Relations are more than Bytes: Re-thinking the Benefits of Smart Services with People and Things

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ABSTRACT

Critical approaches to smart technologies have emerged in HCI that question the conditions necessary for smart technologies to benefit people. Smart services rely on a relation of trust and sense of security between people and technology requiring a more expansive definition of security. Using established design methods, we worked with two residents' groups to critically explore and rethink smart services in the home and city. From our data analysis, we derive insights about perceptions and understandings of trust, privacy and security of smart devices, and identify how technological security needs to work in concert with social and relational forms of security for smart services to be effective. We conclude with an orientation for HCI that focuses on designing services for and with smart people and things.

CCS CONCEPTS

• **Security and privacy** → *Social aspects of security and privacy*; • **Human-centered computing** → *User studies*;

KEYWORDS

Smart Cities, Security Theory, IoT, Digital Civics, Participatory Design, LEGO

1 INTRODUCTION

Smart cities are increasingly at the centre of research in HCI [20, 37]. The smart city concept relies on new digital technologies to gather data (environmental and social) in order to enable civic infrastructures and services to work more efficiently. In this regard, HCI research has looked at the processes of data production and data use at both government [37] and community level [20]. Such research has pointed both to the difficulties of innovating in an over-regulated space, and to the challenges of realising financial benefits of smart technologies for the wider population. Other work [4, 8] has more explicitly called for the democratisation of the potential efficiencies of technologies by putting civic needs at the centre of our future smart cities.

For smart technologies to realise efficiency benefits, people must engage with the technologies to produce data and for that to happen, people must feel safe and secure. To achieve this, smart infrastructure and smart consumable technologies (which we will hereafter call "smart technologies", or IoT) must be reliable in terms of availability and performance, but in itself this does not necessarily engender feelings of safety and security. A sense of safety and security comes through clarity in terms of who or what is doing the securing, and what type of securing is being undertaken. Bringing these questions into the design of smart technologies and services connects digital civics thinking with broader (and critical) security theory literature.

In this paper, we argue that HCI would benefit if the interest in digital civics is connected to the broader security theory literature - in order to develop processes and systems that can successfully deliver civics-centred services. In order to achieve this, we extend the broader definitions of security used in HCI research [17, 18]. These come from work that argues that engaging with an expanded view of security is crucial for HCI. Our work contributes to digital civics and HCI more broadly [4, 35, 42], by developing further understandings of the impact of smart city services on civic life. This contribution can then, we hope, be used to inform the future design and implementation of smart services and technologies.

This paper is based on civic engagements with two geographically and demographically distinct communities. The engagements described and analysed in this paper have resulted in two concrete outputs: (1): detailed reports on how trust and security is perceived in the digital civics context; (2): a refined orientation towards design models that deal with civic security and smart technologies, which are based on communal processes of trust-making.

2 BACKGROUND WORK

We draw on the digital civics literature and on the security theories literature in order to develop a theoretical underpinning for the analysis of our study data.

The Smart City and Digital Civics

In recent years, the concept of the smart city has gained significant traction among corporations and governments. The concept centres on the use of the latest advances in hardware and ICT that gather data to make the services running our cities more efficient, safer and more sustainable. Enacting such a vision requires access to data concerning energy use, transport consumption and social interaction which is currently being generated in enormous quantities in cities around the world.

Critiques of the smart city vision and related practices have begun to emerge in HCI [4, 4, 8, 11, 15, 21, 37]. Among these critiques, the smart city project is considered the material expression of top-down visions favouring efficiency, technical and transactional services - attending primarily to the interests of corporations and government administration, rather than to those of citizens individually or collectvely. These critiques have resulted in calls for an increased level of democratic participation [4]. This participation should place "smart citizens" at the core of smart cities [38] in such a way that smart cities would become noticeably more "citizenscentric" [11].

Efforts to enact a more inclusive smart city vision such as this have yet to develop upon the advantages that techniques of co-production can bring to their design. What may constitute a "smart citizen" is also yet to be fully clarified, particularly when considering the multiple ways in which citizens and citizenship can be conceptualised theoretically and in practice. While citizenship may encompass a set of legal, social and political rights, as well as duties, Cardullo and Kitchin highlight how the smart city, "underpinned by a neoliberal conception of citizenship, favours consumption choice and individual autonomy ... that prioritise market-led solutions to urban issues" [11]. Taking such a rights-based approach to citizenship requires clarity on citizens' needs, and on the question of what may constitute a "just" smart city grounded in civil, social and political rights and the common good [11, 15, 28].

Along these lines, Asad and Le Dantec [4], drawing on Forlano [21], advocate on behalf of the notion of smart cities that are rooted in civic engagement and participation via innovative technologies, thus increasing the opportunities for collaborative city-making. Citizenship in this way becomes more than a lightweight consumer-feedback activity. Re-imagining the smart city in line with principles of democratic participation also sits within trends in HCI's turn to civic technology [6, 37] as well as HCI orientations towards the digital civics agenda [42]. This agenda advocates technologies that support different forms of civic progress, facilitating the shaping of place and community [4, 36, 45, 52]. A number of studies have begun to explore the simultaneous opportunities and challenges that smart technologies present for supporting public benefit and interest [4, 15, 35, 45]. This entails the ability to access and use technology to collect or transfer data. It also entails the ability to process and make sense of this data and employ it towards specific civic ends [35, 45].

HCI scholars have unsurprisingly called for the necessity to develop civic capacity, including digital literacy and fluency skills. Approaches to building such skills must be attentive to people's differing socio-economic conditions and their capabilities [49]. However, capabilities and access alone is insufficient; as noted in the Introduction, people must also feel safe and secure when doing so. Indeed, only when an individual feels confident in their data production practices and cared for in a technological environment will civic capacity be built up, ensuring that the use of the technology will be of the most creative and productive kind.

This requires the designing of technology that responds to an individual's capabilities and needs, while also attending to the need for an individual to have a sense of safety and security in its' use. By developing smart technologies that fulfil this perspective, HCI would be at the forefront of developing new relational models of civic-centred smart services. These would enact the principles of democratic participation and accountability in a more pronounced way than is currently seen. To achieve this vision, our understanding of digital civics and relational services needs to be expanded to include broader security positions. In the following section, the background literature related to this more expansive security position is outlined.

Security and the Smart City

Smart cities bring into sharp focus the questions of who or what is to be protected. Security studies have been shaped by tensions between schools of thought on where the focus of security should lie, what constitutes security (and for whom) as well as what makes for effective protection. The tension between the need to protect the state and the need to protect the individual is a theme that also runs through many of the

technological security debates of the last 30 years [5, 7, 33]. These debates within the technological security domain have retained their characteristic focus on technology as the centre of enquiry. The shift that we have described in the digital civics agenda (towards collaborative and relational design to be delivered by technologies), suggests, however, that a different approach to security is needed in order to meet the demands of this shift. Such an approach would foreground the notion that trust (through social relationships) can be protected through technological security. The digital civics agenda is already orientated towards notions of trust and community-based approaches to the security of people through technology [34].

At the same time, privacy, security and trust are recurring themes in smart city HCI research [4, 12] and require HCI practitioners to locate security design within a political, economic and social agenda [17]. Digital civics thus also requires a broader definition of security that includes normative and qualitative dimensions of security, defining security as more than simply the technologies that facilitate protection. Sociologist Anthony Giddens argued just such a conceptualisation by claiming that security was not only an artefact but also a quality - one that is required for social integration and that enables 'basic trust systems', stable interactions across societies, collectivities and individuals [22] (p.38). Social interaction enables a negotiation of values and a building of trust-relationships that fold out into this broader process of securing. Giddens also raised the notion of the internal security dialogue, resulting in 'ontological security'. This is the mechanism that reproduces the conditions of trust for people, through the building and maintaining of relations, and through the 'routinization' of everyday life. Digital civic thinking thus needs to consider how civic technological innovation is to engage with the ontological security of individuals and communities in which technological innovations are deployed.

Bringing technological security into conversation with social forms of security, requires asking critical security questions as a key part of the design of smart cities. Such questions include: "Who or what is being secured, and for whom?" and "Who or what is doing the securing?" [51]. The importance of asking and re-asking such fundamental questions is underscored by the work of Thomas Hobbes, the influential 17th Century British philosopher. In his work 'Leviathan', Hobbes argues that the citizen must willingly restrict their activities to comply with the will of the state - but only in return for the state affording security to the citizen [29]. This exchange forms the basis of the social contract. Hobbes' vision of a secure society has on occasion been countered by a more liberal, market-driven approach to security, based on cooperation between parties seeking to achieve mutual economic benefit [40]. Recent technocratic visions of the smart city are often underpinned by a mix of both of the above security outlooks, compliance tempered by trade-offs, and economic incentives.

Hobbes points to the potential for diminished creative contribution and production if the individual cannot share the responsibility for security with institutions of power such as the state. Hobbes' work highlights the need for clarity at all times on the essential security questions - if individuals are to creatively contribute to society.

It is therefore essential, we argue, that the digital civics agenda and HCI consider a broader framework for understanding security. Negotiating the tension between freedom and control, compliance and collaboration, requires technological forms of security and protection, but also requires social forms of security. It is these that constitute the relational processes - those that enable people to feel ontologically secure.

The following study examines the interactions between social and technological forms of security and presents qualitative participant-led responses to those tensions.

3 STUDY: BENEFITS AND THE SMART CITY

The study presented in this paper is composed of two study sites: Pallion, a suburb in the north west of the City of Sunderland in the North East of England and Brixton, a district in the south of London. The focus of the study was to better understand under what conditions a smart city realises benefits for the citizen. The study was designed to examine what "smart" meant to participants in the context of smart technologies and smart services. The study also examined what benefits smart technologies and services bring to people, and under what conditions those benefits are to be realised.

Contexts

Both studies were conducted with participants who had some experience of smart technologies but who were not early adopters of such technologies. Both study sites were located in cities that have smart city programmes. We selected one study site in North East England and one in South East England in order to compare and contrast the participants' smart cities outlook. A report produced by the Institute for Fiscal Studies [30], highlights that the North East of England has a higher concentration of inequality, relative poverty and lower living standards than the South East. Both studies also represent urban areas that have much to gain by the adoption of an effective, smart infrastructure that supports the citizen.

Study Site One: Pallion is a suburb of Sunderland in the North East of England that was once a site of shipbuilding. Once this industry went into decline, unemployment rose in Pallion. According to the UK's Office for National Statistics (ONS), 30.7 percent of those employed in Sunderland are

in professional or managerial jobs with the remainder of those employed evenly spread out across the skilled labour market, service industry and unskilled labour market [41]. Welfare claimant figures for Sunderland were at 17.1 percent at the time of writing [41]. Pallion is one of the areas of Sunderland that is affected by high levels of unemployment, ageing population, a migration-out in the 19 to 35 age group and an international migration-inwards [3].

Study Site Two: Brixton is located within a London borough where 60.2 percent of those employed are in professional or managerial roles [41]. The remainder of the workforce is predominantly split between those in skilled occupations or in the service industry. 9.9 percent of the Borough of Lambeth are claiming welfare benefits [41]. The local authority characterises the Lambeth Borough as ethnically diverse [24] with just under half the population identifying themselves as Black, Asian or coming from a minority ethnic group. Brixton has a reputation for innovative community responses to social challenges and is home to the "Brixton Pound" - a local currency and an alternative to British sterling [44]. Whilst Brixton is located in a more prosperous region of the UK, as with Pallion it faces challenges in terms of provision of housing stock and is the ninth most deprived borough of London [25].

As these demographic descriptions reflect, both study sites are facing a number of social, economic and political challenges. The community groups through which participants were recruited tackle these regional challenges. In the case of Pallion, participants were recruited through a community organisation that predominantly works with welfare claimants, those seeking employment and those in need of money management support. Reflective of this, six out of the seven Pallion participants were claiming welfare of some type. Three of the participants had been employed in the skilled labour market and the remaining four in either the service industry or unskilled labour market. In the case of Brixton, participants were recruited through a community organisation that specialises in community innovation and supporting community start-ups. Reflective of this profile, all Brixton participants had been employed in either the professional, skilled or service industry markets.

Study Design and Methodology

In this section, we describe the research design and methodology that was used in this study. The methodology is based on 'creative security' [19], a technique for participative and playful engagement. Creating a safe space where participants can explore their concerns and imagine alternative futures is an important principle of creative engagement. Paediatrician and psychoanalyst Donald Winnicott referred to the role of 'transitional objects' in the play of children and adults - creating 'an intermediate area of experience, to which inner

reality and external life both contribute' and that can help to engender trusted shared spaces [60]. We have used this engagement protocol since 2013 with over 300 participants over five years: [26, 27], maintaining and strengthening it as we have done so.

The research design stimulates making-activities by combining specific provocations with research questions. This activity encourages participants to reflect on particular challenges posed by the introduction of technology, and to reflect on the potential impacts of this on everyday life as well as some potential responses to those impacts. Creative activities induce space for reflection and provide participants with techniques and methods to externalise and share their concerns and emotions regarding technology use in particular contexts. In this study, physical modelling using LEGO was the chosen creative activity. Outputs from some of the physical modelling sessions are presented in Fig. 1.

The LEGO modelling approach creates 'rich pictures' [39], encouraging participants to reflect and build on their understanding of the ways in which technology is woven into everyday life. This allows them to examine their concerns in rich detail, in such a way that is often not possible while using alternative research methods - questionnaires, surveys, interviews, for example. Our approach can be situated amongst an established body of related scholarly literature [9, 10, 46, 48] and commercial practice [43].

We used the following standardised engagement protocol with both groups in this study. After introducing the study, we ran a short brainstorming session where participants responded to 2-3 carefully constructed prompts. Participants used story sheets to capture their ideas. These prompts were: "What is smart technology?", "What services do smart technology provide?", and "How do you use smart technology?" Then we introduced the LEGO modelling component where participants work on scenarios and issues raised during the initial brainstorming segment. Participants were asked to describe a current or potential future use of smart services in their everyday lives.

Participants used the brainstorming outputs to consider further questions during the LEGO modelling component, and were invited to use a colour code for adding bricks: to denote data, infrastructure, and actor relationships. The further questions were: "When and how do you feel safe and secure with smart technologies and services - what does the government need to know about this?"; and "What risks and opportunities are there in such technologies?"; also "How do you actively participate in safety and security when using smart technologies and services?" Each session concluded with an opportunity for participants to feedback and discuss themes emerging during the session as a whole.

Participant Recruitment and Method. We recruited participants through community centres at each of the study sites. Research funds paid for the hiring of the room for the engagement, meal and refreshments for the participants as well as the time spent by the gatekeeper on recruitment. Ethical approval for the research was granted by the research institution. Our participants, particularly the ones in Brixton, used the term 'IoT' to refer to the combination of smart technologies, smart services and smart infrastructures. LEGO was used with both groups, engaging 7 participants in Sunderland and 9 in Brixton.

The outputs of the data gathering can be seen in Fig. 1. The data was gathered using the engagement protocol outlined in the previous section. Each session concluded with a group discussion where the groups merged their different models in order to study potential connections between the different outputs (Fig. 1, far left) and reflected on the outputs as a whole. Data was gathered using the methods and process outlined below.

Data Gathering and Analysis. Data was generated in the form of LEGO models, annotations made by individual participants, facilitator observations, notes of collaborative outcomes from the brainstorming, and final group-feedback contributions. Thematic analysis was conducted by two researchers on the collected data. Initial findings were written up and sent to the participant groups for feedback to be included in the final reporting of the study findings.

Additional data gathered for analysis included: a). Recordings of the sessions which were used as the basis for transcripts. b). Hand-written annotations placed on models by participants, and text gathered from the story sheets, and c). Investigator notes.

The recordings of the sessions were transcribed and then the photographic documentation was combined with the transcriptions. Themes in the modelling and the discussions were identified and written up as a report to be shown to participants for feedback.

Working within a semi-smart context. Participants were recruited from communities that potentially stand to gain considerably from the implementation of a smart city vision but who were not early adopters of smart technologies. This selection criteria meant that participants did not necessarily have considerable lived-experiences of smart technology use. We therefore selected a participatory approach that would encourage participants to reflect on the use of smart technologies and smart services and made provision for participants to imagine smart technology adoption as well as factually report on their experiences to date.

Early work was carried out to identify the best way to reach the community and to engage them on the theme of smart technology. This work involved establishing what the community considers to be smart technology; what role such technology has and might have in their everyday lives; and what the benefits of such technology might look like for them. The examples they provided included smart energy meters, water meters and solar panels, which have been introduced by providers into the community, as well as banking applications and chip cards used with mobile devices.

4 ANALYSIS AND FINDINGS

Using the approach described above, we worked with conceptualisations of technology as presented by the participants. The participants interchangeably talked about smart technologies and smart services, resulting in a degree of slippage in their descriptions, some of which appears in the quotations below.

Our analysis of the data reveals three key themes: 1) Smart technologies can exacerbate socio-economic insecurities which make individuals feel more isolated and hostile to smart city visions. 2) Smart technologies can engender a feeling of being "marketised" and being exploited for the benefit of the government and commercial institutions. This can make the individual feel vulnerable seeing the government and commercial institutions as potential threat actors. 3) Smart technologies can often be seen as offering unrealisable benefits.

However, our findings also reveal that communities have the collective capacity to respond to these challenges when they are given the opportunity and support to do so. In the following subsections we expand on these themes showing the results of our data analysis. Participants' speech is shown in italics.

Civic Vulnerabilities: "the gaps between people"

Participants identified the potential for smart technologies to exacerbate the economic and social vulnerabilities of citizens. Money management was a topic, cited by Sunderland participants, where smart technologies were felt to be more likely to favour those on high incomes. Participants reported that when managing a low income *"auto renewal subscriptions like PlayStation can catch you out,"* and that *"there's too much small print isn't there!"* Contactless payment cards were given as an example of everyday smart technology that was not satisfactory for those on low incomes. These cards were described in the story sheets made by one participant as *"Bad: doesn't show in account until a few days later - [the card was] given by bank - not asked if you want it".* This of course is problematic when managing a limited budget online and when ATMs or branch visits are not practical. Such constraints reinforce the feeling and impression that smart technology is primarily focused on the higher end of the economic market. However, this was not the only perspective. Whilst still agreeing that smart technologies often
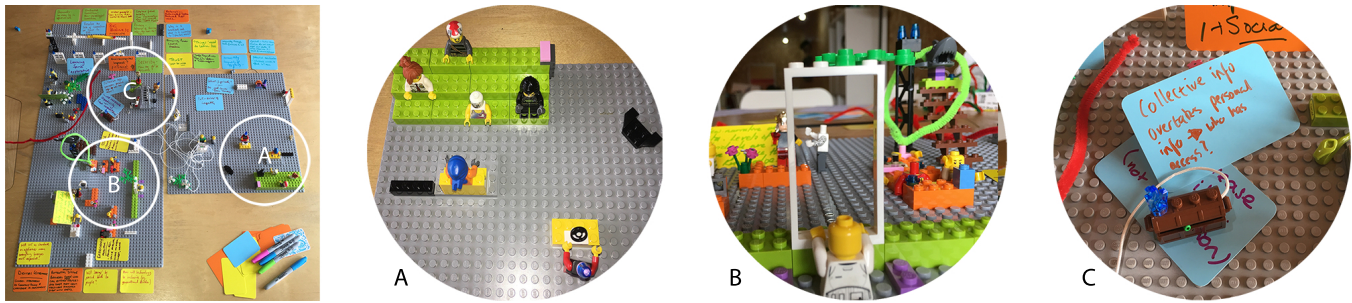
Figure 1: An overview of the study method. Joined LEGO models (centre) made by participants at the workshop held at the Impact Hub in Brixton, London in 2017. A: The public enter 'The Library of IoT' for a demonstration concerning smart applications and skills; elsewhere, IoT enabled 3d printing is demonstrated; B: The view of the new employee arriving at 'The Office', to be scanned by an array of technology embedded in the doorway; C: 'The Connected Street' model, showing "the chest of ideas"; blue bricks on heads and doorways denote connectedness, social interaction, wellbeing and security.

benefit those on higher incomes, other participants showed how friends and family can step in to help manage these challenges in lower income settings. An everyday scenario of this kind was described: *"My brother phones and asks me to transfer a few pounds so he can buy something in the shops. I am a personal banker!"* Other people in Sunderland saw the potential for using technology to help them manage their bank accounts and the finances of others: *"I get a text on my phone if I get low on funds,"* said one participant.

Similarly, our participants explained that smart technologies can impose changes that are not suitable for the home environment. A participant observed that: *"There is terrible heat loss through the bad single glazed windows, so there'd be no point in smart meters to save money when it all goes out the windows."* This comment reveals a mismatch between the provision of smart metering and the everyday realities of housing and family economics. It was observed that *"With smart meters you can maybe end up paying more for your gas and electric."* In the group discussions that took place in Sunderland after the LEGO models were built, it emerged that there is no adequate financial compensation provided, nor any help in planning for, the physical changes that have to be made in the home as a result of having meters compulsorily installed: *"I was given no choice about having the smart water meter."*

In Brixton, there was a heightened awareness of digital and financial exclusion, although this was typically not demonstrated through first-hand examples. A point of discussion was *"the gaps between people who are connected and people who aren't connected"* - a gap that was said to be getting wider: *"It's really easy to spend a lot more money if you don't have access to the internet ... If it were possible, for example, for people to use the technology to help them prevent food wastage, then these gaps might be narrowed a little ... While a fridge can easily last you 20 years, a smart fridge might save you lots*

of money on food, but if you can't afford one, you're in a catch 22 situation. The same with cars ... only some people are going to benefit from savings and from having access to information and opportunities."

A response to this gap was made by the Brixton participants who placed an importance on the social interactions within the community and amongst friends and family. For example, in Brixton, one group constructed a LEGO model depicting 'The Connected Street' (Fig. 1, part C): participants saw the benefit of disclosing information in a connected community space "right outside houses". As shown in Fig. 1, part C, above each residence door is a blue light which symbolises the way that awareness for the community is raised whenever there is an issue inside one of the residences. The model was summarised by the group spokesperson: *"In this street, people know when to water the plants because they are connected IoT, because you want to bring people outside their homes to talk to each other. There is privacy in the space of the house, but there's a level of connection too as in the example built into the model: a person who has fallen over and cannot reach the phone. There has to be a way of knowing when there is an issue inside a home, a means of moderating the demands for privacy to ensure personal security."* In this model, the picture of vulnerability that is given has been moderated by the inclusion of a degree of community connection facilitated by a smart technology use that supports the everyday security of people.

Is it 'smart' for me? Reflections on the smart 'exchange'

Participants in Sunderland expressed misgivings about the way in which they suspected their data was being traded by providers of smart services: *"We're using this for saving money so it's not fair that we lose control over the data."* In one case the lack of clarity and transparency prompted the statement

that *"there's always a catch."* A degree of cynicism about the motivations behind the introduction of smart technology and services was displayed in both locations, particularly in Sunderland: *"I don't know if smart is really smart."* One person stated: *"it's only for their benefit if they're bringing out technology ... I only go on JobSearch, that's it. I'm petrified of them [apps]."* Another participant observed that it felt like one was *"being monitored in your own home - you expect it in other places, but not at home"*, adding that there is a sense that *"anyone can watch"*. This perception of being surveilled, the participant said, is also increased *"when you click 'Like' on social media"* and elsewhere.

"A lot of systems just don't make sense", said one participant in Sunderland, describing an instance where a request was made for a credit card replacement to be delivered to a relative while on holiday; *"the bank doesn't know how to process a genuine issue, and can only deal with cases like fraud"*, saying that this shows that the systems are not really that smart. This example, whilst not directly a smart technology example, shows that everyday issues of financial security (i.e. having access to a credit card) were not being met by the bank and instead the bank's greater concern about fraud was the focus of the banks' policy. *"We get a lot of them going through', the customer services say, so they just don't pay attention to the exceptions, and just follow a dumb script"*, said the participant. Such experiences made participants doubt that the services to support smart technologies would be sufficiently smart.

In initial discussions at the Brixton workshop, a participant observed that *"business is a producer of the technology, but also stands to gain from consuming the data that the technology generates in use by consumers. Given this relationship, how can ordinary people trust the information they have about where this data goes and what it is used for?"*

This challenge was exemplified in the Brixton model titled 'The Connected Street' that included a "contested" repository or *"the chest of ideas"*. This repository contained all of the data that is held and transferred between the main actors of the model. It was described by the model creators in this way: *"In the centre is an idea's or data box that sits between the people, government, and big business. In this 'chest of ideas' we have all sorts of collective ideas and data sitting there, and we don't know who owns it, and who can use it and for what purposes."* This model illustrates the complexities and resulting confusion in the ways that individuals, institutions and businesses might handle data and the potential that such confusion has for making smart technologies less smart for the citizen.

The importance of clarity in terms of the values and beliefs woven into the smart deployment was brought out in the Brixton models. For example, another Brixton group modelled the real and potential impacts of smart monitoring in the workplace, situated in the context of *"It's the 'Wild West' right now."* This was 'The Office' LEGO model (Fig. 1, part B), and its creation was explained as follows: *"We created a futuristic highly monitored office space. Workforce morale is closely monitored by entry systems, and a whole range of inputs and measures, including facial recognition, voice and mood analysis, words spoken and written on any kind of shared media, sweat, urine, and so on. The system measures your capacity as an individual to work that day, and additionally measures the efficiency of teams. The system then offers you work according to your capacities on that day; hence, on a bad day the workload you are given will be less."* This explanation highlights that the monitoring system can both be used to support the workers but also to control them and for employees to feel safe and secure within that workspace, the employer has to clearly articulate how such technologies are to be deployed. Without this, the employee may decide to restrict their engagement resulting in diminished outputs.

Barriers and enablers to realising smart benefits

Our data shows many barriers to realising smart benefits. One barrier was the lack of clear benefit. Smart technologies need to have a particular use, and that use has to be clear and relevant to people's lives for people to want to adopt them. Some of our participants reported that they had partners who enjoyed 'tech for tech's sake', but most felt that to engage fully with smart technologies and services there had to be a purpose beyond simply using technology. The lack of clear benefit was felt to be a barrier to the use of smart technology.

A further barrier to realising the benefits of smart technology was seen as the difficulties in understanding how to use it. For example, one participant in Sunderland spoke about how the complexities of use can lead to a lack of confidence resulting in a lack of technology adoption: *"In my house there is no water meter, and devices like the smart TV are kept on sleep and standby as far as possible. It is also south-facing which means I can save some energy on lighting and heating. I did enquire into getting help with adding solar panels but they just asked me questions like 'how big is your roof and which direction does it face in?', which I didn't know the answers to, so this just put me off. I read that it actually costs more to switch fluorescent lights on and off, so I just keep them on most of the time."*

Lack of affordability of smart technologies was identified as another barrier to realising benefits. In Brixton, 'The Library of IoT' was the name given by participants to the LEGO model (Fig. 1, part A) addressing this problem: *"There is potential for huge swathes of the population to be excluded if individuals aren't able to afford IoT technology... [This] can become a real wedge between people."*

The Brixton workshop produced an example of how the community might respond to the barriers of complexity, lack

of clear benefit and affordability: 'The Library of IoT' model (Fig. 1, part A): *"We chose to make a new kind of library space, somewhere for the public to come to deepen their understanding of the Internet of Things, to actually see and play with connected devices, a 3d printer for example. Just as importantly, this is a place for visitors to be in the company of other people in the same position, and to work alongside others who wish to learn about how the Internet of Things works and what it can do for them. This is a place of facilitation, networking, shared assets, and shared interests to be explored. This kind of technology would benefit from being experienced in more neutral way, in a 'half-way house' between commercial and domestic contexts."* Such an approach would go some way, they said, to addressing the knowledge, confidence and usability barriers experienced older users and those with physical and cognitive impairments: *"the barriers to using IoT are going to be much higher for older people and those with disabilities too."*

The Library of IoT encourages the freedom and facilitation to share their data as widely as they wish which was regarded as a potential enabler of smart benefits. *"From here a person can manage how their data is used once it has been shared, with helpers on hand to manage privacy settings as well as a host of other related functions that support confidence, trust, transparency and security."*

Such a space encourages the realisation of smart technology benefits for individuals and communities by being situated close to local neighbourhoods, and most importantly, by being seen as a space that exists purely for the public good, and does not represent commercial or governmental interests and agendas. One participant said: *"What we have drawn on is that the library is a trusted, neutral, respected, community space that people go into in the expectation that it is there to serve them, not them to serve it."* The model illustrates the kinds of benefits of smart technologies that the communities in Brixton feel are realisable with community support and interaction.

5 DISCUSSION

The creative envisioning articulated in the LEGO models that were developed by our participants prompts us to reflect on the variety of ways in which HCI can contribute to new processes and technologies that are able to realise smart benefits for collectivities as well as individuals. The solutions proposed in the LEGO models call for the following actions: (i) developing combined service and technology offerings that can be calibrated for different socio-economic contexts; (ii) identifying the capability supports needed to deliver benefits; (iii) developing design methods to support the identification of security trade-offs resulting from smart deployments; (iv) encouraging HCI practitioners and communities to co-design and deploy civic security models underpinning smart city

services. In the following sub-sections, we unpack what form these four actions might take.

Socio-economic variations and capability gaps

Insights produced by the workshops reveal key design assumptions about the social, economic and technological capabilities of the people that smart technologies are intended to interact with. This takes the discussion well beyond the technical and psychological capabilities typically identified in the usability literature: such as is found, for example, in the HCI literature on usable security [13, 47]. Our findings lead us to highlight that socio-economic inequalities described in the HCI4D and ICT4D literature also have a strong relevance to studies located in the global north [1, 2, 32]. Our participants have encountered an assumed socio-economic equality that did not reflect their own socio-economic situation. The responses of participants reflect that the impact of smart technology and smart services on communities can differ greatly according to their socio-economic conditions and related vulnerabilities. Our findings have brought to light that in Sunderland our participants felt exploited by smart technologies rather than served by them; also that our participants, in Brixton, perceived smart technologies as being potentially exclusive - as opposed to being inclusive.

Our findings, therefore, point to the necessity for HCI to be attentive to the uneven experience of smart technology roll-out - an experience that is conditioned by and intimately related to socio-economic conditions. Previous work has advocated for a focus on the recognition, identification and visibility of unjust practices, in order to design responses that enable civics to reach their full potential [16]. In light of our findings, we expand on this work by inviting future research to examine further how smart technologies are entangled with different socio-economic conditions. Specifically, further work should identify how particular entanglements and relations have an impact on individual and collective senses of ontological security.

Sen's capability approach may provide the HCI community with a position to better assess people's socio-economic condition in terms of income, resources and primary good. This is summarised as: "The opportunity to achieve valuable combinations of human functionings - what a person is able to do or be" [50]. It also cites "the positive freedom they have to enjoy valuable 'beings and doings' " (as ICT4D scholar Oosterlaken notes) [54]. Capability analysis identifies where people are not able to carry out the things that they would value doing. In the smart city context, such an analysis would evaluate why smart technologies and services do or do not allow people and communities to take advantage of the things they would value doing. In particular, when designing and planning smart city initiatives, a capability analysis might reveal how benefits from the initiative are to be distributed

geographically. Technological, relational and economic capabilities, and situated knowledges [23], can be thus be brought to bear on assessments: as to where gaps in these capabilities might appear in such distributions. Augmentative smart technology might be designed and then deployed in order to help reduce these tensions and fill these gaps, by supporting communities to develop social interactions and relational capabilities in appropriate ways. Consider here how one group in Brixton conducted their own form of capability analysis in their model of 'The Office', by representing how *"the system then offers you work according to your capacities on that day"* - on a bad day, they said, when things are not going so well, the workload will be reduced (Fig. 1, part B). This could be said to be a prime example of how a system could be both relational and 'smart'.

Whilst the Sunderland and Brixton studies were conducted in isolation from each other, contributions from the Brixton participants reflect a compassionate understanding of the challenges facing those who are as, or more, socio-economically marginalised than themselves. The Brixton responses also give extensive practical guidance as to how capabilities might be built into communities like Sunderland - showing great potential for HCI to support capability-building across and between disparate communities. Whilst technologies clearly provide greater "capital-enhancing opportunities for those of higher socioeconomic status" [55] (p.33), recent literature also shows how internet skills and the resulting distribution of costs and benefits are key dimensions affecting outcome [55]. There is therefore potential to develop processes and technologies that enable communities to support each other by envisioning capability-sharing and capability-building practices.

Security trade-offs

As we reported, Hobbes' theorising of security [29] points to the social contract between citizen and state being built on a trade-off between individual freedoms and the protections afforded by an institution of power. From this perspective, a sense of security appears to be predicated on a 'promise' that is entrusted by the state to protect citizens in return for certain compromises in the freedoms of citizens. In the two study sites, participants felt that the state and the commercial markets were unable or unwilling to offer the necessary protections for individuals, leading to a deep sense of mistrust - especially a distrust of narratives that equate data protection (the 'Bytes' in the title of this paper) with personal security. Our findings reveal key examples of where the trust between the citizen and the state no longer works and where security is threatening to break down as a result. Such examples include concerns about the increased potential for digital fraud and unauthorised monitoring of the individual. Our participants' mistrust appears to be entangled with a sense

that government has abandoned and neglected its relationship with the citizen. On this point, see the comments on the need for a *"trusted, neutral, respected"* space identified in 'The Library of IoT' model, Fig. 1, part A). This is coupled with the replacement of government by commercial service providers appointed to deliver civic services, with significant consequences for the way that human values may be reduced to monetary ones within these relations (see the various references to being caught out by *"small print"*, *"catch 22"*, and *"there's always a catch"*, *"paying more"* for smart services, and the question: *"how can ordinary people trust the information they have?"*, especially given the commercial context of these services.

The working premise of the smart city vision appears to be the security-economic trade-off described by security studies in HCI for example: [31]. However, our wider qualitative analysis shows that non-monetary security trade-offs are also very important in this area. For example, our participants described and envisioned new forms of smart services that would be beneficial to their communities. These LEGO models reflect upon forms of security that come about through social relations where trade-offs are constrained by technological uptake, and that might also include certain losses of privacy in exchange for community support *help that is available "right outside [our] houses"* (for this, see 'The Connected Street' model, Fig. 1, part C).

The written annotations on the models, and recordings of the verbal presentations, reveal the negotiations that led to the vision of civic-centric security depicted in the Brixton LEGO models. These models show collective approaches to responding to the amplification of technology-enabled forms of control (including technological surveillance). In both Sunderland and Brixton participants remarked on their sense of *"being monitored in your own home"*, and that *"anyone can watch"*, and that it felt like is was *"the 'Wild West' right now"* in the way that they felt that their data was being traded by corporations and within government. This perceived collusion between the government and the corporations change the nature of the social contract and with it the sense of safety and security within a community. The Brixton models bring to the fore how safety and security can be engendered in return for community engagement and participation. In these models the use of community space, relational approaches to technology support and a clear and open discussion about the values and goals represented in smart deployments are used to build the social contract at a local level.

Shared models of civic security

Our findings develop upon the work of earlier studies on security and sociality in HCI [19, 56, 57], by posing critical security questions and using a range of security framings to analyse the data. Asking "who is doing the securing" and

"what is to be secured" has been a critical and productive way to analyse smart technologies and services, and to assess relations between civics, government and markets.

Monetary values appear, in this data, to be a fundamental driver of the relations between civics and smart technologies. Our participants associated the deployment of smart technology with neoliberal political models of civic interactions conceptualised as market transactions [59]. As a response to this, Brixton participants presented an alternative vision for smart technologies, where communities can potentially co-produce the conditions of what for them would be a secure environment. As a result, the mechanisms of exchange are more sensitive and inclusive - technologically, economically and socially. The values underpinning the 'Library of IoT' are based on 'looking after' one another: *"this is a place to be in the company of people in the same position [as oneself]"*. We should note that this is not the same as the promise of individualised protection and security that is offered by Hobbes. On the contrary, our participants' re-imagination of smart technologies is focused on recovering fundamental communal values (the *"chest of ideas"* in Brixton's 'The Connected Street' model, Fig. 1, part C). These values enable citizens to realise their capabilities and to live as well as possible [53]. This takes us to a different understanding of security - one that is characterised by an continuing process of nurturing and caring for each other, underpinned by collective rather than individual responsibilities, including those that help to bring about discussions of what constitutes agreed forms of security.

Future work, we suggest, may seek to further develop participatory processes inviting the users of smart technologies to consider and then re-imagine new models of security, as well as to co-design new mechanisms and processes for securing the relations between civics and institutions.

6 CONCLUSIONS

In this study, we have argued that a wider definition of security can guide the analysis of smart technology adoption. In addition we have suggested that this approach would be able to deliver a wider range of civic benefits for all those who live within the smart city. Our observations have related to the politics of social and economic inclusion and exclusion that are so often embedded into the design of smart technologies. Specifically, we have enquired into the impact of smart technologies on communities where diverse socio-economic conditions prevail.

If smart technologies are to realise their benefits, we must look critically at the values and policies carried and reproduced by the technological artefacts we design. We must also look at the socio-economic and political matrix in which these artefacts are deployed. As part of this, it is crucial that discussions around smart infrastructures are not restricted to

the technical dimension, and that these discussions go on to consider the implications of the varying socioeconomic conditions in which these technologies are going to be used. In doing so, we will attend to the call within HCI for increased reflexivity and accountability in relation to these technologies [14, 58]. We therefore advocate the shared production of relationally enriched security models. Such models will recognise that there are variations in capabilities and circumstances, and will take us closer to a more democratic, relational and citizen-centric enactment of the smart city.

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