Bitbarista

Bitbarista: Exploring Perceptions of Data Transactions in the Internet of Things

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ABSTRACT

We are surrounded by a proliferation of connected devices performing increasingly complex data transactions. Traditional design methods tend to simplify or conceal this complexity to improve ease of use. However, the hidden nature of data is causing increasing discomfort. This paper presents BitBarista, a coffee machine designed to explore perceptions of data processes in the Internet of Things. BitBarista reveals social, environmental, qualitative and economic aspects of coffee supply chains. It allows people to choose a source of future coffee beans, situating their choices within the pool of decisions previously made. In doing so, it attempts to engage them in the transactions that are required to produce coffee. Initial studies of BitBarista with 42 participants reveal challenges of designing for connected systems, particularly in terms of perceptions of data gathering and sharing, as well as assumptions generated by current models of consumption. A discussion is followed by a series of suggestions for increasing positive attitudes towards data use in interactive systems.

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces

Author Keywords

Design; Internet of Things; Data Transactions; Privacy; Supply Chains

Figure 1. Bitbarista ready to serve

INTRODUCTION

Since modernists claimed that *less is more*, principles of minimalism and simplicity have become increasingly influential in design. In Interface Design, Norman [21] classically advocated for interfaces that are clear from clutter and distraction, allowing users to focus on the task at hand. Nielsen [20] defended the need for interfaces where dialogues do not contain information that is "rarely needed". Although much has happened in interface design since then, the drive for minimal information remains largely influential. Apple Inc. is praised for its user interfaces with fewer buttons, menus and dialogue boxes. Amazon Dash offers a simple one-button device as an interface for ordering goods. Behind the scenes, however, these devices are performing increasingly complex tasks. Smartphones are constantly exchanging data to offer users the right information at the right time, and connected devices such as the Amazon Dash conceal intricate exchanges with multiple stakeholders.

As reported by previous research, however, the accuracy with which technology infers users' activities can be disturbing [26]. Events such as the 2011 disclosure of GPS data storage by Apple Inc. without open consent create suspicion towards what happens behind the scenes. Discomfort levels increase as people acknowledge that data transactions may occur without explicit agreement. This is problematic, particularly as more everyday objects become enhanced with digital connectivity. This tension between interfaces that hide complexity of data transactions to increase ease of use, and the amount of

background transactions that are necessary to sustain seamless interactions, argues for revisiting arguments for more seamful design approaches [7], increasing visual complexity [18], as well as recent arguments for more transparency regarding data exchanges [15].

In this paper we present Bitbarista, an Internet connected coffee machine that attempts to communicate complex data processes involved in analysing price changes and selecting best choices for near-future coffee bean supplies. The machine envisions a scenario in which it would be able to gather consistent information on the state of coffee producing countries, revealing issues that affect end-prices. Nowadays, consumers are often unaware of these issues, which may include political, work and climatic changes. Instead of reducing information overload, the machine proposes to expose its analytics process, attempting to communicate the way data is narrowed down to a few options. The aim is to explore perceptions of transactions in the Internet of Things (IoT) by presenting a scenario in which exposing this complexity would have a positive effect on how users perceive the machine. Our initial study of Bitbarista identifies positive attitudes towards the displaying of data, as well as the challenges of designing alternative models for data transactions.

RELATED WORK

Work within the design community has focused on raising awareness of data transactions taking place, by developing sophisticated sensory cues and exploring people's involvement and engagement with data and IoT devices. Houben et al. [15] developed Physikit, a tangible interface for users to engage with these transactions. Metha et al. [19] present a haptic system that creates an 'itch' to warn people of data sharing, enabling users to set their privacy preference using a 'scratch', finally suggesting that haptic systems, being nonvisual and silent, are ideal for communications regarding privacy issues. These are important proposals to make hidden data exchanges more detectable. However, previous work [1] has shown that simply providing more control and more transparency around data exchanges are not straightforward solutions to the problem of increasing levels of user comfort in this context.

The benefit to users of personalisation has been demonstrated in studies, which also acknowledge the need to protect privacy, thus highlighting the tension between the desire for personalised experiences and discomfort with sharing personal information [4, 9, 17]. Other studies have explored perceptions of data gathering and use practices [14, 6, 26, 12, 23, 30] as well as users' disclosure of personal data and perceptions of related security risks, for example on social media sites [31, 13, 8]. These studies reveal that designing for complex data transactions is an area in need of considerable attention.

Efforts to address the problems of security and privacy in this context have focussed on trust building [9], offering a balance of control over data [17], improving the efficacy of consent and permission processes [16, 28, 5, 2], and raising awareness of the security risks of disclosing personal information [3, 29]. Dupree et al. [11] developed personas representing different types of attitude towards privacy and security concerns and behaviour, in an attempt to clarify the range of attitudes and approaches to managing data.

In terms of understanding perceptions of data transaction in IoT, Worthy et al. [30] used a probe described as an ambiguous IoT device, installed in participants home for the period of a week, to explore concerns arising from its presence and activities. The study showed that the artefact faded into the background of participants' routines and trust was identified as a critical factor. With more ambient characteristics, Worthy et al.'s probe presents remarkably different affordances when compared to Bitbarista.

Approaches to date respond to current models of data access and gathering. They often treat these models as a given, rather than attempting to propose a different one. In contrast, Bitbarista proposes a system where choices offered are based not on users' previous choices and preferences, but on the broader contextual picture behind those choices, and how these affects others in the complex web of data transactions. We propose a system that increases the transparency of data used in the transaction taking place in an attempt to build trust.

There have been a few commercial systems that contribute to expand awareness of data, such as online tools that inform on background information of products (e.g. provenance.org and carbon footprint toolkits). Bitbarista is different from these tools in that it integrates different data sets into the design of a physical machine and displays it in the context of purchase, creating a direct link with users.

BitBarista can also be placed among movements that attempted to look beyond traditional principles of design. Slow Technology [22], Slow Design [27] and Temporal Design [24], for instance, attempt to look beyond dominant narratives of efficiency and time-saving. In line with these movements, Reflective Design [25] focuses on engaging people in critical reflection, as does Critical Design [10] from a different angle. Some proposals have also attempted to inform users about the complexity of factors that lead to critical events in the world, such as Wired's Cutthorat Capitalism (wired.com, 2009), a game that attempts to create empathy and communicate motivations for piracy in Somalia. Bitbarista aligns with these design movements in the sense that it proposes an alternative way of integrating data in the design of interactive systems, one that is not focused on efficiency but on information. It also attempts to create a more direct link between consumers and producers across the globe.

BITBARISTA

Bitbarista is a technology probe designed to explore perceptions of data processes in the Internet of Things. The coffee machine is connected to the internet and serves coffee in exchange of a bitcoin contribution towards its next coffee supply. It purportedly browses online data on the state of coffee-producing countries looking for information on climate, work conditions, political situation, infrastructure, price stability and demand, and selects top-ranked options in 4 categories: best quality, lowest price, lowest environmental impact and highest social responsibility. The machine offers users the opportunity to choose one of these options for its next supply,

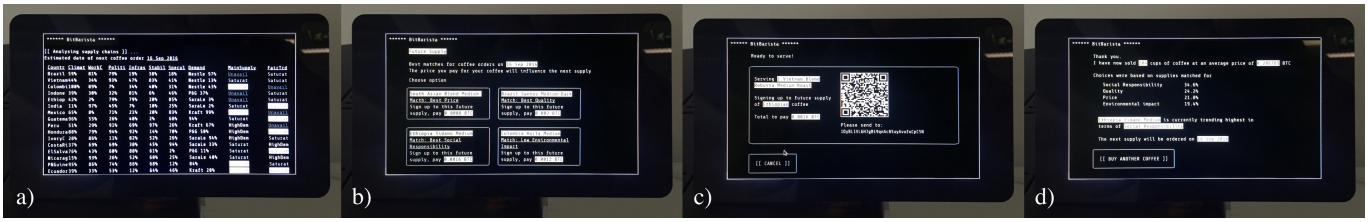

Figure 2. Bitbarista a) Analysing data on the state of coffee producing countries; b) Narrowing down results to 4 options; c) Selling coffee for bitcoin contribution towards next supply; d) Situating choice within the pool of choices previously made

paying for their coffee accordingly. After the purchase, a new screen situates the choice within the pool of choices previously made, all anonymised, displaying the supply most likely to be ordered next. The machine presents some autonomous features: it can administrate its revenues, order coffee, and rewards people for helping with its maintenance, e.g. by refilling coffee beans, filling its water tank, and cleaning it.

Bitbarista attempts to illustrate the complexity of factors involved in coffee supply chains, from production to distribution and purchase, in order to give users a stronger sense of participation in this process. It suggests that data could help to bring end consumers closer to the source of products, reducing intermediaries, and asking how users would receive this proximity. The autonomy of the machine to purchase coffee and set up prices are central in this context. The machine also indicates that choices are made collectively. It asks how people would react to making choices with this collectivity in mind, while placing choices in the future rather than the present. Although the machine only purports to browse data in real time, and the data that it claims to have found is not fully available at that precise moment, its categories were defined based on recent technical reports on coffee production[1], and the process that it illustrates is not far-fetched. Our motivation was to design a connected device that would provide a more positive attitude towards data display, usage and sharing.

Bitbarista is different from most IoT devices in the sense that
a) it displays rather than conceals data processes;
b) it connects data to the situation experienced, placing users within the forces that govern this data; and
c) it offers options for users to choose how they would like to participate in this process.

Ultimately Bitbarista was designed to investigate
a) if communicating the complexity of events that result in products being available for consumption would have a positive impact on users, and could therefore be seen as a feasible design approach,
b) the overarching perceptions towards diverse sets of relatively unprocessed data, e.g. how participants relate, categorise and imagine data in the context of IoT.
c) how comfortable people would feel interacting with an IoT system that uses data to illustrate this complexity.

[1]e.g. www.ico.org/news/icc-111-5-r1e-world-coffee-outlook.pdf, www.agra-net.com/agra/international-coffee-report/daily-market-report

BITBARISTA STUDY

In order to understand the effect of BitBarista, we carried out an initial study with 42 participants in total. In particular, the study aimed to understand:
a) how aware participants were of the complexity of issues involved in supply chains and in which extent connected devices could help increase this awareness.
b) what impact data presented by Bitbarista would have on participants. If, for instance, they would be more empathetic towards data that connects to positive principles of environmental and social responsibility. In particular, we wanted to find out if these principles would increase their level of trust in the machine, and if different kinds of data would lead to different levels of trust represented, for instance, by a willingness to share data with these systems. We also aimed to explore if people would be more naturally inclined to share principles with a system, for example if they thought this system could help promote these principles.
c) if different sorts of data would motivate different attitudes towards data use and sharing. If, for instance, sharing principles and ideas would be regarded more positively than sharing other kinds of data.

Questionnaire as a probe

The study was organised around a questionnaire that complemented Bitbarista as a probe. The questionnaire was lightweight and quick to complete. It was designed not to test the interaction or to validate design decisions, but to provoke discussion around the 3 points above. It differed from traditional questionnaires as some of its questions left space for interpretation. Central to the study was the interaction with the machine. The questionnaire followed up from this interaction, raising issues around data transactions more generally, e.g. by asking about ideas of autonomy, or diverse sorts of data that could be perceived as personal. After filling in the questionnaire participants were asked about motives behind each response in a semi-structured interview. The questionnaire had 5 questions in total and was divided in two sections:

Section I) Participant profile:
Q1) The only question of this section consisted of a series of 5-point Likert scales (1 = strongly disagree, 5 = strongly agree) which attempted to understand how participants saw the impact of their purchasing choices: if they considered that their choices affected what is available in shops, if they affected producers, suppliers, people across the globe, and if participants thought their purchasing choices would have an impact in the future. It also asked if participants felt their

Table 1. Q1: How participants perceived the influence of their buying choices (Average of Likert scale 1= strongly disagree, 5=strongly agree)

My buying choices	*Phase I*	*Phase II*	*Both*
Affect what is available in the shops	3.6	3.7	3.7
Affect producers and or suppliers	3.7	3.9	3.8
Affect people across the globe	4.0	3.8	3.9
Will have an impact in the future	3.8	3.6	3.7
Are constantly tracked	3.6	3.6	3.6

purchasing choices were constantly tracked. The aim was to understand how much they felt part of the complexity of factors that Bitbarista attempted to illustrate.

Section II) Perceptions of data transactions around Bitbarista

This section consisted of 4 additional questions, answered via a series of checkboxes:

Q2) The second question presented 10 checkbox options to investigate how participants understood and perceived Bitbarista's features. These options were defined in 3 strands:

a) 4 options corresponded to features that accurately defined what was presented, and were introduced to test comprehension of the machine. These options were: "Connect to the web", "Gather information from producers", "Gather data on the state of producing countries", and "Buy coffee".

b) 3 options were inaccurate, and could be seen as potentially invasive. They were not presented as features of the machine, and were introduced to investigate issues of privacy. "Talk to banks", "Find out how many Bitcoin I have", and "Access data on my phone" were inaccurate features, as the machine uses bitcoin for transactions and therefore does not need to establish any direct connection with the phone, talk to banks, etc.

c) Finally, 3 options were open-ended: features that were not presented as characteristic of Bitbarista but which could be interpreted as such. These options were introduced to probe into ideas of autonomy. "Decide what kind of coffee I drink", "Change the price of my coffee", and "Talk to other coffee machines", were open-ended.

Q3) The next question concerned participants' perception of whom Bitbarista was working for: if it was working for themselves, for coffee growers, coffee distributors, a coffee machine manufacturer, a technology company, or simply for itself. The idea was that participant's perceptions of motives behind Bitbarista would be likely to influence how they perceived the system as a whole.

Q4) The fourth question asked whether participants perceived sharing different kinds of data (e.g. buying history, buying principles, personalisation settings, etc.) to have a positive, negative or no impact on Bitbarista.

Q5) The final question referred to what Bitbarista could do in the future, if it would help to improve the quality of their coffee, help coffee growers, help to support a fairer production chain and if it would go about learning participants' preferences, access their data and give access to their bitcoin account.

Probing situations

The questionnaire attempted to invite reflection on particular issues around data awareness, access and sharing in the Internet of Things. It was implemented in two situations, firstly in an exhibition space, where participants interacted with the machine, filled the questionnaire, but were not interviewed, secondly in a more formal environment where participants were interviewed about their answers after using the machine and filling in the questionnaire.

I) Exhibition

Bitbarista was set up in an technology-related exhibition space within a larger festival in the UK. Participants were therefore members of the public who chose to visit this exhibition, and were not formally recruited or interviewed. A sign was attached to the machine explaining how it worked, and focusing on its ability to take bitcoin payment and to reward people for carrying out small maintenance services. Invigilators carried a smartphone with a bitcoin wallet, which was lent to visitors if they did not have their own. They also asked participants to fill the questionnaire after they had purchased a coffee. This interaction was sometimes followed by a conversation, which was not audio recorded. We gathered 28 questionnaire responses in two weeks of the exhibition, as reported in the next section.

II) Interview Study

We subsequently organised a study in a more controlled environment. Feedback received in the exhibition did not affect the design of this study. We recruited 14 participants in total (6 females and 8 males). 11 in campus (6 support staff, 5 PhD students) and 3 externals. 6 aged 20-29, 4 30-39, 3 40-49 and 1 50-59. Participants presented diverse backgrounds, including security, technical staff, and researchers and students in informatics, arts and the humanities.

BitBarista was set up in a dedicated room, where the study took place. Participants were asked to consider a scenario in which the machine was installed in their work space. In case they did not own a bitcoin wallet, they were asked to use a mobile phone setup for the study, and to imagine that this was their own. Participants used the machine to purchase a coffee, were invited to fill the questionnaire and were asked about their answers in an interview. The questionnaire probe was used to guide and loosely structure the interview, while guaranteeing thematic consistency across participants. Interviews took 20-40 minutes, enabling us to delve into the thinking that drove responses to the questionnaire, and to reflect on motives behind responses given in the exhibition space.

Before interacting with the machine, participants were asked about their technology literacy, usage of portable devices, knowledge of Internet of Things and bitcoin. 3 participants considered themselves novices (P2, P4, P12), 3 experts (P10, P11, P14), and 8 considered themselves dabblers in technology. 2 participants did not own a smartphone or tablet (P4, P12). 7 were confident about their knowledge of IoT, and 6 were confident about their knowledge of bitcoin. Only one participant owned a bitcoin wallet (P13).

Table 2. Q2: Percentage of participants who perceived BitBarista as having the following features:

	Phase I	*Phase II*	*Both*
Accurate features (related to understanding of the machine)		Total aggregated 83%	
Connect to the web	93%	93%	93%
Gather information from producers	86%	86%	86%
Gather data on the state of producing countries	61%	86%	73%
Buy coffee	79%	79%	79%
Inaccurate features (related to issues of privacy)		Total aggregated 51%	
Talk to banks	29%	43%	36%
Find out how many bitcoin I have	68%	43%	55%
Access data on my phone	61%	64%	62%
Open-ended features (related to ideas of autonomy)		Total aggregated 44%	
Decide what kind of coffee I drink	36%	29%	32%
Change the price of my coffee	57%	50%	53%
Talk to other coffee machines	50%	43%	46%

RESPONSES TO QUESTIONNAIRE

Most answers to the questionnaire were relatively consistent in the exhibition and interview setup. Questions were not meant to assess participants' knowledge or the success of the machine, but to trigger conversation.Therefore what motivated responses became clearer after the interviews.

Participant profile: impact of consumption vs privacy

Responses to the participant-profile section of the questionnaire, which aimed to understand how participants considered their buying choices, scored higher for socio economic impact (3.8 average across responses to the first 4 questions) than for perception of choices being constantly tracked (3.6 average) (see **Table 1**). This suggests slightly higher concern about the impact of consumption than about privacy.

Bitbarista features: conduit for human-decisions and data

In the second section of the questionnaire, Bitbarista features presented as accurate (its ability to connect to the web, buy coffee, gather information on producers and the state of producing countries) were acknowledged in 83% of the cases. Inaccurate features scored lower (51%) while open-ended features, introduced to investigate ideas of autonomy, (decide what kind of coffee I drink, change the price of my coffee, and talk to other coffee machines) scored the lowest (44%) (see **Table 2**). In the interviews, it became clear that the open-ended "decide what kind of coffee I drink" was not marked because participants understood the machine as a conduit for human-made decisions, while the option "change the price of my coffee" was not marked because they saw Bitbarista as a neutral conduit for data. Such responses indicate a lack of perceived autonomy of the machine, as discussed in the next section.

Table 3. Q3: Participants who agreed Bitbarista is working for:

Bitbarista is working for	*Phase I*	*Phase II*	*Both*
Me	64%	79%	71%
Coffee growers	61%	64%	62%
Coffee distributor	36%	71%	54%
Coffee machine manufacturer	46%	57%	55%
Technology company	54%	79%	66%
Itself	54%	15%	34%

What lies behind Bitbarista: technology companies in line with coffee growers

Regarding whom Bitbarista is working for (**Table 3**), high scores were observed in "for me", for "coffee growers", and for a "technology company", which suggests that participants were able to reconcile the interests of possibly disparate entities. We observed a significant difference in results for "coffee distributor" and "itself" in responses given at the exhibition and in the interview study. "Coffee distributor" scored low in the exhibition and high in the interview study, and for "itself" scored high in the exhibition and low in the interview study. As discussed in "Limitations and Future Work" section, we assume that this difference refers to the way Bitbarista was introduced to participants, emphasising its autonomous features in the exhibition, and holding a neutral position in the interview study.

Overarching perception towards diverse data

Perceptions of kinds of data shared with Bitbarista (**Table 4**) were consistently positive in both phases for options "buying history", "buying principles", "thoughts on creating a better future", and "coffee preferences", and consistently negative for "mobile phone number", "facebook page" and "credit card details". As suggested by the interviews, this difference potentially relates to how participants understood the context in which data would be used, as some participants suggested that negative views are related to a lack of perceived connection between the kind of data and what Bitbarista does.

"My buying history" was seen more positively in the exhibition than in the interview study. As also suggested by the interviews, this may be due to participants being concerned that their buying history could be revealed to work colleagues, once they were asked to consider their work environment as a scenario of usage in the interview study. Sharing "my coffee preferences" was consistently regarded as positive, indicating the importance of differentiating between preferences (set by users) and history (recorded automatically).

Bitbarista in the future: supporting a fairer production chain while learning about users preferences

Perceptions of what Bitbarista could do in the future (**Table 5**) differed slightly in the exhibition and in the interview study, with all options scoring higher in the interview study, except "give access to my bitcoin wallet". Options that scored the highest were "help coffee growers", "support a fairer production chain" and "learn about my preferences", which indicates a positive attitude towards Bitbarista's use of data to support different consumption models.

Table 4. Q4: Perceptions of the effect of sharing data with Bitbarista (positive=1, neutral =0, and negative effect =-1)

	Phase I	*Phase II*	*Both*
My coffee preferences	0.74	0.77	0.75
My buying principles	0.63	0.58	0.61
My thoughts on creating a better future	0.61	0.58	0.60
My buying history	0.67	0.23	0.45
My mobile phone number	-0.20	-0.31	-0.25
My facebook page	-0.17	-0.31	-0.24
My credit card details	-0.35	-0.23	-0.29

Table 5. Q5: Participants who thought that BitBarista could:

Bitbarista could:	*Phase I*	*Phase II*	*Both*
Help improve the quality of my coffee	61%	64%	62%
Help coffee growers	64%	93%	79%
Support a fairer production chain	61%	100%	80%
Learn about my preferences	78%	86%	82%
Access my personal data	50%	57%	54%
Give access to my bitcoin account	43%	36%	39%

INTERVIEW RESPONSES

Interviews with the 14 participants were audio-recorded, transcribed, and coded into 12 labels. The coding was carried out by two researchers individually, who cross-checked consistency and extended the number of labels to 18. These labels were grouped into the the main themes represented by the subsections below.

Extended Connectivity

In discussions triggered by Question 2 (see Table 2), it became clear that most participants believed that Bitbarista would carry out data transactions beyond the observed system. As indicated by questionnaire responses, participants understood that BitBarista was connected to the Internet and that it was able to gather data regarding coffee growers and their circumstances, but the interviews also revealed that participants assumed a direct connection between Bitbarista and the smartphone, after the latter was used to complete the purchase. This belief led the majority of participants to assume that BitBarista would connect to other systems and applications on the Internet, that it would be able to gather personal data, trace their coffee choices back to them, and exchange this information with third parties. While most were uncomfortable about this exchange, a few had a more positive perspective as they trusted that this exchange would be done for a good cause.

Assumption of data exchange with the smartphone.

Most participants (**P1, P2, P3, P4, P5, P8, P12, P14**) were convinced that BitBarista would gather data from the phone: *"my phone is connected to the network, and this is connected to the network [and] any time two devices talk to each other, there's potential for them to talk in more ways than you intend"* (**P2**). In two cases (**P1, P4**) this perception remained even after being told that no data was exchanged between the devices *"yeah, you tell me it's a one-way system, but it might be a two-way system [...] Like all these things develop over time. Turns out they should get updated, 'oh by the way, we've all thought of something where we're going to need your data'"* (**P1**). Other participants were uncertain about the nature of the connection between BitBarista and the phone (**P6, P7, P9, P10, P11**) *"I'm not even sure about how it could track, but I'm guessing it would"* (**P6**). Only **P13** trusted the system to ask for permission before accessing data on the phone: *"Usually they all ask for permission"*.

Assumption of personal identification.

Most participants took for granted that Bitbarista would be able to identify them. This assumption was largely drawn from previous experience with digital devices where preferences and behaviours were tracked (**P1, P2, P3, P4, P5, P6, P8, P9, P11, P13**). For example, **P6** noted *"I think just because it's digital it's already even causing traces, and possibly how I'm, um, kind of frequently buying coffee"*. In some cases they understood the data connection discussed above to have been made through the bitcoin wallet, but didn't understand how this worked: *"I assume it would remember me by the bitcoin wallet. Um, so yeah, it should know who I am"* **P13**. **P2** thought that smartphone payment would guarantee identification, while payment via a touchscreen on the machine would guarantee anonymity: *"If I was only touching the screen and it was in an office then it wouldn't be able to identify me"*.

Personal identification as expanding vs limiting experience

Participants also saw benefits in Bitbarista identifying them. **P2** considered this identification a reward for effort put into deliberately making ethical choices: *"do I care if it can be traced back to me? I'm actually quite happy to say I'd buy this kind of coffee, because I make, I try to make ethical choices when I buy my coffee and I'm, like, putting a lot of effort into that so then I don't mind"*. This identification was also seen as allowing for a more personalised coffee experience (**P1, P2, P3, P4, P11**). It would learn about personal preferences, logging and creating a data set of choices, together with time records of purchases, therefore creating a record of coffee drinking habits, while being able to respond to these records *"if it will analyse my buying history and it will adapt accordingly, that means that it will help improve the quality of my coffee, as in the coffee that I like, um, so that would be great"* (**P1**).

Conversely, **P6, P11, P13** thought that gathering data about their choices would reduce the possibility of expanding their experience. This data would constrain their future choices as participants would only be presented with choices recorded in their profile, rather than completely new ones: *"when everyone's getting similar messages, it's just very easy to fall into, kind of, a pattern that isn't really - your own traces."*, and **P11** says, *"If you constantly push the 'I want to save the environment', would it...yeah, offer more of that sort of thing?"*

Data gathered might misrepresent participants.

Among participants who did see positive aspects in being identified, 3 of them also reported mixed feelings about this identification, as the data gathered about coffee preferences was also regarded as sensitive (**P2, P3, P4**). **P4** described how she would not want her choices to be revealed in an office environment *"What if someone in the office has less money*

than another person [...] I'd feel embarrassed, I wouldn't want to use it if I was the person who couldn't afford the thing". This view takes into account, not just the interactions with the machine, but the broader context of the office space in which choices are made.

As expressed by **P4** above, there was a concern that data gathered about coffee choices could potentially misrepresent participants (**P3, P4, P5, P13**). *"I would maybe choose the cheapest option on a certain day, and then on another day I might want to be more environmentally friendly, so, you know, it's maybe not a true representation of me, it might be just that I don't have enough bitcoins this week so I'm going to pick the cheapest one"* (**P5**). **P13** expressed concern, less for what the machine recorded and more for how other people might interpret and judge what was recorded *"Cause people, people make judgments on things they see somewhere else, without context. It, it isn't so much that something knows about those things, it's that someone will make a decision about what they found out from that thing"*.

Data gathering accepted if relevant to what Bitbarista does
Participants **P2, P3, P7, P9, P10** were concerned about the system gathering information that they considered irrelevant to purchasing coffee, such as their phone number and bank account details: *"if Bitbarista got information, got personal data about me that was irrelevant to my coffee buying choices that I didn't want it to have then I don't think I'd be very happy about it"* (**P2**). This was compared to experiences with other systems *"I don't really understand why some things need to have access to your location, to your photos, or even things that, are things not related to what it does"* (**P9**). (**P4, P14**) conversely mentioned being comfortable about Bitbarista accessing data that is relevant *"if you are collecting data on the preferences of people, on coffee drinkers all the time, then that has the potential to improve the quality of the coffee you drink."* (**P14**).

Data transactions beyond Bitbarista

Negatively viewed in the context of marketing purposes
Most participants (**P1, P2, P4, P5, P6, P7, P9, P10, P13, P14**) assumed that data transactions would be carried out beyond the Bitbarista system *"every time you give information to your device you give it to a company of some kind"* (**P2**), *"it's technical, so somebody must be getting something from it"* (**P10**). This assumption was mostly accompanied by negative feelings *"actually, if it was able to access data on my phone then I probably wouldn't want to use it"* (**P10**). **P2, P4, P5, P7, P9, P11, P13** thought that their data could be used for other purposes, such as targeted marketing or assumed that it would be crossed with other personal data such as from their social media accounts *"from a kind of gut reaction [...] possibly it's connecting to other things like Facebook, or Amazon, and it may be looking at preferences and, you know, maybe soon I'm going to get a lot of coffee ads in my Facebook"* (**P5**).

P4, P6 and **P9** reported a sense of powerlessness stemming from the necessity to interact with devices and data gathering systems, while at the same time being unable to control access to their personal data from these devices: *"I'm always very reluctant to say yes to that, but then sometimes you can't get it if you don't say yes to it. Um, but it is a sort of 'hmm', just because otherwise you won't be able to use it at all, and I will say yes to it"* **P9**.

Positively viewed if within the Bitbarista system.
In contrast to the above, participants were generally neutral and even enthusiastic about the possibility of Bitbarista talking to other coffee machines (**P1, P2, P3, P9, P11, P13, P14**): *"so they all, you know, would they come to know what you wanted, then as you walked up to them, would it produce your coffee for you"* (**P11**), *"if there was like a whole network in the building, like, maybe they could borrow beans from each other. I could see that working"* (**P13**).

Positively viewed if for a good cause.
Participants **P5, P7, P10, P13** said that although uncomfortable with aspects of data sharing beyond the Bitbarista system, in particular if it was used for marketing purposes, they would be happy if their data was used for a good cause, in this case shared directly with coffee growers, who might be able to make positive use of the data to benefit their businesses. For example **P7** said *"there are problems with people who share their data and how marketers can use it, but then I feel like this is about how can you make the supply chain a bit more responsible, so, if, if it is used for a good cause, I think that it would have a positive impact"*, **P10** affirmed that *"if it was fair trade sort of stuff, then actually it was helping these people who were, who might need my information, my data would, would help them"* and **P13** noticed *"it's more focused and it's, you feel like that's going to help. Yeah, that feels okay, for it to understand my coffee preferences"*.

Bitbarista data: display, accuracy and neutrality

Data transparency.
All participants were positive about the idea of accessing more information on the state of coffee-producing countries, *"people might be more, um, might be more thoughtful of what coffee they're selecting"* (**P9**). Bitbarista presented data from these countries in a crude format, displaying raw figures rather than a simplified version designed for easy consumption. **P2, P7** and **P9** commented that this made them feel that the information presented was more objective and accountable *"the fact that it's looking through lots of different kinds of numbers and comparing them, and I can see it, I think that seeing it doing that makes me feel like I'm observing a decision-making process that somehow... it's totally, I realise it's totally subjective, but it feels more objective"* (**P2**). As discussed in the next section, most participants also commented on the positive effect of this information on their choices.

Questioning data accuracy and dependability of supply chains
It is however concerning that the great majority of participants (**all except P1**) did not question the origin of the data *"I think the biggest magic of all is that they get all this data about social responsibility and whatever it is, wherever this data is coming from"* **P7**. Only **P1** did so *"it's nice that it can analyse the different coffee supply options using data that it probably finds, but where does it actually get the data from?"*. **P1, P4, P6, P7, P11, P14** did however question the accuracy and dependability of data provided by humans to the machine

"I think the risk would be in people providing the data" (**P1**), *"because it's very difficult to, you know, check the supply chains and if they actually are as responsible as they pretend to say"* (**P7**) *"I think that's hard to gauge [...] 'cause some parts of the process might be very corrupt and another part might treat people really well"* (**P6**). **P13** questioned the ethics behind those writing algorithms for the system *"if someone wrote an algorithm to like, make money off the coffee machines instead of like, help local producers"*. **P4** and **P6** finally questioned the possibility of reducing complex data on the state of producing countries to 4 simple choices, *"the problem is that it's, it's a summary of something that's really quite complex"* (**P6**).

BitBarista as passive conduit for data.

As mentioned, Bitbarista was designed with simple autonomous behaviours and we introduced a few options in the questionnaire to trigger conversation on this autonomy. As reflected by questionnaire responses, few participants thought that the machine would be able to decide what kind of coffee is served (32%), how much the contribution towards each coffee cup would be (53%) and if it communicated with other coffee machines (46%). In other words, participants perceived Bitbarista as largely passive, a device controlled by human-decisions or fluctuations in the accessed data. This was reflected in the interviews of participants **P1, P2, P7, P10, P13, P14** *"somebody's programmed it to work a certain way. And so it's actually that person's intention and also their action"* (**P2**), *"does the machine itself change the price of my coffee? Like that doesn't seem like it does, it's more that it accesses trends, accesses coffee but doesn't, doesn't change the price of my coffee"* (**P14**).

Reflections on the supply chain

As mentioned above, the data display provided participants with a sense of what happens within supply chains, and participants were positive about this experience. This positivity was mostly evident in the interviews of participants **P2, P3, P5, P6, P8, P9, P13, P14**, who commented on a number of ways in which they felt this would be beneficial to them and the wider supply chain.

Effect of data on choices within and beyond Bitbarista

Participants **P2, P3, P5, P6, P8, P9, P13** commented on how the data provided caused them to reflect on their coffee choices: *"it's allowing me to make more informed choices, and I could pick a more environmentally friendly grower, or I could pick one that's the cheapest"* (**P5**), *"if it's on a screen in front of you, you're doing it, and then you're more aware. And that will influence my choice"* (**P9**). **P2 and P9** described how the experience would also cause them to reflect more on their choices beyond Bitbarista, *"then I would probably change my choice from what was in supermarket"* (**P9**).

Reflections on the effect of Bitbarista on supply chains

P3, P5, P6, P14 stated in the interviews that choices made as a result of the information displayed could impact the supply chain, and possibly reduce some of the intermediaries that were perceived as benefitting unfairly for their role: *"Because I think, obviously, it gives people more choice and then it exponentially affects people down the line more"* (**P5**). **P14** went further to consider the a new model for supply chains *"because a coffee grower could sell directly to the machine, and this becomes their point of presence or whatever, that perhaps makes their relationship a lot more tangible, whereas before they were always behind a distributor, for instance"*.

Reflections on business models behind Bitbarista

Some participants (**P4, P5, P7, P8, P11, P13**) expressed uncertainty about the business model behind Bitbarista and the organisations and individuals involved in it, assuming that some sort of profit would be made by someone: *"I'm not exactly sure where the revenue is being directed and to whom. I just don't know who actually, um, makes money from this, whether it is somebody who sells it, or if it gives money back to the coffee producers, or...this is the one I'm not certain about"* (**P7**). **P5** reflected on how profit would be made through the commercialisation of data *"if there's somebody who was to buy the data from the company, or, you know, if the company was selling data or the manufacturers or the, the coffee growers were then selling the data or accessing the data"*. **P4** questioned if the model would work for other entities in the supply chain, *"I mean the whole bitcoin thing you are going for, in these developing countries, I don't know how that works for someone in Ethiopia who probably doesn't own a computer, I don't understand how this translates for everyone else"*.

DISCUSSION

Awareness of supply chains

The Bitbarista system presented people with a broader context of data transactions to support their choices. As revealed by questionnaire responses, participants in the initial study exhibited concern about the impact of their buying choices on people across the globe, producers, suppliers as well as shops. Indeed they were even slightly more concerned with the impact of their buying choices than with the possibility of these choices to be constantly tracked.

Given this background, most reported that Bitbarista had a positive impact on their awareness of the supply chain. In the interviews, 10 out of 14 participants declared that Bitbarista increased reflection regarding the context in which their choices were situated. They discussed the potential of Bitbarista to support more informed choices that would ultimately have an impact on coffee growers. 4 participants explicitly described its potential to reduce intermediaries and consequently increase the number of coffee options available. Despite largely tied to traditional models of consumption and profit, 6 reflected on business models behind Bitbarista, with one of them considering a more alternative approach.

This positive perspective also influenced participants willingness to share data. The majority believed that sharing certain types of data in the context of the Bitbarista system would be positive, provided it was for a good cause, either in providing an improved coffee experience, or by the data being used to help disadvantaged actors within the supply chain. Despite some suspicion about the reliability of the data used to illustrate what actually happens in coffee supply chains, the study suggests that displaying this complexity of data back to users can potentially increase accountability and trust in the system.

Impact of Bitbarista's data display

Despite the reservations expressed above, participants were on the whole positive about an apparent transparency of information provided by the Bitbarista data display. 3 even stressed the relative rawness of the data as a positive aspect of the system, commenting that it seemed more objective, and therefore possibly more accurate, enabling them to make an informed decision rather than be persuaded by marketing forces.

There were nonetheless criticisms towards the way the system handled the data. Bitbarista displayed various sorts of data sets from coffee producing countries, and then offered 4 choices as a result of this analysis. Some participants viewed this as reductive. Somewhat surprisingly, despite some scepticism as to the accountability of data provided by humans to the system, only one participant questioned the origin of the datasets.

BitBarista was seen as a passive conduit for data and other people's decisions. This is apparent from the responses in question 2, in which participants were asked to judge whether BitBarista was capable of a number of autonomous behaviours, and most answered in the negative. Neutrality was also apparent in comments regarding BitBarista?s connection to the supply chain, the data it displays, and the choices it derives from this. Participants discussed who might be responsible for decisions regarding its behaviour and functions, and were uncertain about their neutrality. But the system itself as neutral.

The idea of an autonomous object that can make decisions about, for example, the pricing of coffee, and present this information independently, is new, and does not accord with traditional assumptions about linear chains of value connected to monetary transactions. Creating awareness of these new models, and the positive potential of such unfamiliar systems presents a major challenge to designers.

Overarching perceptions towards diverse sorts of data

A number of participants commented that they felt positive about data that seemed relevant to the particular transaction taking place. This confirms results of previous studies (e.g. [17, 6]) that show that sharing data perceived as irrelevant to a transaction tends to be considered unacceptable. This is largely a question around user perceptions of what is relevant, and as suggested by Bitbarista, it is possible that this may be expanded by enabling people to see the broader picture of their transactions.

It suggests that people may benefit from being shown how their data might be shared beyond the immediate transaction, and used across the various entities involved in the supply chain. Ultimately this could enable people to make more informed decisions about whether data sharing is relevant and appropriate, and if it will have a positive benefit either to themselves or to others.

While participants were positive about identification with their choices, 4 of them expressed concern about being misrepresented by their data. Data drawn from a single anonymous choice may be acceptable. However when this forms part of a 'buying history' linked to them and in a way that may characterise them, participants were concerned that this could lead to profiling and inaccurate judgement. Others were concerned that it would lead to being offered reductive choices in the future based only on what they have chosen in the past, thus reducing the possibilities of new experiences.

Perception of data transactions and normalisation of data gathering

The study of Bitbarista shows that, although participants were presented with a system that gathers no data, almost all of them assumed that it did. 62% of all participants and 8 of 14 interview participants believed that Bitbarista would gather data from the mobile phone. 11 out of 14 participants also believed that Bitbarista would be able to identify them through their interactions with the system.

As the Internet of Things expands and data transactions increase, there is a rising need to rethink approaches to data. User discomfort and anxiety around data gathering has been documented in numerous studies. In a study published in 2014, Shklovski et al. [26] showed that users were not aware of the extent of data gathering practices of applications on mobile devices. Once they understood this, it caused them discomfort, even though they still continued to use them. In 2016, Phelan et al.[23] reported rapidly changeable attitudes of users towards privacy issues, and that although users may accept or reject privacy risks based on considered assessment, they are still uncomfortable about the potential results of decisions. In another study published in 2016, Bilogrevic & Ortlieb [6] found that users are also aware of the potential for data aggregation to de-anonymise their data, and showed that users perceive the aggregation of the least sensitive data sets to be less comfortable than the most sensitive data sets in isolation. It is predictable that the level of uncertainty and discomfort will escalate as consumers enter into more and more contracts with increasing numbers of services and smart objects.

This reveals a great challenge for designing for non-data gathering systems, because absence of data gathering and sharing counteracts people's previous experiences, and goes against their assumptions of what an IoT system does. So when a new IoT device is introduced, people will assume that data gathering is taking place unless the are informed explicitly that it is not. And even then this may not be enough to gain trust. We question if the practice of continual data gathering is always necessary or indeed useful, as in the absence of accurate knowledge, invasive practices are assumed. People do not feel that they can control this, and this may ultimately inhibit engagement.

LIMITATIONS OF THE STUDY AND FUTURE DIRECTIONS

The design of Bitbarista and the study reported in this paper have provided initial insights on the effect of using an IoT device to contextually display data related to coffee supply chains back to users. There is potential to expand on the study presented here, addressing the limitations of the work, as well as expanding on the design of Bitbarista by considering its specifics.

The study explored insights derived from an initial interaction with BitBarista. Few variations in responses gathered in the exhibition space and in the interview study, as reported in section "Responses to questionnaire" suggest that these responses

may have been affected by differences in the implementation of the study. In the first case, the study was carried out with ad-hoc visitors of a technology-related exhibition, while in the second participants from a range of demographics were recruited. In the exhibition space, the interaction was brief, while in the more controlled environment, participants had time to reflect on their choices and responses. The way Bitbarista was presented, reinforcing its autonomous features in the exhibition, but holding a more neutral position in the interview study, may have affected particular responses, such as to the question of whether Bitbarista was working for itself. However it did not affect responses to more nuanced questions regarding autonomous features of the machine, which scored low in both situations.

All in all, the study could be elaborated to include specifically consistent groups from different demographics, thus comparing and contrasting the perceptions of people with different interests, backgrounds and technical knowledge. It could also consider more naturalistic approaches where interaction time would be defined by users, would take place on a regular basis, and understanding of the machine would not be mediated by introductions but would grow over time instead.

A more naturalistic approach would not only allow us to understand how reactions develop over time, but also how the collectivity of participants may affect attitudes towards not just coffee, but to more general purchasing choices. Only a few participants in this initial study had their own bitcoin wallet, and therefore did not use their own mobile phones to carry out the purchase. A more naturalistic approach would involve setting up their phones with a digital wallet beforehand, or restricting participation to those who already have the system installed. The last however would conflict with the intention of involving groups with varied backgrounds.

Future design directions

We identify different ways in which the design of Bitbarista could be further explored, by considering, for instance:
a) the specifics of interface design and presentation of the data, in order to optimise organisation of the information, screen size, typography, details of the interaction such as duration and time response, etc, which would inform the optimisation of the system.
b) a design exploration of autonomous machines that could offer alternatives to dominant models of profit. We are particularly interested in how the autonomous nature of the machine will affect views of its position within the supply chain, and how it could act as a direct and neutral link to coffee grower.
c) the design of algorithms that return reliable options of coffee supplies back to users
d) the practicalities of involving producers in the commercialisation of coffee through Bitbarista.

CONCLUSION AND IMPLICATIONS FOR DESIGN

In this paper we present Bitbarista, a coffee machine that proposes a new approach to data access and usage for the design of IoT devices. Rather than focusing on ease-of-use, Bitbarista focuses on revealing data transactions, attempting to communicate and place users within the complexity of factors involved in coffee production, distribution and purchase. In the paper, we present a study designed to gain initial insights into perceptions of data transactions not only around the Bitbarista system but also around interactive systems more broadly. To do so, we designed a questionnaire that complements Bitbarista as a probe. The questionnaire subtly provokes discussion on issues around data access, sharing, and machine autonomy.

In line with previous studies, we found that participants were more comfortable about data gathering that was perceived as relevant for the interaction taking place. Bitbarista however expands the notion of what is relevant, by placing participants within a broader context of production and consumption. Responses to the study suggests that despite usual discomfort, participants were happy to share data as it was perceived to be for a good cause. In face of current practices of data gathering and sharing, however this trust is not easy to gain. Interview responses suggest that participants are weary of data gathering taking place in unclear or secretive ways. Increasing transparency of data transactions, as Bitbarista does is therefore a good step forward. Based on these conclusions, we draw a few design implications as reported below.

Implications for design

The main design implication of this study is to highlight how communicating the complexity of transactions and the reasons for these transactions to occur can have a positive impact on how users perceive an IoT system. This includes:
a) Communicating what kind of data is gathered from users, and making it absolutely clear when no data is gathered. A non-data gathering convention or certificate would be something to be considered in this case.
b) Allowing people to understand the model of value creation behind the system. The Internet of Things opens space for new models to be created that do not necessarily fit usual assumptions of linear chains of value connected to monetary transactions. Designers should focus on designing systems and interfaces that embody and communicate these new propositions.
c) Allowing machine-made decisions to be questioned and personalisation to be constantly tailored by users. While automatisation and concealment of transactions may facilitate ease of use, inviting people to follow and go back in this process in order to tailor its parameters may increase trust. Perhaps it is time to make a case for interfaces that increase complexity and time of use, even displaying information that is “rarely needed".

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