Entangled Ethnography: Towards a collective future understanding

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ABSTRACT

In this work, we develop a vision for *entangled ethnography*, where constellations of people, artefacts, algorithms and data come together to collectively make sense of the relations between people and objects. This is grounded in New Materialism's picture of a world understood through entanglement, through resonant constellations, through a multiplicity of unique individual viewpoints and their relationships. These perspectives are especially relevant for design ethnography, in particular for research around smart connected products, which collect data about their environment, the networks they are a part of, and the ways they are used. However, we are concerned about the current trend of many connected systems towards *surveillance capitalism*, as data is colonised, machinations are hidden, and a narrow definition of value is extracted. There is a key tension that while design, particularly of networked objects, attempts to go beyond human centeredness, the infrastructures that support it are moving towards a less than human perspective in their race to accumulate and dispossess. Our work tries to imagine the situations where participants in networked systems are richly engaged, rather than exploited. We hope for a future where human agency is central to a respectful and acceptable collaborative development of understanding.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

Object Oriented Ontology, Thing ethnography, Ethnomining, ethnography, surveillance capitalism, Biography of Artefacts, third wave HCI, ethics

1 INTRODUCTION

In this paper we explore the concept of *entangled ethnography*— an avenue for design research into human practices that involves people more deeply in making sense of their interactions with connected products. We aim to support research that contributes design insight while avoiding intrusion, surveillance and disempowerment. We build on developments in New Materialism, a philosophical movement which reconsiders the position of human amongst non-human actants, weaving a connected picture of the entanglements between humans and things [7, 23, 26]. This leads to a vision where the unfolding relations between people and things build a vibrant picture of human and non-human activity. There are two hopes here:

1. Consensual understanding is more powerful than data acquisition: By acknowledging that data without grounding is unreliable, that there are crucial subtleties of experience that need to be interrogated in concert with those involved, we see a world where participation is a more common option than data extraction and dispossession.

2. Objects and situations are as useful as modelling individuals: where surveillance uses things to record the actions of people, we can turn this so that people's biographies of objects carry equal weight, shifting the weight of surveillance from humans to constellations [13]. Having those directly engaging with objects in the wild involved in collaborative sensemaking with researchers about understanding situations – rather than behavioural models of people – gives them more power, pushing back against surveillance.

This paper engages with the New Approaches to Research & Design and Public & Private Spaces themes of the Halfway to the Future conference. Our work picks up on some of the challenges discussed for third wave HCI, modulated through the current sociotechnical climate [6]. This work also explores how technology can support collaborative sense-making in a similar way to the work of Heath and Luff [25]. Issues arise of scale, surveillance, reductionism and the impacts of a data-driven capitalist appropriation of design principles. There are key concerns around the flows of data, and how these practices can be scaled up to fit alongside the massive deployments that characterise modern IoT infrastructures.

Philosophically, we are interested in the intersection of ethnographic practice and critical HCI theory, with an attempt to create a space where thick description and richness is privileged as a foil to reductionism, and engagement with human actors is a counter to dispossession. Practically, we are also concerned with how we can

generate usable design insights, at scale, without compromising the agency or privacy of the people.

This paper contributes a theory driven exploration of more-than human centred ethnography, which we call *entangled ethnography*. It acknowledges that objects will increasingly capture and share data about their use, and that computational intelligence will increasingly be used to make sense of this data. In response, it posits a practice for research and design where:

- The relations between humans and things are paramount, both for the design of new or better objects and the understanding of human practices surrounding these objects.
- Data is the start of the process, not the end. Human truth is sought to make sense of data collected, so that meaning is constructed collaboratively between researchers, algorithms and the networks of people and objects in the world.
- Humans act as biographers of objects just as much as the other way round: where Thing Ethnography uses objects to understand human behaviour, in an entangled approach, the humans understand the object behaviour and requirements.
- Human attention is extremely valuable, and any work carried out should be sensitive to this, aiming to use technology to make the most use out of people's limited time.

2 BACKGROUND

By surveying critical theory and ethnography literature we develop a vision for new ways of understanding behaviour. While traditional ethnographic and anthropological techniques allow us to understand the rich complexities of human behaviour and motivation across cultures and demographics through direct observation and long term immersion, new methodological and theoretical developments promise to facilitate observation of both human and non-human actors at the intersection of their interaction.

2.1 Object Oriented Ontology

Harman's Object Oriented Ontology (OOO) [23, 24], a part of the New Materialism school of thought, seeks to redefine the treatment of humans, objects and their relations. In particular OOO creates a 'flat ontology' where humans are not seen as privileged or distinct from other objects, and *object* represents anything from material things, to individuals, properties, actions or abstract notions. The essence of these objects is inaccessible to us and unknowable, but we can understand the relations and observe the entanglements between them. Building on this work Bogost develops a philosophical practice of alien phenomenology [7], which attempts to understand these intrinsically unknowable experiences of objects through the use of unavoidably anthropomorphic metaphors. The practical implications of these ideas are that it is important to recognise the agency of objects to shape the world around them (in line with earlier work around Actor Network Theory, e.g. [11]). Rather than being passive, the things around us have power, and understanding how this power works is necessary for understanding complex situations. Bennet [3, p.20–29] illustrates this mode of thinking by exploring how the various components of the electricity grid, from electrons and waves through transmission lines up to legislature and laws, can collectively fail and produce blackouts. Foregrounding the individual perspectives of objects, their unique relations

to each other, creates a more vibrant picture of the world, with a deeper understanding of the networks and relations that increasingly support our daily lives. From a design point of view, products can be seen not as isolated objects, but the end result of a coming together of designers, manufacturers, materials and their producers, supply chains, regulatory bodies, the imaginaries of retail and marketing and so on. This is especially relevant in the context of 'smart' or connected objects, where their functioning is distributed to include cloud servers and communications networks. Similarly, as objects can sense and respond to the world more, their perspectives become more clearly articulated, and can be explored by humans investigating their data streams. When attempting to understand human experience, accounting for the interconnected relations between things—both material and immaterial, both human and non-human—creates a multitude of points to probe and question.

2.2 Contemporary Ethnography

In parallel, there has been a trend within ethnographic practice to broaden the scope of enquiry. In particular, George Marcus develops *multi-sited ethnography* [28, 29] to grapple with issues of interconnectedness: *"Strategies of quite literally following connections, associations, and putative relationships are thus at the very heart of designing multi-sited ethnographic research."* [28].

The philosophical developments in OOO and speculative realism discussed above, have directly inspired the development of *thing ethnography*, that explores the use of things as co-ethnographers that give a new perspective into human behaviour [19, 20]. Data collected through sensors and cameras attached to domestic products, can help develop an understanding of the minutiae of people's engagements [12, 19, 20]. An ethnographic exploration of everyday home activity conducted by Giaccardi et al. [19] used home appliances, including kettles and mugs instrumented with cameras, in order to record and reveal the situated nature of home activity.

Other ethnographic practices also leverage the value of a thing perspective through the collection of data. Ethnomining continuously gathers data generated by a smart device about human activity and uses it as a resource for sensemaking [1, 4]. Anderson et al. [1] used data logging from an array of personal computing devices to generate detailed visualisations of activity, which were used in contextual inquiry interviews, enabling co-creation of data and insight [1]. Using a similar log based data capture ethnomethodological approach, Fischer et al. [17] used temperature and humidity sensors placed in people's homes as a support tool for energy advisors, who in collaboration with homeowners made sense of the data and provided advice.

Meanwhile, the Ethnobot project [43] uses a chat-bot to interact with participants, simultaneously collecting data and guiding activity, through the anthropomorphisation of human-computer interaction. By adopting new thing-led perspectives, we are developing research practices that can examine the rich entanglements of human behaviour with things. This use of ethnographic research practice comes under the umbrella of design ethnography, which aims to gain rich insight into the lives of people in order to find design solutions that cater to their needs [37].

The development of software has also been examined through ethnographic research practices. Here, the Biography of Artefacts

perspective, developed by Pollock and Williams [32], emphasises the value of *strategic ethnography* for research into technology design development. They are critical of the use of short ethnographic studies with small groups at places of work, which privilege local interactions and produce inadequate accounts of technological and organisational change. To address this Pollock and Williams [32] propose the development of strategic ethnography, which broadens its research scope across wider time-scales, addressing technology at different moments in its life-cycle, across different organisational users, with a broader view of technology development in order to develop holistic biographies of artefacts.

We share in the concerns raised by Pollock and Williams [32] and George Marcus [28] regarding the traditionally limited scope of ethnographic deployments. We address them by examining some of the opportunities afforded by the use of technology as co-ethnographers in order to work across a large number of people within dispersed geographies.

2.3   More-Than Human Centred Design

The design of products and interfaces within Human Computer Interaction (HCI) has largely focused on simplifying the human experience by creating intuitive and cognitively undemanding interactions [21]. Within design these aims have largely overlapped with Human Centered Design (HCD), which caters to the needs of users and creates seamless interactions [21]. While reducing complexity has been a key trend within design it is juxtaposed with the increasingly complex networks of IoT products and digital services available to users across their working and home environments [6]. Susanne Bødker [5] identifies different 'waves' of evolution of the field of Human Computer Interaction, the first wave was characterised by a model-driven study of human factors, the second wave was characterised by human-centered techniques focused on *"cooperation, learning, and participation"*, while the third wave of HCI broadens notions of contexts and applications to include 'artifact ecologies' that exist within a complicated network of activity [6].

Coulton and Lindley [13] argue that HCD approaches are limited by their focus on the immediate user and that third wave HCI approaches need to address challenges around this increasing complexity where *"the notion of human centred ceases to be useful"*, they call this new approach more-than human centred design. In order to untangle some of this complexity researchers have developed the use of metaphors as a design thinking tool [13, 31], in a similar fashion to Ian Bogost's alien phenomenology metaphors [7]. These metaphors often take on the form of visual speculative designs that focus on the behaviors of IoT devices and how they connect, communicate and act as part of a network [31]. Pierce and DiSalvo [31] use metaphors to address network anxieties by making data-flows and abstract notions explicit and visible, Pschetz et al. [33] use speculative devices to embody ideas of autonomy and control. Meanwhile, Coulton and Lindley [13] have developed the metaphor of constellations to describe the independent-but-interdependent perspectives of objects. They ground their work within OOO philosophy in order to extend human-centered design thinking [13]. Within their metaphor IoT objects, hardware, software, algorithms and networks come together to create a constellation of star-like

entities, that although at times invisible, exert tangible forces on each other [13]. Within this paper we have adopted the use of the constellations metaphor as a way to ground our work within OOO theory and embrace the entangled complex nature of design ethnography within the connected devices context.

2.4   HCI in the Wild

In the wild HCI research methods vary widely and include diary studies, experience sampling, field studies, and observations [8, 14, 27, 30]. In a similar fashion to developments within contemporary ethnographic practice, in the wild research methods are also utilising data collection and capture from technology. Contingent experience sampling in particular, relies on data and algorithms to facilitate real-time responses from uses based on triggers from data streams [16, 40, 46, 49]. By eliciting participant responses close to the time of the activity of interest, this approach ameliorates issues around retrospective recall [46]. However, contingent ESM tends take the researcher out of the context of real-time research and instead rely on data and algorithms to trigger real-time participant feedback. Furthermore, contingent ESM is known to disrupt participant activities, which can affect the quality of responses and question the validity of findings. [46]. With particular relevance to our research is the use of research products and technology probes, which are research artefacts deployed in the wild to explore people's experiences around technology in situ [27, 30]. While qualitative data about participant experiences has traditionally been gathered through post-hoc interviews or the traces left on the artefacts [30, 45], the development of ever smarter and more connected IoT products has raised questions about the potential of live data to support situated research. Recently the work of Burnett et al. [10] investigated the potential of supervisory digital twins, virtual rendered representations of products that respond to live data about the way they were being used, to be used as a resource for design led research.

2.5   Ethics of Data-Gathering for Design

Data gathering through products in the wild is subject to an array of thorny ethical issues such as the potential exploitation of human labor and time. Coulton and Lindley [13] argue that today manufacturers defend data gathering through the promise of better user experience, but by not making the ways that data creates further value for them explicit, they are diminishing user agency, a form of data colonialism [44]. The use of data-gathering for the development of products is part of a wider trend called *prosumption*, which utilises user labour for financial benefit [34]. Prosumption is characterised by the trend of companies to engage consumers in the process of production [34]. Traditionally prosumption capitalism has been seen to exploit its customers by requiring them to take an active part in the creation of the products that they consume, for example the invention of fast food restaurants where people are expected to serve themselves thus diminishing the need for hired staff. However prosumption associated with the Web 2.0 is more ambiguous in the way that value is produced [34]. Users are often motivated to take an active part in production because they see it is personally beneficial, they are more critical of the process and often expect to pay little for services [34]. For example, while YouTube

and Facebook rely on people to continuously create and consume content in order for them to make advertisement revenue, those engaged in producing content for these platforms may feel that they benefit by feeling more connected to friends or progressing their career as a vlogger. In a similar fashion Jennifer Whitson [48] postulates that everyday surveillance tied into gamification elements of the quantified self can be seen as enjoyable and acceptable. Surveillance entangled in play can encourage behaviour change that can be seen as fun and even beneficial by users. While not addressing questions of profit creation, she is keen to highlight that *"the black box of the software that hides the rules from us"* may create unrewarding experiences, highlighting a one directional power dynamic.

Although people willingly participate in surveillance and prosumption when they see a personal benefit, it is unclear to what extent they understand how the data collection process they are part of creates value for corporations and even universities. As Shoshana Zuboff highlights in her work on *surveillance capitalism*, our experiences are rendered as behavioural data combined with machine intelligence to create predictions about our behaviour, which are sold on the marketplace, for example Google selling data to target advertisements [50]. While it began with predicting click through behaviour, this model is increasingly being used within physical designs.

The ethics of data collection is a highly contextual issue, especially with connected products. While the question of what data is being collected is a starting point, it quickly becomes important to understand what is being done with that data, who can see it, what inferences are drawn from it and what levels of control the users have. Many devices today use data flows as a core part of their functioning - the Nest thermostat collecting data about it's users in order to predict their behaviour and turn the heating on at the right time. Devices that collect information on their own performance as a means of predicting failure or scheduling maintenance are much less problematic [39], for example, predictive maintenance is a vital part of servicing Rolls-Royce jet-engines, which capture vast amounts of telemetry data about their functioning [2]. In contrast devices that collect data in order to better understand their users are much more ethically ambiguous [50]. Shoshana Zuboff highlights that data collection through smart devices does not necessitate surveillance capitalism and that these ethical issues can be tackled by avoiding the creation of black boxes and giving exclusive ownership and management rights of personal data to the user [51].

These issues and potential solutions can be explored through a critical approach to design. For example, the 'Living Room of the Future' explores the future of media production and smart devices where *"media content adapts in response to user data collected from IoT devices situated in the living room and the adaptation, in turn, actuates connected devices (e.g., speakers, lights, window blinds, heating, etc.) in order to enable the media experience to reach beyond the screen into the living room"* [36]. The project makes explicit the acts of requesting and collecting data about the users, but then stores it on a 'Databox' [15] that physically situates the data with the user, giving them control over access to it and responding to concerns regarding privacy, trust and control within data-driven media.

3 ENTANGLED ETHNOGRAPHY

Our vision for *Entangled ethnography* builds on these research themes and practices in order to develop an understanding of human behaviour through data collection from products in the wild, intertwining behaviour, experience, objects and environment. Our core notion here is that entanglements between people and things can help us make sense of the ways that they each carry out their existences. More properly, this might be called entangled design ethnography, as we are primarily focusing on the kinds of ethnographic questions that support designers in their work. The central driving force is to understand how to create assemblages of people, algorithms, devices and networks that allow us to understand the ways that objects are used in practice, and develop design insights that help to make better, more appropriate artefacts that both address the needs of users and the needs of the wider environment they are a part of.
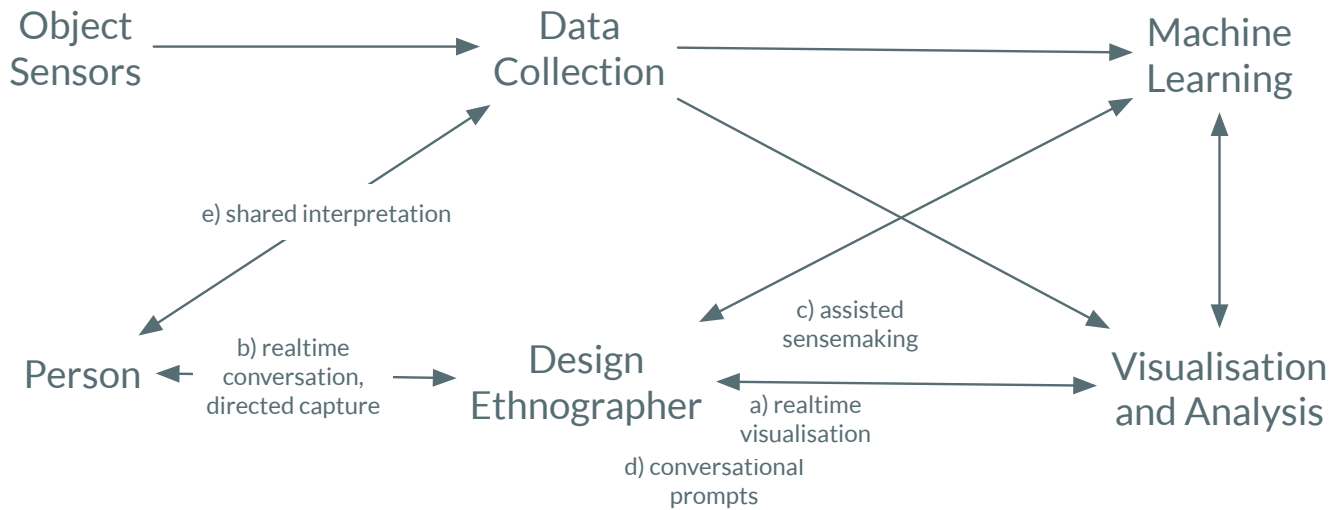
Entangled ethnography aims to create a broad more-than human centred ethnographic approach by combining the object orientation of thing ethnography [19, 20] with the interconnected constellations of Coulton and Lindley [13] and the extensiveness of critical ethnography [32].

Data is clearly fundamental to this kind of work, but it is important to take data in a broad sense, to include collection of qualitative responses, notes, images, and video, as well as simply quantitative data generated by sensors. It is important to bring the participants into this—a camera on a device is a surveillance device, but asking a user to take a photo of how they are using things can be a collaborative act. Equally important is developing a nuanced and connected understanding of what data is used for and what the benefits are.

Entangled ethnography is an argument that by working with rather than against users, devices can develop more insightful pictures of their use. While thing ethnography fruitfully uses objects as co-ethnographers, entangled ethnography is the engagement of both participants and things in a continuous co-ethnographic practice. For the people that want to engage with the sensemaking of their relationship with the things around them, having a voice in the process can be empowering. Similarly, understanding the nuances of behaviours and interactions across the increasingly vast network of human and non-human agents can help inspire design.

We build on the following criteria:

- Some forms of ethnomining and data analysis are necessary to work at today's scales, making sense of data from multiple sites, over significant periods of time, with the involvement of a broad range of participants or users of technology.
- Data on its own is limited in its ability to provide rich insights into people or their relations to objects. Interpretation from human participants is crucial to making connections outside of the narrow view of data, whether to internal states, enriching context or understanding some of the complex networks of action and relation that occur in modern life. This interpretation is expensive both for researchers and participants in terms of time and mental energy, and should be focused on areas of interest.
- If we want to interrogate what has happened in a moment, the closer we can get to that moment the better, both for

Figure 1: An overview of the Entangled Ethnography process, showing how real-time visualisation (a) leads to real-time conversations with users of objects (b) that can result in directed capture of data surrounding a situation. This can then be understood through a sensemaking process (c) where machine learning supports deriving meaning from the data. As more is understood, machine learning algorithms can contribute to the contextual enquiry (d), e.g. by triggering conversations and giving context to the researchers.

human recall and for the ability to uncover, articulate and develop extra contextual information.
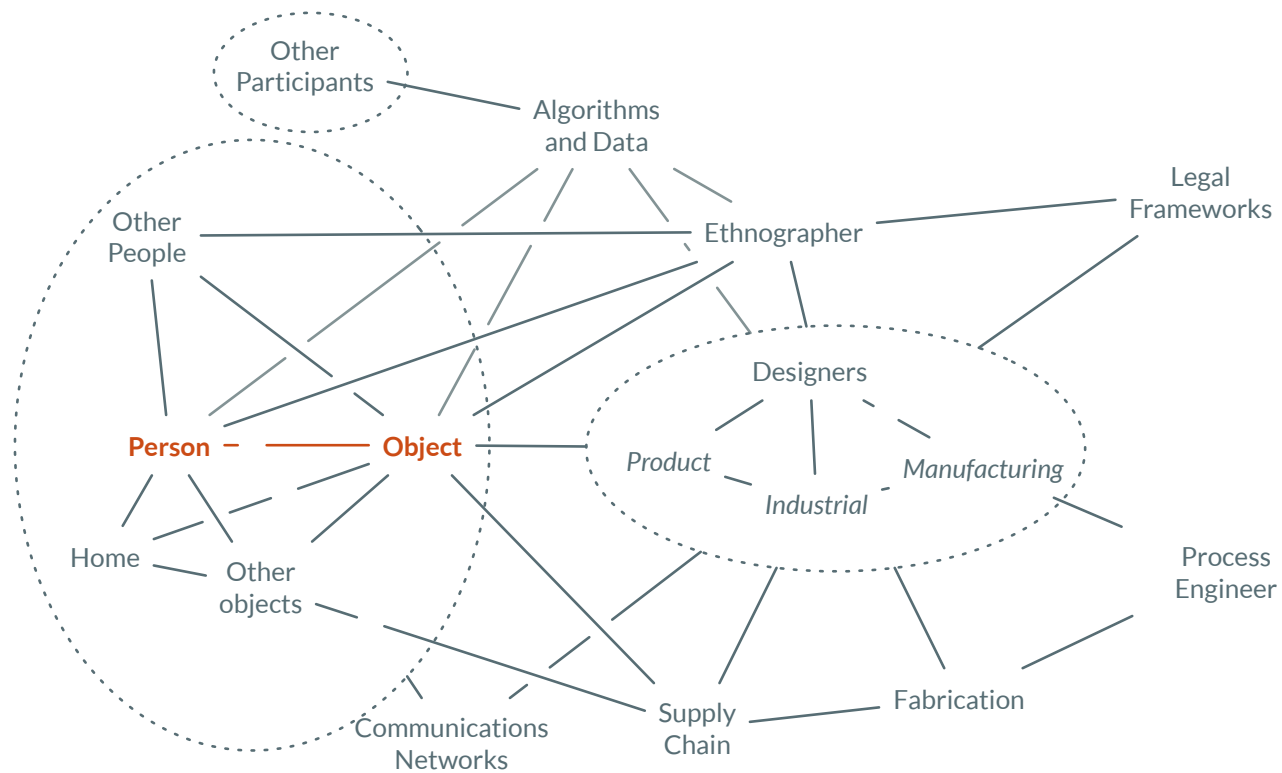
- Similarly, algorithmic analysis on its own is unlikely to provide a solid basis for insight or action. Collaborative sensemaking processes are necessary that continually ground truth the output of algorithms with both an ethnographic understanding of the situation and participants reflections.
- The acceptability of the process is key; at a surface level, this means making sure that participants are willing and engaged, but can be taken further to ensure an alignment of values between the designers and the users of objects, and to develop a sense of participation in the design process that extends well into the lifetime of the objects being designed.

3.1 Entangled Ethnography in practice

In practice, an entangled ethnographic approach could be enacted as follows (see Figure 1 for an overview).

- Sensors are attached to objects that capture information about how they are used. This is a broad and potentially deeply problematic statement, which we will come back to later (see Acceptable Sensing section below). In short, we would emphasise the object's point of view: what environment is it experiencing? is it being dropped, vibrated, turned upside down? To some extent, what does it know about how it is being used?
- Ethnographers use this live data feed to look for moments of interest. The sphere of interest can change over time, as a nuanced view of interaction is built up, and research questions develop.

- The ethnographers communicate with the participants based on these moments of interest. In line with contingent experience sampling, the aim is to target interactions at particularly interesting moments. The communication can include discussions with participants through a chat system, including requests for photos or videos, or pre-defined contingent experience sampling questions automatically sent based on triggers from the live data, such as the object accelerating beyond a certain value. This contextual inquiry would build up a carefully aligned picture of what is happening combining sensor data, photo and video capture and interpretation close to moments of interest.
- Insights generated from these contextual inquiry activities will be used to annotate the data and add supplementary field notes.
- This forms the basis for analytic work, where a combination of visualisation and machine learning is brought together to support sensemaking. Through future research we hope to develop techniques that would allow us to work with algorithms in collaborative ways, negotiating the territory between human and machine understanding, such as:
  - Using human annotation to train models, then extending the models to additional participants or sites, testing examples and hypotheses.
  - Using unsupervised techniques to spot novel behaviour, and directing human attention to those moments.
  - Allowing designers to develop hypotheses and test them against data coming in, working towards tests for particular occurrences.

Figure 2: Constellation of actors in the Chatty Factories project, showing the situation under consideration. It consists of connections between people and products, communication and data sharing with designers and ethnographers, then a connection through the different design stages, through the manufacturing process and supply chain to create the actual product under investigation.

There is a hope here that by setting up the right collaborations, maintaining human engagement, even imperfect and limited algorithms will be of use.

- As this analysis comes together, it can be fed directly back into the conversation between ethnographers and participants, by prompting conversation at particular moments, and supplying the current interpretation of the situation for discussion, making sure that any conversation is a chance to influence the picture that is being built up, and to reflect back the context of enquiry.

Taken together, this works to create a constellation of investigating that involves the object under investigation but extends out to entangle researchers, algorithms, datastores and eventually manufacturers, suppliers, other users and beyond.

4 CASE STUDY: CHATTY FACTORIES

An initial method based on these principles has been tested through deploying sensorized Bluetooth speakers in the wild with participants who used them in their daily lives, in their homes and beyond [22]. This study is situated within a project that seeks to generate design insight from product data in a manner that supports rapid redesign and manufacture in response to the way that products are used—a form of *use sovereignty*[9]. This kind of design process requires us to make sense of the complex constellations of actors, both human and non-human involved in the design, production and use of these artefacts (Figure 2).

Each of the speakers we developed sends out a continuous stream of sensor data in addition to its normal operation with data about orientation, movement, temperature, connectivity etc. as well as reporting on its intended function of playing music - track titles, volume, playback status and so on. This data is presented along with a digital twin of the object to the researcher through a dashboard [10]. This realtime visualisation of live data streams allows the ethnographer to monitor activity and engage the participants at key times about interesting activity they are seeing through direct messaging, prompting for explanation, context and image or video capture. We have seen that directly communicating with participants lets us collect rich insights that ground truth the quantitative data, encourage reflection on events that could otherwise be missed, and sensitively collect images and video showing a context of use—for full details, see [22].

We have taken several measures in order to increase the acceptability of the research process, as discussed by Rooksby et al. [35]. Unlike thing ethnography and ethno-mining which often rely on the collection of video footage and GPS data [1, 19, 20], we do not collect location, audio, or video from the IoT devices used in

research. Currently data collection and storage is centralised to two university institutions working in collaboration. However the ownership of the raw data belongs to the participants, who have the right to withdraw or withhold data in perpetuity. Yet, as we scale the use of our ethnographic practice beyond the university setting, we believe that there are further considerations regarding not just data ownership but also the creation of value through data collection.

5 FUTURE VISION OF ENTANGLED ETHNOGRAPHY

5.1 Ethical Sensing

There are a raft of ethical and privacy issues around data collection. Our concerns centre on ethics and privacy, but also extend out to include the care we take with people's time and attention or the power balances between designers, researchers and users of objects. In an ideal world, a sense of entanglement would provide a guide for carrying out studies by supporting participants agency. Practically, a more concrete framework is useful, and the Theoretical Framework for Acceptability can be brought to bear [38]. While intended to make sense of health interventions, it has been applied to personal data [35] and identifies a set of concerns that underpin many interventions into people's lives. Distinct from working with ethical issues, this considers more broadly how acceptable a process is to users, and works on several dimensions. Excluding Self efficacy, which is aimed at personal health interventions and does not translate directly here, we will relate the considerations from the framework below:

- Affective Attitude: how do people feel about the intervention. Developing the right relationships with participants is important here, emphasising participation and choice over covert surveillance and acquisition. Valuing participants contribution and time is key to creating an ongoing, mutually supportive context for research.
- Burden: perceived effort of participating. Our preliminary findings indicate that user-researcher communication is at times taxing to participants [22]. We feel that similarly to ESM, some level of disturbance is warranted in order to limit retrospective recall and gather contextually grounded thick descriptions of moments of interest. For long term deployments, it is clear that an increasingly sensitive approach to asking ground-truthing questions is required. We aim to decrease the burden on participants by limiting interactions through the use of algorithmically generated triggers, such as those used in contingent experience sampling, alongside the identification of key moments by training machine learning models. This would limit interactions to a handful of moments that are truly interesting. This is a site where computational support can help, as data is quickly labelled, and moments of uncertainty or novelty highlighted as the basis for a conversation.
- Ethicality: of the process as a whole. In particular, how does any data collection and analysis line up with the participant's value systems; does it affect their autonomy or control. Building a model of human behaviour through the use of data collection is susceptible to thorny ethical issues. This is a

place where giving users control of their data is crucial, and supporting an engagement with the interpretation of their data can be meaningful. In addition, it is vital to carefully select the ways data is collected: less personally identifying data can often still give useful insight, and bringing participants into the capture process can ensure that they both know what is captured and consent to it.

- Coherence: how well do people understand the process and their role within it? While some of this can be dealt with by explanation, much is down to the way the participatory process is handled. Some of the key questions that need to be explored are what is the ultimate objective of data collection, who benefits and in what ways, and how are users/participants engaged in the process.
- Opportunity costs: what is given up to participate. Apart from the burden of participation, the main issues are that any object with sensors and intelligence attached is likely to be more unwieldy, expensive and power hungry than its non-sensorised cousin. However, in a world of increasingly networked products, cheaper sensors and data, this is likely to be increasingly negligible.
- Perceived effectiveness: how much do participants believe the work makes a difference? In this case, the primary focus is on how much effect participants believe that their contributions will have to design and understanding. This again lines up with values of transparency and entanglement - as participants are brought into the sensemaking process, they can see and shape the ways they are understood, and have a deeper connection to the research effort as a whole. Part of this may also come through connecting people to the fruits of their labour - finding ways to give them updated versions of products, containing the changes derived from their actions and sensemaking.

Overall, there is a strong correspondence between the direction of the Theoretical Framework for Acceptability and cultivation of human agency within the context of data collection and sensemaking. Conversely if we are to argue for a more-than human centred ethnographic practice, a human-centred acceptability framework may be limiting in the way we evaluate its effects on the broader constellation of objects. As discussed in the Ethics of Data-Gathering for Design section, key considerations for the use of entangled ethnography are the ways that value is created and for whom. We strongly agree with Shoshana Zuboff's guidelines for avoiding surveillance capitalism by avoiding black boxing and giving ownership and management rights over personal data to users/participants in a clear, understanding and empowering way [51]. One way that this can be facilitated is through the use of Databox type systems that store and process data locally, only exporting data with exclusive permission from the owner [15]. Alternatively, if the data is not stored locally users should still have full control over the ways in which it is used, sold, analysed, and by whom it is seen. Future considerations for ways that data gathering and collaborative sensemaking may affect a constellation of interconnected objects, may include environmental, political, and societal impact, although it is currently unclear how those can be evaluated.

5.2 Expanding Moments

Data and time have a nuanced relationship. In particular, data extends the present moment, as viewpoints on it can be refined and developed after the fact. On the one hand, this can be coercive and corrosive: As discussed at a presentation at a Singularity University event by Brad Templeton, a privacy expert, things that are currently being recorded could have significant implications for our privacy and rights in the future when AIs would be able to look into your past and see what you were doing at any point in your life [47]. However, if it can be constructed properly, an entangled approach to understanding can bring together the various perspectives and sources of data to create understanding that was not available in the moment, connecting chains of action between people and the objects around them. This shapes the way that data is collected, as research questions emerge and can be rapidly asked using digital tools, continually shaping the way that data is collected and the situation is conceptualised. These conceptualisations extend both forward in time by shaping new data collection, and backwards by shaping the analysis of data already captured and processed.

At the same time, this expands across space, by connecting moments with other participants. Nuanced similarities between activities in multiple sites allow for a somewhat strategic ethnography [32] albeit in an ad-hoc manner. As suggested by Pollock and Williams [32] in their strategic ethnography practice, entangled ethnography should look at the whole lifespan of products and systems, creating biographies of each part of the constellation of entangled things, users, researchers and organisations. As a result an ethnographer would be able to examine the minutiae of qualitative and qualitative data associated with a single product and they would be able to describe how user behaviours change over time. Moreover they would be able to have a holistic view of effects that exceed questions of human behaviour and needs, such as the relationship between the materials used in products and their potential to be recycled or reused, in order to support mindful research and industry practices. In essence entangled ethnography has the potential to make visible the ways IoT objects, users, networks, ethnographers, designers and manufacturers affect each other over time.

5.3 Data, Matter and Constellations

More and more, the products around us are born digital, with identifiers and histories, provenance and models. They increasingly resemble Bruce Sterling's [42] Spimes: futuristic manufactured objects, "material instantiations of an immaterial system". Within our vision, the entangled non-human things are becoming more 'spimey' [42]. As well as having an increasing animacy and ability to affect their environment or interact with the world around them. Part of this work is to support these new vibrant constellations [13], where networks of people and objects come together to shape matter and data. By broadening the scope of ethnographic practice it is able to address the issues of complexity raised by third wave HCI [6].

In the same way that ambiguity can highlight issues and perspectives that can enrich design practice [18], we are interested in a vision for entangled ethnography that can create a new interpretative relationship between designers, people, things, needs

and perceptions. There are connections to be found all the way from a designers annotation on a digital file, through the process of manufacture, into the momentary interaction with a particular user, then back through sensors and data analysis to a contextualised response to the original question. By understanding and supporting these long range entanglements, the constellations created can emphasis valuing people for their viewpoints and understanding, as reflective, relational collaborators, connected to the results of their participation. They also allow the things more space for agency, and more of a say in their design process, moving towards a sense of *designing by data* [41]. In a similar way to Fischer et al.'s use of data gathered from IoT home sensing systems, where energy advisors and homeowners collaboratively interpret data logs and create actionable insight [17], we feel that actionable insight can be collaboratively created between researchers, users, and things. Overall, this is a development of human-machine inter-agencies around ethnographic processes: how can we enlist humans and AI alike in the task of developing rich, nuanced understanding.

There is a shift away from any pure sense of ethnography here, in that this kind of investigation is fundamentally disruptive—participation in reflective activities and sensemaking is very different from going about one's business naturally. This goes beyond the burden of participation, and changes the nature of the relations between researchers and participants. If we were developing techniques for understanding the world as it is, this disruption and divergence from natural practice would likely be a step too far. However, as the aim here is to bring end users into the design process in pursuit of creating beneficial changes, the desire for purity can be weighed against the immediate responses and increased agency of the participants. Entanglement affects systems, and this approach will be more appropriate for some situations than others.

6 CONCLUSION

Through this paper, we have tried to make the case that a practice of digitally *entangled ethnography* is emerging, bringing together emerging theory about how we understand the interconnected world around us with (and for) networked and sensitized infrastructures. The challenge is to navigate towards a shared, vibrant, participatory understanding, finding ways to engage in data collection and interpretation while avoiding the pull of surveillance capitalism and its attendant will to capture and control flows of data. In the context of third wave HCI, this offers routes to really centre on the interactions [6] while embracing the current key challenge facing HCI work: how to work at scale without losing the vibrancy of human experience. By finding acceptable, entangled ways to collaborate between computational and human intelligence, we can work towards a vision of connected human-machine inter-agencies that develop broad contextual understandings to support human activities.

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