Learning from the Veg Box: Designing Unpredictability in Agency Delegation

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ABSTRACT

The Internet of Things (IoT) promises to enable applications that foster a more efficient, sustainable, and healthy way of life. If end-users are to take full advantage of these developments we foresee the need for future IoT systems and services to include an element of autonomy and support the *delegation of agency* to software processes and connected devices. To inform the design of such future technology, we report on a breaching experiment designed to investigate how people integrate an *unpredictable* service, through the *veg box scheme*, in everyday life. Findings from our semi-structured interviews and a two-week diary study with 11 households reveal that agency delegation must be warranted, that it must be possible to incorporate delegated decisions into everyday activities, and that delegation is subject to constraint. We further discuss design implications on the need to support people's diverse values, and their coordinative and creative practices.

Author Keywords

Autonomous Internet of Things (AIoT), agency delegation, breaching experiment, veg box, qualitative study.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous.

INTRODUCTION

The Internet of Things (IoT) promises to enable applications that foster a more efficient, sustainable, and healthy way of life. To deliver on these promises, future interactive systems and services may need to include elements of automation and autonomy, allowing people to delegate some degree of agency to IoT systems to permit them to act on their behalf. We refer to this subset of the IoT as the Autonomous Internet of Things (AIoT). Such systems may proactively respond to sensed environmental changes, effectively performing tasks on behalf of users. While these systems are expected to work seamlessly, such expectations may not always be met in practice because of incorrect predictions caused by limited data sets, biases in the data, and limitations of computational models. Moreover, conflicting constraints imposed by users as well as different service providers (e.g. delivery) and good suppliers involved in the system have the potential to produce in unexpected results. As such, the design of interaction mechanisms that enable users to work around this unpredictability is an open challenge in HCI [28, 45].

Nascent instantiations of the AIoT focus on the domestic environment and include smart thermostats [47, 48, 49], domestic appliances [4, 13], energy systems [2, 3] and cleaning robots [17, 43]. With a few exceptions, which have studied off-the-shelf products such as the Nest Thermostat [47, 48] and the Roomba [17, 43], prior studies around autonomous systems in the home have focused on research prototypes. Recent work has also outlined the challenges for designing interactions with smart autonomous products, such as the delegation of control between people and the products, and how to position such products in human activities as partners [10, 38]. Indeed, the partnership between users and systems is essential for successfully designing future autonomous systems [16, 28]. To enable this partnership, it is important to understand *agency delegation* between users and systems, which we define as the act of transferring the responsibility of performing a task to an agent. Building upon prior work and to inform the ongoing design of future AIoT systems, we present the qualitative study of everyday practices around an established service that exemplifies agency delegation, through the *veg box scheme*, in an effort to understand the social grounds upon which agency delegation turns.

In subscribing to the veg box scheme users delegate agency to the service provider as to the particular food

ACM 978-1-4503-5620-6/18/04…$15.00
https://doi.org/10.1145/3173574.3174021

items they receive in much the same way as one might delegate agency to an autonomous service, such as a thermostat to which one might delegate the *decision* to heat or cool a home. However, unlike an autonomous thermostat, which simply decides whether to increase or decrease the temperature, delegating agency to the veg box provider is to relinquish decision-making to an inherently *unpredictable* system in which one does not know just what decisions will be made beyond the fact that it will result in some unspecified kinds of fruit and veg being delivered.

It might be argued, following Yang et al. [47], that an autonomous thermostat is unpredictable as well, but this is not equivalent to the veg box. Imagine arriving home and your autonomous heating is not behaving as you expect: you just change it up or down as you prefer. Imagine, by contrast, arriving home and – should you have to cook – that you find yourself confronted by a potentially alien and even unpalatable set of ingredients. Add to the mix hungry people who must be catered for in and amongst all the other things that need doing as part of the daily round. The potential unpredictability of the thermostat is not at all of the same order of unpredictability as the veg box. Furthermore, the content delivered to subscribers depends on a potentially complex network of factors: not all the produce delivered is grown on the farm; some of it is acquired from other local or remote farms. How the provider decides what to acquire from where is not necessarily obvious to consumers. We see another similarity, then, between the veg box, and IoT products, given that lack of transparency has sometimes been noted as a limitation of IoT products [47, 50]. Indeed, the unpredictability inherent in the veg box appears to run contrary to a great many aspects of daily life, where the need to tightly manage activities and events is paramount to ensuring their accomplishment. It is not that unpredictable things don't occur in everyday life, they do and in the form of innumerable contingencies, but unpredictability is more often than not an unwelcome guest that household members seek to manage through the construction of routines, which 'glue' everyday life together [44].

The veg box, as mundane as it might be, would appear to *breach* the routine in rendering the mundane provision of food unpredictable. It thus provides a lens, much as Harold Garfinkel's 'breaching experiments' [23] provided a lens, to explore the taken for granted grounds upon which everyday phenomenon, including agency delegation, turn. As Crabtree [14] points out, breaching experiments provoke, in the etymological sense of 'call forth' – but do not *necessarily* 'disrupt' (a common misreading of breaching experiments) – how the taken for granted orderliness of an obstinately familiar world is accountably provided for by 'members' or users. Construed as such, the veg box may then surface the tacit grounds upon which agency delegation turns in this case and how the unpredictable is woven into everyday life.

Against this background, we conducted a qualitative study through semi-structured interviews and a two-week diary with 11 households in the UK. We seek to understand how people manage agency delegation and integrate what is essentially an inherently *unpredictable* service into everyday life. Findings suggest that agency delegation must be warranted, that it must be possible to incorporate delegated decisions into everyday activities, and that delegation is subject to constraint. We consider the potential impact of these social organisational issues on the design of a future AIoT supporting food-based practices in the home, and the challenges of making agency delegation accountable to meal planning, persons' schedules, food-centred values, adaptation and innovation, and the social division of labour in which computational agency will ultimately be embedded.

Research contributions and goal

This work contributes to the understanding of 'smart' autonomous systems in the home [2, 3, 4, 13, 47, 48, 49] through the study of the veg box as a service that has a digital (the Web and email interface) as well as physical component (the actual delivery of goods), and that supports agency delegation. We also make a contribution to food HCI (e.g. [7, 12, 29]), and to sustainable HCI (e.g. [11, 20, 29]) through the report of food practices around a supply scheme designed to be environmentally and socially sustainable. The goal of studying veg box users is to learn from their practices, to inspire and inform the design of future autonomous IoT technology for the home (rather than to specifically inform the design of interactive technology to support such user group). We are keen to learn how agency delegation is integrated in everyday life, especially when it involves uncertainty. In particular, our work focuses on agency delegation in food-based practices, and we see the veg box scheme as a relatable service that already exists in the market and also has an element of unpredictability.

RELATED WORK

Herein we review related work on agency delegation to further ground our framing of the veg box scheme as an instance of such systems. We also review HCI studies that have examined food practices to position our approach in the literature.

Agency delegation

The mechanism of agency delegation is central to interactive systems that include elements of automation and autonomy. The idea that users delegate control so that the system can "do something" on the user's behalf has for instance been reflected early in Horvitz's development of mixed-initiative interaction [26]. However, studies of such systems in use in everyday life are still sparse, with some notable exceptions. Alan et al. for example found that 'flexible autonomy', i.e., the ability to assign different levels of autonomy to systems, can be a promising way to engage users over prolonged periods of time with an electricity tariff-switching agent [2]. Costanza et al., found

that people at times struggle to align the rational planning element required to effectively use an agent-based booking system that would save them money with their everyday routines [13]. Related to this prior work, in this work we are particularly interested in how consumers deal with the autonomous decision-making element in veg box schemes, i.e., the lack of user control over the items included in the box. In particular, we are keen to explore how people integrate this element of unpredictability in their everyday food practices, and where this rubs up against their routines.

Food HCI

Researchers in HCI and Ubicomp have developed and evaluated technologies to support food-based practices, such as promoting healthy eating [8, 9, 36], helping users execute complicated cooking tasks [25] and recommending easy-to-prepare meals to users [33]. In contrast to these works, we focus instead on how users interact with an existing autonomous service. By so doing, not only are we able to observe emerging practices around autonomous services, we are also able to examine established practices around which such services aim to operate.

Studies have also investigated existing food practices in the home environment. Cha et al. conducted an observational study that focused on understanding users' organisational habits in the kitchen (e.g. unpacking and storing of groceries) to formulate design implications for organisational robots [7]. Similarly, Comber et al. conducted contextual inquiries with ten households to identify people's general domestic food practices, focusing on food purchasing and consumption [12]. Kuznetsov et al. conducted an in-situ fieldwork to observe the work of practitioners of at-home food science, which involves practices such as food preservation and fermentation [29]. Their contribution focuses on how technologies can help practitioners to adopt food science as a habitual and everyday practice.

Other food-related HCI research has focused on sustainability. For instance, Clear et al. conducted a study using various enquiry techniques to capture students' food preparation activities, focusing on their cooking habits and greenhouse gas emissions to develop design interventions for sustainable cooking practices [11]. In contrast, other studies examined users' experiences of food waste, and its connection to other food practices and reasoning behind them [20, 22]. For example, Ganglbaeur et al. evaluated Foodsharing.de, a community platform that supports food waste reduction by enabling users to collect or offer food items to other users for free [21]. Our work is similar to these studies as we examined domestic food practices through various qualitative methods. However, our work extends current research in that we focus on how users embed an autonomous food service – a veg box scheme – in their existing food practices.

BACKGROUND: VEG BOX SCHEMES

Veg box schemes historically started as a way for consumers to support local farms and get fresh fruit and vegetables directly from them [34]. Originally consumers would pay upfront for a yearly or half-yearly supply of produce, which they would then get delivered (or be collected) weekly or fortnightly. Nowadays most schemes have taken a more commercial turn, and those who run the scheme may grow only part of the produce that they distribute to customers, with the rest being sourced from other farms that may be local or not.

In particular, in the UK, where our study took place, fruits in some periods of the year tend to be imported from abroad. Subscriptions are no longer over the long term, but customers can buy boxes on an individual basis, generally just with the constraint of a minimum size order. Some schemes allow customers to select exactly what produce they want to receive or to specify a "blacklist" of items that they never want to receive. Most services advertise the list of items in the weekly box a few days in advance, either on websites or via email, and many also publish recipes as suggestions for how to use the box content.

It is of note that veg boxes schemes are different from 'recipe box' subscriptions – i.e., a weekly or fortnightly box that contains the exact ingredients for cooking a specific number of predefined recipes. The critical difference is that recipe boxes are self-contained, and do not require integration with customers' existing food practices in the same way that veg boxes do (as the content of the veg box generally needs to be complemented by other items in order to be turned into meals). For this reason, we decided to focus strictly on veg boxes, as we believe they offer a richer opportunity to observe whether and how such a service rubs up against existing everyday practices.

The motivations and experiences of users of veg box schemes have been investigated through a number of academic studies, typically conducted through surveys [39]. For example, Brown et al. [6] conducted surveys in France and England to determine the motivations and barriers for consumers to subscribe to fruit and veg box schemes. Findings from their study suggest that the box's low food travel mileage is the most important motives for English veg box consumers to subscribe (so-called 'altruistic reasoning'). While for French consumers' receiving high quality produce was more important ('hedonistic reasoning'). A preference for out-of-season food was reported as the main barrier for English consumers to commit to a veg box scheme. The next main barrier for English consumers was identified to be the cost of the box, which is also the main barrier for French consumers.

STUDY

For the purpose of our study, we worked with a community farm running an organic veg box scheme in Sutton, London, England. The farm helped us to recruit participants from their existing customer base by advertising our study

	Household Information			Size	Freq.
Subscribed group	**Ella**	42	Unemployed	small	weekly
	Husband	42	In financial services		
	Tanya	35	Health policy specialist	small	fortnightly
	Husband	32	Actuary		
	M. child	4	-		
	Abby	39	Project manager	medium	weekly
	Husband	42	Musician		
	M. child	3 mon.	-		
	Sofia	38	UX Designer	medium	weekly
	Husband	49	UX Designer		
	F. child 1	1	-		
	M. child 2	3	-		
	Emily	31	Marketing coordinator	small	fortnightly
	Boyfriend	36	Sales manager		
Non-subscribed group	**Ines**	24	Nanny	medium	weekly
	Boyfriend	24	Software developer		
	3 housemates	-	-		
	Laura	30	Unemployed teacher	small	weekly
	Andrea	34	IT specialist	large	weekly
	Husband	37	Software developer		
	M. child 1	8 mon.	-		
	M. child 2	2	-		
	Daphne	47	Physiotherapist	large	weekly
	Husband	45	Barrister		
	M. child 1	14	-		
	F. child 2	10	-		
	M. child 3	10	-		
	Liam	48	Freelance photographer	small	weekly
	lodger	-	-		
	Zoe	23	Editorial assistant	small	weekly
	3 housemates	-	-		

Table 1 – Table of participants. Bold indicates who took part in the interviews; italics indicate household members who are not regularly involved in the participant's food practices. One participant, Daphne, had to switch their box size from small to large (because of the kids not being at home in the first week).

on their marketing email list and through their social media accounts. Five participants were recruited from the existing customer base; we refer to them as the 'subscribed' group. Another six participants were interested in veg boxes but were not subscribed to any at the time. We enrolled these to the 'non-subscribed' group and subscribed them to a veg box scheme from the same farm (for consistency) based on their household size and their preferences, such as whether to include fruits and potatoes. The purpose of the two groups is to enable us to observe both established and emerging food practices around the veg box. One of the participants switched their box size from small to large during the study, following on from her children not being at home during the first week of the study. See Table 1 for a detailed overview of participants.

Method

Data collection was conducted over three discrete phases:

Entry Interviews. Participants in the *subscribed* group were asked questions about their motivations for subscribing, how the veg box affects their food practices and also other opinions related to the service. Participants in the *non-subscribed* group were instead asked about their existing food practices and their knowledge around veg boxes in general. After the interview, they were given instructions regarding the diary study phase. These interviews lasted between 14 and 36 minutes.

Figure 1 – A large family size veg box.

Diary Study. Participants were asked to report for 14 consecutive days when they used or disposed of any veg box content, as well as any non-use, such as eating out or making food that did not involve the veg box. The information was reported through WhatsApp. To send a diary report, participants had to take a photo of the ingredients or the dish they made and annotate the photo, either through text or audio (e.g. Left of Figure 2). We offered participants to send daily reminders, and 7 of them accepted. The choice of the diary study allowed us to understand something of participants' actual use of the veg box.

Exit Interviews. These focussed on understanding how our participants went about the decision to prepare the dishes involving the veg box contents. Participants in the *non-subscribed* group were also asked about their experience of the veg box and the likeliness of them continuing the subscription. These interviews lasted between 18 and 56 minutes.

Participants

We recruited 10 females and 1 male participant (Table 1). One participant (Sofia) was subscribed to a different company, but her subscription was similar to the veg box scheme offered by the partner farm. Our participants cover various lifestyles and were mostly located within the vicinity of London. Each of our participants considered themselves as the person mainly responsible for food-related tasks in the household.

Reward

Participants received up to £60, according to a reward scheme based on their group and their level of engagement in the study. Those in the subscribed group were paid £32 for taking part in the study, plus an extra £2 for each day that they report at least once. Such a way of incentivising participants to send reports was inspired by a previous diary study [41]. Participants in the non-subscribed group were provided with 2 weeks' worth of free veg boxes, roughly costing £20 per veg box. Additionally, they received an

Reports	Freq.
Meals involving items from veg box	143
Veg box items thrown away	13
Veg box items eaten raw as snack	47
Veg box items difficult to identify	2
Non-use of veg box items (e.g. eating out)	48

Table 2 – Summary of diary reports across the entire study.

extra £1.50 for each day that they reported. Incentives were handed to the participants during the exit interviews.

Diary reports

Overall, 7 participants were able to send daily reports for 14 days. The remaining 4 participants missed at least one day of reporting, of these, two told us that they forgot to report, one had to be in hospital, whilst the remaining one (Tanya) cancelled her subscription towards the end of the study as a result of the introduction of a small collection fee. The diary reports were used primarily as prompts for the exit interviews, rather than as primary data. However, Table 2 conveys a sense of the variety of information we received, and the level of engagement of our participant with the study and with using the box content.

The veg box scheme

The farm offers a number of options for the veg boxes, ranging from small (6-7 items) to large family size (9-10 items) veg boxes (Figure 1). Each veg box is available in two variants: with or without potatoes. Fruit boxes can be included as part of the veg box or as separate. The farm provides a list of upcoming items 2-3 days before the veg box is delivered via email and on the website. Customers can 'blacklist' produce they dislike, which would then be replaced, however, this option is not publicly advertised, and it is made available only on a case-by-case fashion. Although customers can choose the size and type of the box and whether to include or exclude certain produce, its content is still decided by the farm. Users can buy additional items to top up the box, but not to replace the boxes' contents. The farm also provides various options for delivery frequency, ranging from once a week to once a month.

Participants in the subscribed group learnt about the scheme through local promotional events, word of mouth, or via online searches. Table 1 shows the subscription choices of our participants regarding the size of their veg boxes and delivery frequency. Participants in the subscribed group accounted for how they came up with their subscription choices based on two factors: 1) their usual vegetable consumption, and 2) their anticipation of how long produce will stay fresh. We made subscription choices for the non-subscribed group based on their preferences to include or exclude fruits and potatoes.

The farm offers two options to receive the boxes: either through home delivery for a small fee or for free from a number of collection points. Collection points include local

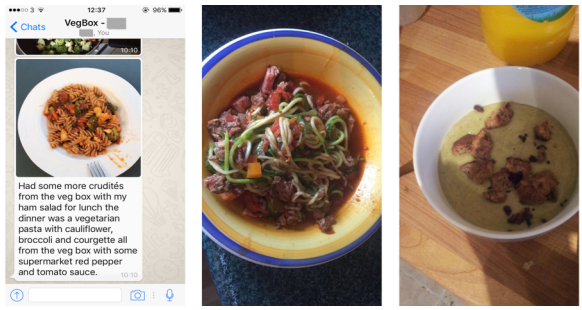

Figure 2 – (Left) Screenshot of a participant's Diary entry (Ella). (Middle) "Courgetti" – The spaghetti noodles were replaced with spiralised courgettes (Daphne). (Right) A photo report of a soup made to hide the taste of some vegetables (Emily).

churches, cafes, shops and the farm itself. As noted above, the farm introduced a small fee during the study (less than the delivery fee) for collecting the veg box from anywhere other than the farm. For convenience and as part of the compensation for their time, we decided that our participants in the non-subscribed group would receive the boxes through home delivery.

Several members of the non-subscribed group gave additional instructions about receiving the box, such as leaving them with their neighbours or making sure that the box was not left in a completely visible location to avoid theft. It is also worth noting that some of them expressed willingness to collect the boxes from a collection point. In contrast, all but one of the participants in the subscribed group collected their veg boxes. This delivery choice was influenced by monetary cost, although participants reported that collecting the boxes was inconvenient. Produce in the veg box is largely grown at the farm or at other farms in the locality, though some (particularly fruit) comes from further afield and even abroad.

WHAT'S SEEN IN THE BREACH

Herein we present the themes that emerged from an inductive thematic analysis of the data [5]. Two researchers were involved in conducting the interviews. The interviews were audio-recorded, fully transcribed. The transcripts were then open coded and the open codes were grouped in broader categories into key themes that '*make or break'* agency delegation in everyday life that are presented in the following.

Exercising some control

Clearly the opportunity exists for users of the veg box scheme to exercise some control over its inherent unpredictability a) by expressing preferences in the course of box selection, and b) by blacklisting items. For example, Zoe provided an example of how they expressed their preferences in the course of box selection.

> Zoe: *Yes, in general and week by week, so I had quite a lot of potatoes then I'd be like actually I've got potatoes, I don't need any more so don't send me any this week, send me something new.*

The statement accounts how exercising control over items in the veg box can be occasioned. Here, already having

items available that might be included in the veg box occasioned explicitly flagging potatoes as undesired in that week. Yet, it is clear that the control is limited to declaring undesired items; the participant orients to the remaining unpredictability in what they might receive instead ("send me something new").

Only one person took advantage of the option to blacklist items.

> Tanya: *They did once give us this, like, really awful green tomato. I'll eat anything that's fresh, but they were awful. I let them know on my account. I was, like, don't give me them ever again, please.*

Warranting delegation

It would thus appear that to participate in a veg box scheme is to accept unpredictability as a condition of engagement, but it is important to appreciate that in doing so agency delegation is *warranted* on various grounds, i.e., participation in agency delegation is subject to various conditions being met. Here, we orient to these warrants made available in participants' accounts.

Firstly, our participants warranted agency delegation on grounds of "locality".

> Tanya: *I quite like the idea of Sutton community farm because it's about, you know, local people growing veg. And I like the whole ethical ethos behind it.*

This concern with the local as a warrant for agency delegation glossed a number of interrelated drivers, such as the motivation to support "local people" and the connected "ethical ethos". Relatedly, participants explicitly oriented to a concern with seasonality of the produce.

> Daphne: *I like the idea of having that seasonal approach of what you've got and you have to make your ... because when you shop at a supermarket all the time everything's always available and so you don't shop, you don't cook seasonally, which is a shame. And so I quite like the fact that you're getting stuff that is obviously in season as far as possible, so it gives you an idea of what actually is around (...).*

Daphne here expresses their appreciation of seasonality as a value provided by the veg box distinct from the "everything's always available" value provided by supermarkets. Thus, agency delegation was warranted in terms of buying local produce, and high quality and seasonal local produce at that, and was something that therefore supported the local non-profit farm, as well as the local community more broadly.

Other participants also warranted agency delegation on grounds of enabling a "healthy diet". For example, one of our participants had recently turned vegan, and took advantage of the veg box as an opportunity to enforce her diet:

> Emily: *That is kind of part of the reason why I started getting the box, because when I went vegan I wanted to make sure that I had a varied diet, and I thought this would like force me to have some vegetables I would never buy because maybe I don't like them that much but I'll still eat them.*

Others warranted agency delegation on the more mundane grounds that the veg box scheme provided them with "peace of mind", in ensuring that they always had a supply of fresh fruit and vegetables to hand.

Agency delegation was also warranted on the grounds of "value for money".

> Ines: *I think it's fair enough for the price. The products are very good, the taste is awesome. It's not the same taste when you buy it at the supermarket, it's not. You can feel the taste, the real taste, so I think it's very, very fair enough. And I don't think it's too expensive – I think it's very cheap, because they bring it to your home, you don't need to go out. You don't need to carry the bags. They take your job.*

As Ines makes visible, value for money is not simply reducible to matters of financial cost, but includes the other costs implicated in going and getting food for oneself (particularly time and labour). Ines also highlights the taste of locally grown produce, which was a topic that was brought up by others as well.

> Andrea: *I mean getting to know the boxes over two weeks I could see what I would really like to have and it's like the cucumbers maybe and the marrows and those things that grow so well here and they actually taste so much better just being grown right here.*

Not only does Andrea appreciate the taste of the locally grown veg, they also orient to discovering the things they really liked. These elements of discovery and serendipity frequently came up. Thus, one of the key drivers of agency delegation was the "element of surprise" occasioned by the veg box.

> Sofia: *The box exposes us to vegetables that otherwise we wouldn't try or think about buying or even have available in the supermarket, like the Swiss chard or the rhubarb or kohlrabi. Like I had never tried it before, right, because I'm not from here and the vegetables are different, I would just never end up trying them. So that's kind of good, that you are forced to actually use the things you don't know.*

Our participants broadly welcomed the unpredictability of the veg box and how it enabled the discovery of new foodstuffs.

> Liam: *I guess it just makes you do things differently than you would do. Yes and I like most vegetables. Just means you have a variety that's different things. You wouldn't necessarily choose to pick up yourself. I sort of like that about randomness aspect of it.*

Liam here highlights that he liked the "randomness aspect" of the veg box which occasioned "doing things differently".

Relatedly, the effect the veg box had on participants' cooking routines was valued explicitly:

> Daphne: *I might well consider restarting because it was quite, I did quite like the challenge of using up and also because I had got my milk ... because I stopped getting my food being delivered because I'd got into a rut and so I quite liked, and so I suppose it's quite nice to have a sort of jolt out of your rut. And to have to sort of consider more what you're, put a little bit more thought ... because again, I like cooking so it's quite nice to have that sort of challenge.*

Daphne here describes appreciating the veg box in that it challenges the usual cooking routine by providing a "jolt out of your rut", which encourages to consideration and thought.

Thus far, participants' accounts have made the grounds upon which agency delegation turns visible, including valuing the local, seasonal ethos the box brings, which people have associated with a healthy diet, peace of mind, value for money, and taste. In particular, 'the element of surprise' and discovery of new items, as well as the challenge this provided for people's routines warranted accepting the uncertainty of agency delegation. The next theme explores how our participants got on with incorporating the veg box in their everyday life.

Incorporating the veg box in everyday life

It was clearly the case that the unpredictable has to be *incorporated* into the orderliness of everyday life and the activities that constitute it.

> Tanya: *During our weekly shop I will have a look at the menu, and the list of vegetables – because they release that, I think, on a Tuesday – and I'll just see what we're getting and then what else we need. Dependent on that, we'll buy whatever else I think that we want to have that week.*

The "menu" Tanya speaks is her meal plan for the week ahead. Of course, not everyone makes meals plans, but all of our participants routinely complemented the veg box to varying degrees to enable its incorporation into everyday life. Our participants commonly bought staple items that they did not receive in the box to permit a range of recipes, and many (like Tanya) bought specific items to match what was received in the veg box to provide for specific meals.

The veg box does not stand-alone then, but is *planned in* to grocery shopping and frequently *built in* to the delivery of specific meals. The unpredictable is made at home in an orderly world through the intentional weaving of veg box contents with other items to meet prospective need. Thus, agency delegation turns on the ability for the unpredictable to be made *accountable* to the particular demands and needs of everyday life: e.g., what we want to eat next week, and even what we want to eat on particular days or at particular times.

It may be the case that the items that get delivered are things the participants would routinely buy and that the veg box fits in with participants' usual meals. However, it may also be, and indeed often was, the case that situations arise where participants have to *adapt* recipes in order to fit the contents of the veg box in with their meals.

> Emily: *So whenever there is something that comes in that I really don't like the taste of I just put it in the soup, because then you can hide the taste* (Right of Figure 2).

Participants routinely adapted recipes, and for variety of reasons both positive and negative, including people not knowing what to do with particular vegetables, not liking them, getting children to eat them, and using up leftovers.

The need to adapt what's in the box to the local order also fosters *innovation*.

> Daphne: *As I say, we had the courgettes and my husband's not a massive fan of courgettes until I tried spiralising them. Then he decided actually he loves those spiralised courgettes and, well, we can now replace spaghetti with courgettes spiralised. So that was great. That was a good discovery to make.*

Daphne's "spiraliser" is a kitchen gadget that allows her to cut vegetables into long pasta-like ribbons. Whether spiralising courgettes (Middle of Figure 2), or turning nasturtium flowers into spicy pakora, or making rich tomato-based vegetable sauces, etc., our participants innovate in order to incorporate the unpredictable into the local order, sometimes (but by no means always) resulting in "good discoveries". In describing such "good discoveries" participants at times explicitly oriented to the sensual delight of recipes improved with items from the veg box.

> Liam: *I often have pasta just with tomato sauce and tuna, which as now I will throw lots of vegetables into it, which will significantly change the amount of vegetables I have in my diet. That was a very easy dish and I was surprised at how nice it was to be crunching on vegetables in a pasta dish.*

Liam here describes the surprise and sensual delight they experienced from augmenting a simple dish they routinely cook with veg box items. Thus, incorporating the unpredictable into the local order *requires* innovation as it seems to us that the unpredictable *has* to lend itself to "good discoveries" if it is to be sustainable. Simply compelling people to adapt to what they are given – e.g., through "hiding" unloved vegetables in soups – is likely to result in agency delegation being revoked.

A further theme that emerged from the study speaks to the barriers that encumber incorporating agency delegation in everyday life.

Barriers to agency delegation

There is a strong sense then in which agency delegation is *constrained*, not only in that an agent's actions must be

accountable to the local order but also in that its actions must facilitate the local order, and it is in the latter respect that the veg box becomes problematic particularly amongst the non-subscribed group. These constraints may, then, be seen as barriers to agency delegation or organisational features of it that must be accommodated on the pathway to adoption. Whether they are accepted or rejected turns on their alignment with the grounds that warrant agency delegation in the first instance.

> Andrea: *They bulk it out with some of the fruit, obviously stuff that they've sourced elsewhere because it's – you wouldn't grow bananas and melons locally. The bananas are from Peru, so same as buying from anywhere really.*

Andrea was not the only participant who noticed that fruits in the box were often *not* sourced locally, nor who thought it worth the extra cost and commitment when you can buy such things "anywhere", and for less.

> Tanya: *I don't actually think it's cost effective, particularly sometimes for the quality of the food that you get and the amount that you waste. Because, you know, the Co-op [a supermarket] does three items every week where it charges, like, 69p. So you can get a bag of potatoes for 69p. You can get a courgette, or a broccoli, for 69p. Tomatoes can be 69p. That's nothing for vegetables, and actually the quality's very good.*

Agency delegation must not only comply with the grounds upon which it is warranted then, be it a concern with locality or value for money (etc.), but insofar as financial control is being delegated then agents must also demonstrate that they are "cost effective". As Tanya makes visible, this goes beyond a concern with money alone. It is money in relation to other *calculable benefits* that matters, e.g., that much the same quality can be had and with less waste by shopping at the Co-op.

The issue of waste was a major concern for participants in both groups.

> Liam: *I'm often in a rush, so I figure I probably have less food waste if I buy pre-made things from Marks and Spencer's [another supermarket] and take the hit on extra packaging than if I was to buy lots of fresh food to cook and then waste what I cook and things.*

For Liam, the issue of waste comes down to a *calculable trade-off* between creating food waste or packaging waste. Most of our participants, like Liam, expressed concern about getting more than they might use in a veg box, and when this occurred some took active steps to avoid food waste.

> Zoe: *I just put them out on the table. [My housemates] helped themselves, and whatever wasn't taken then they were put in the compost.*

Five of our participants gave, shared or swapped veg box contents with housemates, neighbours, friends or family to avoid food waste. Four also composted spoiled or undesirable food items in a bid to recycle them. For the rest, some veg box content inevitably ended up in the bin.

> Sofia: *We have situations that's like, what do we do with them? It's like, I don't know, let's not do them today. So I think they probably – they might go to the garbage, just because we are ignorant, or lazy to Google it.*

It is also the case that Liam was not alone in often being "in a rush", and this too is consequential to agency delegation.

> Andrea: *It's a nice idea but modern life gets in the way, and that's the key thing with these veg boxes I think. It's a bit of – I kind of want to know what I'm going to get in a way. Yes, I want to be inspired – there's these other ideas which my brother's actually subscribed to which is "Hello Fresh", they send you a recipe as well and all the ingredients to make up that meal. So that's the other thing. It's like, yes, you get a random thing, and you want to be inspired to make something new, but then you have to think that you have to go and buy your other things to go with it. So that's going to be tricky sometimes.*

As Andrea makes clear, calculation also includes the potential for agency delegation to gear in with her "modern life". Incorporating the veg box into everyday life then, can be burdensome and makes visible how agency delegation can be a double-edged sword; it's not always straightforward to innovate or adapt meals around veg box items, it can be associated with additional hassle and cost ("having to go and buy your other things to go with it"). Others voiced a related concern more succinctly in terms of *timing*.

Daphne: *My only problem with it was is it arrived on a day... it, like, arrived in the... towards the end of the week, and I'd already done my shopping at the beginning of the week, so sometimes I'd end up with... so that... so I think I found it slightly awkward in terms of that.*

The timing between their shopping and the arrival of the box has made things "awkward" for Daphne. All of the participants who were not regular subscribers commented how they would find it difficult to commit to a regular subscription because of misalignment of veg box delivery timing and their schedule. It is not only a matter of having to go and buy other things then, but of having the opportunity.

Agency delegation thus turns in significant respects on its ability to gear in with people's busy schedules and this latter point speaks to the observable embeddedness of agency delegation within a social division of labour. Thus, agency delegation turns on its *coordination* with *multiple actors* and their *activities*. Whether it be gearing into schedules, or shopping opportunities, or just who is doing the cooking today and for which people, or even eating out, our participants made it perspicuous that agency delegation is accountable to and must mesh in with the social division of labour in which it is embedded and resides.

IMPLICATIONS FOR DESIGN

So what have we learnt about agency delegation from what we have seen in the breach? We can see that agency delegation is *warranted*, i.e., that it turns upon some justification for surrendering autonomy and delegating agency to another party. We can also see that it must be possible to *incorporate* agency delegation into existing everyday activities. And we can see that agency delegation is subject to *constraints* that can act as *barriers* to adoption. The ways in which agency delegation is warranted and incorporated into everyday life are therefore accountable to a range of calculable concerns that determine its fate.

We do not, of course, suggest that this all there is to agency delegation. In our study, agency is delegated to another human, not to software. We recognise too that our findings are very much tied to agency delegation in relation to food, and much of what we have to say here will be related to this particular domain. We also acknowledge the limitation of our study that direct comparisons between the IoT and veg box schemes cannot easily be made given that, unlike IoT products, veg box schemes are not based on sensor data collected from users. Nonetheless, we take it that the veg box study elaborates salient insights for the design of an Autonomous Internet of Things (AIoT) more generally, insofar as any uptake of the AIoT will have to be warranted and incorporated into everyday life by end-users in the face of a heterogeneous array of contextually dependent calculable concerns that put hard constraints on adoption. Thus, even at a high level, our findings furnish design with researchable topics of broader relevance, which we discuss in turn.

Supporting creativity

While automation is typically driven by values of efficiency and convenience (cf., [13]), our data revealed that a different set of values and benefits could be derived from delegating agency to an external service. Many of our participants found the "element of surprise" of the unpredictability of which vegetables their box would contain made them more creative in their cooking. Others valued the discovery of previously unknown vegetables. Others were delighted by the sensual experience of enhanced recipes. This suggests that a certain degree of unpredictability in agency delegation can speak to a different set of values: delight, discovery, and creativity. This result points to opportunities for autonomous technology to offer users items or actions that they may not expect as a feature. It also suggests that users of autonomous systems may be tolerant to unpredictability, at least if its cause is understood and accepted (in the case of the veg box, the seasonal availability of items).

We feel encouraged then to stress that A-IoT design should not only strive towards optimality, accuracy, etc., but also accept that uncertainty can in fact lead to beneficial user experience. This finding chimes with Gaver's work on ambiguity as a resource in design [24], as well as Roger's appeal to move Ubicomp applications beyond the agenda of calm computing towards applications that foster creativity [37]. There is much room then for new agendas in domains typically motivated by convenience and efficiency, such as smart homes and the IoT. Work in this space has already begun, for example to explore how the unpredictable can delight and surprise people, and how it might support creative practice (e.g. [30]).

So what can design do? Insofar as unpredictability is welcomed into everyday life, then we would also add that supporting the practices of *adaptation* and *innovation* is an important ingredient to add to the design mix. Users will need to adapt and innovate to be able to incorporate the unpredictable into their everyday life. Without them, and the serendipitous discoveries that often accompany them, there is no solid ground for agency delegation to stand on and the warrant will inevitably be revoked. After all, people do not just want to make do with what they are given, especially food. And how might we support adaptation and innovation through design? Considering the food domain, creative ideas how to prepare, combine, and cook items could be provided[1]. Aside from recipes, this could include instructions how to adapt existing recipes, how to manage a surplus of items to avoid waste, or how you might 'hide' flavours of undesired items.

Supporting value calculation

More in general, in a domestic food context, it is clearly the case that the grounds upon which an AIoT might stand are manifold: locality, seasonality, health, value for money, serendipity, and creativity all warrant agency delegation with respect to food. The grounds are not static either, but subject *continuously* to calculable concerns to do with warrant compliance, and cost effectiveness with particular respect to quality and waste. It might be said, then, that a heterogeneous *array of values* motivates and sustains or curtails agency delegation. The array is important. No particular value or combination of values is ubiquitous. It all depends on the local order, on just what these people, in this house, value. There is need then to cater for all and support people's value calculation practices through design to enable effective agency delegation, where effective means that agency delegation can effectively be incorporated into the local order. Rather than to attempt creating autonomous agents that are assumed to act flawlessly, we advocate for mixed-initiative approaches [2], in which agency can be fluidly transferred from the system to the user and vice versa to support the user's own value calculation.

So how would or could you enable value calculation through design? One approach could involve solutions that allow people to express their values, and define how computational agents should respond to them. Technical approaches that have been explored in the literature include

[1] An example is https://www.ibmchefwatson.com/

value sensitive design in agent design [18, 19], and preference learning. For example, PlateClick employs a quiz-based user interface to elicit people's food preferences, which can then be used in an online learning framework [46].

An alternative approach is to make information relevant to the values and to the device or service easily available to the users. For example, in the case of autonomous systems that mediate domestic *energy consumption*, data about financial savings on the utility bills, about fuel efficiency and about the origin of the energy (e.g. gas, wind, solar) could help users to continuously evaluate the system's performance and hence grant or revoke agency. Such an approach has recently been demonstrated by a small variety of research projects [2, 3, 4, 49]. Similarly, for *autonomous cars*, it may be useful to display information related to the financial cost of each trip (such as in [42]), the fuel efficiency, and how long the trip will take – for all these variables the comparison between autonomous operation and manual mode should be shown.

More in general, we see potential for AIoT systems to integrate techniques that can track the *provenance* of goods and the derivation of decisions, such as distributed ledgers [1]. For example, in the case of the veg box, our data suggests that customers question and make assumptions about where the produce comes from[2] [31], and why it is included in a delivery. Is it local, or does it come from far away? Does it come from an environmental and socially sustainable supplier? A recent project considering this approach is Bitbarista [35], which explored the application of crypto-currencies (based on distributed ledgers) to link the users of a coffee machine to remote farmers growing the beans.

Supporting local coordination

Our findings highlight the challenges of actively integrating agency delegation into everyday activities. Hence it is not sufficient for a computational agent to 'merely' attend to its delegated business: that business must also be made accountable to other mundane matters implicated, in this case, in the provisioning and consumption of foodstuffs. Thus, agency delegation around the veg box must *integrate* with household shopping, to ensure that meals can be provided, and even with specific plans as to what just what will be eaten and when. Again, incorporating agency delegation into everyday life is an *ongoing* matter conducted in response to calculable concerns with scheduling and coordination. Thus, integration extends to gearing agency delegation in with the social division of labour.

There is need, then, for design to support **coordination** to enable effective agency delegation, where effective here means that computational agents can demonstrably mesh their actions in with other local actors and (food related) activities. Research has demonstrated the design of agents that draw on further digital resources to enrich the grounds upon which agents take action. Resources have included for example people's calendars as a way to coordinate availability [32], and people's location as a way to provide services just-in-time [40], invoking the trope of "remember the milk" services that remind people at just the right time when they are near the shop on their way home (along the lines of e.g. [27]).

The IoT offers potential to extend this work, taking into account the operation of (Internet connected) domestic appliances and smart jars able to sense and report their own content (e.g. [15]), as well as harvesting information from social media and shared calendar accounts, and from personal device location. This information could then be combined with data about available supply to extend stock control and supply chain optimization through "the last mile" to the home, not only in terms of incoming goods, but also facilitating food sharing and food waste reduction, extending existing practices [22]. It should be noted, however, that designing a system to integrate such heterogeneous sources of information in a timely and relevant manner is still a technical challenge. However, the point we wish to make is not that all solutions lie in automation, but to provide enhanced digital resources for people to make their own decisions, to provide resources that support people's own coordination practices.

CONCLUSIONS

In this paper, we report the findings of a qualitative study, through semi-structured interviews and a two-week diary study with 11 households in the UK, which seeks to understand how people manage a veg box scheme as an instance of an inherently unpredictable service. In particular, we focus on how people manage agency delegation and integrate the veg box into their everyday life. Our findings suggest that agency delegation must be warranted, that it must be possible to incorporate delegated decisions into everyday activities, and that delegation is subject to constraint. We consider the potential impact of these social organisational issues on the design of a future AIoT supporting food-based practices in the home, and the challenges of making agency delegation accountable to meal planning, persons' schedules, food-centred values, adaptation and innovation, and the social division of labour in which computational agency will ultimately be embedded.

ACKNOWLEDGMENTS

This research was partially funded by the Engineering and Physical Sciences Research Council [grant numbers: EP/I011587/1 and EP/N014243/1]. Study approved by University of Southampton Ethics Committee (ref: 19339). The diary reports are available at http://doi.org/chpm.

[2]Tracking the provenance of food has also been the aim of several companies, such as Project Provenance Ltd (https://www.provenance.org/)

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