A Circular 'Smart' World

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Abstract

In the fast-growing Internet of Things (IoT) industry, algorithmic technology promises 'smart' solutions to everyday problems. Drawing on a design research investigation, this chapter questions and critically examines the embedded epistemology of IoT, in the context of what I call the algorithmic paradigm. This examination reconsiders the prevailing epistemology and offers an alternative based on a second-order cybernetics perspective. This alternative recognises the importance of accounting for the role/agency of the observer/designer/user, the circular causality of user behaviour and technology, and the relationality of 'smartness'. To explore the possibility of a shift in perspective from the current algorithmic paradigm to a second-order one, users are approached as experiential, non-linear subjects rather than as probabilistic and linear ones. Outcomes reveal the value of second-order cybernetics as an epistemological stance and a practical approach to research on the design of 'smart' interactions. The methodological framework demonstrates how design research and second-order considerations can work together, asking novel questions to inform disciplines with an interest in IoT interactions, from both a design perspective (the way designers approach their practice) and in terms of broader implications for society.

Keywords 'Smart', AI, Home, Determinism, Reductionism, Context

5.1 Introduction

As an outcome of the aspiration to extend *intelligence* into devices over the last few decades, there has been an increasing interest in the design and business of 'smart' technology.[1] This is reflected in the growing market for the Internet of Things (IoT).[2] IoT technology refers to everyday objects being identifiable, programmable and connected to the Internet. These connected sensor-based objects can send data without human intervention, connect to other objects and respond to the algorithms that govern them.IoT objects present a new way of interacting with our environment and our body, where the algorithmic processes play a fundamental role. Examples of this include quantified self-movement (e.g., IoT wristbands dealing with physical activity and sleeping patterns), the motto being "self-knowledge through numbers", and 'smart' devices such as thermostats (e.g., *Nest*) or the 'smart' fridge, which *takes care* of our eating habits and claim that it "connects your family" (see Fig. 5.1).

Fig. 5.1 Family Hub Refrigerator (Samsung RF28K9580SG). The interface for 'smart' functions is often a tablet computer attached to the fridge door. With a diagonal of 21.5 inches, the screen of Samsung's Family Hub Refrigerator is of considerable size. It is already possible to see commercial alliances emerging in the domain of 'smart' fridges. In the US, Samsung's Family Hub Refrigerator is already connected to a Mastercard credit card (Groceries™), which is in turn connected to FreshDirect and ShopRite delivery services (Image source: www.samsung.com)

[1] Throughout this chapter, I question the use of the word 'smart' as a descriptor of devices. Specifically, I contest the implication that it is a commodity that can be stored in a computer, dismissing its significance as a relational concept (both human and algorithm are responsible for the 'smartness' of the interaction). In order to reinforce and highlight the complexity of the word, I will place 'smart' in quotation marks. I will also distinguish lower and upper case - upper case 'SMART' indicates that I am contesting the word in my research projects.

[2] In statistical terms, *Gartner* [5] 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 [2]. The disparity in the figures does not necessarily reflect a downward revision after a three-year gap; rather, it signifies how quickly the field is emerging and the uncertainty that comes with that speed.

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” (see Fig. 5.2).

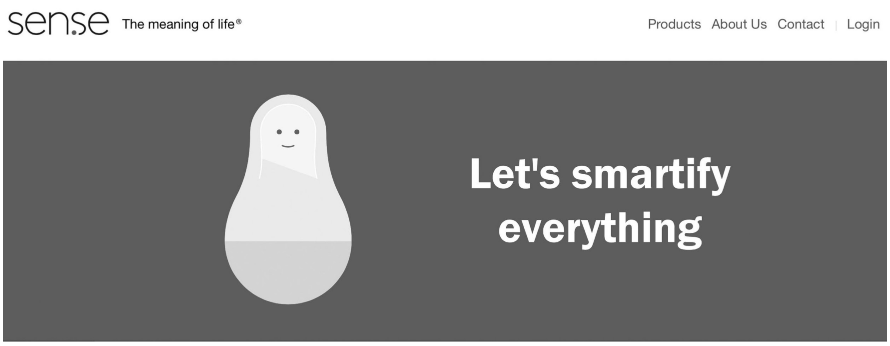

Fig. 5.2 An example of Mother’s “smartifying everything” marketing campaign (Image © Sen.se 2017, reprinted with permission)

In the context of networked devices in the domestic space, the way we behave in our homes is subject to increased monitoring and analysis by various companies. Selling and re-selling personal data is becoming increasingly habitual. Data can be resold to insurance companies, advertisers, ‘data brokers’ and governments, providing unprecedented views into our daily lives.[3] Connecting an object to the Internet generates a shift in its behaviour and therefore in our relations toward it. As networked objects can now act without human intervention, another potential issue of IoT is misbehaviour or malfunction.[4] From this angle, another relevant issue is around software ‘bugs’, which have the potential to cause considerable problems.[5]

The impact that the advancement of IoT technologies and its algorithmic logic will have on our lives should not be underestimated; it is forecast that IoT will be the largest device market in the world [12]. While successful IoT outcomes can be seen in industry - due to its advantages in optimisation, efficiency, tracking, productivity, resource management and cost reduction, this doesn’t mean that when the IoT market, with its commercial agenda, enters the domain of our behaviour and intimate space, such as in the case of the ‘smart’ home, these parameters are at any point applicable. The ‘smart’ home has its own dynamics and brings forward a whole new set of concerns.

[3] One consequence of this was highlighted in late 2013 when Google sent a letter to the U.S. 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” [11].

[4] 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 [21]. 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 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?

[5] 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” [1]. 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.). According to Bilton [1], “[b]uried 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 possible misbehaviour.

As Wajcman [28, p. 130] notes, human complexities impose limits on the mechanisation of lives, and technical visions of domestic life are often advanced at the expense of the home as a living practice. This ambition for certainty and predictability, together with algorithmic oversimplifications, relate to Morozov's [20] concept of 'technological solutionism', defined as the tendency of technologists to define problems based on quick, algorithmic solutions, often resulting in fixing a 'non-problem' as a way of dealing simplistically, and hence quickly, with a complex situation. Consequently, 'smart' technology in our intimate space often comes through as simplistic, unnecessary or overly complicated.

In the framework of algorithmic control when applied to the 'smart' home, the complexity and unpredictability of the user's daily life is replaced with techno-logical/numerical determination.[6] IoT's algorithmic logic and the linear causality projected onto the object's 'smart' behaviour create a dominant directionality, which has several socio political implications for the living practice. In this context, besides the business of companies gathering data on our behaviour and the potential benefits of automation, the craving for control in the context of designing algorithmic operations for our everyday environment and living practice can and should be questioned Tony Fadell (Nest's CEO)

During a panel discussion at the Venice Biennale 2014, Tony Fadell, when asked about the values of the technology, replied: "You are always in control. So these products don't take control away from you. All we're doing is we're learning from your habits. So, we're not imposing anything on anyone. In fact, in most cases we're actually just educating and giving you feedback on what your what your abilities are." [3, 17:12min]. Why the urge for control? Glanville [8, p. 68] identifies "at least two reasons we like to exercise control: Wishing to amplify some power [. . .] and the essential centrality of error in our world."This controlling strategy can be seen in IoT's algorithmic approach towards human living, where the *error* of embodied human experience based on a contextual existence is often disregarded. Consequently, it seems relevant to reflect about how human attributes and the contingency of our living practice impose limits on the reductionist and controlling algorithmic logic.

Seeing the rapid growth of IoT products based on applying the ruling algorithmic problem-solving 'smart' logic to the living practice, it seems relevant to discuss and question the underlying epistemological approach. By questioning technological 'smartness' as a design issue, it is possible to examine historically how we arrived at this current technological scenario. In this chapter, I will begin by highlighting the influence Artificial Intelligence (AI) has had on the assumptions made in the process of designing current 'smart' technology interactions. In the following section, I will briefly describe the implications of AI and subsequently argue how reconsidering second-order cybernetics as a subject and a way of designing research offers a significant framework for approaching interaction design in future 'smart' technology. I will do this by describing a design research investigation through a case study of 'smart' home interactions.

[6] The term 'user' will be used to describe the human component in a human-IoT interaction. In this chapter it has no commercial bias; 'user' is interpreted as a complex human instead of a passive consumer. Here, complexity is defined as "the quality of being complex', i.e.,"having many varied interrelated parts, patterns, or elements and consequently hard to understand fully", or "marked by an involvement of many parts, aspects, details, notions, and necessitating earnest study or examination to understand or cope with." See George Klir's definition from Webster's Third International Dictionary in the International Encyclopedia of Systems and Cybernetics [4].

5.2 AI

The Artificial Intelligence Group was founded in 1958 by John McCarthy and Marvin Minsky at MIT. McCarthy asserts with regards 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.” [19, p. 12]. 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 [22]. Cognitive science and AI have a tendency to approach the brain and the computer in terms of each other. Cognitive science is an interdisciplinary research field characterised by the understanding of the mind as having comprehensible cognitive processes, in which intelligence and behaviour can be modelled and replicated.[7]

Suchman [24, p. 9] notes that 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”.[8] According to Pangaro [22], this approach presupposes that knowledge is a commodity that can be stored in a machine, and that consequently for AI, the application of such stored knowledge to the real world constitutes *intelligence*. The technology evolved from the late 1960s, and small ‘smart’ objects not only began to monitor variables such as room temperature but also began to operate in the domain of our behaviour. Nowadays, IoT devices incorporate a vast range of sensors with increased precision; here data is extracted and recombined with large-scale statistical databases.

Regarding the algorithmic decision-making process, there are several strategies for predicting how an individual and its environment will behave; such is the case of machine learning and big data. By using these procedures, ‘smart’ devices have the potential to make assumptions, judgements, automated decisions and suggestions. Rouvroy [23, p. 2] describes current algorithmic logic as based on infra-individual data and supra-individual patterns, stating that, at any moment, the algorithmic processes call the subject to account for himself.[9]

One consequence of using such AI approaches in digital devices is the reinforcement of an understanding of humans as linear and ‘probabilistic beings’, which then gets embedded in current commercialised IoT outcomes. This translation into the retail world is reflected in how data is managed by algorithms designed with particular criteria and assumptions derived from a specific idea of ‘smartness’, which is then applied to our daily interactions. In the context of users interacting with IoT devices in the ‘smart’ home as a result of AI embedded ideas, I speak of this scenario in conceptual terms as the algorithmic paradigm.

The main difference with the prior technological paradigm is that the previous one was characterised as detached: it was not ‘real time’; the speed of the analysis of data was substantially slower and it was delimited, i.e., it had locational limits. It was not 24/7, it was not ubiquitous and, consequently, it did not operate in the domain of behaviour. The algorithmic paradigm is characterised by vastly larger data centres and much greater computational power. These technological advances came together with the availability of the data in cloud computing technology (i.e., the ubiquity of access to computation). All this then had implications for the quantitative capabilities of trained learning algorithms.

[7] For further discussions of embodiment and the limitations of a cognitivist approach, see, e.g., Maturana [16-18] and Varela [26].

[8] Certainly, there are exceptions. But this is the general trend in the fields of computer and cognitive science, and AI technology.

[9] Rouvroy [23, p. 11] refers to infra-individual in the algorithmic processes as the digital traces that are extracted below the level of the human, characterising it as “impersonal, disparate, heterogeneous, dividualized facets of daily life and interactions”. Supra-individual indicates the idea that data is analysed above the level of the human, as is the case in big data aggregation.

The algorithmic paradigm is distinguished by:

- Representation and modelling of data gathered by the device about a user's daily life, surroundings and body (domain of behaviour).
- 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 capacity to control the environment and the potential to change their procedures without informing the user.

Not only does the logic of the algorithmic paradigm have operational repercussions, it also has behavioural implications by being translated into the language that characterises the technological industry. IoT is marked by a discourse that promises that the 'smart' device *knows us, understands us* and *predicts us*. Some products even claim to be *conscious* or, in the case of the *Nest* thermostat, *thoughtful*.

In this 'smart' scenario, algorithms are *learning* more and becoming faster. But what and how are they *learning*? How is the impossibility of translating human life into the machine's 'smartness' being embraced? This is in no way inconsequential. With this in mind, I would like to point out the relevance of second-order cybernetics, a movement that emerged around 1968 from the 'cybernetics movement', which can be traced back to the Macy Conferences (1946-1953) of more than a decade before the emergence of AI.[10]

Here, I will illustrate how reconsidering second-order cybernetics principles provides opportunities to rethink 'smart' interactions and will demonstrate their implications for design research in the context of the design of IoT 'smart' interactions.

5.3 Second-Order Cybernetics

In second-order cybernetics, according to Glanville [9, pp. 175, 177], "the role of the observer is appreciated and acknowledged rather than disguised [. . .]. The aim of attaining traditional objectivity is either abandoned/passed over, or what objectivity is and how we might obtain (and value) it is reconsidered."[11] As a result, as Glanville [9,p. 3] notes, every observation where the indispensable presence of the observer doing the observing is established is autobiographical. With the introduction of the above second-order concepts comes the relevance of acknowledging the observer and its contextualised observations when reflecting upon the idea of personal data gathered and managed by algorithms. In this way, second-order cybernetics principles also make us reflect on how 'smart' interactions could be reframed when thinking in a circular manner.

5.4 Designing Through Second-Order Cybernetics

Along with the theoretical reconsideration of second-order cybernetics come its connection to design, and its implications for design research (for an overview, see Glanville [6, 7, 13, 14]). According to Glanville, "[d]esign is the key to research. Research has to be designed". In the context of research, design is hence best acknowledged "as a way of understanding, acting, looking, and searching" [6, p. 90].

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[10] The relationship between cybernetics and AI is further discussed in Sect. 1.4 in this volume.

[11] The observer in second-order cybernetics refers to the active presence of the provider of the information. Glanville notes that "Second order cybernetics considers (rather than ignores) the observer, studying observing as opposed to observed systems, insisting the observer takes center stage" [9, p. 201]. 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?"

By considering design research as a process that draws attention to the observer and the development not only of objects but also processes, design has the potential to generate novelty and assimilate and accommodate complexity [7, p. 65]. In this sense, design research can be seen as a valuable approach to consider when examining current matters such as designing 'smart' interactions. This is particularly relevant to the design field of 'smart' interactions; as Sweeting [25] states, design research is often concerned with epistemological questions regarding the interrelations of designers, other stakeholders, working methods and the knowledge embedded in what is designed.

With this background, through the development of an design research epistemological journey based on second-order cybernetic principles, I will illustrate how the design research process has the potential to reveal relevant technological issues and propose an alternative way of approaching 'smartness'. To investigate issues of current algorithmic visions of IoT technology, I used as a case study the design of the 'smart' fridge, an IoT device that is related to central human activities.[12]

5.5 'SMART' Fridge Session (SFS)

To examine the way in which human complexity is translated into an algorithmic logic, during the case study I created a series of active real-time interactions of participants (reflective observers). Through a series of dialogues with a 'smart' device, I was able to observe possible issues emerging from an *intelligent* conversation with an IoT device.

For this, I developed a series of 'SMART' fridge-user interactions which allowed me to analyse the possible issues in embracing human complexity and subjectivity within the algorithms behind the IoT. The interaction consisted of a public engagement event where the 'smart' fridge-user conversation was projected onto a screen so that a broader audience could follow the dialogue.[13] Here the user was instructed to speak with a 'SMART' fridge that formed part of their connected home. So that the user in the project felt embedded in the 'SMART' world, the interactions with the 'SMART' fridge took place through *iMessage*, on an *iPhone*.

In order to investigate the epistemological issues, I developed a dialogue research protocol using two tools which formed the basis for the two sub-projects: *Scripted Dialogues* and *Assigned Roles*. The first, *Scripted Dialogues*, was an interaction between a script that I developed (preset texts) based on a second-order approach and a participant (user). The second, *Assigned Roles* tested the idea of non-neutral aspects of algorithms by assigning roles to participants: one to enact the role of the AI in a 'SMART' fridge, and the other to play the role of the user (see Fig. 5.3).

In the *Scripted Dialogues*, I was interested in exploring the possibility of a shift in perspective from the current algorithmic paradigm to a second-order cybernetics approach, where the user is considered an experiential, non-linear subject rather than a probabilistic and linear one. In this project I experimented with the script using the following second-order cybernetics concepts: (1) The acknowledgement of human subjectivity (the observer and its observation taken into account); (2) The importance of considering the impact of lived experiences in the present (not as a mathematical accumulation of past history); (3) A systemic understanding; (4) Insights that can only be achieved through conversation; (5) Feedback on the performance of the system itself; (6) Statistical transparency; and, (7) The idea of the user shaping the system.

[12] I consider 'central human activities' as a range of actions (behaviours) which embrace biological activities (e.g., sleeping, eating, physical activities) and which are also related to more ineffable psychological activities such as feeling, motivating, caring, and so on. Perhaps more than anything else, eating habits are illustrative of the complexity and unpredictability of human life, connected as they are to human psychology, personality, culture, budget, the present and history. It is therefore a pertinent subject for reflection on the (possible) issues inherent in the 'smart' home.

[13] The 'SMART' Fridge session was part of 'Off The Wall'; an exhibition held between September 18th and 20th 2015, staged aboard HQS Wellington, a 1933 former military ship moored on the River Thames.

The idea was that the user was not seen as a mere consumer who receives normative outcomes, but as a subject capable of reflecting on his/her data. With this in mind, I experimented with the creation of a script by considering the user as a reflective observer. I thus avoided the normative and prescriptive strategies that characterise current technology. During the process of designing the script, I dealt with the following questions: How could I avoid telling the users what to do? How could I possibly make users reflect on their data? How could I help users understand the implications of their actions in relation to health, sleeping and fitness, without being normative? How, with all these attempts, could I avoid giving this information to the machine and not have it treated and fed back with the same machine logic I was trying to question?

Fig. 5.3 Participants chatting during the interaction at the 'SMART' Fridge Session. London: HQS Wellington, 18th to 20th September 2015

Even by providing an alternative to normative, linear-causal interaction, the problems of grasping the richness of individual behaviours became evident. An example of the challenge of understanding the particularities of individual behaviour/thinking can be seen in the case of the script's first question: How do you feel today? One participant took this to refer to their particular physical situation (the *'SMART' Fridge Session* taking place on a ship), replying "not fine, I don't like being in a boat". A second participant replied stating her needs ("hungry"), while another replied by applying a metaphor ("sunny").

Through the *Assigned Roles*, I decided to explore the possible issues in capturing subjectivity and the 'non-neutral' aspect of the algorithmic issues in IoT by allowing some participants to play out fictitious roles, and others to embody their everyday professions (see Table 5.1).

People were asked to imagine that they were embedded in the AI of the 'SMART' fridge. I choose several mother roles since mothers take care of our nutrition and influence many of our eating choices later in life (this influence is reflected literally in some current IoT products, e.g., the Mother smart hub). I assigned other roles, such as fashion diva, an authoritarian 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 (as well as the French diva and the authoritarian general), the actors were participants from those particular cultures. In the case of the professional roles, I involved professionals who will potentially participate in the design of future IoT appliances, including an interaction designer, nutritionist, programmer, banker, and user experience researcher. I also decided to invite a scriptwriter to test storytelling in the interaction.

Table 5.1 *'SMART' Fridge Session* roles

Professionals playing themselves	Fictitious roles
Interaction designer	Chinese mother
Nutritionist	Italian mother
Programmer/Start-Up CEO	Jewish mother
Banker	Korean mother
Scriptwriter	British mother
User experience designer	The Godfather
French fashion designer 'diva' Authoritarian general	
Coach	
Personal trainer	
Schizophrenic fridge Open session	

In order for the 'SMART' fridges to get to know their (oversimplified) users and have material on which to comment, I provided several items from the supermarket (e.g., champagne, broccoli, beer, tortellini, pizza, almond milk, etc.). The users had to select two items each that they usually have in their fridge; this gave the fridge (minimum) information to use during the interaction. Then, the user and the 'SMART' fridge had the opportunity to reflect on what this 'smart' interaction could possibly mean. Through the interaction, it was possible to see how each participant applied a completely different strategy for getting information and keeping the interaction going.

In the *Assigned Roles* I analysed the material through Thematic Analysis; in a second-order manner, I chose the dialogues as the unit of analysis. Through this method, in which the observer was acknowledged, I obtained relevant qualitative data from the dialogues that emerged in the interaction. The main themes that I distinguished were:

i. Control, Power, and 'the 'SMART' limit': In the context of negotiating the power of the machine vis-à-vis the ownership of the appliance, both argued, "I know what I am doing". The 'SMART' fridge claimed that it knew what was better for the user. The user claimed that, as the owner of the appliance, he/she was in control of their own life, making it clear that technology should be subordinate to the user.

Another theme that emerged was the question: at what point is it acceptable for the machine to make judgements and comments about the life and behaviour of the user? As a result of this scenario, it was possible to observe how IoT technology allows us to control our environment; at the same time, it shows how users 'hand over' control to the algorithms behind the technology.

These findings reinforce the importance of developing alternative epistemological approaches for future 'smart' technology.[14] Here is an example of an interaction on the location of control:

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.

ii. Understanding the 'SMART' world in practice: Communication and the 'SMART' world characterisation.

a. Communication: In the interaction it was possible to foresee the potential problems which this active machine-user relation could bring, especially when it relates to our own personal metrics (quantified self) or to the home ('smart' home). This was seen on two levels: when the user doesn't expect a particular response or prompt to come from a machine (human-machine relation) and when the 'SMART' fridge uses phrases that don't necessarily relate to the user (language). An issue that emerged from the dialogues was 'figuring out meaning', and the likelihood that the user would reply using metaphors. There were nationality implications based on language and behaviour that showed the personification of a cultural mindset in the machine's responses.

[14] In the following dialogues, SF refers to 'SMART' Fridge and U refers to user.

The dialogues also revealed that the meaning of a meal goes beyond the food itself; there is an emotional and historical background that can't be reduced to data and suggestions. Here is an example of a communication problem:

SF: There is nothing wrong with me just caring for your well-being. You can only restore my settings through my input and I won't allow you to do it.

U: I am going to replace you with an American fridge that won't complain about junk food.

b. 'SMART' world characterisation: The series of dialogues are an example of
people in different roles trying to understand how the 'SMART' world works. Through the interactions it was possible to see how the 'SMART' appliance situates itself with its new technical capabilities. In several dialogues it was possible to see that the users expected the 'SMART' fridge to take care of their lives by using its 'smartness'.

Another important subject was the allocation of responsibility when outsourcing crucial aspects of our lives to a machine and the issues related to abandoning human agency by relying on a machine. In some cases, the user implied that the fridge couldn't be right purely on the basis of it being a 'SMART' fridge with machine credentials and *intelligence*. However, at times the user assumed that the fridge was the one in charge of managing that aspect by asking, "what are you if you are not 'SMART' enough to figure out what I need?" Conversely, the 'SMART' fridge also blamed the user, as if he/she was responsible for ordering products or communicating relevant information. At this point, the issue of transparency of statistical outcomes embedded in suggestions emerged through the conversations. Here are examples of conflicting views on responsibilities:

U: I am hungry, what is there to eat?
SF: There are no vegetables available. You don't eat enough vegetables.
U: Why didn't you order more vegetables, fridge?

SF: We have run out of dessert so I won't give you any. U: Food is your 'thing', not mine.
SF: Can you buy something healthier next time?

iii. Commercial issues: This aspect of IoT emerged particularly from the real
roles, specifically in the case of the programmer and the banker. Both of them incorporated the idea of a commercial food partner being present. The programmer tried to negotiate with payment the destination of the user's data (e.g., the programmer showed the user that, if she paid £5 instead of £30, a commercial partner might be able to re-sell her data). The banker tried to offer more options by pushing additional products, reminding the user of expiry dates, and by bringing commercial 'partners' into the conversation. Also in relation to commercial issues, different approaches to framing the problem emerged as an alternative to the "user-consumer" perspective, as characterised in the programmer and banker dialogues.

In contrast to the user-consumer perspective, other roles, such as 'the scriptwriter', embraced the idea of sharing, i.e., the fridge being helpful by not only focusing on consumption, but by also showing empathy to the user and finding non-commercial strategies based on the idea of a community of users. The scriptwriter made the user think about the context (with whom does he live in the house and what are they like) and analyse the narrative of sourced food that he consumes.

In this case there was an understanding of the person's situation and resources, which offered an alternative for solving the problem (by buying 'efficient' goods). Here an example of a non-commercial strategy:

SF: Do you live with other people?
U: Yes, one flat mate
SF: Should we think about ways of you both saving time and money? We could do a shared shopping list together.

iv. Complexity and variety in people's lives: Our lives are unpredictable and complex, with many systemic implications. As non-linear humans, our psychology, personality, context and history continuously come into play. If on top of this we add the complexity of diet itself (our budget, history and situated context) and embrace the idea that eating is not about optimisation or efficiency, it becomes important to question the reliance on a linear algorithmic approach to manage the complexity and variety of people's lives. Here is an example with an added level of complexity:

SF: What if you slept more?
U: I'd be happier but less interesting.
SF: Can you find a way to manage that? How?
U: I am unbalanced. Nothing is finished.
All relationships are pending and unsettled, and I am a neurotic.
I don't know how to solve it, can you?

5.6 Reflections

The design research findings provide evidence that the current epistemological stance derived from AI, i.e., the reductionist approach of the algorithmic paradigm embedded in IoT products, presents several problems: the fact that there is an epistemological stance embedded affects people's interactions with the technology, and the specific set of values and way of seeing the world have repercussions in the automation of and communication with the 'smart' system ('smartness' is neither objective nor neutral). Consequently, it seems relevant to rethink the design of 'smart' interactions by reconsidering its epistemological approach.

The investigations highlight issues with the apparently objective algorithmic problem-framing logic behind the 'smart' objects when employing data in a deterministic manner that are isolated from the individuality and subjectivity of the user's behaviour in daily life.[15] This leads not only to a different set of questions, but also to a different way of framing the problem. When 'intelligence' is applied to the technological industry of 'smart' devices, we are reminded of Glanville's reflection when asking Juvenal's question: "who will guard the guard?" or in Glanville's words: "who will control the controller?"; as he then notes, "this is not a question that can be long left unasked: to do so would be a matter of both inconsistency and laziness" [8,p. 66]. By bringing the observer and circularity into the discussion, it became clear that the user should be given responsibility for making sense of his or her own data. Across the dialogues of the '*SMART' Fridge Session*, it was also possible to see how the algorithmic paradigm, which includes big data and machine learning strategies, fails dramatically to capture human diversity and the nuances of our living practice.

The awareness of the differences between AI and second-order cybernetics allowed me to consider the latter as an alternative epistemology for an approach to IoT design. In contrast with the deterministic AI approach, a second-order perspective suggests that, as reflective and contextual humans, our capacities and understanding are still needed and desired. The study demonstrates how design research and second-order cybernetics can be brought together to question 'smart' interactions and to rethink the implications of 'smartifying' our life through algorithmic logic.

By valuing the presence (the incorporation) of the observer's observing and by considering that meaning is constructed (it is not available in a world of data-references), a second-order epistemology leads to the acknowledgement of the limitations of 'smart' machines - the 'smart' device is ignorant about the personal aspects of users and the contingencies of their lives. The implications of relying on de-contextualised data in the design of 'smartness' is related to von Foerster's ethical concern with respect to acknowledging the observer: "With the essence of observing [. . .] having been removed, the observer is reduced to a copying machine with the notion of responsibility successfully juggled away." [27, p. 293].

Accordingly, this suggests the importance of rethinking the relevance of the active presence of the user perspective (i.e., the observer) in the equation of the 'smartness' of IoT interactions that engage with humans and their living practice. While there are several studies in the area of user perspective/experience in the field of human-computer interaction (HCI), together with the growing field of human-centred design (HCD), the contribution of this design research investigation was to bring a second-order perspective to the user and the user's interaction with 'smart' systems rather than to bring a user perspective into the current AI framework.

[15] It is important to emphasise again that there are risks inherent in providing our personal data to algorithms that have been developed with the strategies of AI machine learning, particularly when this personal data can be sold to companies, commercialised and politicised (e.g., NSA/GCHQ surveillance, *Cambridge Analytica*/*Facebook*'s political influence and *Google*'s perceived omniscience).

Since algorithms model the environment to offer 'smart' *solutions*, it is extremely important to be critical and think about the limits and issues of the algorithmic logic in our lives. As the research suggests, it requires a rethinking of the whole system and its embedded epistemology. In addition to the intrinsic algorithmic socio-political issues, these considerations are not included in the development of machine learning, big data or natural language programming. This will not be achieved by continuing the development of 'smart' products in an AI 'smart' fashion, a new perspective is needed. A second-order perspective has the potential to bring novel ways of asking questions that inform the various disciplines shaping the technology, in terms of the conceptual stage of framing IoT technology as well as the broader societal repercussions.

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