic Forum, Geneva / INSEAD, Fontainbleu, p.x.

Elsden, C., Kirk, D.S., Selby, M., & Speed, C., 2015. Beyond Personal Informatics: Designing for Experiences with Data. In *Workshop proceedings of CHI 2015.* New York: ACM.

England, L.,2015. The CEO of Slack says that Siri is 'nearly useless'. *The Business Insider UK,* 18 August 2015. Available at: http://uk.businessinsider.com/slack-ceo-apples-siri-useless-ai-virtual-assistant-slackbot-2015-8?IR=T&r=US

Eno, B., 2001. Interview about ‘Oblique Strategies’. *BBC Home,* 22 September 2001. Available at: http://www.bbc.co.uk/dna/place-nireland/A635528

Eno, B. & Schmidt, P., 1975. *Oblique Strategies: Over 100 Worthwhile Dilemmas*. Apollo, London.

Evans, D., 2011. The Internet of Things: How the Next Evolution of the Internet Is Changing Everything. *Cisco Internet Business Solutions Group (IBSG),* April 2011. Available at: https://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf

Fadell, T & Koolhaas, R., 2014. Elements of Architecture, 5000 years of architecture... and now what? architecture and technology?. Interview Koolhaas,R., Fadell, T & Maak, N. Biennale Architettura 2014 - Conversazioni / Talks (Architecture and Technology). Venice Biennale, 2014. Available at: https://www.youtube.com/watch?v=dxqFqbAp2Fo

Fantini van Ditmar, D & Lockton, D., 2016. Taking the code for a walk. *Interactions,* 23(1), pp. 68-71.

Foucault, M., 1988. In Martin, L.H & Gutman, P.H, eds., *Technologies of the Self: A Seminar with Michel Foucault.* London: Tavistock.

Frayling, C., 1993. Research in Art and Design. Royal College of Art Research Papers series, 1(1).

Gaffney, G., 2007. Ludic design: an interview with William Gaver. *UXPod*, 23 February 2007. Available at: http://uxpod.com/ludic-design-an-interview-with-william-gaver/

Gartner., 2014. Gartner Says 4.9 Billion Connected "Things" Will Be in Use in 2014. Press release, 11 November 2014. Available at:http://www.gartner.com/newsroom/id/2905717

Gartner., 2015. Gartner's 2015 Hype Cycle for Emerging Technologies Identifies the Computing Innovations That Organizations Should Monitor. Press release, 18 August 2015. Available at: http://www.gartner.com/newsroom/id/3114217

Gillespie, T., 2014. The Relevance of Algorithms. Boczkowski. In Gillespie, .T., Pablo. J & Foot K.A,., *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge, MA: The MIT Press.

Gillespie, T and Seaver, N., 2015. Critical Algorithm Studies: a Reading List. *Social Media Collective Research Blog.* Available at: http://socialmediacollective.org/reading-lists/critical-algorithm-studies/

Glanville, R., 1981. Why design research? In Jacques, R. A & Powell, J, eds., *Design:Science:Method*. Guildford: Westbury House, pp. 86–94.

Glanville, R., 1996. Communication Without Coding: Cybernetics, Meaning and Language (How Language, Becoming a System, Betrays Itself). *MLN*, 111 (3), pp. 441-462 (German Issue). Available at: https://www.univie.ac.at/constructivism/papers/glanville/glanville96-communication.pdf

Glanville, R., 2003. Second Order Cybernetics. Systems Science and Cybernetics. In Parra-Luna, F , ed., *Encyclopedia of Life Support Systems (EOLSS)*. Oxford ,UK: Eolss Publishers

Glanville, R., 2004. The Purpose of Second-Order Cybernetics. *Kybernetes* 33(9/10), pp. 1379–1386. Available at: http://cepa.info/2294

Glanville, R., 2014. Systems Thinking: New Directions in Theory, Practice and Application. International Federation for Systems Research. *Proceedings of the Seventeenth IFSR Conversation*. Schriftenreihe: SEA-Publications. Available at: http://www.anzsys.org/docs/ifsr-2014-conv-proc.pdf

Gleick, J., 2012. *The Information*. London: Fourth Estate.

Glink, I.R., 2014. Jan. 31: The self-cleaning house was patented on this day 30 years ago. *Yahoo,* 31 January 2014. Available at: https://www.yahoo.com/realestate/blogs/spaces/jan--31--the-self-cleaning-house-was-invented-today-30-years-ago-194512933.html?ref=gs

Goffey, A., 2008. Algorithm. In Fuller, M, ed., *Software Studies*. Cambridge, MA: The MIT Press.

Goodman, M., 2015. Hacked dog, a car that snoops on you and a fridge full of adverts: the perils of the internet of things. *The Guardian*, 11 March 2015. Available at: http://www.theguardian.com/technology/2015/mar/11/internet-of-things-hacked-online-perils-future

Groner, R, Groner, M., & Bischof, W. F., 1983. Approaches to heuristics: A historical review. In R. Groner, M. Groner, & W. F. Bischof, eds., *Methods of heuristics*. Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 1-18.

Halpern, S., 2014. The Creepy New Wave of the Internet. *The New York Review of Books*, 20 November 2014. Available at: http://www.nybooks.com/articles/archives/2014/nov/20/creepy-new-wave-internet/

Hammersley, B., 2015. Possible Problems of Persona Politeness. Blog post, 17 July 2015 . Available at: http://www.benhammersley.com/worknotes/2015/7/17/possible-problems-of-persona-politeness

Hern, A., 2015. Peeple rating app removes controversial features to appease critics. *The Guardian,* 6 October 2015. Available at: http://www.theguardian.com/technology/2015/oct/06/peeple-ratings-app-removes-contentious-features-boring

Hippo, St Augustine (397–400 AD). *The Confessions of St Augustine*, 8:7. Available at: http://www.stoa.org/hippo/

Honan, M., 2016. Nightmare on Connected Home Street. *Wired Magazine,* 13 June 2014. Available at: http://www.wired.com/2014/06/the-nightmare-on-connected-home-street/

iControl Networks., 2015. State of the Smart Home 2014. *iControl Networks*. Available at: http://www.icontrol.com/insights/2014-state-smart-home/

International Telecommunications Union, 2015. Measuring the Information Society Report. Internet Report 2015. CH-121. Geneva, Switzerland. Available at: http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf

Ivanovas, G., 2005. Trivial and Non-Trivial Machines in the Animal and in Man. *Kybernetes,* 34 (3-4), pp. 508-520.

Jonas, W., 2006. Research through DESIGN through research - a problem statement and a conceptual sketch. *Design Research Society (DRS) International Conference in Lisbon, 1-4 November 2006*. Available at: http://www.iade.pt/drs2006/wonderground/proceedings/fullpapers/DRS2006_0230.pdf

Juniper Research., 2014. Smart Wearables Market To Generate $53bn Hardware Revenues By 2019. *Juniper research,* 9 September 2014. Available at:http://www.juniperresearch.com/press/press-releases/smart-wearables-market-to-generate-$53bn-hardware

Katyal, N.K., 2014. Disruptive Technologies and the Law. *Georgetown Law Journal,* 102, pp.1685-1689. Available at: http://georgetownlawjournal.org/files/2014/08/Katyal-Disruptive.pdf

Kelly, J.F., 1984. An Iterative Design Methodology for User-Friendly Natural Language Office Information Applications. *ACM Transactions on Office Information Systems*, 2(1), pp.26-41.

Knuth, D., 1997. *The Art of Computer Programming*. 1-3. Reading, MA: Addison Wesley.

Krysa, J and Sedek, G., 2008. Source Code. In Fuller, M, ed., *Software Studies*. Cambridge, MA: The MIT Press.

Kuhn, T.S., 1962. *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Leigh Brown, P., 2002. Son of Carwash, the Self-Cleaning House. *The New York Times*, 17 January 2002. Available at: http://www.nytimes.com/2002/01/17/garden/son-of-carwash-the-self-cleaning-house.html

Lessig, L., 1999. *Code and other laws of Cyberspace.* New York: Basic Books.

Lockton, D., 2011. 'Mental models of HVAC systems, ethnography sessions at the Department of Energy & Climate Change. Report for the CarbonCulture / EMPOWER project, Brunel University, University of Warwick.

Lunden, I., 2015. Amazon Launches AWS IoT — A Platform For Building, Managing And Analyzing The Internet Of Things. *TechCrunch,* 8 October 2015. Available at: http://techcrunch.com/2015/10/08/amazon-announces-aws-iot-a-platform-for-building-managing-and-analyzing-the-internet-of-things/#.ajcjygr:pALM

Luo, S., Jin, J.S. & Li, J., 2009. A Smart Fridge with an Ability to Enhance Health and Enable Better Nutrition. *International Journal of Multimedia and Ubiquitous Engineering,* 4(2), pp. 69-80. Available at: http://www.sersc.org/journals/IJMUE/vol4_no2_2009/7.pdf

Manovich, L., 2013. *Software Takes Command*. London: Bloomsbury Academic.

Markoff, J., 2015. *Machines of Loving Grace: The Quest for Common Ground Between Humans and Robots*. First Edition edition. New York: Ecco.

Marks, P., 2016. To make computers better, let them get sloppy. *New Scientist,* 30 March 2016. Available at: https://www.newscientist.com/article/mg23030672-500-to-make-computers-better-let-them-get-sloppy/

Martin, B. & Hanington, B., 2012. *Universal Methods of Design*. Beverley, MA: Rockport.

Maturana, H., 1997. Metadesign "Human beings versus machines, or machines as instruments of human designs?". *Instituto Terapia Cognitiva (INTECO).* Santiago, Chile. Available at: http://www.autopoiesis.com/documents/Maturana%201997a.pdf

Maturana, H., Dávila, X & Dubberly, H., 2013. Systemic and Meta-Systemic Laws. Translated by Marco Huerta. *ACM Interactions*, 20 (3). Originally excerpted from Habitar Humano: en seis ensayos de Biologia-Cultural. Available at: http://www.dubberly.com/articles/systemic-and-meta-systemic-laws.html

Maturana, H., 1972. Biology of Cognition. In Maturana, H. & Varela, F, eds., *Autopoiesis and Cognition: The Realization of the Living*. Dordrecht: Reidel.

Maturana, H. and Varela, F.,1992. *The Tree of Knowledge: The Biological Roots of Human Understanding.* Boston: Shambhala Publications Inc.

Mayer-Schönberger V and Cukier, K., 2013. Big Data: A Revolution that Will Transform How We Live, Work, and Think. London: John Murray.

Mead, M., 1968. Cybernetics of Cybernetics. In von Foerster, H.,White, J.D., Peterson, L.J. & Russell, J.K, eds., *Purposive Systems: Proceedings of the First Annual Symposium of the American Society for Cybernetics*. New York: Spartan Books.

Medhora, S., 2014. Uber says sorry for raising fares during Sydney siege. *The Guardian,* 24 December, 2014. Available at: https://www.theguardian.com/technology/2014/dec/24/uber-says-sorry-for-raising-fares-during-sydney-siege

Merleau-Ponty, M., 1965. *Phenomenology of Perception*. London: Routledge & Kegan Paul.

McDuff, D., 2004. Introduction. In Dostoyevsky, F., *The Idiot*. London: Penguin.

McMillan, R., 2015. The Hot Yet Little-Known Trend That'll Supercharge AI. *Wired Magazine,* 12 February 2015. Available at: http://www.wired.com/2015/02/hot-yet-little-known-trend-thatll-supercharge-ai/

McMillan, R., 2014. Inside the Artificial Brain That's Remaking the Google Empire. *Wired,* 16 July 2014. Available at: http://www.wired.com/2014/07/google_brain/

McOwan, P & McCallum, L., 2014. When fridges attack: the new ethics of the Internet of Things. *The Guardian,* 8 September 2014. Available at: https://www.theguardian.com/science/alexs-adventures-in-numberland/2014/sep/08/when-fridges-attack-the-new-ethics-of-the-internet-of-things

Michael, M and Gaver, W., 2009. Home Beyond Home. *Space and Culture*, 12 (3), pp. 359-370.

Michael, M., 2012a, De-signing the Object of Sociology: Toward an 'Idiotic' Methodology. *The Sociological Review,* 60 (1), pp. 166–183.

Minsky, M., 1968. *Semantic Information Processing*. Cambridge, MA: The MIT Press.

Moore, P. & Robinson, A., 2015. The quantified self: What counts in the neoliberal workplace. *New Media & Society*. doi:10.1177/1461444815604328

Morozov, E., 2013. *To Save Everything Press Here: Technology, Solutionism and the Urge to Solve Problems that Don't Exist*. London: Allen Lane.

Negroponte, N., 1976. *Soft Architecture Machines*. Cambridge, MA: MIT Press.

Nicol, R and Bremner, C., 2014. Domestic Renewal: Resetting the Table and Repairing the Domestic. *Interiors.* 5(1), pp. 55-70.

Nilsson, N.J, 2009. *The Quest for Artificial Intelligence*. Cambridge: Cambridge University Press.

Norman, D.A. & Draper, S.W., 1986. *User Centered System Design: New Perspectives on Human-Computer Interaction.* Lawrence Erlbaum Associates, Hillsdale, NJ.

Novak, J., 2010. *Learning how to Learn*. Cambridge UK: Cambridge University Press.

Pangaro, P. (1996) Obituary for Gordon Pask. *The Guardian,* 16 April 1996. Available at: http://www.pangaro.com/Pask-Archive/guardian-obit.html

Pangaro, P., 2013. “Getting Started” Guide to Cybernetics. Accessed December 2015. Available at: http://www.pangaro.com/definition-cybernetics.html

Parry, T., 2015. The Internet of Things Is About Experience… and Data. Multichannel Merchant, 9 June 2015. Available at: http://multichannelmerchant.com/blog/the-internet-of-things-is-about-experience-and-data-09062015/

Pask, G., 1975. *Conversation Cognition and Learning: a cybernetic theory and methodology*. Amsterdam: Elsevier.

Pask, G.,1963. The Conception of a Shape and Evolution of a Design. In Jones, J.C & Thornley, D.G, eds., *Proceedings of the Conference on Design Methods.* London: Pergamon Press, pp. 153-168.

Pasquale, F., 2015. *The Black Box Society: The Secret Algorithms That Control Money and Information*. Cambridge, MA: Harvard University Press.

Payne, S.J., 1991. A descriptive study of mental models. *Behaviour & Information Technology*, 10(1).

Perec, G., 2002. Approaches to What? 1973. In Highmore, B, ed., *Everyday Life Reader*. London: Routledge.

Pierce, J., 2015. Working by Not Quite Working: Resistance as a Technique. PhD Thesis. *Alternative and Oppositional Design.* Carnegie Mellon University. Available at: http://reports-archive.adm.cs.cmu.edu/anon/hcii/CMU-HCII-15-109.pdf

Pólya, G., 1945. How To Solve It. Princeton, NJ: Princeton University Press.

Price, R., 2015. The incredibly simple way to find your 'secret' Uber passenger rating. *Business Insider,* 11 February 2015. Available at: http://uk.businessinsider.com/uber-passenger-rating-how-to-customer-stars-how-do-i-2015-2

Rees, J., 2015. *Refrigerator (Object Lessons).* London: Bloomsbury Academic.

Rogers, E.M., 1962. *Diffusion of Innovations.* New York: The Free Press.

Rouvroy, A., 2012. The end(s) of critique: data-behaviourism vs. due-process. In Hildebrandt, M & De Vries, E, eds., Pre-publication version of chapter published, *Privacy, Due Process and the Computational Turn (Philosophers of Law Meet Philosophers of Technology)*. London: Routledge.

Rowland, C., Goodman, E., Charlier, M., Light, A & Lui, A ., 2015. *Designing Connected Products: UX for the Consumer Internet of Things*. Sebastopol, CA: O'Reilly Media.

Schön, D.A., 1984. *The Reflective Practitioner: How Professionals Think In Action*. New York: Basic Books.

Sengers, P., Boehner, K., David, S & Kaye, J., 2005. Reflective Design. In *CC '05: Proceedings of the 4th Decennial Conference on Critical Computing*, ACM Press, pp. 49-58.

Shannon, C.E. & Weaver, W., 1949. *Mathematical Theory of Communication*. Urbana, IL: University of Illinois Press.

Speed, C. & Barker, C., 2014. New Domestic Locations: Reconfiguring the home through the Internet of Things. *20th International Symposium on Electronic Art*, Dubai.

Sprenger, Florian., 2015. *The Politics of Micro-Decisions: Edward Snowden, Net Neutrality, and the Architectures of the Internet*. Meson Press.

Steele, B. Shopping with Amazon Dash buttons made me less forgetful. *Engadget,* 15 November 2015. Available at: http://www.engadget.com/2015/11/15/amazon-dash/

Stein, S., 2015. Misfit Flash Link review: A bargain fitness tracker with a split personality. *CNET,* 20 August 2015. Available at:http://www.cnet.com/products/misfit-flash-link/

Steiner, S., 2012. Smart fridge? Idiot fridge, more like. *The Guardian,* 11 January 2012. Available at: http://www.theguardian.com/lifeandstyle/2012/jan/11/homes-fooddrinks

Stengers, I., 2002. *Penser Avec Whitehead*. Paris: Le Seuil.

Stengers, I., 2005. The Cosmopolitical Proposal. In: Latour, B and Weibel, P, eds., *Making Things Public: Atmospheres of Democracy*. Cambridge, MA: MIT Press, pp. 994–1004.

Sterling, B., 2004. When Blobjects Rule the Earth. *SIGGRAPH, Los Angeles, August 2004*. Available at: http://www.viridiandesign.org/notes/401-450/00422_the_spime.html

Sterling, B., 2005. *Shaping Things*. Cambridge, MA: The MIT Press.

Sterling, B., 2009. Design Fiction. *ACM Interactions*. 16 (3),pp. 20-24.

Sterling, B., 2014. *The Epic Struggle of the Internet of Things*. Moscow: Strelka Press.

Strengers,Y., 2011. Designing Eco-Feedback Systems for Everyday Life. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*, pp. 2135-2144.

Suchman, L., 1987. *Plans and Situated Actions : The Problem of Human-Machine Communication*. New York: Cambridge University Press.

von Foerster, H., 1973. On constructing a reality. In Preiser, F. E, ed., *Conference on Environmental Design Research on April 15, 1973.* Virginia Polytechnic Institute in Blacksburg, Virginia.

von Foerster, H., 1979. Cybernetics of Cybernetics. In Krippendorff K, ed., *Communication and Control in Society*. New York: Gordon and Breach. Available at: http://www.univie.ac.at/constructivism/hvf/137.1

von Foerster, H., 1992. Ethics and Second Order Cybernetics. *Cybernetics and Human Knowing,* 1(1), pp. 9–20.

von Foerster, H., 1995a. Cybernetics and Circularity, May 17-2. Available at: http://www.cybsoc.org/heinz.htm

von Foerster, H., 1995b. *The Cybernetics of Cybernetics*. 2nd ed. Minneapolis, MN: Future Systems Inc.

von Foerster, H and Poerksen, B., 2002. *Understanding Systems: conversations on epistemology and ethics*. New York: Kluwer.

von Foerster, H., 2003. *Understanding Understanding: Essays on Cybernetics and Cognition.* New York: Springer.

von Foerster, H., 2011. In Bernhard Poerksen. *The Creation of Reality: A Constructivist Epistemology of Journalism and Journalism Education.* Charlottesville, VA: Imprint Academic.

von Glasersfeld, E., 1987. *The Construction of Knowledge, Contributions to Conceptual Semantics*. Seaside, CA: Intersystems Publications.

von Glasersfeld, E., 1990. An Exposition of Constructivism: Why Some Like it Radical. An Exposition of Constructivism: Why Some Like it Radical. In Davis, R. B, Maher, C. A. & Noddings, N., eds, *Monographs of the Journal for Research in Mathematics Education*. (4), pp. 19–29.

Whitson, J.R., 2015. Foucault's Fitbit: Governance and gamification. In Deterding S & Walz S, eds., *The Gameful World*. Boston MA: MIT Press.

Wajcman, J., 2015. *Pressed for Time: The Acceleration of Life in Digital Capitalism*. Chicago: University of Chicago Press.

Waters, R., 2015. Investor rush to artificial intelligence is real deal. *Financial Times,* 4 January 2015. Available at:

http://www.ft.com/cms/s/2/019b3702-92a2-11e4-a1fd-00144feabdc0.html#a

Weigel, M., 2016. ‘Fitbit for your period’: the rise of fertility tracking. *The Guardian,* 23 March 2016. Available at: https://www.theguardian.com/technology/2016/mar/23/fitbit-for-your-period-the-rise-of-fertility-tracking

Weiser, M., 1991. The Computer for the Twenty-First Century. *Scientific American,* 265(3), pp. 94-104.

Weiser, M & Seely Brown, J., 1996. The Coming Age Of Calm Technology. Xerox PARC. Available at: http://www.teco.edu/lehre/ubiq/ubiq2000-1/calmtechnology.htm

Weiser, M & Seely Brown, J., 1997. The Coming Age of Calm Technology. In Denning P.J & Metcalfe R.M, eds., *Beyond Calculation*. New York: Springer.

Weizenbaum, J., 1966. ELIZA—A Computer Program For the Study of Natural Language. Communication Between Man And Machine. *Communications of the ACM*, 9 (1), pp. 36–45.

Wiener, N., 1948. *Cybernetics, or Control and Communication in the Animal and the Machine*. New York: John Wiley & Sons, Inc.

Winograd, T and Fernando F., 1986. *Understanding Computers And Cognition: A New Foundation for Design*. Norwood, NJ: Ablex Publishing Corporation.

Wang, U., 2015. What It's Like to Live in This Smart, Energy-Efficient Home of the Future. *Smithsonian*, 22 June 2015. Available at: http://www.smithsonianmag.com/innovation/what-its-like-to-live-smart-energy-efficient-home-future-180956001/#JoUhiLt7qFxEjZ3U.99

Wolf, G. & Kelly, K., 2007. Quantified Self: Self knowledge through numbers. Available at: http://quantifiedself.com/about/

Woolgar, S., 1990. Configuring the User: the case of usability trials. *The Sociological Review*, 38 (1), pp. 58–99.